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An Analysis of Cost Premiums and Losses Associated with USAF Military Construction (MILCON)

Daniel L. Blomberg

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**AN ANALYSIS OF COST PREMIUMS AND LOSSES ASSOCIATED WITH
USAF MILITARY CONSTRUCTION (MILCON)**

THESIS

Daniel L. Blomberg, Captain, USAF

AFIT-ENV-13-M-02

**DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY**

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AN ANALYSIS OF COST PREMIUMS AND LOSSES ASSOCIATED WITH USAF
MILITARY CONSTRUCTION (MILCON)

THESIS

Presented to the Faculty

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Air Education and Training Command

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Engineering Management

Daniel L. Blomberg, B.S.

Captain, USAF

March 2013

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AN ANALYSIS OF COST PREMIUMS AND LOSSES ASSOCIATED WITH USAF
MILITARY CONSTRUCTION (MILCON)

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Abstract

Military construction (MILCON) represents 40% of the federal government's \$30 billion construction budget. The federal budget is fixed; therefore, any cost overages likely affect project scope or requirements. This study investigated if MILCON procurement costs more than private industry construction and if so, what causes the cost premiums. A combination of in-depth literature review, expert interviews, a unique case study, expert surveys, and geospatial statistical analysis answered the research question. The case study evaluated two nearly identical projects to determine how internal factors, in addition to public laws, affect MILCON cost premiums.

This study confirmed the existence of MILCON cost premiums. Additionally, 11 major cost premium themes emerged: overly restrictive statements of requirements, failing to balance risk, stifling or not applying innovation, unique MILCON requirements, parameterization of the execution process, selection of construction specifications, schedule and submittal policies, perception of MILCON construction agents, anti-terrorism/force protection requirements, Federal Acquisition Regulations, and socioeconomic laws and policies. Additionally, in spite of the contract requirement similarities, once complete, the studied projects differed by over a year of construction time and \$7 million. Research frequently cites federal laws and policies as the primary cost premium driver; however, this research demonstrated internal construction policies, which the military can control, also cause increased cost premiums.

To my beautiful wife and daughter.

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Daniel L. Blomberg

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AN ANALYSIS OF COST PREMIUMS AND LOSSES ASSOCIATED WITH USAF MILITARY CONSTRUCTION (MILCON)

I. Introduction

The purpose of this chapter is to introduce the topic of study, provide limited background information, set the research objectives, and present an overview of the research methodology. This chapter defines military construction (MILCON) and provides a limited background into MILCON execution, procurement, and acquisition methods. This limited background provides a baseline for the primary and secondary research objectives. Based on these objectives, this chapter summarizes the methodologies applied and codifies the scope and limitations. Finally, this chapter outlines the remainder of the thesis. This chapter sets a uniform knowledge base for the white paper and two scholarly articles.

Background

Military Construction

The MILCON program is a multi-billion dollar yearly acquisition and capitalization endeavor. For fiscal year (FY) 2013, the Department of Defense (DoD) requested almost \$12.5 billion for MILCON (112th Congress 2011). However, budget constraints and scarce resources for the coming years have forced the DoD to take a hard look at all expenditures, including construction. As part of this hard look, the United States Air Force (USAF) decreased its proposed FY13 MILCON budget from \$1.3 billion to \$400 million, almost a 70% reduction (Schogol 2012). The final FY 2013

MILCON budget authorized \$6.5 billion of DoD MILCON with only \$258 million for the USAF (112th Congress 2013). The reduction in MILCON spending has resulted in a desire to stretch each construction dollar as far as possible.

Title 10, United States (U.S.) Code, Section 2801, defines military construction as “development, conversion, or extension of any kind carried out with respect to a military installation. MILCON includes construction projects for all types of buildings, roads, airfield pavements, and utility systems costing \$750,000 or more” (Department of the Air Force 2010). MILCON projects are large enough to require capitalization into the real property records. This capitalization process is similar to construction in the private sector, where large construction projects are capitalized as company assets. In addition to the explicit definition of MILCON projects, the U.S. government has also issued directives and policies regarding the execution of MILCON projects. Department of Defense Directive 4270.5 dictates that, with few exceptions, the “Department of the Air Force shall use the services of the U.S. Army Corps of Engineers (USACE) or the Naval Facilities Engineering Command (NAVFAC) for design and construction of the annual military construction program” (Department of Defense 2005). If USACE and NAVFAC do not object, the Air Force can also execute a limited number of projects through the Air Force Center for Engineering and the Environment (AFCEE) (Department of the Air Force 2010). In October of 2012, AFCEE and the Air Force Civil Engineer Support Agency (AFCESA) consolidated under a single entity called the Air Force Civil Engineer Center (AFCEC); this thesis will generally refer to AFCEC in lieu of AFCEE or AFCESA. The selection, and policies, of design and construction agents may cause cost premiums for Air Force MILCON projects.

AFCEC sponsored this research effort to validate the existence of cost premiums associated with the Air Force MILCON program, and if premiums exist, determine the causes of these cost premiums. Additionally, AFCEC desired identification of possible mitigation techniques that could be applied to reduce costs. This research adds to existing research, reports, and similar investigative efforts that have occurred or been requested by varying agencies in recent years.

Military Construction Cost Premiums

Anecdotal evidence frequently supports the notion that cost premiums are associated with MILCON procurement when compared to private sector construction. Recently, researchers have worked to validate the existence of additional costs associated with MILCON execution. Pope (1990) investigated MILCON versus private industry/commercial construction from a cost perspective. The goal of his research was to discover key “successes” from private industry construction and incorporate the lessons into the MILCON process. His research showed quantitatively that military construction does cost more than private sector construction. His research effort pointed to specific factors that increase cost: additional administrative requirements; more strict military standards; contract clauses and procurement restrictions; and legislative requirements, specifically the Davis-Bacon Act (DBA) (Pope 1990). However, further investigation is required because legislation and contract requirements have changed and been adapted numerous times since Pope’s research.

In 2011, faced with austere budget conditions, the House Armed Services Committee noted that an assessment of construction unit costs found a noticeable

difference between MILCON costs and comparable facility construction in the commercial sector (112th Congress 2011). The challenges specifically mentioned in this report align with Pope's (1990) research, including legislative and contract clauses. The committee noted that the cost for MILCON appeared to be 25% to 40% more than private-sector construction. Based on this discovery, the committee directed the Secretary of Defense to report on these cost premiums and develop courses of action to reduce these costs (112th Congress 2011). Based on this guidance, AFCEC codified some Air Force cost premiums and found a 37% cost premium for Air Force MILCON (Hartford 2012). These recent studies demonstrate that the research conducted by Pope (1990), and the additional research efforts he proposed, is still valid in 2012. There are cost premiums associated with MILCON execution when compared to private sector construction.

Military Construction Execution

Many research efforts have focused on varying aspects of MILCON execution. These studies have concentrated on private industry best practices such as relational contracting, schedule performance, and design-build procurement methods. All of these research efforts have posed additional topics for investigation, including some specifically focusing on variables affecting construction costs.

One of these industry best-practices, alliancing, was investigated from an Air Force perspective. Recently, alliancing has become a performance enhancer and cost reducer in private sector construction. Alliancing involves forming an advanced partnership where risk and reward are shared among the contract parties toward the

common goal of increased performance; it can increase performance and reduce costs, but federal acquisition regulations restrict some of the required aspects (Johnson et al. 2012). However, alliancing is simply an improvement on partnering, a policy adopted by USACE; thus, some aspects of alliancing can be implemented into MILCON and should pay dividends. Additionally, Johnson et al.'s (2012) research demonstrated that alliancing can reduce pricing fluctuations in design-build projects.

Unlike alliancing, the DoD and private industry have both adopted the method of design-build. To that end, multiple research efforts have focused on design-build procurement. Rosner et al. (2009) analyzed the performance of 835 MILCON projects, including 278 design-build projects, to see if execution method affected schedule, performance, and cost growth. The analysis showed that design-build resulted in better performance for complicated construction; additionally, their research found that the facility type and cost have more influence on schedule than method of execution method (Rosner et al. 2009). Gannon et al. (2012) analyzed design-build procurement in terms of scheduling shortfalls and found that restrictions in USACE design-build methodology caused schedule and cost growth. Additionally, his research resulted in the concept of a construction “cone of uncertainty” showing variability in schedule based on percentage of the design completed (Figure 1). Other industries, such as computer science, have applied this cone of uncertainty to cost (Little 2006).

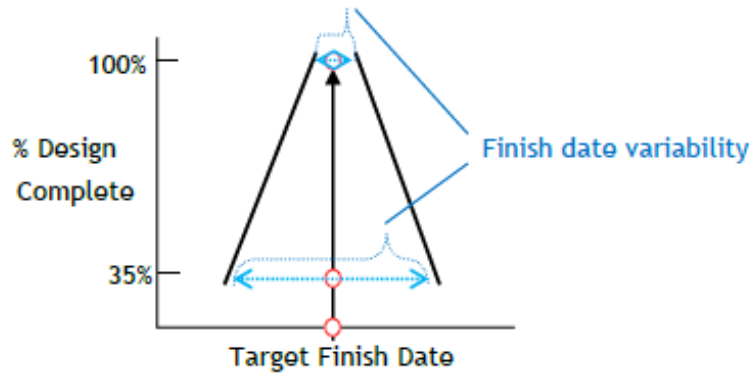


Figure 1: Schedule cone of uncertainty (Gannon et al. 2012)

These research efforts, and the frequent use of design-build in military and private industry construction, pose additional questions relating to MILCON cost premiums. The concept of Gannon et al.'s (2012) cone of uncertainty may also be applicable to construction cost in addition to schedule. Between method of execution, design agent, and contractual partnering/alliancing, it becomes apparent that MILCON procurement is a complicated process involving many variables that could contribute to cost premiums.

Research Objectives

The overall research objective is to answer the question: do MILCON costs exceed private industry construction costs, thereby reducing the cost performance and effectiveness of USAF construction, and if so, what causes the MILCON cost premiums? This research objective was met by integrating research questions posed by the literature and direction from AFCEC to meet the following objectives:

1. Validate the existence of cost premiums associated with MILCON compared to private-sector construction.
2. Determine the variables that cause/affect MILCON cost premiums through the analysis of internal processes.

3. Analyze a limited number of variables to determine the effect on cost premiums. Additionally, examine interactions between variables such as acquisition and execution method affecting scheduling.
4. Create mitigation strategies for the analyzed variables for the USAF use to reduce MILCON cost premiums.

These research objectives revolve around meeting the Air Force's goal of reducing the cost of military construction procurement while also increasing performance. Also, an additional objective of the research is to investigate MILCON cost premiums from both the government and construction contractor points of view. A more accurate and unbiased determination of variables affecting cost should be discovered by analyzing both sides of the procurement process.

Research Approach

In order to meet the research objectives posed above, four phases of analysis occurred. The research objectives were met through the combination of two scholarly articles and a white paper with their supporting appendices. The three articles are each supported by one or more research phases. While each phase of the research was critical to answering the overarching problem, each article had a different purpose or audience. Figure 2 illustrates the four phases, the inputs required, and how each phase linked to the three articles.

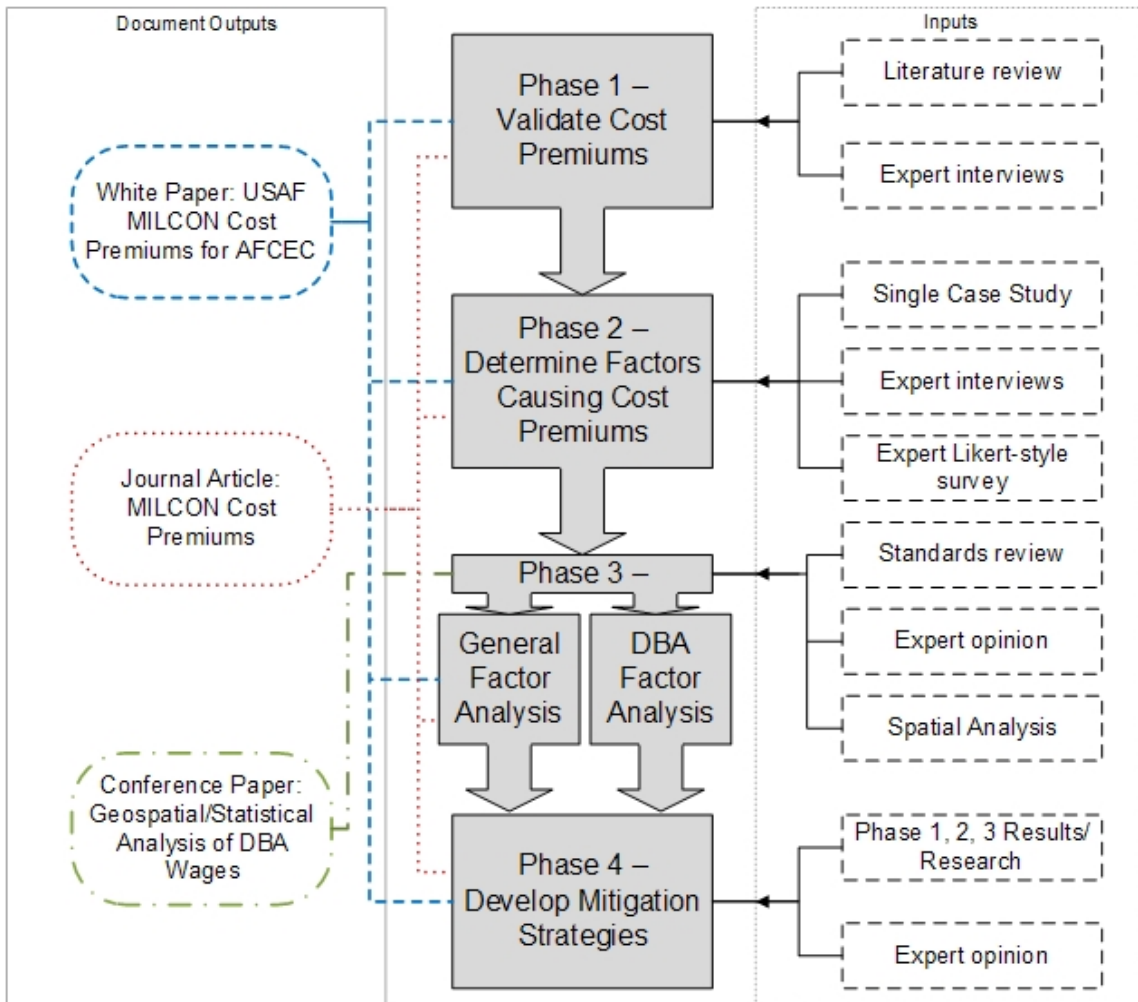


Figure 2: Research Approach, Inputs, and Outputs

Phase 1 – Validate Cost Premiums

The first phase answered the first research objective related to validating MILCON cost premiums. This analysis involved a literature review of existing research and reports relating to MILCON and private industry construction costs. According to Krathwohl (1998), a literature review has four functions: show which facets are important, show the depth of previous research, relate the problem to previous explanations, and determine methods and designs to use and avoid. For this research

effort, the literature review helped scope the investigation while also meeting the phase 1 requirement to validate the existence of MILCON cost premiums. Past research demonstrated that there are substantial cost premiums. This research phase supported the white paper for AFCEC as well as the journal article. Additionally, the consolidation of MILCON cost and execution related research provides stepping stones for AFCEC to utilize for future research.

Phase 2 – Determine Factors Causing Cost Premiums

The second phase of this investigation into military cost premiums determined the factors that cause cost premiums. An analysis of factors causing cost premiums based on internal MILCON processes was developed based on expert opinion and a case study. This section provides background information on causal analysis and case studies as well as a brief overview of the application of these methodologies.

Causal Relationships

Developing a causal relationship is the best way to develop mitigation methodologies for MILCON cost premiums. To show a causal relationship, the entire causal chain must be analyzed, not just the last step (Krathwohl 1998). For example, the requirement to buy an American-made bolt may add to the cost of construction. However, the entire causal chain would show that although the bolt did increase the cost of construction, the implementation of a law set a policy that required the contractor to procure the specific bolt; the cause of the additional cost is actually the implementation of a law. A key element of causal relationships is they “are always inferred, never proven” (Krathwohl 1998, p. 131). This statement means that causal relationships developed by

research are not necessarily proven but rather not disproven. The framework chosen for analysis of MILCON procurement is designed to create a theory while documenting and validating some of the causes of MILCON cost premiums.

Case Studies

The concept of utilizing case studies to develop theory has existed since the late 1960s and continues through today (Eisenhardt 1989). Eisenhardt (1989) described how to build theories from case studies. Her synthesis of previous work related to case studies developed a singular roadmap directing the use of case studies for theory development. Her eight-step process includes defining the research question, selecting case(s) to be studied, creating data gathering protocols, collecting the data, analyzing the data, shaping the hypothesis, comparing with similar and conflicting literature, and reaching closure. For this investigation, comparison to existing literature helps limit threats to internal validity. The use of case studies in analysis typically “combines data collection methods such as archives, interviews, questionnaires, and observations” (Eisenhardt 1989, p. 534). The qualitative and quantitative data provided by case studies require the use of multiple methodologies during analysis. The qualitative aspects of the case study serve to describe the aspects of MILCON procurement that cost more than private industry or between construction agents, whereas the quantitative analysis seeks to describe the cost and schedule differences. According to Ellram (1996), a case study is an appropriate methodology to answer these questions.

Early in the research effort, the number of cases requiring study must be set. Analysis can be completed using multiple case studies or a single case study. A single

case study can be analyzed because “each case study is in and of itself a self-contained experiment, with unique context that is part of the experiment” (Ellram 1996, p. 100). A single case is appropriate when it “represents a critical case to test a well-formulated theory, an extreme or unique case, or a case which reveals a previously inaccessible phenomenon” (Ellram 1996, p. 100). In the case of this research effort, a single case study is utilized because the DoD has never before constructed two of the same buildings in the same location at the same time via different execution methods, an inaccessible phenomenon. When utilizing a single case study, it is imperative to minimize threats to validity to allow for generalization of the results. This can be accomplished by utilizing multiple data sources within the case study, such as focus groups, meetings, after-action reports, and memos (Ellram 1996). The use of quantitative documentation, standards, and written and verbal qualitative information helps limit the threat to validity posed through the use of a single case study.

Case study analysis is not without its weaknesses. First, the use of case studies can yield theory and causes that are overly complex (Eisenhardt 1989). The volume of data available based on case studies and the researcher’s goal to use all of the data available can cause this weakness. To limit this weakness, the research should focus on applicable, simple, data while keeping in mind the need for internal and external validity. Second, the results of case studies can be so specific or narrow that the results cannot be generalized (Eisenhardt 1989). To limit this weakness, the researcher must ensure theory developed from a case study has external validity. A theory requires external validity in order to be generalized to the entire population (Kratwohl 1998). The research was designed to explain a theory and then validate the explanation with industry experts; this

explanatory case study with validation design helps improve the external validity (Yin 2009). While the case study alone cannot limit all threats to internal and external validity, validating the results with additional data, such as interview and survey data, can lend credibility to, and improve, the validity of the results.

Likert-style Survey

Surveys describe or quantify “the attitudes, beliefs, or behavior of a population” (Patten 2009). The survey used in this study was developed to determine the level of influence different factors have on MILCON cost premiums based on expert opinion, or beliefs. The influence of different cost factors could not be quantitatively calculated due to the lack of similar, specific, data between private industry and MILCON projects. Additionally, the survey provided validity to the case study results and thereby allowed a limited generalization of the results. The survey consisted of two overarching questions. Both questions ask the respondents to rate the level of influence factors have on the cost of MILCON projects; however, the first question asks for a comparison between MILCON and private industry construction while the second question requires a comparison between the case study projects. Each of these two overarching questions had a series of cost premium factors listed underneath that required a Likert-style response.

All respondents rated how each factor influences cost premiums; therefore, the standard Likert scale was not appropriate. The standard five-point Likert scale breaks down as Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), and Strongly Agree (5); however, this survey used: Not at All (1), To a Limited Extent (2), To a Moderate

Extent (3), To a Large Extent (4), and To a Very Large Extent (5) (Carifio and Perla 2007). In this case, no negative responses were required because respondents were told to assume that MILCON cost premiums exist based on previous literature; therefore, no factors could lower the cost of MILCON compared to private industry. One of the limitations of the scale, as written, is that it does not associate a percentage or dollar figure to each rating. This limitation is partially mitigated by ensuring respondents all qualify as experts in the career field and have enough breadth of knowledge to understand the size and scope of MILCON projects.

Methodology Application

In the case of this specific research, two projects constructed via the same statement of requirements at Joint Base Elmendorf-Richardson (JBER), Alaska, were compared to search for the root causes of differences in cost and performance. By focusing on the differences between the projects and cost premiums rather than the base cost, the results drawn from these Alaska projects can be applied regardless of location. Contract requirement differences and after-action reports were analyzed to determine factors that could cause cost premiums. Additionally, semi-structured interviews with contractors specializing in MILCON and private industry construction projects allowed for the determination of additional factors shown to cause cost premiums.

Industry experts validated all of the determined factors through the use of a Likert-style survey. In total 32, or 75%, of the survey questions relate to requirement differences noted during the case study analysis. To limit the survey length, factors quantitatively known to cause cost premiums, such as Davis-Bacon Act wage rates, were

omitted from the survey. However, Federal Acquisition Regulations (FAR) drive many of these quantitative factors, so the factors were included in a general form. The combination of these two research streams allowed for the creation of a comprehensive list of factors that cause MILCON cost premiums.

Phase 3 – Cost Premium Factor Analysis

The third phase focused on an in-depth analysis of one factor, Davis-Bacon Act (DBA) wage rates, shown to cause cost premiums and general analysis of other influential factors. The further investigation of variables was based on expert opinion obtained via a survey on the influence of each variable as well as the ability of the USAF to affect the factor. Additionally, limiting the quantitative in-depth analysis to a single factor occurred due to data availability and expert insistence that these wage rates represent a large cost premium. This phase utilized the results of expert interviews, geospatial analysis, and statistical inquiry. Phase 3 allowed for a detailed understanding of the root causes of some of the cost premium factors.

Quantitative Geospatial Analysis

Geospatial analysis is a unique method of quantitative analysis providing for both statistical analysis based on geography as well as visual representation of data and results. Specifically, geospatial analysis is the “formal quantitative study of phenomena that manifest themselves in space” (Anselin 1989). Geospatial analysis is grounded in statistics and mathematics while adding elements of space. Geospatial analysis of data must meet all the requirements of the performed statistical tests being performed and have valid and accurate geospatial parameters. Another key attribute of geospatial

analysis is its ability to create a single time-based sample out of a series of geospatial data points (Anselin 1989). This ability means geospatial analysis of a set of data across an area can be considered a single point in time comprised of hundreds or thousands of geospatially attributed points. However, one of the main flaws to geospatial analysis is the existence of geospatial errors. Geospatial errors exist when the location data of a point is not accurate enough for the level of analysis or differs from the point's true location (Anselin 1989). However, in this research, the analysis of wage rates occurs mainly on a national level and at its smallest point across an entire Air Force base. Any location geospatial error is negligible due to the large area covered.

DBA and Bureau of Labor Statistics (BLS) wage rates are both geospatially related. The wage rates are representative of a specific location on earth. Geospatial analysis of these wage rates allowed for the determination of differences across space. Additionally, through the use of surface generation, a limited amount of data, such as DBA wage rates at USAF bases, could be extrapolated to present a visual of wage rate trends across the country. Geospatial analysis allowed for the examination of wage rates across space at a point in time.

Statistical Analysis

Research performed during phase 3 required the use of inferential and descriptive statistics. Descriptive statistics, such as the mean, histogram, and standard deviation helped present the survey results. Non-parametric statistics provided ranks for the level of influence of each surveyed cost premium factor based on each of the three demographics. The three demographics are USACE personnel, USAF civil engineers

and contracting officers, and contractors. Finally, inferential statistics described the statistical significance of results based on a large quantity of data. For the analysis of DBA wage rates, inferential statistics based on a multivariate analysis of variance (MANOVA) and matched pairs t-test provided confidence intervals and p-values representative of the statistical significance of the results. These quantitative methodologies were critical to conclusions based on the third phase of this research approach.

Phase 4 – Develop Mitigation Strategies

The fourth, and final, phase developed mitigation strategies for the factors shown to cause cost premiums. The development of these mitigation strategies answered the final research objective by showing where cost mitigation efforts could be applied. The recommended mitigation strategies were synthesized from existing literature, expert interviews, or a combination of both. Additionally, mitigation strategies were developed based on the linkage between influential cost premium factors and the case study contract requirement differences. This research phase provided Air Force Civil Engineers and AFCEC with documented evidence that can be used to adapt MILCON procurement rules and execution.

Scope and Limitations

This research effort focused on USAF MILCON procurement. Although the findings may apply to other branches of the military, the scope of the research was USAF MILCON primarily executed through USACE or AFCEC. Additionally, all cost premium causes presented are only directly applicable to non-contingency MILCON

procurement. Furthermore, the quantitative Davis-Bacon Act wage rate research applies only to the carpenter and electrician trades at USAF bases.

As with all research, there were limitations to this study of MILCON cost premiums. The lack of quantitative data was the largest limitation. Since data related to the same facilities constructed on and off base were not available, it was not possible to do an exact comparison and factor analysis. Additionally, contractors were not able to provide an equivalent estimate of costs for constructing a MILCON facility off base. Finally, the USAF does not track any loss in scope during pre-final bid negotiations in any database. This means that if a bid comes back too high the USAF does not document changes implemented to ensure the bid meets the programmed amount. Results were determined from qualitative source data and expert opinion due to the lack of quantitative data.

The use of a single case study makes the result difficult to generalize to all MILCON projects. However, the case study presented a unique opportunity to analyze internal factors that affect cost between the standard process and a more innovative approach. In this case, the unique dataset and validation with industry experts through surveys and interviews help overcome limitations to generalizability. For expert validation, the small sample surveyed, and limited population of experts with general MILCON knowledge and experience with the specific case study, limited the statistical significance. However, even with the limitations mentioned above, this research presents viable causes of cost premiums as well as possible mitigation strategies. In addition to the general limitations mentioned in this section, each article contains a description of the applicable limitations.

Organizational Impact

Military construction cost premiums affect the ability of the military to meet its war fighting mission by expending limited resources in an inefficient manner. These cost premiums have limited construction performance and become noticeable line items in austere budgets. Due to these premiums, leaders have been tasked to find ways to mitigate excess costs. Additionally, based on Congressional requirements, the Air Force is required to do a MILCON cost premium analysis. Through this research, the Air Force should be able to reduce its MILCON spending while gaining construction performance. Furthermore, determination and mitigation of variables causing cost premiums should more closely align MILCON procurement with private industry practices. Increasing the similarities will enable construction contractors to more efficiently utilize their resources on both government and private construction contracts.

Determining the cost premiums of MILCON procurement is a key step in reducing military spending. The reduction of wasteful spending in MILCON projects should be value-added for the military unit requiring a facility as well as the contractor executing the project. While people generally scoff at the concept of “doing more with less,” the determination and mitigation of MILCON cost premiums should allow the Air Force to do just that. Increasing the efficiency of military construction will result in increased mission capabilities and reduced taxpayers bills.

Overview

This chapter provided the framework for the study by describing the impacts of cost on federal procurement, the need and desire for the research effort, the research

objectives, the research approach, and the organizational impacts. This thesis follows a modified scholarly article format and presents three separate articles, a white paper and two scholarly papers, in chapters two through four. Although each article can be read as a standalone, they flow from one to another with Chapter II providing the most background information and results to Chapter IV providing in-depth analysis of a single factor. Specifically, Chapter II contains the MILCON cost premium white paper developed for AFCEC. In addition to cost premium factors and mitigation strategies for USAF MILCON procurement, the white paper provides extensive literature review. The detailed look into the many causes for MILCON cost premiums provided the basis for the next chapter's journal article. Chapter III contains the journal article submitted to the *Journal of Construction Engineering and Management*. The article synthesizes expert interviews, the case study, and survey results to present general themes shown to cause MILCON, and thus public-sector, cost premiums. Chapter IV presents the journal article submitted to the *Lean Construction Journal*. The article quantifies cost premiums based on DBA wage rates through a comparison with local area wage rates. Chapter V provides overarching conclusions and serves to provide a simplified answer to the MILCON cost premium research question. Additionally, Chapter V contains suggestions for future research. Finally, appendices A through D support the three articles by providing further details, such as additional background information, detailed methodologies, and full results.

II. White Paper: Report for AFCEC on MILCON Cost Premium Research, Causes and Mitigation Strategies

This chapter contains the white paper developed for the Air Force Civil Engineer Center (AFCEC) use. The goal of the white paper was to provide an extensive literature review of previous research relating to military construction (MILCON) and methods of executing MILCON. The literature review presented in this white paper also provides detailed background for Chapters III and IV. Additionally, the white paper includes analysis of factors causing or influencing cost premiums from the United States Air Force (USAF) perspective. Also, this white paper includes expert suggestions directly relating to the mitigation of cost premiums during USAF execution of MILCON. Finally, this white paper suggests future research avenues related to MILCON cost premiums. Appendix A and Appendix B contain additional supporting information for this white paper.

Report on MILCON Cost Premium Research, Causes, and Suggested Mitigation Strategies

Developed for the Air Force Civil Engineer Center

Introduction

The United States Air Force's (USAF) military construction (MILCON) budget, with the exception of the deliberate pause in fiscal year 2013, is worth billions of dollars yearly. However, anecdotal and limited quantitative evidence has shown that MILCON procurements costs hundreds of millions of dollars per year more than equivalent construction would cost in the private sector. The Air Force Center for Engineering and the Environment (AFCEE), which was recently combined with the Air Force Civil Engineer Support Agency (AFCESA) to form the Air Force Civil Engineer Center (AFCEC), sponsored research to determine the causes of MILCON cost premiums. This white paper is one element of the MILCON cost premium research. The sponsored research resulted in two other documents, a geospatial and statistical analysis presented in a scholarly article regarding the effects of Davis-Bacon Act wage rates and a journal article presenting the analysis of a case study and survey regarding USAF MILCON generalized to public-sector construction. This white paper provides USAF civil engineers information regarding MILCON cost premiums from an Air Force perspective. Additionally, the specific cost premiums have been categorized according to how much control different levels of the USAF or DoD engineer community have over each cost premium. By providing a thorough background and a simple list of findings and

suggestions, this paper sets the foundation for change in the MILCON procurement process as well as suggested improvements to allow for future, more in-depth, research.

Literature Review

This literature review establishes a foundation of knowledge related to military construction based on published literature and standards. The purpose is to understand the characteristics of MILCON procurement, applicable rules and regulations, and research as it relates to MILCON procurement and costs. This literature review begins by defining key terms and standards that apply to MILCON level construction. A discussion of construction execution methods and acquisition processes follows the MILCON background. Although this literature review references previous, published, research efforts, the following section focuses specifically on previous research and investigations directly related to MILCON cost premiums. All components of this literature review combine to form a comprehensive and cohesive picture of MILCON and previous research.

Military Construction Standards

Military construction, known as MILCON, is a specific type of construction executed by military entities. Title 10, United States Code, Section 2801, defines military construction as “any construction, development, conversion, or extension of any kind carried out with respect to a military installation. MILCON includes construction projects for all types of buildings, roads, airfield pavements, and utility systems costing \$750,000 or more” (Department of the Air Force 2010, p. 25). The second sentence of the definition is the unique attribute of MILCON type construction; specifically,

MILCON projects cost \$750,000 or more. Military construction with costs below this threshold is called unspecified minor military construction and is governed by different rules and regulations (Department of the Air Force 2003). The difference between MILCON and minor military construction starts with the funding stream, military construction authority as opposed to operations and maintenance funds, and continues into execution agents, authorities, and limitations on the type of construction authorized (Department of the Air Force 2003). However, this research endeavor focuses solely on large MILCON projects; therefore, the background information presented is primarily applicable to MILCON procurement rather than unspecified minor military construction. While officially codified in public law, Air Force engineers utilize guidance provided in Air Force Instructions (AFI). The applicable AFIs break MILCON procurement into planning and programming (AFI 32-1021) and then design and construction (AFI 32-1023).

MILCON Planning and Programming

The first phase of a MILCON project, planning and programming, occurs at least 3 to 5 years before project execution. AFI 32-1021 dedicates an entire chapter to MILCON project planning because it sets the foundation for a MILCON level project. The AFI dictates that installations must “identify future facility needs 3 – 5 years in the future and determine which needs cannot be met with existing facilities” (Department of the Air Force 2010, p. 7). Once installation leaders identify and approve the needs, further planning actions focus on a certificate of compliance ensuring the project, as planned, meets environmental, seismic, and explosive arc and airfield clearance

requirements in addition to other requirements based on additional AFIs and executive orders (Department of the Air Force 2010). While this planning phase occurs long before project approval or execution, it is a critical component of MILCON procurement; failure to properly plan ensures project failure.

Once engineers complete a certificate of compliance, the project can enter the programming phase. AFI 32-1012 defines programming as “the process of developing and obtaining approval and funding for MILCON projects” (Department of the Air Force 2010, p. 25). It is during this phase of MILCON procurement that the project is further developed and codified by engineers and the end-user. In order for approval to be granted by the Air Force, Office of the Secretary of Defense (OSD), and Congress, the project must be developed, justified, and include a cost estimate (Department of the Air Force 2010). Additionally, in an attempt to control excess costs, all MILCON projects over \$2 million require the completion of a detailed economic analysis (Department of the Air Force 2010). Engineers and comptrollers work together to complete economic analyses on MILCON projects. Once the project programming is completed, the project documentation is sent to Headquarters USAF (HQ USAF) where it competes with other MILCON requirements throughout the Air Force. HQ USAF sends the finalized and prioritized list of MILCON projects to the OSD for entry into the 6-year Future Years Defense Program (FYDP). The FYDP is a portion of the president’s budget that is submitted to Congress. Finally, Congress receives the list of MILCON projects requested and decides whether to provide authorization and appropriation for each project (Department of the Air Force 2010). Once authorization and appropriation are received from Congress, the MILCON project can enter the design and construction phase.

MILCON Design and Construction

AFI 32-1023 contains the governing documentation for the design and construction of MILCON projects. The AFI sets goals, rules, and restrictions for the design of Air Force facilities. Specifically, it mentions that facilities should “enable mission execution and enhance occupant safety and quality of life by providing sustainable facilities” (Department of the Air Force 2010, p. 10). It requires functional flexible designs developed with accessibility and cost management in mind (Department of the Air Force 2010). The 2010 version of the AFI now specifies that design decisions should be based on the life-cycle cost of a facility; however, this requirement is not in the programming AFI which provides guidance for MILCON project programming and estimating (Department of the Air Force 2010). This lack of consistent guidance means that although the design should be cost effective based on the life-cycle costs, Congressional authority and appropriations have already fixed the project cost. The AFI continues by specifying that designs must meet Unified Facility Criteria (UFC); commercial standards, such as National Electric Code or National Fire Protection Code; Engineering Technical Letters (ETL); and the Whole Building Design Guide (Department of the Air Force 2010). Additionally, the AFI specifies the use of “the United States Green Building Council’s (USGBC) LEED Green Building Rating System as a tool to incorporate sustainable design principles and subsequently to measure the sustainability achieved” (Department of the Air Force 2010, p. 17). The remaining portion of the AFI’s chapter is dedicated to requirements that may not apply to all projects, such as utility metering, environmental regulations, and design management (Department of the Air Force 2010). The AFI attempts to control cost and scope by

mandating, post Congressional approval, that project scope remain fixed, and that costs can only increase by 25% without reprogramming and approval (Department of the Air Force 2010). This mandate fixes the scope at least 3 to 5 years before project design. While costs can change; additional funding is not authorized by Congress and comes at the expense of other MILCON projects. MILCON budgets are fixed on a yearly basis; therefore, overages from one project are removed from another project unless Congress authorizes additional funding. Once the design is complete, the MILCON project is transferred to the construction phase.

AFI 32-1023 also focuses on construction management, specifically the roles and responsibilities of the construction management team and the phases of construction. The construction manager (CM) is the individual or team responsible for monitoring construction on a day-to-day basis. AFI 32-1023 dictates 22 tasks that are the responsibility of the CM. In general, the CM monitors and reports on construction progress, oversees the construction agent (CA) including changes and scheduling, completes documentation for all changes and funding requests, and is responsible for ensuring the project meets its requirements (Department of the Air Force 2010). The unique role of the Air Force CM is to oversee another military entity executing the contract (AFCEC, USACE, or NAVFAC) as well as the contractor doing the work. This layer of oversight ensures construction projects, regardless of method or agent of execution, meet Air Force needs. With the roles of the CM defined, the AFI continues by specifying the phases of construction. Per the AFI, these phases include: the construction management plan dictating roles, responsibilities, procedures; a red zone meeting held at 80 percent of construction completion; construction acceptance

procedures; and post-occupancy inspections to ensure proper construction completion, and that errors are remedied within the warranty period (Department of the Air Force 2010). Additionally, the AFI specifies the ability to occupy the facility during construction and joint occupancy, as well as noting that the CM and CA share responsibility for ensuring the quality of construction (Department of the Air Force 2010). The construction phase of MILCON procurement is one of the shortest in the long MILCON process but is also the most visible, and the phase that creates an enduring facility.

MILCON Roles and Responsibilities for the Air Force

Although the MILCON procurement is a DoD-wide enterprise, Air Force application of MILCON procurement differs from the implementation by other branches. These differences are most noticeable in the oversight and execution of the construction phase. This section clarifies the roles and responsibilities of key players based on AFI and DoD guidance. Table 1 presents a simplified list of agencies and entities with unique responsibilities in the Air Force MILCON process. Additionally, Table 1 specifies the branch of the entity as well as whether it is local to the base or a field operating agency (FOA) functioning out of a dislocated location.

Table 1: MILCON Agency/Entity Roles and Responsibilities

Name	Branch	MILCON Role/Responsibility
Design Agent (DA)/ Construction Agent (CA)	Army, Navy, or Air Force (FOA likely)	The DoD component responsible for the technical execution of the construction or design and performs the duties of the contracting officer.
Design Manager (DM) / Construction Manager (CM)	Air Force (local)	Air Force organization designated to manage construction and interface with the DA/CA. Responsible for local construction oversight and ensuring project meets USAF needs.
Air Force Center for Engineering and the Environment (AFCEE/AFCEC- West)	Air Force (FOA)	Air Force MILCON program manager and possible DA/CA or DM/CM. Creates planning guidance and provides technical planning assistance for Air Force engineers.
Air Force Civil Engineer Support Agency (AFCESA/AFCEC- East)	Air Force (FOA)	Develops, coordinates, and interprets UFCs and ETLs to ensure compliance with all policies. Responsible for the ETL system. Responsible for facility energy conservation, metering, and renewable energy via Air Force Facility Energy Center.
<i>Note: All roles/responsibilities adapted from AFI 32-1023 (Department of the Air Force 2010)</i>		

DoD Directive 4270.5 dictates the specific agencies authorized to act as the DA, CA, or DA/CA. Additionally, the directive states that, with few exceptions, the “Air Force shall use the services of the U.S. Army Corps of Engineers (USACE) or the Naval Facilities Engineering Command (NAVFAC) for design and construction of the annual military construction program” (Department of Defense 2005, p. 3). However, the directive allows AFCEC to execute a limited number of projects if the Air Force and NAVFAC/USACE agree it is the “most efficient, expeditious, and cost-effective way” to complete a project (Department of Defense 2005, p. 3). Having USACE and NAVFAC execute projects with additional oversight provided by Air Force construction and design managers creates unique relationships. Compared to Navy and Army MILCON

procurement, the Air Force provides an additional layer of oversight over both the contractor as well as the DA/CA. These roles and responsibilities are critical to successful MILCON procurement.

Construction Specification Standards

Construction specifications define facility requirements. Generally, three forms of specifications are used: method-based specifications (MBS), end-result specifications (ERS), and performance-related specifications (PRS) (Dhakal et al. 2009). The MBS is the classical form of specification where the design and construction agent prescribes construction procedures for the contractor to follow. With ERS, the contractor is fully responsible for the construction procedures and quality control, but the construction agent accepts or rejects the final results based on an explicit quality assurance plan. Finally, the PRS grew from statistically based quality assurance specifications and are specifications that relate quality characteristics and/or life-cycle costs to expected performance of the work completed (Dhakal et al. 2009). Studies by the Federal Highway Administration and analysis of paving contracts in New Brunswick provide further evidence that moving from MBS to ERS does not result in performance degradation (Dhakal et al. 2009). MILCON projects can utilize any of these construction specification standards but frequently use MBS.

Project Management

Prior to the detailed discussion of MILCON execution and acquisition, it is important to understand that all methods have benefits and disadvantages. The best approach attempts to balance advantages and disadvantages so that no party is wronged.

The project management “iron triangle” (Figure 3) shows the facets of a project that must be balanced: scope/performance, schedule, and cost. In general, project managers are able to optimize two of the three elements through the selection of acquisition and execution method (Chan et al. 2004). Based on the needs of the user, the critical facets can vary. Additionally, all cost premium factors will apply to at least one of the facets of the project management iron triangle. This means that project managers will be able to understand the additional costs and sacrifices being made by each factor causing MILCON cost premiums. The combination of a basic understanding of the project management iron triangle, as well as the in-depth knowledge of where each cost premium lies, allows project managers to better manage MILCON procurement.

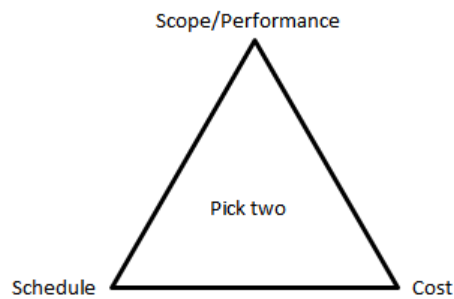


Figure 3: Construction iron triangle

MILCON Execution

This section focuses on the methods of execution and acquisition utilized for MILCON procurement. In private industry, many execution and acquisition methods are available including design-bid-build, design-build, multi-prime, construction manager at risk, construction manager, engineer-procure-construct, and private-public-partnerships (Kelleher and Walters 2009). However, policies restrict MILCON execution to specific methods of execution, generally the traditional design-bid-build (DBB) or the design-

build (DB) method (AFCEE 2008). This section will briefly describe each applicable execution method followed by a discussion of current research into MILCON execution. Further information is available in AFCEE's (AFCEC's) *United States Air Force Project Manager's Guide for Design and Construction*.

Design-Bid-Build

The traditional method of construction execution is the DBB process. In this case, the Air Force issues a request for a design to an architect-engineer (A-E) firm (AFCEE 2008). The Air Force works with the design agent to fully define the project scope and cost (AFCEE 2008), which is used to update the programming documentation that goes to Congress if completed prior to Congressional approval. The A-E firm completes the design of the entire facility including “drawings, specifications, design analysis, and cost estimate” (AFCEE 2008, p. C-1). These construction documents become the property of the Air Force at contract completion. Once Congress authorizes the MILCON project, the designs are given to a separate contractor for construction. The advantage to this method is that the design features are known so the bids should be very accurate (Kelleher and Walters 2009). Additionally, the DBB method has been tested in court; consequently, dispute resolution is generally predictable (Kelleher and Walters 2009). However, the DBB process does not take into account contractor and subcontractor input and may not reflect correct material pricing at the time of project execution; these issues can end up delaying a project or requiring additional funding (AFCEE 2008). The design-bid-build process has been utilized since the start of federal

construction procurement, but over time construction execution has shifted towards a design-build relationship.

Design-Build

The design-build execution method is based around the “master builder” concept where a single contractor designs and constructs the project (Kelleher and Walters 2009). While the Air Force lists six variations of the DB method, they all revolve around a single contractor taking the project from start to finish, thereby improving execution speed and reducing overall project costs (AFCEE 2008). Even though the advantages appeared immediately, policy restricted the Air Force from utilizing the DB method until the Clinger-Cohen Act of 1996 (Rosner et al. 2009). The traditional DB method is the two-step or one-step method where a contract is awarded based on a set of specifications and/or preliminary design and the contractor then designs and executes construction in one fluid motion (AFCEE 2008). The difference between the one-step and two-step method is that in the two-step DB process contractors are short listed based on qualifications; shortening the list of prospective bidders increases competition among the technically capable construction firms (Molenaar et al. 1999). The design-build+ method is a form of DB which brings the contractor into the planning phase early to help with all phases of execution; these contracts normally involve the award of a contract to a construction team that executes a series of construction projects (AFCEE 2008). Another variant is the design-build (turnkey) method. For this method, a fixed price is established along with minimum requirements and contractors bid with the expectation of building multiple versions of the same facility for a set cost (AFCEE 2008). All of these design-

build methods shift risk from the government onto the contractor but allow for potential cost and time savings; the private sector uses design-build extensively and has become the preferred method for Air Force MILCON execution.

Previous researchers have determined factors that can influence or help determine the success of a DB project. Chan et al. (2004) performed a meta-analysis of previous literature and determined the criteria used to determine DB project success. Their research found that four objective criteria and five subjective criteria characterize success. The objective criteria are time, cost, quality, and safety. The subjective criteria are: meeting specifications/employer's requirements; conformance to expectation of project team members; functionality; aesthetics; and reduction in dispute (Chan et al. 2004). Lam et al. (2008) applied those criteria to develop a mathematical model to predict DB success. Their investigation also identified success factors and determined causal relationships between the critical success factors and success indicators. Lam et al.'s (2008) research utilized time, cost, quality, and functionality as the success indicators. The model determined that the critical success factors for DB success include "the project nature, the effectiveness of project management action, and the application of innovative management approaches" (Lam et al. 2008, p. 336). For project nature, Lam et al. (2008) determined that successful DB projects provide room for contractor input, are decently complex, allow the contractor to propose and implement alternative solutions, and allow the contractor to design structures to suit their construction methods. Effective project management for DB requires proper contract documentation and controls to allow contractor flexibility while ensuring all requirements are met. Finally, the adoption of innovative management approaches includes using value management

and patterning (Lam et al. 2008). Value management involves removing project elements that do not increase value. Partnering involves establishing relationships between contractors and construction agents where all parties work towards common goals together rather than at each other's expense (Lam et al. 2008). Research demonstrated that these three elements are critical elements of DB project success.

Other Execution Methods

Air Force MILCON execution is generally a tightly controlled process; however, waivers can be obtained to utilize a variety of execution methods when cost or time savings are evident. For example, construction can be executed using the U.S. General Services Administration (GSA) schedule catalog by procuring turnkey facilities with installation (GSA 2012). Another alternative execution method is the procurement of MILCON facilities through an Enhanced Use Lease (EUL). The EUL allows the Air Force to trade property for construction services (Bates 2011). These alternative execution methods are only a sample of the possibilities; however, these methods are used infrequently due to the extra effort required for execution.

MILCON Acquisition Methods

The acquisition method, or construction contract type, for MILCON is the means used to fund and contract MILCON execution. The construction contract types utilized for Air Force construction procurement include the following (AFCEE 2008).

- Indefinite delivery indefinite quantity (IDIQ) – multi-period contracts for an unknown number of construction requirements
- Firm fixed price – a lump sum contract

- Fixed price with economic price adjustment – a lump sum that can be adjusted for economic contingencies
- Fixed price with incentive firm – a fixed price contract that allows for adjustment of profit and final contract price
- Fixed price with award fees – a fixed price contract with an award based on Government evaluation
- Cost plus incentive fee – a cost reimbursement contract with an adjustable incentive fee
- Cost plus award fee – a cost reimbursement contract with an award based on Government evaluation
- Cost plus fixed fee – a cost reimbursement contract that pays cost plus a fee that is fixed at the inception of the contract

Although additional procurement methods exist, they are rarely utilized in MILCON and therefore not discussed here. In addition to the information provided in the *USAF Project Manager's Guide for Design and Construction*, the Federal Acquisition Regulation (FAR) part 16 governs all of these acquisition methods. Furthermore, the pricing for cost plus can be based on established pricing, actual price paid, or catalog prices; these details are solidified during contract award or advertisement and vary from project to project (AFCEE 2008). In general, most MILCON projects strive for a firm fixed price where the costs are known up front. However, the use of firm fixed prices requires the contractor to commit to a set price early in the design process (Molenaar et al. 1999). Both firm fixed and cost plus, including their variants, can be utilized with any execution method. The execution and procurement method options require design and construction agents to select the execution and acquisition method.

Research in MILCON Acquisition/Execution

The multitude of acquisition and execution methods has led to a series of research endeavors attempting to determine how execution and acquisition methods affect MILCON performance. This section focuses on research into execution methods followed by research into acquisition and procurement method.

Design-Bid-Build and Design-Build Research

The performance of MILCON projects based on execution method has been investigated in terms of cost, performance, and schedule. Molenaar, Songer, and Barash (1999) investigated design-build evolution and performance in the public-sector. They focused on performance differences in DB projects based on the one-step, two-step, or qualifications-based method of execution. The qualifications-based method utilizes a lower level of design, allows prequalification of bidders, and the award is competitively negotiated rather than the lump sum utilized for the one- or two-step process. The results of the 104 public-sector projects they studied show that the two-step process, which limits the number of bidders, has the best schedule and budget performance. However, the research shows that qualification-based execution results in significantly lower administrative burdens by transferring the responsibility onto the contractor (Molenaar et al. 1999). Overall, their results suggest that the Air Force should utilize the two-step DB execution method in order to maximize cost and schedule performance.

Rosner, Thal, and West (2009) narrowed design-build research to Air Force MILCON projects by analyzing 835 projects against six performance metrics based on execution method. They analyzed 278 design-build and 557 design-bid-build projects;

the disparity in the number of projects analyzed by execution method was based on the fact that DB was not heavily utilized at the beginning of the study period (1996-2006) (Rosner et al. 2009). The six metrics the projects were measured against were unit cost, cost growth, schedule growth, modifications per million dollars, current working estimate/programmed amount ratio, and total project time; additionally, they performed the analysis based on facility type. Their research concluded that DB outperformed DBB in two metrics, cost growth and the number of modifications, while DBB outperformed DB for project time (Rosner et al. 2009). However, the project time performance was to be expected because DBB projects sometimes have “off-the-shelf” designs available and thus design time is not included. A 2009 study of U.S. Navy dorm construction found similar results; DB resulted in reduced cost and schedule growth (Hale et al. 2009). The Navy study found that the reductions in cost and schedule growth, as well as overall construction schedule, were statistically significant (Hale et al. 2009). Finally, the Rosner et al. (2009) research effort revealed that the DB method was best suited for “seven out of nine facility types: airfield pavements, operations, corrosion control, administration, dormitories, fitness centers, and child development centers,” while storage and operations facilities did not favor one method over the other. Overall, the authors advocate the utilization of DB for the majority of Air Force MILCON procurement.

Gannon, Feng, and Sitzabee (2012) completed additional research into schedule performance for design-build projects. Their research was based on a quantitative and qualitative analysis of three MILCON projects executed by USACE and overseen by the 88th Civil Engineer Directorate at Wright-Patterson AFB, Ohio. The research question

considered was: “do initial schedules specified in federal design-build facility procurements provide reliable forecasting for project control” (Gannon et al. 2012). Furthermore, this question was refined by setting the goal of understanding the scheduling process and analyzing how changes affect schedule uncertainty. The results of the study show that modifying the project results in cost and schedule growth; specifically, the later the change occurs, the stronger the negative effect on schedule and cost. Additionally, Gannon et al. (2012) observed that USACE required the initial schedule in the first 2 months of a DB project although it takes 8-11 months to reach the 100% design milestone (Gannon et al. 2012). Based on case studies and observations related to construction scheduling Gannon et al. (2012) developed the cone of uncertainty (Figure 1) to demonstrate the variability in schedule based on design percentage completed. The recommendation from their study is that MILCON design-build procedures should align more closely to private industry policies and allow for flexible scheduling until the design is solidified (Gannon et al. 2012). While the DB method is known to outperform DBB, their research shows that policies must be adapted to gain all the performance improvements available.

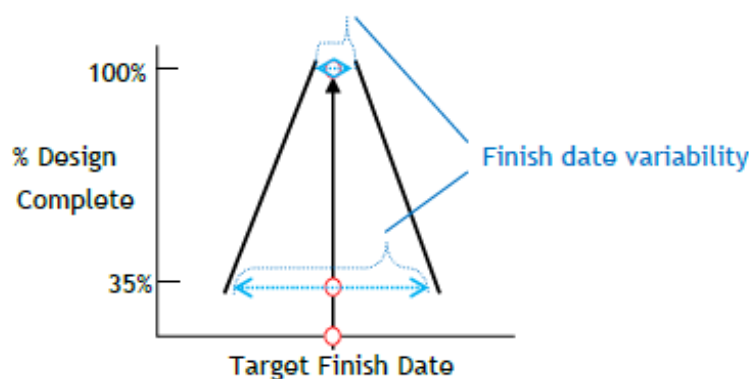


Figure 4: Schedule cone of uncertainty (Gannon et al. 2012)

Acquisition/Procurement Method Research

Regardless of the execution method chosen, there are a variety of acquisition methods available. Research has shown that 88% of public-sector projects use lump-sum fixed price contracts (Molenaar et al. 1999). Due to the heavy utilization of fixed price contracts, and restrictions on cost growth for MILCON projects, little research has investigated alternative acquisition methods. However, options exist for the procurement, or award, of fixed price contracts. El Wardani, Messner, and Horman (2006) compared these procurement methods for design-build projects. They compared four methods (sole source, qualifications-based, best value, and low bid) against three performance metrics (cost, time, and quality). These four procurement methods can be utilized to select contractors for almost any acquisition method. Sole source selection is the selection of a single contractor based on performance and qualifications at the expense of price competition (El Wardani et al. 2006). The Air Force is unable to use sole source selection for most construction due to FAR restrictions. Qualifications-based selection is the selection of a contractor based on a request for qualifications; once selected, the DB contract is directly negotiated with the most qualified contractor (El Wardani et al. 2006). The best value selection, supported by the Air Force as of 2010 and the most flexible selection method, allows the selection of a contractor based on evaluations of the design and cost. Finally, low-bid selection chooses a contractor based solely on cost. The study results show that low-bid has the lowest initial cost but the highest cost growth and very high schedule growth, 9.82% and 5.64%, respectively (El Wardani et al. 2006). These results align with guidance from AFCEC that dissuades the use of low-bid selection for MILCON procurement (AFCEE 2008). Additionally, El

Wardani et al. (2006) found that qualifications-based selection results in excellent performance for cost growth and speed of construction, especially for low-complexity projects. However, the best value method results in top performance in terms of schedule growth at the expense of initial cost. Their study did not investigate if the higher cost of best value is related to design enhancements not offered by the other procurement methods. Overall, El Wardani et al. (2006) conclude that no one procurement method outperforms any other method in all performance metrics; therefore, the procurement method must be selected based on the most critical metric for each project.

Recently, Sullivan (2011) performed further investigation into best value procurement for construction versus other methodologies including Lean, Six Sigma, and Total Quality Management (TQM). He investigated these management methodologies for use in construction because, in his opinion, construction has been “slow to adapt” with many projects over budget and behind schedule. The results of his research show that best-value allows owners to select the best-fit contractor based on past performance, assessing and limiting risk, interviews, and prioritization of cost and performance (Sullivan 2011). Additionally, Hammad et al.’s (2010) research of public building projects found that selecting based solely on low-bid could result in underbidding and excessive change requests. Furthermore, Sullivan (2011) found that best value benefits both the owner and contractor while many of the other efficiency tools benefit one party significantly more than the other. His findings also show that some management methodologies are ill suited to construction, including TQM which primarily improves vendor to supplier relationships. Overall, Sullivan’s (2011) research effort supports the

utilization of tried and true construction procurement methods such as best value over newer management programs.

MILCON Cost Premiums

Large construction projects are inherently complicated endeavors; for the Air Force, strict planning, programming, and executing guidance, as well as the variety of execution and acquisition avenues available, increases these intricacies. MILCON projects throughout the DoD are a multi-billion dollar line item on Congressional budgets each year, making them prime targets for cost saving measures (112th Congress 2011). The costs, limited quantity, and complicated nature of MILCON projects result in a variety of research comparing MILCON costs to private industry costs.

MILCON Cost Investigations

The cost of MILCON projects has been investigated multiple times over the past two decades. Pope (1990) investigated MILCON procurement compared to private industry from a cost perspective. The stated goal was to discover “successes” from private industry and integrate these successes into the MILCON process in order to realize cost savings. His research investigated four specific questions: is there a difference in administrative effort between MILCON and private industry, do MILCON standards differ from national and local standards, are contractors restricted or constrained when working on MILCON projects compared to private industry, and does the Davis-Bacon Act (DBA) cause MILCON wage rate differences compared to private industry. Additionally, if differences were found in any of the areas, Pope (1990) investigated whether those differences impacted construction cost. Pope’s (1990, p. 7)

research also attempted to determine if privatization, or the “transfer of government services, assets and/or enterprises to private-sector owners . . . when those owners and suppliers have the capability of providing better services at lower costs,” allowed for more efficient MILCON execution. However, in the 22 years since his research, privatization has not been heavily used or considered for MILCON projects.

In the background of his research, Pope (1990) discusses that a consensus could not be obtained as to whether federal facilities cost significantly more than their private industry counterparts. One study found the cost ratio between federal and private construction was 151 to 100 while another found private costs to be 64.5% of federal costs with a final studying finding no significant difference (Pope 1990). However, the study showing differences found “no hard evidence of cost differences arising from intangible factors such as labor standards, specification restrictions, extra federal documentation, or restrictive procurement policies” (Pope 1990, p. 38). Industry experts disputed this point and presented other reports faulting procurement methods and administration for cost increases (Pope 1990). These conflicting reports precipitated the need for Pope’s (1990) study specifically comparing MILCON projects to private industry construction.

Pope (1990) conducted interviews with government engineers, managers, and contracting officers and then interviewed contractors with government and private industry experience. The semi-structured interviews were conducted with the goal of answering each of the four investigative questions. Pope (1990) found that the government believed that administrative requirements did not increase costs while the contractors disagreed, stating that administrative requirements did cause increased costs.

For the remaining investigative questions, both government employees and contractors believed construction standards, contract clauses, and the Davis-Bacon Act caused cost increases above private industry costs. Additionally, Pope (1990) validated through quantitative comparison that the prevailing wage rate set by the Davis-Bacon Act was more expensive than wage rates paid in the local area. His research showed that in 1990, MILCON procurement was more expensive than private industry construction; however, in 22 years, there have been many regulatory changes affecting MILCON procurement including tweaks to the Davis-Bacon Act.

Beach (2008) analyzed MILCON cost and schedule performance based on the major command (MAJCOM) and the construction agent executing the project. He sought to investigate the ability of MAJCOMs to accomplish projects with regards to schedule and cost contrasted against other MAJCOMs; additionally, he investigated how well the CAs accomplished projects compared to each other. The CAs investigated include USACE, NAVFAC, and AFCEE. Beach (2008) analyzed 1,322 completed USAF MILCON projects utilizing the earned value analysis metrics of cost performance index, schedule performance index, and the cost-schedule index. The study did not take into account any reduction in project scope or facility performance losses due to the data provided and use of regression analysis. These types of losses are not documented quantitatively and consistently across the Air Force. Overall, his research found that the Air Force MILCON program “consistently delivers projects that are under budget” but frequently over schedule (Beach 2008, p. 81). This finding validates the idea that MILCON projects are designed and executed to their programmed amount at the expense of schedule and requested capabilities. Another interesting result of Beach’s (2008)

study is that the Pacific Air Forces (PACAF) MAJCOM and Alaska district (POA) of the USACE have the best cost and schedule performance in comparison to other MAJCOMs and districts. Additionally, no major variation appeared in cost or schedule performance based on the type of facility constructed (Beach 2008). His quantitative research effort analyzed the internal performance of MILCON projects based on the costs and schedules set by the MAJCOM and CA; however, the research was accomplished without regard to how long construction should take or appropriate construction costs.

In 2011, the House Armed Services Committee (HASC) noted that the Department of Defense was unable to “provide competitive construction costs with comparable type facilities in the commercial sector” (112th Congress 2011, p. 291). The committee noted that MILCON unit costs are typically 25% to 40% more than private-sector costs (112th Congress 2011). The HASC highlighted key challenges it believes contribute to the cost increases including federal contracting requirements, such as Davis-Bacon wages and federal sub-contracting and small-business goals; additional design requirements, such as anti-terrorism/force protection (AT/FP) measures; energy efficiency objectives; and a robust construction management capacity providing construction oversight. Although Congress sets many of these requirements in Public Law, the committee found the markups to be “excessive and limit the purchasing ability of the” DoD (112th Congress 2011, p. 292). The report requires the Secretary of Defense to report on these cost premiums; this requirement required input from the Air Force via AFCEC. In early 2012, the AFCEC construction management section determined USAF MILCON unit costs are up to 37% higher than private industry construction (Hartford 2012). Table 2 breaks down AFCEC’s probable causes of USAF MILCON cost

premiums and the cost increases associated with each. The fact that there are no equivalent data sets for a private industry project and a MILCON project limits the AFCEC study. Therefore, the study compared historical unit costs from USAF MILCON to available private industry historical unit costs (Hartford 2012). The HASC report and AFCEC study form the basis for continued research into the causes of MILCON cost premiums.

Table 2: AFCEC Study Cost Premium Summary (Hartford 2012)

Cost Premium	% Increase
Product: Type of Construction and Restrictive Specifications	10%
Product: Energy and Sustainability Requirements	2%
Product: AT/FP Requirements	2%
Product: Facility Service Life	Inconclusive
Process: Base Security Requirements	5%
Process: Project Planning and Definition Issues	3%
Process: Contract Administrative Burdens	5%
Process: Contracting Requirements – Socioeconomic Clauses	3%
Process: Contracting Requirements – Business Protection Clauses	1%
Process: Contracting Requirements – Labor Clauses	6%
Process: Contracting Requirements – Bonding (Miller Act)	Inconclusive
Process: Contracting Requirements – Insurance	Inconclusive
Process: Contracting Requirements – Quality Control	Inconclusive

Research supports the notion that MILCON costs more than equivalent private sector construction. Additionally, interviews with industry experts confirm that, in general, MILCON costs more than equivalent private industry construction. Table 3 provides a summary of the causes of MILCON cost premiums according to previous research. Most of the previous research has focused on, and faulted, policies or laws outside of the DoD or USAF’s span of control. Analysis of the previous research validated the existence of MILCON cost premiums. This research adds to the body of

knowledge relating to the causes of MILCON cost premiums by primarily examining internal causes.

Table 3: Causes of MILCON Cost Premiums According to Previous Research

Factor Influencing Cost Premiums	Type (Internal/ External)	Previous studies		
		Pope (1990)	112 th Congress (2011)	Hartford (2012)
Additional administrative requirements	Both	✓		✓
Strict military standards	Internal	✓		
Contract and procurement restrictions	External	✓	✓	✓
Davis-Bacon Act wage rates	External	✓		✓
Socioeconomic clauses/requirements	External		✓	✓
Construction type and restrictive specifications	Internal			✓
Energy and sustainability requirements	External		✓	✓
Anti-terrorism/force protection requirements	Both		✓	✓
Base security requirements	Both			✓
Project planning and definition issues	Internal			✓
Government quality-assurance capacity	Both		✓	

Specific MILCON Cost Investigations

In addition to research into the general costs of MILCON procurement, other studies have focused solely on singular, key, elements of MILCON execution. Researchers have suggested that the MILCON cost increases over private industry start with planning and programming. Conference proceedings cited by Pope (1990, p. 41) state “the MILCON design and construction agent is forced . . . to manage cost to the Congressionally authorized and appropriated programmed amount”. Managing MILCON projects to this programmed amount pushes the programmer to increase the estimate in order to ensure project success regardless of the number of years until construction or changes in material costs or economic conditions. Additionally, once the

programmed amount is fixed, the “designer is urged to ‘design to budget’ since there is no motivation to return excess funds” (Pope 1990, p. 42). This demonstrates how MILCON cost additions can begin in the early phases; however, cost premiums can continue into the design and execution of construction.

Nielsen (2007) investigated how change orders during construction of MILCON projects affect overall performance. He specifically investigated 31 MILCON projects and the data loaded into the Air Force civil engineer’s database, ACES. The results of his research show errors in pre-construction activities, such as unforeseen site or environmental conditions, user changes, and design errors, are the most common causes of MILCON change orders. Nielsen’s (2007) quantitative analysis determined most change orders were due to design deficiencies and user change requests with the fewest caused by value engineering proposals, exercised options, and unforeseen environmental site conditions. Additionally, Nielsen (2007) found that USACE and NAVFAC had lower change order costs than AFCEC; however, he points out that the results are questionable due to inaccurate and incomplete data used for analysis. Gannon et al. (2012) researched how the types and scope of change orders affected MILCON scheduling. Their research showed changes resulted from Air Force/USACE driven contract modifications, definition and sequencing corrections, weather delays, hidden rework, and process learning. The research shows that executing change orders late in construction execution causes inaccurate tracking of both schedule and costs in the time leading up to award of the modification as well as immediately afterward (Gannon et al. 2012). The results of both Gannon et al. (2012) and Nielsen’s (2007) studies suggest

MILCON project managers should ensure pre-construction activities, especially design reviews, are well executed to limit change orders and, therefore, limit cost overruns.

Data Gathering and Analysis

A combination of quantitative and qualitative methodologies were utilized to determine the factors causing MILCON cost premiums. Data inputs included the use of an extensive literature review, a single MILCON project case study, government and contractor expert interviews, a Likert-style survey, and geospatial and statistical analysis. The synergy of these data sources allowed the determination of MILCON cost premium causes and the development of this white paper. This white paper does not, in general, present specific quantitative values for each MILCON cost premium.

Case Study

The case study was based on two weather shelters constructed at the same time, with the same basic requirements, by two different construction agents at Joint Base Elmendorf-Richardson (JBER), Alaska. USACE constructed one weather shelter while the 673d Civil Engineer Group (CEG) with AFCEC constructed the other one. In the end, the CEG weather shelter cost 27% less (~\$7M) and took less than half the time to construct while meeting or exceeding all requirements. To determine the causes of the cost and schedule differences, an analysis of contract documents, after action reports (AAR), and interview data occurred.

Interviews and Survey

Semi-structured expert interviews were conducted with government personnel from contracting, civil engineering, and USACE who were familiar with MILCON and the case study projects. Additionally, further interviews were conducted with contractors experienced in MILCON and private-sector construction. The interviews utilized open-ended questions to allow the respondents to mention causes of MILCON cost premiums or mitigation methods without guiding the discussion. Finally, a 43-question Likert-style survey was developed based on discoveries made during the interviews and case study. A limited number of government and contractor experts rated the level of influence each factor has on MILCON cost premiums as: not at all, to a limited extent, to a moderate extent, to a large extent, or to a very large extent. The respondents represented three demographics: USAF personnel, including civil engineers and contracting officers; USACE personnel; and contractors. The results of the survey also linked back to specific contract requirement differences noted during the case study.

Geospatial and Statistical Analysis

Analysis of DBA wage rates required the use of geospatial and statistical analysis. The comparison of DBA wage rates at USAF installations with Bureau of Labor Statistics (BLS) average wages outside of the base quantified the hourly differences between MILCON and civilian wages. Inferential statistics were used to describe the differences and validate the statistical significance. Descriptive statistics were applied to analyze the case study's cost and schedule differences. Responses to the Likert-style survey were analyzed using descriptive statistics including non-parametric ranking and

distribution analysis. The combination of statistical and geospatial methods allowed some MILCON cost premiums to be quantified.

Limitations

As with all research, there are limitations to this study of MILCON cost premiums. The lack of quantitative data is the largest limitation. Since data related to the same facilities constructed on and off base is not available, it is not possible to do an exact comparison and factor analysis. Additionally, contractors are not able to provide an equivalent estimate of costs for constructing a MILCON facility off base. Finally, the USAF does not track any reduction in scope during pre-final bid negotiations in any database. This means that if a bid comes back too high, the USAF does not document changes implemented to ensure the bid meets the programmed amount. Results were determined from qualitative source data and expert opinion due to the lack of quantitative data.

The use of a single case study makes the result difficult to generalize to all MILCON projects. However, the case study presented a unique opportunity to analyze internal factors that affect cost between the standard process and a more innovative approach. In this case, the unique dataset and validation with industry experts through surveys and interviews help overcome limitations to generalizability. For expert validation, the small sample surveyed, and limited population of experts with general MILCON knowledge and experience with the specific case study, limited the statistical significance. However, even with the limitations mentioned above, this white paper presents viable, researched, causes of cost premium as well as possible mitigation

strategies. All cost premium causes presented are only directly applicable to non-contingency MILCON procurement.

This white paper does not contain detailed information regarding the data or methodologies applied. Detailed information is available in the full MILCON cost premium research thesis published in March of 2013. The full thesis is available at www.DTIC.mil and is titled *An Analysis of Cost Premiums and Losses Associated with USAF Military Construction* by Daniel Blomberg. The full thesis contains the survey distributed, the raw case study contract requirement differences, and statistical and geospatial analysis information.

Cost Premium Causes & Mitigation Strategies

This section contains the major factors shown to cause MILCON cost premiums from a USAF perspective. While the survey contained 43 possible factors based on expert interviews and case study analysis, this section highlights the main cost premium causes and categorizes them into general themes. Additionally, the cost premiums are broken into sections by the ability of the USAF to affect change. The USAF controllable cost premiums include factors that cause additional costs but can be mitigated internally by the USAF. The DoD controllable cost premiums contains factors that can be mitigated by working with other DoD entities such as USACE and NAVFAC. Finally, the outside DoD control cost premiums contain factors that cannot be directly changed by the USAF or DoD but cause additional costs. By breaking down cost premium causes into these categories, USAF engineers can focus their efforts on areas where change can be implemented.

USAF Controllable Cost Premiums

This section contains cost premiums that can be controlled, mitigated, or affected by the USAF. Each cost premium contains a description, limited analysis, and suggested mitigation strategies.

Development of Overly Restrictive Requirements

Description: The USAF develops requirements for execution by a, possibly separate, design and construction agent. These requirements are sometimes above what is required or are not adapted to the facility environment. This cost premium is also directly related to “stifling or not applying innovation” in this section and “selection of construction specifications” in the DoD controllable cost premiums section.

Analysis: Survey and interview results indicated that most USAF engineers and contractors fault the construction agent for overly-prescriptive requirements. However, further investigation showed that the USAF is partially at fault for the overly specific requirements. Research found that the USAF required explicit materials in specific facilities based on commander discretion, squadron heritage, or a “that’s what we’ve always done” mentality. Specifying these requirements adds additional costs to the initial construction as well as the life-cycle because it limits facility use. While it appears that architectural standards do not add a significant cost, engineers must ensure that the standards are not based on the wants of a single person but rather a methodical, life-cycle cost conscious, process. An example of this was the use of a low slope metal roof on the CEG weather shelter rather than the architecturally recommended built-up roof. The built-up roof increased costs and limited construction methodology without any

advantage except for meeting the architectural standards. Project managers must ensure the architectural standards do not limit construction practices unnecessarily. Additionally, analysis found that AFIs specify square footages for specific functions. While this is useful by not allowing functions to expand too much, engineers in cold-weather climates mentioned that the square footage requirements sometimes do not allow enough space for all required functions and the appropriate amount of insulation. In this case, the stringent requirement is hurting the life-cycle cost of the facility by increasing energy usage. Furthermore, the square footage and programming requirements have not been fully adapted to open floor plan technology or architecture.

Mitigation: AFIs should either specify internal square footage rather than overall footprint or be updated to allow for square footage deviations based on environmental conditions. Additionally, facility requirements for new bed-downs should be specified at an overall level, as broadly as reasonable, and restricted from local commander deviation. Finally, the USAF must not over-prescribe requirements to the design/construction agent for design-build projects. The USAF should specify end-results and the functions required rather than material and methods. Local base engineers should ensure architectural standards are not adding an unreasonable cost to facility acquisition.

Selection of Acquisition Method Including a Failure to Balance Risk

Description: Inappropriate selection of the acquisition method does not motivate the contractor to reduce costs or apply innovative techniques. Also, the USAF does not gain cost savings through the selection of the execution or acquisition method because the balance of risk does not appear to vary based on the methods selected.

Analysis of acquisition method: The literature review contained extensive background information regarding the acquisition methods available to USAF personnel. However, most MILCON projects are programmed and executed as firm fixed price contracts. This has two main issues; first, contractors may be designing and constructing to the programmed amount rather than to meet the actual requirements (Pope 1990). Second, there is little incentive for construction agents, USAF engineers, or contractors to innovate or reduce costs since none of these stakeholders can use the savings. If USAF personnel implemented firm fixed price with incentives, they could incentivize the contractor to reduce life-cycle costs rather than initial costs, thereby giving the government long-term savings while not affecting the contractor's expected bottom line. The selection of acquisition method can help balance risk and motivate innovation. Additionally, DB cost savings are not as evident in MILCON procurement as private industry construction because all parties do not share the savings. While the FAR currently disallows the outright sharing of savings, engineers can use savings from DB to award bid options, thereby increasing MILCON performance while not negatively affecting the contractor. The CEG weather shelter demonstrated how cost savings could be used to fund bid options and resulted in an improved facility.

Analysis of failure to balance risk: In private sector construction, risk shifts based on the execution and acquisition method (Kelleher and Walters 2009). Shifting from design-bid-build to design-build shifts risk from the construction agent to the contractor. However, in MILCON procurement, sometimes the risk shifts so far toward the contractor that it causes cost premiums. To avoid litigation, construction agents choose to specify every requirement possible even in DB execution. To combat the additional

risk, contractors are forced to raise their prices. This imbalance of risk directly affects construction costs. A method that helps mitigate risk involves partnering with the contractor. AARs for the CEG project lauded a partnership-oriented process as a large success in the CEG project that reduced cost while allowing for a more aggressive schedule. Additionally, research by Johnson et al. (2012) codified how the USAF can partner with contractors within the confines of the FAR.

Mitigation: The USAF should create simple guidelines to help engineers and contracting personnel select the correct acquisition method based on desired results. Additionally, the USAF should volunteer to test a variety of acquisition methods that reward reducing costs by sharing the savings. Requesting this as a pilot study would provide the evidence required to adapt the FAR to allow for sharing of profit savings, thereby motivating the government and contractors to work together. Furthermore, USAF engineers need to be aware that risk can be shifted based on the execution and acquisition method. If the contract is not modified to reflect this shift in risk, then the selection was made in name only and no cost savings will be obtained. USAF engineers should also work to partner with the contractor to balance risk and allow each party to help the other succeed.

Stifling or Not Applying Innovation

Description: MILCON construction agents write and regulate, sometimes unknowingly, innovation out of many construction projects, thereby requiring the use of older, more expensive, techniques and materials.

Analysis: The weather shelter AARs and interviews with contractors revealed a common theme that MILCON construction agents write requirements and contracts that directly limit innovation. Two of the four factors rated as having a large influence on MILCON cost premiums fell directly into this innovation cost premium category. Additionally, outside research found that one of the three critical success indicators for design-build projects is the “adoption of innovative management approaches” (Lam et al. 2008). The CEG weather shelter project demonstrated how result-based RFPs allow for problem solving via innovative solutions. Generally speaking, the prescriptive nature of the USACE weather shelter RFP limited the design and construction methods. However, USACE stated that feedback from USAF representatives limited the design. Examples of innovative features in the CEG weather shelter include simple things, such as sealed concrete flooring rather than vinyl, to more complicated changes, such as using electrical disconnects rather than installing all hazard-rated electrical infrastructure. These changes saved money up-front in construction and reduced maintenance costs and did not affect the overall requirement for the facility. Construction agents must work with their contractors rather than simply dismissing ideas that do not align to “the way it has always been done.” Contractors have private industry experience and, therefore, are more likely to be aware of new construction techniques or suggest design changes that can improve facility functionality and maintainability or reduce costs.

Mitigation: For DB MILCON projects, ensure RFPs are written in a results-based format that does not unnecessarily limit construction or design techniques. Ensure USAF engineers work with the construction agent, end-users, and stakeholders to educate all individuals on requirements versus wants. Work to change the “culture of no” by

partnering with contractors for solutions and listening to the suggestions. Implement specification changes per “selection of construction specifications” coming up in the DoD controllable cost premiums section.

Cost as a Schedule Metric

Description: The value of the construction sets the allowed construction time.

Analysis: Ribbon Cutter and/or Dirt Kicker metrics set the allowed construction time for USAF MILCON procurement based on the value of the construction project (673d Civil Engineer Group 2010). For example, these metrics would have allowed 820 days for the weather shelter project since it was over \$20 million. The CEG finished 15 bays, two buildings, in just under 12 months while the USACE finished their seven bays in 27 months, including a delay for contaminated soil. These metrics add substantial costs in terms of dollars expended paying the contractor, time without the constructed facility’s functionality, and administrative overhead supporting long duration projects. Additionally, these metrics reduce the ability for the government to negotiate. In the private sector, owners can negotiate by granting more time for lower costs; for USAF MILCON, the contractors know the amount of time allowed and can bid accordingly. For DB execution, the contractor should be specifying the timeframe required; the USAF can then validate the timeframe based on the facility itself rather than a set metric. For example, a large weather shelter can take less time to construct than a specialized data center regardless of the cost of each facility.

Mitigation: Continue to adapt the schedule metrics. The metrics can be adapted based on facility type, cost, and execution method rather than primarily on cost. The new

Ribbon Cutter metrics are an improvement over Dirt Kicker, but the government needs to acknowledge that faster, proper, contractor execution can yield better results for all parties involved.

Frequent Unforeseen Site Conditions

Description: MILCON projects on brown sites, or previously disturbed earth, frequently encounter unforeseen site conditions, such as soil contamination, that require remediation before construction can continue.

Analysis: It is common to find soil contamination on or near the airfield. Prior to construction, this contamination must be remediated. The cost of remediation is not a cost premium because the same requirement exists in the private sector; however, the fact that it occurs after notice-to-proceed (NTP) causes the cost premium. Contractors mentioned that for large brown site construction projects an environmental survey is executed prior to NTP or included in the DB contract. Once NTP is issued, the contractor, and by proxy the government, have begun expending money. If the project is placed on hold, such as during the USACE weather shelter project, the contractor is still paying for overhead and in some cases must pay his employees even though no construction is occurring. This means during remediation the government is paying for construction that is not occurring as well as remediation costs.

Mitigation: The USAF should fund companion projects to do geotechnical and environmental surveys for MILCON brown sites. The up-front cost could easily reduce the overall construction cost of finding contamination or soil issues after NTP issuance.

Additionally, presenting the contractor with geotechnical information can allow for different facility designs during the proposal phase.

Unique Attributes of MILCON Projects

Description: USAF and USACE personnel believe that unique attributes of USAF MILCON projects are responsible for cost premiums.

Analysis: In the expert survey, this factor ranked as the 1st and 6th most influential by USACE and USAF, respectively. However, contractors ranked this factor the 29th most influential cost premium factor. This disparity means that government engineers believe their projects have unique attributes compared to private industry, but these beliefs may be unfounded. Additionally, this belief may cause government engineers to not accept commercial solutions that would work for MILCON. For example, the use of a pre-engineered building (PEB) to construct a weather shelter was a difficult proposition for many government engineers. However, the CEG weather shelter demonstrated that a design-build PEB can meet or exceed all military requirements while allowing the contractor to use standard commercial practices. Although sometimes there are unique requirements, it is more likely that many MILCON facility features are the same as in the private sector. For example, if an administrative facility contains a Sensitive Compartmented Information Facility (SCIF), the entire facility is not a unique administrative facility, only one portion. Engineers must ensure they do not expand a single unique requirement to the entire facility.

Mitigation: To mitigate this cost premium, USAF engineers and stakeholders must not over-specify their requirements. Engineers and stakeholders must be aware of

the requirements for facility functions and not search for unique attributes of the military unit occupying the space.

DoD Controllable Cost Premiums

This section contains cost premiums that can be controlled, mitigated, or affected by the DoD. Each cost premium contains a description, limited analysis, and suggested mitigation strategies.

Parameterization of Execution Method

Description: The USAF and its construction agents are not fully applying design-build (DB) principles and thereby not gaining the performance and cost savings attained in the private sector; in some cases, MILCON procurement costs are higher than the classic DBB execution costs.

Analysis: Government application of DB does not match private sector DB in terms of procedures or benefits; the government, as the owner and construction agent, remains heavily involved in the process including, in some cases, not allowing construction to commence until a design has been submitted and approved (Molenaar et al. 1999; Gannon et al. 2012). In general, the government is adding additional parameters such as specifications, requirements, or oversight that do not allow for optimal DB performance. In traditional DB execution, construction is on-going as the design gets finalized; for example, once the facility footprint has been specified and approved, earthwork can begin while the vertical portions are still being designed. The requirement for design and construction in series rather than in parallel forces the project to match a DBB process with a single contractor and directly adds to costs by extending the

schedule. The CEG weather shelter project allowed for an immediate start based on designs completed to that point. On the other hand, USACE required a complete design package prior to construction. The USACE policy demonstrates how construction agents can operate a DB project in methods suited for DBB. Contractors and USAF personnel surveyed ranked USACE's implementation of DB as the 4th and 6th most influential cost premium factor while USACE ranked it as the 12th. However, USACE ranked the USAF's implementation of DB as the 3rd most influential factor while contractors ranked it 18th and the USAF ranked it 31st. These findings show disconnects between users, construction agents, and contractors. Additionally, these results validate that MILCON DB projects are not being executed using standard DB procedures. DB shifts the risk to the contractor and allows them to proceed faster and cheaper when design and construction occur in parallel and when contractors manage their own resources; MILCON contract policies limit or eliminate these benefits.

Mitigation: Ensure all contract templates have been created using industry standard DB contracting mechanisms rather than DBB. This includes making sure the contracts are requirements based rather than methods based and allow the contractor to manage their own design, schedule, and resources. The over-restriction of DB execution converts the process into a DBB project executed by one contractor.

Sub-factor: Submittal Management and Requirements

Description: The submittal requirements and management system causes MILCON cost premiums.

Analysis: Based on interviews and survey data, the prescribed submittal system utilized by MILCON construction agents adds significant time and, therefore, costs to a MILCON project. For the weather shelter projects, the USACE RFP specified that submittal approval would take at least 30 days once the contractor loaded the submittal into USACE's custom software solution; contractors were also told that construction would be proceeding at risk if executed prior to submittal approval. On the other hand, the CEG specified it would return submittals as soon as possible and only specified a form to be used as a cover sheet. By working with the contractor, the CEG was able to help the contractor execute rapid approval for many elements. Additionally, the USACE specified many submittals as approval required, where work cannot commence without approval, rather than for information. In a DB project, there should not be very many "approval required" submittals since the contractor is responsible for a start-to-finish project that meets all requirements set out in the contract. This extra layer of bureaucracy, with its very strict timelines, is another example of the parameterization of the DB execution method.

Mitigation: Ensure all submittals required meet the expectations of those required for industry standard DB execution. Remove the minimum amount of time to return a submittal and exchange it for a maximum amount of time or a time based on the type of submittal; for example, a full design will take longer to review than carpet swatches. Adapting the submittal policy will directly affect the misapplication of the execution process cost premium.

Sub-factor: Quality Control Requirements

Description: Strict quality control (QC) requirements, beyond industry standards, add additional costs to MILCON projects.

Analysis: The USACE and the CEG treated QC differently for their respective weather shelter projects. The USACE implemented their standard QC and quality assurance process; the contract and RFP stated specific methods for ensuring quality. Additionally, the USACE required the contractor to employ one or more full-time personnel to solely act as QC. In interviews, contractors mentioned that the need for a person solely tasked with QC is excessive. On the other hand, the CEG partnered with the contractor to determine the best QC methods while still meeting USAF and industry requirements. Based on contractor interviews, the CEG process more closely matches QC implementation found in private sector DB construction. Construction agents must remember that the contractor is at risk during a DB project and is responsible for both the design and construction; this transfer of risk can allow deviations from USACE's standard QC policies.

Mitigation: Remove prescriptive QC requirements from DB RFPs and contracts. Require the contractor to propose and coordinate a QC plan with the government. Require the QC plan to meet industry standards and validate that key specifications have been attained.

Selection of Construction Specifications

Description: Overly prescriptive construction specifications increase the cost of MILCON dramatically over private sector construction.

Analysis: Based on the JBER weather shelter project contracts, as well as interview and survey data, most MILCON projects utilize method-based specifications (MBS). The case study revealed 41 contract differences between USACE and CEG execution that directly related to construction specifications. Additionally, three of the four cost premium factors rated as having a large influence on cost premiums directly relate to the selection of construction specifications. All of the contractors surveyed mentioned that prescriptive methods and materials do not allow contractors to fully apply DB practices, be aggressive, or provide more economical solutions. One respondent bluntly stated that “‘don’t confuse reason with requirements’ is rampant and costly.” For DB execution, the use of MBS limits how contractors can design and construct facilities. However, for DBB execution, where the construction agent is responsible for the design and specifications, the use of MBS can be appropriate. Further research showed that MBS, end-result specifications (ERS), and performance-related specifications (PRS) can be used in combination to allow innovation in some areas while ensuring military standards in other areas. Construction agents can apply multiple specification simultaneously to best meet the project’s needs. Additionally, while looking through a thousand-page request for proposals (RFP), the use of templates which included MBS in multiple locations resulted in erroneous, or conflicting, specifications.

Mitigation: DB MILCON projects should fully implement ERS and move toward PRS. Additionally, they should incorporate requirements by standard reference rather than including a link to the reference as well as a MBS. This allows industry standards to be included with ERS evaluation rather than industry standards with prescribed methods of execution that may vary from an updated industry standard. Since the construction

agent sets some standards, the USAF must work with construction agents to impress the need for ERS rather than MBS.

Construction Agent Fees

Description: Initial project estimates do not always include the construction agent fee. The agent fee is taken out of the project, and this, in turn, limits the scope of the project or requires additional funding to meet full project scope.

Analysis: All military construction agents charge a fee to manage a MILCON project. This fee pays to cover litigation, inspection, administration, and engineer staff. While the fee itself is known and has been shown by the Government Accountability Office (GAO) to be reasonable, construction agents have no desire to limit bidding or change orders. Each cost increase or change order provides additional funding to the construction agent. This means that problems during construction, design, or bidding can increase an agency's budget. The construction agent has agreed to perform the MILCON project based on the programmed amount and thus that should be the fee regardless of the bid. Additionally, the USAF does not always gain its full due from the construction agent fee because base civil engineers may do their own inspection and oversight.

Mitigation: First, ensure all project estimates include the construction agent fee. Second, work with USACE, NAVFAC, and AFCEC to set policy that the fee is based on the programmed amount, and that any deviations from that programmed amount do not increase or decrease the construction agent fee. Finally, set policy that allows USAF engineers to work with construction agents to reduce the fee by providing construction inspection and/or administrative support.

Schedule Management

Description: Construction agents, specifically USACE, require the use of non-standard software to maintain the construction schedule. This requirement results in the contractor maintaining schedules in multiple software programs and adds to the administrative costs.

Analysis: This research validated findings by Gannon et al. (2012) by quantifying the schedule management cost premium as the 5th most influential cost premium from the contractor perspective. However, USACE ranked it 36th out of 43 and USAF personnel ranked it 25th. Additionally, contractors mentioned schedule management software in every interview conducted. The software requirements for schedule management do not appear to integrate with industry-standard software solutions such as Microsoft Project. Therefore, the contractor ends up maintaining the schedule in a preferred software solution and providing updates to USACE through a specified solution. For the JBER weather shelter projects, the CEG allowed the contractor to use a preferred software solution as long as it could meet certain requirements such as showing resource allocations and a critical path. The CEG did not encounter any issues with this approach.

Mitigation: Work with construction agents to remove the requirement for specified schedule management software. Develop and implement ERS for schedule management while codifying how to show progress to the USAF and/or construction agent oversight.

Construction Agent Policies

Description: Construction agents such as USACE, NAVFAC, and AFCEC have their own internal policies that can add to cost premiums. Based on interview data, many of these non-standard policies come into effect at project closeout. A specific example is the requirement for separate commissioning events for each major system.

Analysis: Each construction agent has their own internal policies that govern the contractor's responsibilities. While some of these requirements generate individual cost premium factors, some of the more ambiguous elements fall into this cost premium category. Multiple interviews and the CEG weather shelter AAR mentioned commissioning process policies. Some construction agents require commissioning events for each major facility system. This requires the contractor to pay for additional personnel to show up to different events. The contractor passes these costs directly to the government. Contractors and USAF engineers mention that having a combined commissioning event is sometimes appropriate and can save costs on all sides with the same end-result. Other examples of internal policies include approval authorities for a variety of requests and specified timelines for information requests regardless of request scope. In some cases, these rules vary not only by construction agent but also by the base or district.

Mitigation: Task outside personnel to look into these types of additional rules and requirements and determine validity. This could be a perfect application of a *Lean* or AFSO21 event where outside personnel can provide input on the policies. Additionally, the USAF should request a funded lessons learned meeting, or "hot wash," at project closeout with the construction agent and contractor where everyone should feel free to

bring up issues encountered or unproductive (non-value added) work accomplished throughout the project. It can be difficult for personnel implementing the process to notice that a process is not adding value to the MILCON project; these mitigation strategies address the difficulty.

Perception Management and Design and Construction Agent Selection

Description: Negative perceptions about the processes and management style of the USACE causes MILCON cost premiums. While negative perceptions also exist for NAVFAC and AFCEC, the perceptions were more pronounced for the USACE. Additionally, DoD directives specify the construction agent and in most cases it is not the USAF (AFCEC). This specification directly affects the cost premiums associated with perception issues.

Analysis of perception management: This cost premium is the most difficult to quantify. Survey results showed that USAF personnel and contractors ranked the cost premium factor “USAF project through USACE” as the most influential factor while USACE ranked it 26th. Additionally, contractors ranked the cost premium factor “USAF project through AFCEC (AFCEE)” as 6th most influential while USACE and USAF ranked it 21st and 25th, respectively. This result shows that USACE and USAF have the perception they are not responsible for causing cost premiums while contractors feel the need to charge more than they would in the private sector since the project is for the military. Additionally, during the technical evaluation for transferring construction agent from USACE to the USAF for the CEG weather shelter, a contractor specifically brought up, and codified, the “corps factor.” The contractor stated that the supervision and

oversight brought to bear by USACE is significant compared to large corporate customers and other government agency customers (Moser 2009). Additionally, multiple contractors stated that although the USACE has expressed a desire to operate construction projects similarly to the methods utilized off base, none of them had seen USACE actually apply these desires. Furthermore, prime contractors have stated that subcontractors do not provide their best prices due to the additional requirements levied based on USACE involvement. After speaking to USACE personnel, it is the government's belief that there are no valid reasons for this perception; however, in the case of perception, the mere existence of it, regardless of reason, can add additional costs. Whether these costs are billed as additional administrative requirements, additional time for reviews, or additional costs to meet military standards does not matter if the basic requirement is "a USACE project costs more." The JBER weather shelter case study helps validate the existence of this perception-based cost premium since only internal factors could affect the price and schedule. All published AARs stated that many performance gains were attained through the application of "outside the gate" construction techniques rather than a *desire* to apply those techniques.

Analysis of DA/CA selection: One of the fastest ways to validate or mitigate cost premiums due to the use of the USACE is not to use them as the construction agent. While AFCEC is allowed to execute projects, permission is rarely granted. Due to the requirement for USACE to execute projects throughout the U.S. for many different agencies, it has an extreme breadth of knowledge and is not necessarily vested in adapting its MILCON policies for a single client. On the other hand, AFCEC can focus its large scale construction management solely on USAF MILCON. This would allow

AFCEC to be more flexible with its contracts and work to mitigate MILCON cost premiums. AFCEC could even be used to test different theories that could then be implemented by NAVFAC and USACE.

Mitigation: The USACE needs to begin adopting policies previously mentioned in this white paper and publicize its changes. Following that, the USACE needs to ensure that all districts are following the new policy rather than just acting in the status quo. Finally, USACE, NAVFAC, and the USAF need to partner with each other and contractors rather than always trying to blame one another. Mitigating this perception issue could take many years before dividends are noticeable. Additionally, advocate AFCEC as the construction agent for more MILCON projects. Validate the request by detailing how AFCEC would like to work to mitigate MILCON cost premiums by experimenting with contract execution and acquisition changes. Ensure that all parties understand the goal would be to share achievements with other construction agents without them having to deal with the additional burden from trying innovative techniques.

Outside DoD Control Cost Premiums

This section contains cost premiums that cannot be mitigated by the DoD or any of its entities. These cost premiums require outside agencies to enact change; however, the DoD can present options and request changes to mitigate these cost premiums. Each cost premium contains a description, limited analysis, and suggested mitigation strategies.

Anti-terrorism/Force Protection Requirements

Description: DoD and government required anti-terrorism and force protection (AT/FP) specifications add additional cost to MILCON facilities compared to the private sector.

Analysis: UFC 4-010-01 and AFI 10-245 require that MILCON facilities meet AT/FP requirements (Department of the Air Force 2003). However, engineers can include AT/FP costs as a line item during project programming. This helps mitigate the effect of costs associated with AT/FP. Research found that although there is always an AT/FP requirement, the decision of which standard to apply based on facility occupancy varies. For the JBER weather shelters, differing levels of AT/FP requirements were applied even though usage and location were similar. This demonstrates the inconsistencies that can exist through the application of AT/FP requirements.

Mitigation: This cost premium cannot be completely mitigated; however, the inclusion of an AT/FP line item during programming limits the effects on project scope. However, the AFI and DoD instructions should ensure that engineers can easily determine the AT/FP requirements for each facility; the current interpretation allows for gray areas that can change the facility cost.

Federal Acquisition Regulations

Description: The Federal Acquisition Regulation (FAR) restricts and guides government procurement, including the MILCON program. These restrictions and guidance add additional costs, administrative and otherwise, to MILCON execution.

Analysis: Overall, the respondents rated the FAR as moderately influencing MILCON cost premiums. However, specific requirements, such as 8A and small-business policies, as well as additional administrative requirements, were rated as more influential towards MILCON cost premiums. Additionally, there are numerous FAR clauses included in some MILCON projects but not in others. This disparity means that contractors must thoroughly investigate a contract's RFP to ensure there are no additional, or abnormal, clauses. This directly increases the administrative requirements in bidding and the maintenance of compliance documentation. Additionally, the JBER case study demonstrated that FAR requirements can be inappropriately applied through the use of boilerplate templates. Some FAR clauses, such as the use of Y2K compliant material, are left in when they should be removed while other clauses are not appropriately adapted, such as including the full text for cost plus acquisition on a firm fixed price contract. While it is likely that the FAR, and many of its requirements, cannot be removed, the USAF can still limit FAR-based cost premiums by not including extra, unnecessary, FAR clauses. Additionally, the JBER weather shelter case study demonstrated that many cost premiums exist regardless of FAR requirements. Both shelters met FAR requirements but the costs still varied dramatically, thus demonstrating that internal requirements can heavily affect cost premiums.

Mitigation: USAF engineers need to be aware of all FAR clauses included in their construction contracts. Additionally, Congress should be notified of clauses that no longer serve a purpose so those can be removed from public law. Contracting officers and specialists should select FAR clauses based on project requirements rather than a template containing "what was used last time."

Socioeconomic Laws and Policies Including the Davis-Bacon Act

Description: Socioeconomic laws and policies such as the Buy American Act, the Davis-Bacon Act (DBA), and small business policies directly add to the cost of MILCON above private industry. Additionally, DBA prevailing wage rates do not accurately reflect the local area's hourly wages and thereby directly increase MILCON costs.

Analysis of socioeconomic laws and policies: Policies and public law passed by Congress directly add to the cost of MILCON procurement by requiring particular materials, workers, or company usage. This research did not focus heavily on the socioeconomic policies affecting cost premium due to the inability of the USAF to directly mitigate these costs. However, multiple surveys and interviews directly mentioned that these types of policies increase the cost of MILCON procurement. Additionally, small business policy requirements have a flow-down clause where the prime and sub-contractors both have to meet usage requirements. Validating compliance adds at best an administrative burden, and at worst adds costs by motivating small businesses to raise prices since they are guaranteed work.

Analysis of DBA prevailing wage rates: Public law requires the use of DBA prevailing wage rates for all federal construction in excess of \$2,000 (Department of Labor 2012). A 1996 study demonstrated that these wage rates do not accurately represent the local area's wage rates (United States Government Accountability Office 2011). Additionally, a recent study of USAF bases found that the DBA wage rates are 114% and 118% of the local area's hourly wage rate for carpenters and electricians, respectively (Chapter IV). Since labor is generally 30% of a construction's project costs,

these wage rates can directly affect the overall cost of MILCON projects (U.S. Census Bureau 2011).

Mitigation: Sponsor additional research to quantify the cost premiums associated with each socioeconomic policy. Following that, use the data to advocate that Congress change or adapt socioeconomic policies. Specifically, advocate that Congress adapt DBA wage rates to more accurately reflect the surrounding area's wage rates. If required, sponsor additional research to exactly quantify the costs to the Air Force due to DBA prevailing wage rates for use in proposing cost saving measures.

Factors Shown Not to Cause Cost Premiums

This section contains factors initially believed to cause MILCON cost premiums but were determined not to cause cost premiums or only cause a very limited amount of cost premium. This section is included to help guide and scope future research. Research found that safety requirements in EM 385-1-1, the USACE safety manual, do not cause additional cost premiums. This is likely because these safety requirements match OSHA requirements closely and are also heavily utilized outside of MILCON procurement. Additionally, project signage requirements do not represent a MILCON cost premium. Although the USACE prescribes exact signage specifications for the construction site, this cost is negligible for a MILCON project since private industry utilizes similar signs. Finally, the government requirement for warranty performance bonds was shown not to cause noticeable MILCON cost premiums. Based on these findings, USAF engineers should implement EM 385-1-1, in whole or part, on all

contractor construction projects rather than attempting to create and implement their own non-standard safety specifications.

Summary of Cost Premium Cause Categories

The previous sections have discussed in detail the causes of MILCON cost premiums. Table 4 summarizes the findings and highlights the agencies that can implement changes to address each cost premium. Categories that cannot be controlled by any DoD entity have a level of control of “external.” Additionally, Table 4 lists previous cost premium studies that have also faulted these cost premium causes. Based on interview and survey data, mitigation efforts should focus first on the 10 items highlighted with an asterisk (*) due to their larger influence on cost premiums.

Table 4: Summary of Cost Premiums Cause Categories

Cost Premium Cause Category	Level of Control	Previous Studies		
		Pope (1990)	112 th Congress (2011)	Hartford (2012)
Development of overly restrictive requirements*	USAF			✓
Selection of acquisition method including a failure to balance risk*	USAF			
Stifling or not applying innovation*	USAF			
Cost as a schedule metric	USAF			
Frequent unforeseen sight conditions	USAF			
Unique attributes of MILCON projects*	USAF	✓		
Parameterization of the execution method*	DoD			
Selection of construction specifications*	DoD			✓
Construction agent fees	DoD		✓	
Schedule management policies*	DoD	✓		✓
Construction agent policies	DoD	✓		✓
Perception management including construction agent selection*	DoD			
Anti-terrorism/force protection	External		✓	✓
Federal Acquisition Regulations*	External	✓	✓	✓
Socioeconomic laws and policies including the Davis-Bacon Act*	External	✓	✓	✓

Future Research

The AFCEC can help enable future research into MILCON cost premiums by working to gather and provide data for researchers. To fully investigate MILCON cost premiums, the AFCEC must begin gathering data immediately and expect results in 3 to 5 years due to the MILCON process. Some of the key data points that should be collected include:

- Initial programming estimate
- Initial bid, even if it is unofficial
- Initial project scope (less broad than the 1391 (programming document) but more broad than a statement of work)

- Any scope changes implemented to meet cost restrictions (items such as the removal of parking lots, work moved to other projects, removal of interior walls)
- Schedule information including initial estimated time to completion, contractor's schedule used for bidding, and final completion date
- Estimated life-cycle cost at initial bid

While the current software solutions cannot track all of this information; the AFCEC can track this information as part of the move to asset management based facility maintenance and procurement. Tracking the information mentioned above, in addition to the current MILCON data, would allow for quantitative MILCON research.

The AFCEC should also advocate to be the construction agent for MILCON projects. Proper coordination with the Air Force Institute of Technology (AFIT) would allow AFCEC to select an engineer from a given base to be involved in the execution of a MILCON project, including implementing adaptations to attempt to reduce cost premiums, with a follow-on assignment to AFIT to execute cost premium research based on the MILCON project just completed, and finally ending up at AFCEC to implement changes. This series of events would allow AFCEC to take an asset management approach to MILCON costs and groom subject matter experts. Additionally, this approach would allow for experimentation rather than case study analysis. Finally, the AFCEC can enable future MILCON cost premium research by continuing to sponsor thesis-level research efforts. Engaging with AFIT would allow for low-cost research streams while keeping MILCON cost premiums at the forefront of leader's minds. Future research exists in the form of analysis of public laws, such as quantifying the effects Davis-Bacon Act wage rates, all the way to doing a large scale survey of involved

stakeholders to quantify qualitative cost premiums. This research project provides a starting point for many future research streams.

Conclusions

There are cost premiums associated with MILCON procurement. These cost premiums reduce the overall performance of MILCON by frequently requiring the scope of a project to be reduced to meet budgetary restrictions. Additionally, the removal of elements of a project, such as parking and energy efficient products, due to budget limitations decreases the life-cycle performance of a facility. This white paper documented 15 overarching, interconnected, factors shown to cause cost premiums. Addressing any number or elements of these factors will start reducing cost premiums and thereby increase MILCON performance. Engineers should understand that a request to de-scope a project does not mean that the initial estimate was poorly executed, but rather that cost premiums exist and should be addressed. The USAF needs to think about MILCON projects from a final use, or end-result, perspective rather than a “what is wanted right now” view. In a fiscally conservative environment, engineers will begin to accept good enough rather than perfect; on the other hand, reducing MILCON cost premiums could allow engineers to accept the right product with the correct quality. MILCON cost premiums directly affect the ability for the USAF to procure new facilities, remove dilapidated infrastructure, and ultimately execute its combat mission. MILCON cost premiums take away from “tip-of-the-spear” activities without gaining any benefits in terms of facility performance. Regardless of the fiscal environment, the

USAF should begin reducing excess construction costs caused by policy rather than requirement.

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III. Journal Article: Discovery of Internal and External Factors Causing Military Construction Cost Premiums

The journal article presented in this chapter was submitted for publication in the *Journal of Construction Engineering and Management*. At the time of thesis completion, the journal article was not yet accepted or rejected. This journal article presents the results of the MILCON cost premium case study and survey from a more general perspective. While the content has not been changed, technical adaptations have occurred for inclusion in this thesis. Further support and information regarding the content contained in this article is available in Appendix A and Appendix B.

Discovery and Mitigation of Factors Causing Military Construction Cost

Premiums

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Abstract

Each year the United States invests \$30 billion in federal construction. Military construction (MILCON) represents 40%, \$12 billion, of that capital investment. This study confirmed the existence of MILCON cost premiums compared to private sector construction through an analysis of existing research. Then this study evaluated two nearly identical projects and used expert interviews and surveys to determine which factors influence the cost premiums. In addition to identifying 28 factors that moderately or largely influence cost premiums, five overarching cost premium themes emerged: failing to balance risk, additional public-sector requirements, stifling or not applying innovation, selection of construction specifications, and parameterization of the execution process. Additionally, once complete, two nearly identical projects differed by over a year of construction time and \$7 million in spite of the contract requirement similarities. Research frequently cites federal laws and policies as the primary cost premium driver; however, this research demonstrated that internal construction agent policies also cause

increased cost premiums. Mitigating the causes of internal cost premiums could improve public-sector construction cost performance.

Key Words (Subject Headings)

Assets; Contract management; Construction Costs; Construction management; Design/build; Government; Military Engineering; Procurement

Introduction

In 2010 and 2011, the United States spent over \$30 billion for federal construction (U.S. Census Bureau 2012). For fiscal year (FY) 2013, the Department of Defense (DoD) requested almost \$12.5 billion for capitalized military construction (MILCON); however, due to budgetary constraints, the DoD only received authorization for \$6.5 billion of MILCON (112th Congress 2011; 112th Congress 2013). The MILCON program represents a large portion of federal construction; therefore, excess money expended due to cost premiums represents money that is not available for other programs. Additionally, as a result of the near 50% reduction in authorized MILCON, engineers need to improve the cost performance of the MILCON program.

To improve construction performance in terms of life-cycle costs, schedule, and final product received, military engineers implement industry best practices such as design-build execution and asset management principles. One of the twelve facets of asset management in facility execution is using innovative contracting procedures to form partnerships rather than simply relying upon low-bid for contractor selection (Cotts et al. 2010). Innovative contracting requires selecting the proper procurement route for each

project rather than using the same procurement method, the comfortable method, for every project, and that can be difficult for both military and public sector engineers (Lædre et al. 2006). The public sector followed private industry in embracing design-build construction; now it must incorporate asset management thinking into the entire process of facility procurement (Molenaar et al. 1999; Gannon et al. 2012).

Objectives

This paper presents the results of an investigation into USAF MILCON procurement cost premiums. This investigation confirmed that MILCON costs exceed private industry and then investigated possible mitigation strategies for reducing excessive cost premiums. Meeting this goal required a three-fold approach. First, MILCON and private industry costs were identified and analyzed through existing literature. Second, facility construction acquisition and execution methods were explored. Finally, a case study was performed using two MILCON projects. The study examined two construction projects with the same requirements, executed using different procurement methods. Presented here are several factors that influence MILCON cost premiums, which provides valuable insight to both DoD and private construction engineers and contract administrators in all construction industries.

Background and Literature

Additional rules and regulations levied on public construction, including that done by the military, make public construction unique. First, nearly all federal construction must follow the Federal Acquisition Regulation (FAR) codified as Chapter 1 of Title 48 of the Code of Federal Regulation (Federal Acquisition Regulation 2005). Public law

defines military construction as “development, conversion, or extension of any kind carried out with respect to a military installation. MILCON includes construction projects ... costing \$750,000 or more” (Department of the Air Force 2010). In addition to the explicit definition of MILCON projects, the U.S. government also limited which construction agencies may execute MILCON; DoD Directive 4270.5 dictates that, with few exceptions, the “Department of the Air Force shall use the services of the U.S. Army Corps of Engineers (USACE) or the Naval Facilities Engineering Command (NAVFAC) for design and construction of the annual military construction program” (Department of Defense 2005). With USACE and NAVFAC concurrence, the Air Force can execute a limited number of projects through the Air Force Civil Engineer Center (AFCEC) (Department of the Air Force 2010). In October 2012, AFCEC was formed with the merger of as the Air Force Center for Engineering and the Environment (AFCEE) and the Air Force Civil Engineer Support Agency (AFCESA); this paper uses the new title of AFCEC. This study investigated if the policies of the selected design and construction agent cause cost premiums for Air Force MILCON projects. Additionally, due to federal restrictions and policies, many more stakeholders exist in USAF MILCON procurement than in standard industry construction. The end-user of a project can be one or more on-base organizations; the owner, a civil engineer squadron; the design and construction agent, USACE, NAVFAC, or AFCEC; the contractor; and Congressional leaders, who dictate many social and economic policies. The number of stakeholders, with differing interests, makes MILCON procurement a complicated endeavor with many facets that can cause cost premiums.

Military Construction Cost Premiums

Anecdotal evidence frequently supports the notion that costs associated with MILCON procurement are higher than those in the private sector. Recent efforts to confirm the existence of cost premiums associated with MILCON execution include a qualitative study by Pope (1990) in which he compared MILCON to private industry/commercial construction and showed that military construction costs more than private sector construction. In 2011, faced with austere budget conditions, the House Armed Services Committee (HASC) noted that an assessment of construction costs found a 25% to 40% unit cost difference between MILCON costs and comparable facility construction in the commercial sector (112th Congress 2011). Following a request from the HASC, AFCEC codified Air Force cost premiums and found a 37% cost premium for USAF MILCON based on a comparison of historical costs for similar building types (Hartford 2012). Table 5 lists the factors responsible for MILCON cost premiums based on the previous studies. Additionally, the table indicates whether the factor can be controlled by the DoD (internal) or is based on requirements from another entity (external), such as Congress. While all three studies confirm the existence of cost premiums, there are variations in the factors shown to influence the premiums. Furthermore, many of the factors blamed for cost premiums are outside the control of the DoD. These studies serve to confirm the existence of MILCON cost premiums when compared to private industry construction procurement; however, many of the factors addressed cannot be controlled or changed by the DoD.

Table 5: Factors Shown to Influence Cost Premiums Based on Previous Research

Factor Influencing Cost Premiums	Type (Internal/ External)	Previous studies		
		Pope (1990)	112 th Congress (2011)	Hartford (2012)
Additional administrative requirements	Both	✓		✓
Strict military standards	Internal	✓		
Contract and procurement restrictions	External	✓	✓	✓
Davis-Bacon Act wage rates	External	✓		✓
Socioeconomic clauses/requirements	External		✓	✓
Construction type and restrictive specifications	Internal			✓
Energy and sustainability requirements	External		✓	✓
Anti-terrorism/force protection requirements	Both		✓	✓
Base security requirements	Both			✓
Project planning and definition issues	Internal			✓
Government quality-assurance capacity	Both		✓	

Construction Execution and Acquisition

Extensive research has investigated construction execution and acquisition methods for private industry, public industry, and MILCON procurement. These studies focused on private industry best practices such as relational contracting, schedule performance, and design-build procurement methods (Johnson et al. 2012; Rosner et al. 2009; Hale et al. 2009; Molenaar et al. 1999). While public construction strives to meet the performance achieved by private industry, it has to do so in a methodical way to limit risk and meet regulatory requirements.

In private industry, many execution and acquisition methods are available ranging from design-bid-build and design-build to construction manager and private-public-partnerships (Kelleher and Walters 2009). However, MILCON is restricted to limited

methods of execution, which are typically, traditional design-bid-build (DBB) or design-build (DB) (AFCEE 2008). Public-sector construction projects, including MILCON, traditionally used the DBB method where an architect-engineer firm creates a design and a separate contractor constructs the facility (AFCEE 2008). However, starting in 1996, public-sector engineers began following private industry and implementing DB execution where a single contractor takes the project from design through construction completion (Molenaar et al. 1999; Rosner et al. 2009). A 2008 study of 835 USAF MILCON projects determined that DB execution resulted in better performance for complicated construction endeavors (Rosner et al. 2009). Additionally, results published in 2009 for U.S. Navy MILCON living quarters showed a statistically significant improvement in reduction of cost and schedule growth as well as overall construction time (Hale et al. 2009). However, to reduce the risk of inadequate facilities, the public-sector has heavily restricted the use of DB. While research into public-sector DB projects has shown that limiting the number of bidders based on their qualifications is most effective, portions of the FAR limit the number of qualifications-based restrictions that can be used (Molenaar et al. 1999; Federal Acquisition Regulation 2005). Finally, Gannon et al. (2012) found that USACE DB policy forced contractors to commit to a schedule and cost within the first 2 months of a project although it takes 8 to 11 months to reach the 100% design milestone. Consequently, contractors charge more to limit their risk due to changes in the final design. While public-sector construction strives to implement private-industry DB procurement, some significant differences exist.

Research Methods

Research into MILCON cost premiums is a qualitative and quantitative endeavor. An evaluation of research literature confirmed the existence of MILCON cost premiums. Following this confirmation, methodologies were selected based on their appropriateness for analyzing the available data and producing results that limit threats to internal and external validity. A unique case study, including its reports and contract documents, identified internal causes of cost premiums. Following the case study, interviews and surveys identified additional causes and validated and quantified the cost premiums. This section details research methods related to the case study, interviews, and survey.

Weather Shelter Case Study

Two projects constructed during the same time frame at Joint Base Elmendorf-Richardson (JBER) near Anchorage, Alaska, presented a unique opportunity to analyze factors that influence MILCON cost premiums. This opportunity was unique for several reasons. First, the two projects had the same initial requirement: construct a 7-bay weather shelter. A weather shelter is a basic shelter for aircraft and personnel during maintenance, fueling, and arming operations. Figure 5 presents a general single-line diagram of the functional areas required in both weather shelters. Both weather shelters contain seven hangar bays; a support area; ancillary support spaces for building mechanical, communications, and fire protection systems; restrooms; and pass through access (673d Civil Engineer Group 2009; U.S. Army Engineer District, Alaska 2008). Second, the construction agents executed the projects via different contract and oversight methods. The construction agents varied methods based on internal policies, personnel

experience, and expected costs. Finally, since both projects occurred at the same location using MILCON authorized funds, they were subject to the same set of rules and regulations. This limited the number of variables that could cause widely different cost, schedule, and performance results. A single case study is appropriate because the ability to analyze two public-sector projects with the same requirements, but different methods of execution, is a unique and normally inaccessible phenomenon (Ellram 1996). This case studied enabled research into internal cost premium factors rather than the same external factors identified by previous research.

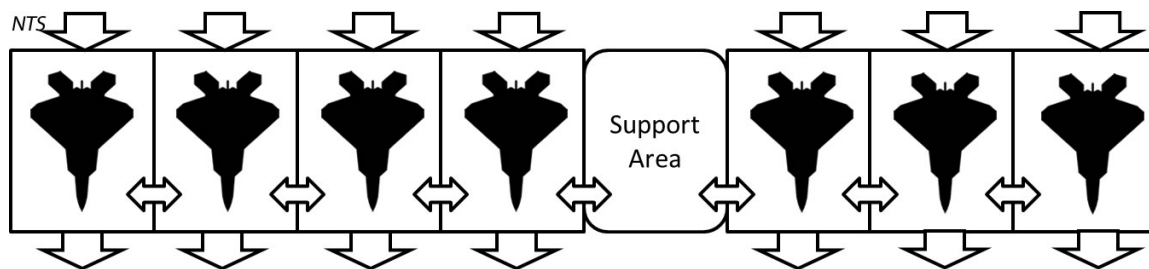


Figure 5: Layout of 7-bay Weather Shelter

Qualitative data, after action reports (AAR), interviews with engineers from the 673 Civil Engineer Group (CEG) and USACE Alaska District, and contract documents were analyzed to determine the factors that affected each project's cost performance. Three different AARs were analyzed to isolate common factors. Additionally, quantitative data, including cost estimates and actual costs, were available for each of the projects.

Interview & Survey

Semi-structured interviews with government and contractor experts in MILCON construction added validity to the case study findings. A purposive sample was chosen

due to the limited sample size and quantity of the experts with the requisite weather shelter and general MILCON knowledge. The interviewers gained insight to develop mitigation strategies and determine factors that could cause cost premiums. The interviewer asked government employees for their opinion on policies that cause cost premiums as well as changes implemented to address cost premiums. Additionally, the interviewer asked contractors about differences between MILCON and private sector construction processes and policies. A survey was developed based on common factors from the interviews as well as additional factors from the JBER MILCON case study.

The survey contained 33 Likert-style questions relating to factors that could cause cost premiums on all MILCON projects and 10 questions related to the JBER weather shelters specifically. The survey asked respondents to rate each factor's level of influence on MILCON cost premiums as:

- not at all
- to a limited extent
- to a moderate extent
- to a large extent
- to a very large extent

The survey respondents represented three demographic groups: USACE Alaska District engineers and contract specialists, USAF civil engineers and contracting officers, and contractors with both MILCON and private industry experience. The results of the survey rated the level of influence different factors, including policy and construction agent variations, have on MILCON cost premiums. The low number of available respondents, 18 in total, required the use of non-parametric descriptive statistics. The

responses were ranked from most to least influential for each demographic group. If multiple factors had the same average level of influence, each factor received the same rank. Additionally, a weighted average for each factor was calculated by averaging each factor's level of influence within each demographic group; this weighted average provided an overall level of influence rank for each factor. The weighted average mitigated the effects of having a varying number of respondents from each demographic. Integration of the case study, interviews, and surveys limits threats to validity and permits limited generalization of the results.

General Results

Weather Shelter Construction Comparison

Although engineers initially programmed both weather shelters to meet the same requirements, the construction techniques, cost, and schedule performance all varied widely. The USACE constructed shelter A represents a standard MILCON DB project. Contractors bid on the project based on a statement of requirements and request for proposal (RFP) developed by the USACE Alaska District. The CEG constructed shelter B by developing a statement of work and using the U.S. General Services Administration (GSA) Schedules Program and eBuy to procure a DB pre-engineered building (PEB) with installation. Both solicitation processes allowed a "best value" based contract award (GSA 2010). In the end, the contractor designed and constructed shelter A using standard construction practices including concrete masonry unit (CMU) walls and a built-up roof system. Shelter B utilized PEB construction practices including a very low slope metal roof, insulated metal panels, and steel support structures. The more costly shelter took

longer to construct and thus far did not result in better performance in terms end-user needs, facility performance, or maintainability. Overall, both facilities perform their mission satisfactorily, but the procurement method, cost, and schedule varied considerably.

Construction Results Differences

Although the requirement for the two weather shelters was the same, shelter A cost \$25.8 million and took just over 27 months to complete while shelter B cost only \$18.9 million and was completed in 12 months. However, shelter A encountered contaminated soil that ended up costing 2 months of construction time. Table 6 contains a description of the work performed, the costs for each shelter, and the percent difference in costs. As shown, all elements of the PEB weather shelter (shelter B) cost less except for the 480V alternating current (AC) power system. While the two projects began with the same requirements, shelter B cost 27% less and took less than half the time to construct when compared to shelter A. Additionally, for both projects the programmed amounts, government estimates, were the same at \$21.4 million. The next portion of this study investigated the cause of these differences.

Table 6: Weather Shelter Cost Comparison

Work Description	Shelter B Cost	Shelter A Cost	% Diff
Shelter Construction & Site Work	\$16,088,586	\$21,932,667	73%
Design Services & Insurance	\$1,240,478	\$2,135,132	58%
270V DC Power	\$461,267	\$683,668	67%
480V AC Power	\$604,988	\$490,678	123%
Compressed Air System	\$144,665	\$225,879	64%
Hangar Floor Coating	\$193,837	\$206,072	94%
Interior Painting	\$142,730	\$143,440	100%
<i>Total</i>	<i>\$18,876,551</i>	<i>\$25,817,536</i>	<i>73%</i>

Contract Analysis

While the AARs identified many process requirement differences between the two projects, this study used the source contract documents to determine requirement differences. Using the request for proposal (RFP) and statement of work (SOW) allowed for an unbiased look into construction policy variations to determine if there were differences that caused cost deviations. Both the RFPs reference additional documents such as Unified Facility Codes (UFC); industry standards, such as National Electric Code; and military requirements, such as Air Force Instructions (AFI) and Engineering Technical Letters (ETL). The differences between the contract requirements were categorized in two ways. First, the difference was qualified as either a similar, but not the exact same, requirement in both projects or a requirement that does not exist in one of the two projects. An example of the former is requiring floor covering but specifying different types. Following that, a determination of the level of difference was qualified based on expert opinion as a minimal difference in requirement, a difference in requirements, or an extreme difference in requirements. Items that existed only in one project were automatically rated as an extreme difference.

The 1,009-page shelter A RFP is a consolidated RFP, SOW, and contract administration document. On the other hand, shelter B released three documents, the RFP, SOW, and contractor administrative requirements, totaling 161 pages via the GSA system. Table 7 states the number of contract requirement differences between the two shelters. In addition to quantifying the requirement differences in each contract, the AARs highlight fundamental process differences. Each overarching cost premium theme contains discussion of the process differences.

Table 7: Summary of Contract Requirement Differences

Difference	Quantity
Similar requirement, minimal difference	31
Similar requirement, difference	35
Similar requirement, extremely different	5
Requirement only in one contract, extremely different	46
USACE more stringent	81
CEG more stringent	3

Expert Survey

The expert survey was completed by nine personnel from USACE, Alaska District, five USAF personnel representing the CEG and Contracting Squadron, and four contractors representing experience with four different companies that have executed MILCON. Table 8 summarizes the results for any factors rated as moderately or largely influencing cost premiums. In addition to the factors presented in Table 8, another 15 factors only influence MILCON cost premiums “to a limited extent” and one factor has no influence on cost premiums. The table also presents the response weighted average and quantifies how many of the contract requirement differences relate to each factor. Finally, the table provides the overall rank based on level of influence and the rank for each demographic. Eighty-three percent of the 102 contract differences linked to the survey fell into the moderately or largely influential categories. The factors that have “specific” for their “applies to” can be applied only to the JBER weather shelter projects; on the other hand, the “general” factors can be applied to the weather shelters and most other MILCON projects. The factors listed in Table 8 were combined with the contract requirement differences, interview data, and open-ended questions at the end of the survey to generate overarching themes regarding cost premiums.

Table 8: Moderately & Largely Influential MILCON Cost Premium Factors

Applies To	Factor	Influence on MILCON Premiums	Weighted Avg. Value	# Contract Rqmt Differences	Ranking			
					Contractor	USACE	USAF	Overall
Specific	CMU vs insulated metal panels for hangar bay walls	Large	4.056	1	2	8	2	1
General	USAF project through USACE	Large	4.052	0	1	25	1	2
Specific	100% hazard rated electrical systems in the hangar bays versus a de-energized system	Large	4	1	2	5	3	3
Specific	Built up low slope roof versus metal panels	Large	3.667	1	4	5	5	4
General	Unique attributes of USAF project vs private industry with similar end-use requirements	Moderate	3.467	2	29	1	6	5
General	USACE implementation of design-build execution	Moderate	3.43	7	4	12	6	6
General	Quality control requirements set by the government	Moderate	3.411	9	8	7	6	7
General	Oversight on contractor by USACE/NAVFAC	Moderate	3.389	1	8	19	3	8
General	Prescriptive design requirements rather than code references	Moderate	3.306	23	16	4	15	9
General	Military design standards/specifications	Moderate	3.259	4	18	2	15	10
General	FAR: 8A/small-business policies	Moderate	3.175	1	18	9	6	11
Specific	Direct digital controls for all HVAC components	Moderate	3.139	1	4	19	25	12
General	USAF project through AFCEE	Moderate	3.139	0	8	19	12	12
General	Submittal process (administration/# of submittals)	Moderate	3.115	14	8	27	6	14
General	Restrictions placed on construction methods	Moderate	3.096	0	18	12	6	15
General	FAR: Administrative requirements	Moderate	3.058	4	8	16	21	16
General	USAF implementation of design-build execution	Moderate	3.05	0	18	3	31	17
General	Restrictions placed on designs	Moderate	3.046	1	16	12	15	18
Specific	Additional capacity required in fire alarm system above and beyond current building scope	Moderate	3	1	18	11	15	19

Applies To	Factor	Influence on MILCON Premiums	Weighted Avg. Value	# Contract Rqmt Differences	Ranking			
					Contractor	USACE	USAF	Overall
General	Submittal timeline (time for approval/rejection)	Moderate	2.974	1	8	30	14	20
Specific	Schedule management requirements required by USACE versus CE squadron	Moderate	2.917	2	4	34	25	21
General	LEED for new construction requirements	Moderate	2.896	2	18	12	21	22
Specific	Internal roof drains versus gutters	Moderate	2.861	1	18	17	25	23
Specific	Inhabited vs low-occupancy anti-terrorism/force protection standards requirements	Moderate	2.806	1	8	31	25	24
General	Federal Acquisition Regulations (FAR)	Moderate	2.758	2	27	9	31	25
General	Design review process	Moderate	2.739	4	27	19	21	26
Specific	Requirement to develop test hangar concrete slabs	Moderate	2.694	1	8	39	25	27
General	Fixed programmed amounts (allowed project cost) early in project development	Moderate	2.528	0	40	19	12	28

Results: Overarching Cost Premium Themes

The analysis of survey results, interviews, and case study data revealed five major overarching themes that influence cost premium which are shown in Table 9. Table 9 also shows the number of survey factors and contract requirement differences applying to each theme. The survey factors and contract differences can fall into multiple themes. These data were combined with the interview and open-ended survey responses to provide the full analysis of each theme.

Table 9: Cost Premium Themes

Theme	# Survey Factors	# Contract Rqmt Differences
Failing to Balance Risk	14	45
Additional Public-sector Requirements	10	18
Stifling or Not Applying Innovation	9	20
Selection of Construction Specifications	11	41
Parameterization of the Execution Process	10	39

Failing to Balance Risk

The selection of acquisition and execution method, such as DB and FFP, directly affects the balance of risk between the contractor and construction agent. Shifting from DBB to DB shifts risk from the construction agent to the contractor (Lam et al. 2008). However, in MILCON procurement, the risk is sometimes shifted so far toward the contractor that it causes cost premiums. In private industry construction, the balancing of risk minimizes cost and enables the contractor to operate in parallel. The interview and open-ended survey question revealed that some construction agents are litigation adverse; therefore, they specify everything possible in their contracts. Contractors price projects

more costly due to the additional requirement to validate the design and construction against the abundance of specifications and regulations. Forty-five contract differences and 14 cost premium factors fall into the theme of imbalanced risk.

The most telling example of an imbalanced risk cannot be quantitatively validated, but the perception appears to cause cost premiums. Contractors stated that the most influential cost premium factor is the construction agent and, in this case, the military construction agents drive cost increases. However, survey result shows that construction agents perceive that they are not responsible for causing cost premiums while contractors feel the need to charge higher prices for MILCON than private sector projects. The ability to implement changes to mitigate this cost premium falls within the realm of the DoD. In this case, even if there is no quantifiable reason for the cost premium to exist, the military should address the perception issue and attempt to mitigate this cost premium.

Research revealed two general schools of thought for the cause of the imbalanced risk. First, military construction agents “partner” with contractors in name only. Johnson et al.’s (2012) research revealed that, in many cases, the construction agent does not partner with the contractor either due to an erroneous belief that the FAR forbids it or to avoid accusations of showing preference for a given contractor. Additionally, the AARs listed partnering as one of the primary drivers for success in the shelter B project (673d Civil Engineer Group 2010; Moser 2009). Furthermore, Lam et al.’s (2008) general DB research found that partnering can result in a higher level of success for DB projects. Public-sector construction agents should look for ways to partner or ally with the

contractor; alliancing can improve cost, schedule, and performance while benefiting both the contractor and construction agent.

An adaptation of Gannon et al.'s (2012) cone of uncertainty (Figure 6) allows for visualization of how the improper application of DB can cause an imbalance of risk. If the construction agent and contractor balance risk, as it affects cost, the balanced cost should appear near the center of the cone. However, as more risk shifts to the contractor, the cost shifts towards the right side of the cone representing higher construction costs. Additionally, the earlier in the design process the contractor is locked in to a fixed cost and schedule, the higher the cost and longer the schedule tend to be. Construction agents can balance risk by using an acquisition method with incentives or award fees that reward the contractor for above standard work, costs, or schedule. By balancing risk via execution method and partnering with contractors, the government can lower construction costs and increase construction performance.

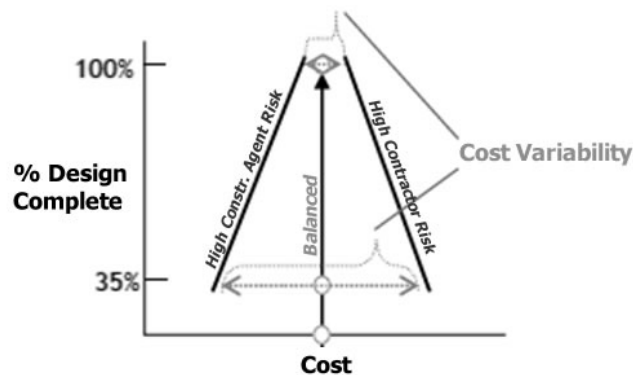


Figure 6: Cost Cone of Uncertainty (Adapted from Gannon et al. 2012)

Additional Public-sector Requirements

The additional public-sector requirements theme encompasses a vast number of rules, regulations, public laws, and policies that can increase public-sector construction

costs compared to private industry. The JBER weather shelter case study presented an opportunity to look into controllable, internal, cost factors since both projects had to meet the same federal regulations and policies. This cost premium theme is represented by 10 surveyed cost premium factors and 18 contract requirement differences. Additionally, the open-ended survey responses frequently brought up additional government requirements such as the Buy American Act and Davis-Bacon Act wage rates. The 5th and 11th most influential cost premium factors, based on the survey, include unique attributes of military projects compared to private industry and FAR 8A and small business policies. Although all military facilities must meet anti-terrorism and force protection requirements, some facilities have more stringent requirements than other facilities based on function and occupancy. Previous research and interview responses have specifically cited military specifications as a cause of cost premiums; however, most construction has moved away from military specifications towards industry standards and UFCs (673d Civil Engineer Group 2009; U.S. Army Engineer District, Alaska 2008). The weather shelter projects demonstrated that construction agents should be aware of the exact requirements for the facility requested and not always assume that the most stringent standards need to be applied. The possible cost premiums can be mitigated by the construction agent through analysis of the requirement itself.

In addition to unique military policies, the federal government has implemented socioeconomic policies that increase the cost of public-sector construction. The survey highlighted small-business policies, such as 8A source selection, and administrative requirements from the FAR as moderately influencing costs. Additionally, the requirement to use Davis-Bacon wage rates increases the cost of public-sector

construction. While the original intent of the Davis-Bacon Act was to ensure a fair wage and ensure wages paid by contractors doing federal work are appropriate for the area, recent studies have shown these wage rates do not reflect the private sector construction industry correctly and cause additional and unnecessary cost premiums (Hartford 2012; Pope 1990). Although many of the specific elements in this cost premium theme are outside the control of the DoD, engineers, contracting specialists, and project managers can limit the effect by treating each project as unique and applying only the necessary specifications for the specific project.

Stifling or Not Applying Innovation

The AAR and interviews with contractors revealed a common theme: the standard USAF MILCON DB process writes and regulates, sometimes unknowingly, innovation out of many construction projects. The innovation theme contains 20 contract requirement differences which apply to 9 different cost premium factors. Two of the factors rated as having a large influence on cost premiums are specific to the JBER weather shelter designs. The remaining factors were all rated as moderately influencing cost premiums. For the weather shelter projects, experts consider the shelter B approach more innovative than the approach used in shelter A.

This study found that construction agents should not limit construction methods or designs for DB projects, especially prior to a design charrette. The shelter A RFP limited the construction to CMU and thereby limited designs and construction methods. However, the shelter A construction agent stated that the end-user's insistence on using certain materials and methods limited the design. The shelter B RFP left the construction

material open as long as it met all requirements; the end-result ended up meeting or exceeding the requirements. Construction agents should work to ensure they are receiving requirements from the client rather than detailed direction. After all requirements have been identified, construction agents and contractors can work together to use innovative or standard practices that best balance schedule, cost, and performance while meeting all the requirements. This is not to say that innovative materials or ideas are always the best option, but they should not be dismissed too quickly. Lam et al. (2008) lends quantitative support to this concept based on their finding that allowing a DB contractor room to provide knowledge and expertise improves DB project success and allows the end-user to select previously unknown alternatives.

Construction agents should educate users on how innovative solutions will meet their requirements. For example, leadership throughout JBER had to be educated on the fact that a PEB is not always an “off-the-shelf” solution and can be designed and built for their precise needs. One of the shelter B innovative ideas was to implement an electrical disconnect rather than installing all “hazard-rated” electrical infrastructure. This single change resulted in large cost savings and emphasizes why construction agents must work with their contractors rather than simply dismissing ideas that do not align to “the way it has always been done.” In another example, the shelter A RFP specified resilient vinyl flooring in its non-aircraft areas while the shelter B RFP allowed the contractor to select the floor covering, which ended up being a coating directly applied to the concrete slab. The shelter A RFP specified vinyl flooring because that is the standard the user was used to; on the other hand, the concrete sealant meets all requirements and ends up being more durable for maintenance activities. From the simple, such as flooring type, to the

significant, such as insulated metal panels rather than CMU, construction agents should allow DB contractors to propose and implement innovative solutions that allow the use of different construction materials and methods without sacrificing quality.

Selection of Construction Specifications

Construction specifications define the requirements for a facility. Generally, construction contracts use three forms of specifications: method-based specifications (MBS), end-result specifications (ERS), and performance-related specifications (PRS) (Dhakal et al. 2009). The MBS is the classical form of specification where the design and construction agent prescribe construction procedures for the contractor to follow. In ERS, the contractor is fully responsible for the construction procedures and quality control, but the construction agent accepts or rejects the final results based on a detailed quality assurance plan. Finally, PRS grew from statistically-based quality assurance specifications and relate quality characteristics and/or life-cycle costs to expected performance of the work completed (Dhakal et al. 2009). Based on the contracts analyzed and the interview and survey data, most MILCON projects utilize MBS regardless of execution method.

For the two weather shelters analyzed, 23 contract requirement differences directly related to “prescriptive design requirements rather than code references.” Additionally, this overarching theme contains three of the four largely influential specific cost premium factors (Table 8). Furthermore, all of the contractors surveyed mentioned that prescriptive methods and materials do not allow contractors to fully apply DB practices such as being aggressive or providing more economical solutions by taking

advantage of local purchase or economy of scale. This finding goes against one of the key DB performance indicators: successful projects allow the contractor flexibility (Lam et al. 2008). However, the utilization of MBS can help the contractor select the appropriate materials and methods that can meet the construction agent's overall requirements.

Based on this, and other research, construction executed using the DB methodology should implement at least ERS and in some cases PRS (Dhakal et al. 2009; Kelleher and Walters 2009). However, some public-sector construction, especially in specialized areas such as the military, will always have unique requirements. Engineers can implement ERS while still including explicit requirements; for example, in the case of the weather shelters, these requirements included concrete floors rated for a specific aircraft for a specific number of passes. The contract for shelter A included references to industry standards, such as those published by ASCE, while also prescribing the floor construction thickness, mixture, and procedures. On the other hand, the shelter B contract referenced the same industry standards and AFIs for the given aircraft but allowed the contractor to design and specify the floor concrete. In the end, shelter A has uniform thickness concrete throughout while shelter B has thicker concrete where the aircraft rests and less thick concrete in non-aircraft loaded areas. By using an ERS rather than an MRS, the contractor developed a method that saved time and money while maintaining the performance requirements. ERS, and thusly PRS, can allow for more innovative designs and potential cost savings without sacrificing performance during DB execution (Dhakal et al. 2009).

Parameterization of the Execution Process

Since the 1996 update to the FAR allowing the use of DB, many federal agencies use it primarily to execute their construction projects. However, government application of DB does not match private sector DB in terms of procedures or benefits; the government, as the owner and construction agent, remains heavily involved in the process including, in some cases, not allowing construction to commence until a design has been submitted and approved (Molenaar et al. 1999; Gannon et al. 2012). Additionally, analysis of the weather shelter RFPs made apparent the over parameterization, or specification, of requirements for a DB project. While all of the cost premium themes, with the exception of additional public-sector requirements, can fall into the parameterization of the execution process theme, this section will focus on additional elements of inappropriate DB implementation.

In traditional DB execution, construction is on-going as the design is finalized; for example, once the facility footprint has been specified and approved, earthwork can begin while the vertical portions are still being designed. The requirement for design and construction in series rather than in parallel forces the project to match a DBB process with a single contractor and directly increases costs by extending the schedule. Additionally, in climates with limited construction seasons, delays caused by these policies are further compounded. For the weather shelter projects, there were 39 contract differences related to the parameterization of DB theme; respondents rated 79% of them as moderately influencing cost premiums. Specifically, the shelter B RFP allowed construction and design to occur in parallel while the shelter A RFP required a complete design prior to construction. However, two of the factors in this theme were contentious

topics during the survey and another two factors revealed widely varying responses between demographics.

The contentious factors shown to influence MILCON cost premiums are the military construction agents' approaches to implementing DB processes. Overall, respondents ranked military construction agents' standard implementation of DB as the sixth most influential cost premium factor. However, the construction agents did not rank the level of influence as highly as contractors or end-users. These findings are significant because it demonstrates possible disconnects between end-users, construction agents, and contractors. Without regard for blame, it is apparent that construction agent requirements and policies are limiting DB execution, thereby adding to construction costs and schedule. However, the execution of shelter B demonstrated that military engineers are able to implement DB execution similarly to private industry.

The other factors that directly relate to the application of DB include schedule management requirements. When asked to compare the shelter A and shelter B schedule management requirements, contractors ranked the shelter A requirements as the fifth most influential factor. Administrative burdens can cause additional costs for contractors while construction agents incorrectly believe the same burdens exist in private industry. The shelter A RFP prescribes schedule management software requirements; however, this prescribed software is not commonly used throughout industry. Survey and interview responses, as well as Gannon et al.'s (2012) previous research, state that the use of non-industry standard software (i.e. Primavera) ends up forcing the contractor to maintain at least two schedules, one in their normal software, such as Microsoft Project, and one in the custom-built construction agent software. The shelter B RFP allowed the contractor

to select the software to be utilized as long as it met standard requirements, such as presenting resource distribution and a critical path.

In addition to the parameterization of schedule management, the two weather shelter projects treated submittals differently. The shelter A RFP specified that submittal approval would take at least 30 days, and construction would be proceeding at risk if executed prior to submittal approval. This policy and the idea of construction proceeding at risk are more appropriate for a DBB contract. The contractor has accepted that risk already through the use of DB; their ability to utilize materials, methods, and procedures of their choosing offsets this risk (Lam et al. 2008). The shelter B RFP more appropriately aligned to standard DB practices and specified that submittals would be approved as soon as possible. By working with the shelter B contractor, the construction agent was able to help the contractor execute rapid approval for many elements. Some construction agents administer significantly more large construction projects than others; therefore, requiring a standardized submittal process helps with the internal administrative burden. However, to allow DB to perform as expected, construction agents should be more flexible with approval timelines; the contractor is taking risk from the construction agent by being responsible for both design and construction.

Summary and Conclusions

This paper presented five themes that influence cost premiums in public-sector, specifically MILCON, construction based on a case study, expert surveys, and interviews. The five cost premium themes are:

- Failing to balance risk

- Additional public-sector requirements
- Stifling or not applying innovation
- Selection of construction specifications
- Parameterization of the execution process

The unique case study allowed for the determination of cost premiums caused by internal processes rather than those stipulated by Congressionally mandated laws and policies. Previous studies have attributed cost premiums to items such as Davis-Bacon Act wage rates and military requirements, but this study demonstrated that internal policies cause some cost premiums. Specifically, the case study demonstrated that internal policies can cause a \$7 million, or 27%, project cost difference. Additionally, by combining expert opinion and AARs with contract documentation, this study was able to show which factors can, and to what degree, influence cost premiums. Although this one case study provides evidence unique to these projects, it does validate the overall cost premium findings. Furthermore, according to Patton (2001), the phenomenological findings based on expert opinions have substantial weight in determining the true reality.

Overall, internal factors based on the parameterization of DB execution cause many cost premiums. Parameterization of DB can occur by selecting restrictive specifications, stifling innovation, and failing to balance risk. Based on previous research, this parameterization directly affects the likelihood of DB success by limiting contractor action and inputs while also expanding the construction timeline (Chan et al. 2004; Lam et al. 2008). Working to address internal causes of cost premiums can reduce costs and likely improve DB performance.

Relevance to Industry Practitioners and Researchers

Although the results of this study focused on MILCON procurement, the findings can have significant implication for industry practitioners and researchers. The fact that many of the factors influencing cost premiums were internal to the executing construction agent suggests that practitioners should begin with an internal audit to reduce costs and improve efficiency. Additionally, studies could further investigate the effects of parameterizing the execution process. This study showed that parameterization caused cost premiums; further research could investigate the effects on schedule, overall construction outcome, and likelihood of litigation.

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Disclaimer

The views expressed in this article are those of the writers and do not reflect the official policy or position of the U.S. Air Force, Department of Defense, the U.S. Government, or the Air Force Institute of Technology.

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IV. Journal Article: A Geospatial Statistical Analysis of Non-Value Added Costs Due to Davis-Bacon Act Prevailing Wage Rates

The journal article presented in this chapter was submitted for publication in the *Lean Construction Journal*. At the time of thesis completion, the journal article was not yet accepted or rejected. This journal article presents the results of the investigation into cost premiums associated with the Davis-Bacon Act (DBA) prevailing wage rates. While the content has not been changed, technical adaptations have occurred for inclusion in this thesis. Appendix C contains further supporting information including additional background and methodology details. Appendix D contains a procedure log for all geospatial and statistical operations carried out in support of this DBA research.

A Geospatial Statistical Analysis of Non-Value Added Costs Due to Davis-Bacon Act

Prevailing Wage Rates

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Abstract

Question: Do prevailing wage rates add non-value added costs to federal construction projects, specifically those executed by the United States Air Force?

Purpose: The purpose of this research is to understand how prevailing (Davis-Bacon Act) wage rates affect the cost of federal construction compared to private industry. Additionally, this paper investigates concerns about the geospatial breakdown of prevailing wage rates.

Research Method: Geospatial and statistical analysis of Davis-Bacon Act prevailing wage rates compared to Bureau of Labor Statistics industry wage rates.

Findings: This paper also quantified a statistically significant difference (16%) in prevailing hourly wage rates versus private-sector wage rates for carpenters and electricians thereby codifying the non-value added prevailing wage based costs. This paper documents how the geospatial breakdown for wage rate analysis for BLS has enough fidelity for DBA wage rate use at United States Air Force installations.

Limitations: This research only investigated prevailing wages at United States Air Force installations for the carpenter and electrician trades.

Implications: This research indicates a need to reexamine prevailing wage rates in pursuit of federal lean construction.

Value for Practitioners: This paper quantifies cost differences, thereby demonstrating opportunities for realizing cost efficiencies, based on prevailing wage rates and promotes the removal of non-value added costs from federal construction projects.

Keywords: contract management, construction management, construction costs, military construction, public sector construction, lean construction, federal facility procurement, federal laws, waste

Paper type: Full paper

Introduction

In 2010 and 2011, the United States spent over \$30 billion for federal construction (U.S. Census Bureau 2012). The Department of Defense (DoD) military construction program is responsible for 40%, or \$12 billion, of the yearly construction expenditures (112th Congress 2011b). Recent research revealed that military construction costs between 25% and 40% more than private industry; specific to the United States Air Force (USAF), one study found the additional costs to be 37% greater (112th Congress 2011b; Hartford 2012). Given this large cost discrepancy, private industry construction can be used as a goal, or baseline, for an analysis of excessive costs in military construction. To meet budgetary constraints and goals, investigating factors that cause military construction to cost more than private industry construction would be of value to the USAF. Therefore, examining military construction costs through lean analysis helps identify areas of value added and non-value added, or waste, costs.

In general, military construction involves constructing or modifying a facility to meet a specific purpose. This one-of-a-kind product makes it difficult to analyze many lean principles such as pull and striving for perfection (Koskela 2004). Many lean construction analysis efforts focus on repetitive processes such as large scale residential construction where lessons learned on one house can be applied to the next (Gustafsson, Vessby, and Risk 2012). Although military construction does not typically involve repetitive efforts, it can still be viewed from a lean construction perspective by focusing on the process, which is repeated for every project, rather than a single one-of-a-kind project.

This study focused on examining labor costs through a lean lens. Labor represents just over 30% of construction costs and is one of the few costs that can be changed without affecting building design or effectiveness (U.S. Census Bureau 2011). Specific regulations guide federal construction procurement; one of these requires the use of the Davis-Bacon Act (DBA) prevailing wage rates (Department of Labor 2012). These wage rates are trade and region specific. Additionally, the Bureau of Labor Statistics (BLS) provides wage rate information for private industry construction through its surveys. The BLS surveys workers throughout the United States (U.S.) and tabulates the information, including hourly wages, based on their trade and locality. If there are substantial differences between the prevailing wage rates and surveyed wage rates, the extra costs can be considered type one, or necessary, waste (Womack and Jones 1996). However, necessary wastes due to regulatory requirements and public law are still wastes that can be addressed. Since wage rate data are geospatially related, an analysis via a

geographic information system (GIS) can be used to compare the DBA wage rates to BLS wage surveys at USAF active duty bases.

Objectives

The overall goal of the research was to confirm and quantify the findings of numerous reports which found DBA prevailing wage rates to be a leading cause of military construction cost premiums compared to private industry construction costs. To achieve this goal, the approach used in the research was to determine, via geospatial statistical analysis, if DBA prevailing wage rates vary greatly from the surrounding area wage rates as determined by the BLS wage surveys at USAF active duty base locations. Therefore, two hypotheses were developed to gain a better understanding of non-value added federal construction costs based on labor wages. The first hypothesis addressed a comparison of prevailing wage rates and private industry wage rates. The first alternate hypothesis is that there is a difference between the DBA prevailing wage rates and the wage rates paid in private industry. The second research hypothesis addressed agency concerns about the geospatial breakdowns used for each type of wage rate. The second alternative is that there is no difference between standardized DBA prevailing wage rates and those surveyed by the BLS based on geographic location. The second hypothesis focused on whether the high and low wage rates occur in the same location.

Background and Literature

Lean Thinking, Construction, and Waste

Originally, lean thinking focused on lean production. Womack and Jones (1996) summarized five principles of lean thinking from a production perspective:

- Specify value
- Identify and map the value stream
- Make the process steps flow
- Let the client, customer, or end-user pull value
- Strive for perfection

However, further studies have demonstrated that some of these lean thinking elements do not work as proposed for lean construction. Koskela (2004) analyzed each of the five principles from a construction standpoint and determined that while Womack and Jones' (1996) five principles are critical to implementing lean practices, many other principles exist, especially in the complex construction environment. Despite these differences, the concept of waste exists in lean thinking regardless of the implementation environment. Womack and Jones (1996) define two types of waste. Type one waste is necessary waste, which consists of activities or costs where value is not created but the waste cannot be eliminated based on current technology or policies. Type two waste is pure waste, which consists of activities that consume resources without adding value such as wait time or rework. Significant amounts of lean construction research have focused on costs and waste and found that showing savings is one of the best ways to motivate companies to implement lean construction practices (Alves and Tsao 2007). This study focuses on type one waste and quantifies the cost to the U.S. government, specifically the USAF.

Prevailing Wage Rates

Prevailing wage rates are the wage rates paid to non-union employees working on projects funded by the government (Cavanaugh 2010). There are multiple prevailing

wage rate programs both in the U.S. and internationally. In the U.S., the McNamara-O'Hara Service Contract Act sets prevailing wage rates for service contracts. The Davis-Bacon Act (DBA) fixes prevailing wage rates for federally funded construction projects; additionally, some states have prevailing wage rate acts for state-funded construction (Cavanaugh 2010). This study focuses on the non-value added costs for construction as USAF installations; therefore, the applicable prevailing wage act is the Davis-Bacon Act (DBA).

In 1931, Congress enacted the DBA to enable fair construction procurement practices (United States Government Accountability Office 2011). Congress designed the act to “to protect communities and workers from the economic disruption caused by contractors hiring lower-wage workers from outside their local area, thus obtaining federal construction contracts by underbidding competitors who pay local wage rates” (United States Government Accountability Office 2011). The Department of Labor (DOL) is responsible for administering the wage rates via its Wage and Hour Division (WHD) (Department of Labor 2012). According to the WHD, “Davis-Bacon and Related Acts apply to contractors and subcontractors performing on federally funded or assisted contracts in excess of \$2,000 for the construction, alteration, or repair (including painting and decorating) of public buildings or public works” (Department of Labor 2012).

Currently, the DOL WHD uses voluntary surveys to determine the appropriate prevailing wages for a region (112th Congress 2011a). Since 1996, the Government Accountability Office (GAO) and the DOL Inspector General have found and annotated issues with the method of surveying used by DOL WHD. Inaccurate survey data, limited scope of surveys, out-of-date union data, and a lack of result validation causes these

issues (United States Government Accountability Office 2011). Although the WHD implemented limited improvements, the process still results in the same type of errors.

The DBA prevailing wage rates are specific to geographical areas (Cavanaugh 2010). The WHD attempts to create wage rates by county but can use any contiguous breakdown based on county areas, federally owned lands, wage data, and metropolitan statistical areas (MSA) (United States Government Accountability Office 2011). While the GAO has documented problems with the method of data collection, public law requires that federal construction contractors use the results (Department of Labor 2012).

Bureau of Labor Statistics

The Bureau of Labor Statistics (BLS) is “the principal Federal agency responsible for measuring labor market activity, working conditions, and price changes in the economy” (Bureau of Labor Statistics 2012). The BLS publishes average wage rates for construction and non-construction trades broken down geographically into metropolitan and non-metropolitan statistical areas (Bureau of Labor Statistics 2011). Since the primary responsibility of the BLS is labor statistics and analysis, it has an expert staff of statisticians and data collectors. To that end, the House Subcommittee on Workforce Protections found that the DOL WHD is an enforcement agency that lacks the expertise provided by the BLS (112th Congress 2011a). However, the WHD stated that it could not use BLS data due to its lack of geographic coverage (112th Congress 2011a).

Federal and Military Construction

This study of DBA prevailing wage rates focused on the effect of those wage rates on USAF military construction. Military construction is “any construction, development,

conversion, or extension of any kind carried out with respect to a military installation” (Department of the Air Force 2010). There are two types of military construction; MILCON, which is, in general, construction activities costing \$750,000 or more, and unspecified minor military construction, which is repair and maintenance of existing facilities or construction costing less than \$750,000 (Department of the Air Force 2010). Public law codifies the rules and regulations governing military construction and requires both types of military construction to use DBA prevailing wage rates (Department of Labor 2012). Previous research has determined that military construction costs more than private industry; many of these studies have found that DBA prevailing wage rates add to the cost premiums, or waste (112th Congress 2011b; Hartford 2012; Pope 1990; Carpenter 1992). The many policies and laws regulating federal and military construction limit the waste analyzed in this study to type one, or necessary waste, and the scope to prevailing wage rates.

Research Methods

Two types of analysis were performed to determine the cost premiums associated with DBA prevailing wage rates. The first was a geospatial analysis that combined the data and allowed for initial analysis. Geospatial analysis is a unique method of quantitative analysis providing for both statistical analysis based on geography as well as a visual representation of data and results. The second analysis was a statistical examination via multivariate analysis of the variance (MANOVA) and matched-pairs t-tests to validate the statistical significance of the geospatial analysis results.

The geospatial analysis involved combining and analyzing geospatial and non-geospatial data from the U.S. Census Bureau, the BLS, and the DOL WHD Wage Determinations Online system. The BLS data were geospatially related to MSAs and non-MSAs. The DBA data are not geospatially related and had to be manually extracted and associated with each USAF base. Additionally, the DBA data are not the same across each area; some regions contain data for many tradecrafts while other areas contain a minimal amount. For this research, the electrician and carpenter trades were analyzed because those trades existed in every DBA wage file and match exactly to a BLS trade.

Geospatial analysis illustrated how the DBA prevailing wage rates and BLS wage survey results vary across space independently from each other. Following the individual analysis, comparative analysis of the two wage rates quantified differences in wage rates and generated a graphic of the differences across space through the use of geographic surface generation. The Kriging method generated the surface by interpolation between data points (USAF bases). The Kriging surface generation method interpolates data based on the weighted moving average and data variance (Hu 1995). The Kriging surface generation method makes more accurate predictions than other models due to its advanced modeling techniques. The BLS wage survey rates did not require interpolation since geospatial data were available for the entire United States.

The statistical analysis used MANOVA and matched-pairs t-tests to determine if the differences between BLS wage survey and DBA prevailing wage rates were statistically significant. By comparing the differences in the wage rates, taking into account the mean, standard deviation, and standard error, an F-test or t-test value is

determined and used to generate a level of statistical significance (Neter and others 1996). A 95% confidence interval was applied to all statistical analyses. To test the second hypothesis, both the BLS and DBA wage rates were standardized using Equation 1.

$$Z = \frac{X - \mu}{\sigma} \quad (1)$$

In the equation Z represents the standardized wage rate, X represents the wage rate, μ represents the average of all the wage rates, and σ represents the standard deviation of the wage rates. The standardizing of the wage rates allowed for a direct comparison of the high and low values by location.

Results and Analysis

Individual Wage Rate Analysis

The BLS and DBA wage rates were analyzed independently of each other both quantitatively and spatially. Table 10 summarizes the quantitative results. The DBA wages had more variability than the BLS rates; specifically, the DBA rates had a multi-modal distribution while the distribution for the BLS rates was mound shaped. The large standard deviation differences between BLS and DBA wage rates emphasize the wider distribution of the DBA wage rates. Additionally, in some locations, the DBA prevailing wage rate is less than the BLS surveyed wage rates. In these cases, the contractors could either pay the lower wage rate, perhaps by bringing in labor from outside the local area, or increase the wage rate to meet the local (BLS) labor rates. If the contractor brought in out of state labor, it would defeat the intent and original purpose of the DBA. However, if the contractor increases the hourly wages to meet BLS surveyed rates, the average

carpenter hourly wage rate would jump by 4.3% to \$25.20. Furthermore, the average electrician hourly wage rate would increase by 2.9% to \$30.18 on USAF construction projects.

Table 10: Quantitative Wage Rate Analysis

Wage Rate	Carpenter				Electrician			
	Average	Max	Min	StdDev	Average	Max	Min	StdDev
DBA	\$24.16	\$43.59	\$7.25	\$10.39	\$29.33	\$48.28	\$7.25	\$9.54
BLS	\$20.61	\$34.26	\$8.81	\$5.75	\$24.69	\$39.33	\$10.02	\$6.15

Wage Rate Differences Hypothesis

The primary hypothesis for this study involved determining whether a statistically significant difference exists between DBA prevailing wage rates and BLS surveyed rates. First, the differences were illustrated graphically. Figure 7 shows the carpenter wage differences between the DBA and BLS wage rates as a geographic surface based on USAF base location. The Kriging method generated the surface from the USAF point data in order to make visualizing the difference easier. The maximum difference is just over \$20 per hour (red) and the minimum is around -\$7 (blue). The Southeast, Texas, and northern Midwest represent the areas with lower DBA wage rates than BLS while the rest of the country has higher DBA prevailing wage rates. Figure 8 shows the wage rate differences for electricians with a maximum difference of almost \$21 per hour and a minimum of -\$17; however, since -\$17 was considered an outlier, the next, non-outlier, minimum wage difference was -\$7 per hour. In the case of electrician wages, very few areas have lower DBA wage rates while most of the U.S. has prevailing wage rates that are higher than those paid by private industry. While both figures demonstrate that the

difference distribution varies geographically, the Northeast, central Midwest, and West have higher prevailing wage rates for both trades.

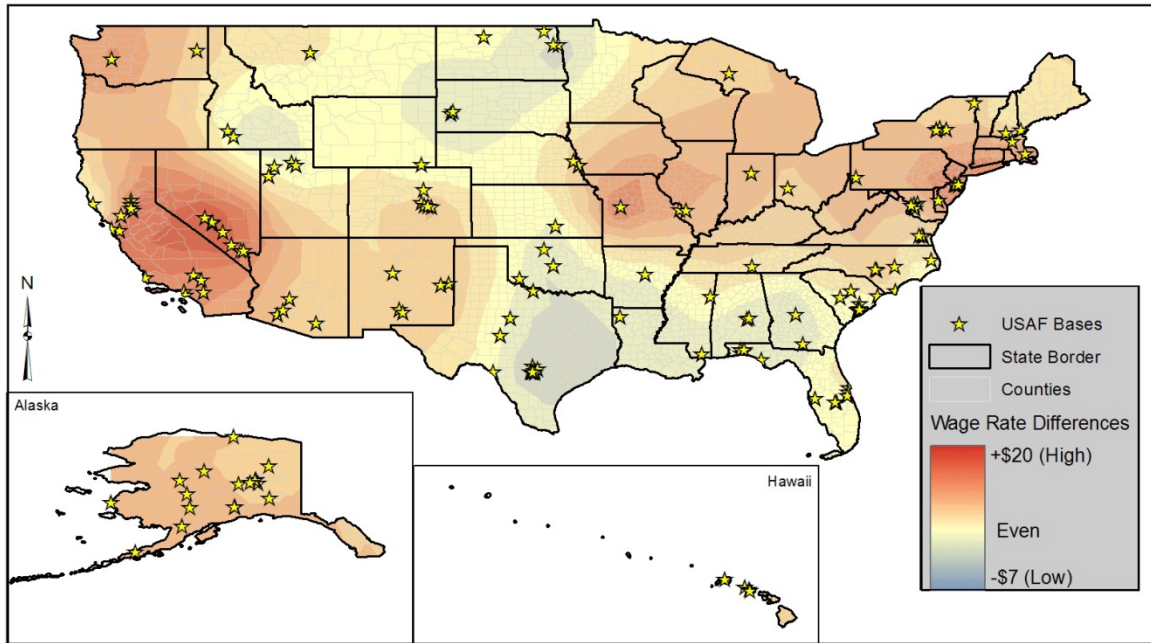


Figure 7: Carpenter Wage Rate Differences

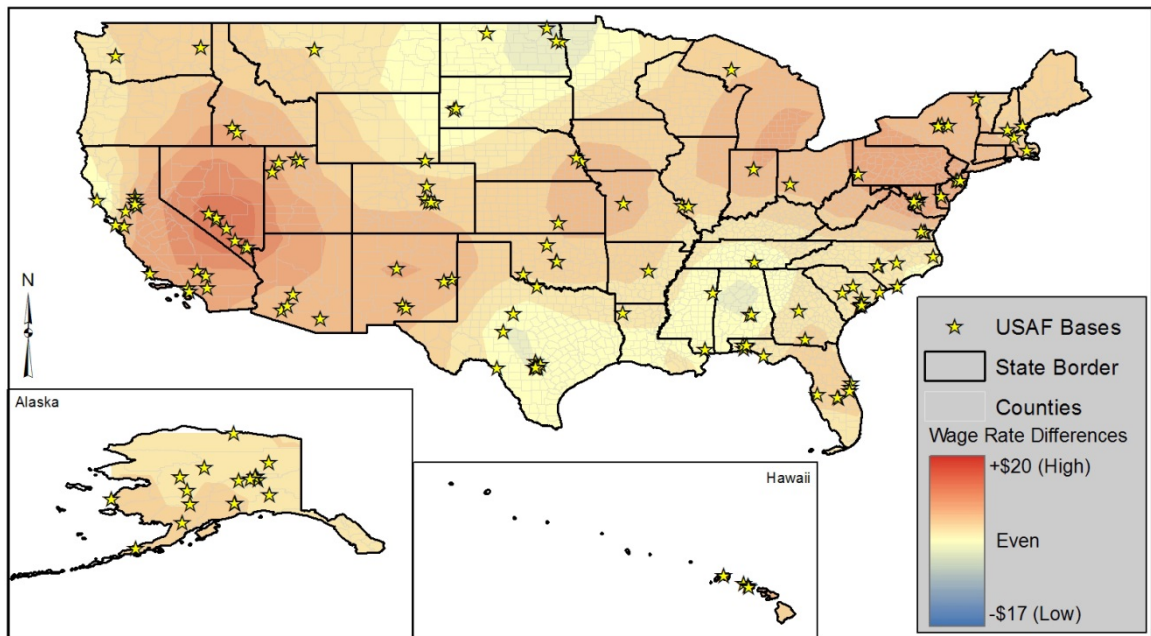


Figure 8: Electrician Wage Rate Differences

Quantitative analysis of the differences between the two wage rates quantified the statistical significance of differences and presented a comprehensive “picture” of the effects of DBA wages on USAF construction. A MANOVA analysis of carpenter DBA and BLS wage rates returned an F-value of 60.97 resulting in a p-value of less than 0.0001 showing statistically significant differences. The matched-pairs t-test returned a mean difference of \$3.55 with a 95% confidence interval between \$2.65 and \$4.44. This means that, on average, the U.S. government expends \$3.55 more per hour as waste to carpenters working on federally funded projects at USAF bases; this additional expense is type one waste.

The MANOVA for the electrician wages also showed a statistically significant difference with an F-value of 108.67 resulting in a p-value of less than 0.0001. In the case of the electricians, the average difference was \$4.64 with a 95% confidence interval bounded by \$3.76 and \$5.51. The monetary value of the waste for electricians is higher than the carpenter waste due to prevailing wage rates. This statistical analysis strongly supports the theory that DBA wages differ from BLS wage rates and are normally higher. Table 11 presents a summary of the differences between the BLS and DBA wages. However, if contractors paid the higher wage rate at locations with lower DBA wages than BLS wages, the average differences for carpenters and electricians would be 120% and 122%, respectively. The results show that, at best, the USAF pays a carpenter 14% more than the surrounding area and could be paying at least 20% more. These large prevailing wage rate premiums emphasize how this “necessary” waste can significantly increase federal construction costs.

Table 11: Summary of Wage Rate Differences

Wages Being Compared to BLS	Carpenter Average Wage Difference		Electrician Average Wage Difference	
	\$/hr	%	\$/hr	%
DBA prevailing wage	\$3.55	114%	\$4.64	118%

Finally, Table 12 shows the number of USAF bases that have prevailing wage rates above and below the BLS wage rate for the surrounding area. The key takeaway is that most USAF bases have prevailing wage rates above wages paid in the surrounding area.

Table 12: Summary of USAF Wage Rate Comparisons

Trade	# of Bases w/ DBA Below BLS	# of Bases w/ DBA Above BLS	% of Bases Below BLS Rate	% of Bases Above BLS Rate
Carpenter	68	121	36%	64%
Electrician	33	156	17%	83%
Carpenter & Electrician	22	113	12%	60%

Wage Rate Geospatial Breakdown Hypothesis

Geospatial analysis was critical to addressing the hypothesis related to DOL WHD’s concern that BLS geospatial divisions would be too inaccurate for prevailing wage rate use. The BLS analyzes wage data based on metropolitan and non-metropolitan statistical areas. The WHD sets DBA prevailing wage rates based on state, county, or smaller areas inside each county. In some cases, the geographic breakdowns differ per trade for the same region. Graphical comparisons of the BLS and DBA wage rates show that the high and low wages, in general, occur in the same region of the country for both trades. Figure 9 demonstrates this similarity for the carpenter trade while Figure 10 depicts the similarities for the electrician trade. The color of the stars represents the DBA

wage rate while the color of the remainder of the map represents the BLS wage rate. As shown, the lower rates occur in the Midwest and Southeast while the west coast, Northeast, and non-continental U.S. have higher wage rates for both DBA and BLS. For the electrical trade, the wage rates are higher in general across the entire country.

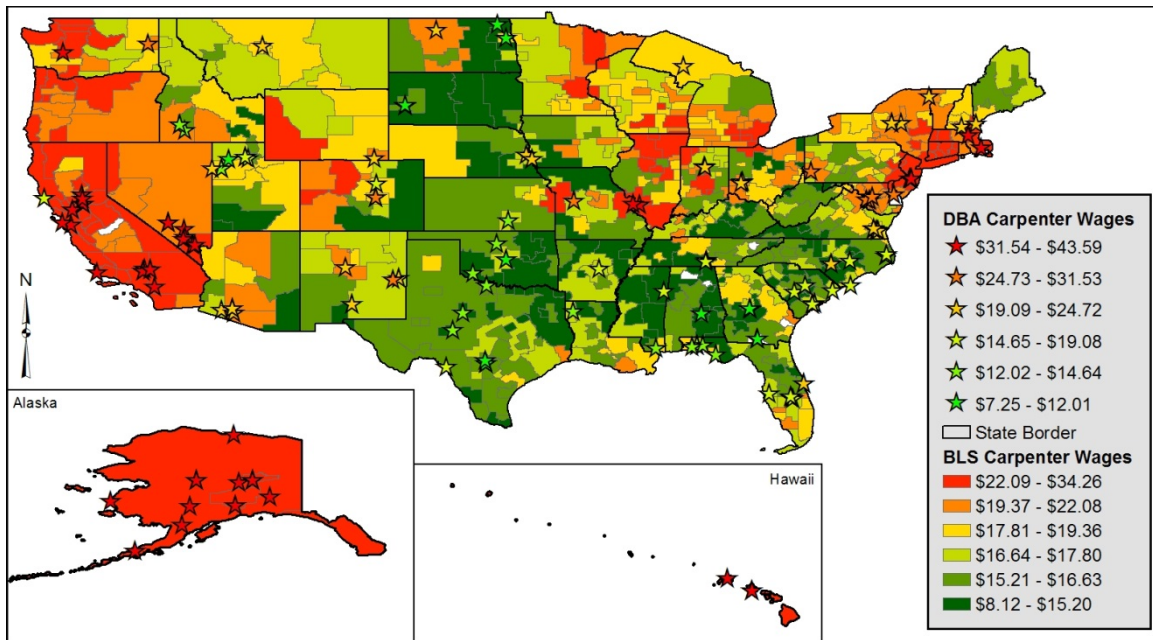


Figure 9: DBA & BLS Carpenter Wage Rate Combined Map

Quantitative analysis directly addressed the second hypothesis and showed the similarities demonstrated graphically. MANOVA performed on the standardized wage rates provided statistical validation of the similar trending. The p-values of 0.5636 and 0.8822 for carpenters and electricians respectively show differences between the normalized wage rates were statistically insignificant. This finding supports the second alternative hypothesis and the notion that the DOL WHD could use the BLS geospatial divisions for setting DBA prevailing wage rates at USAF bases.

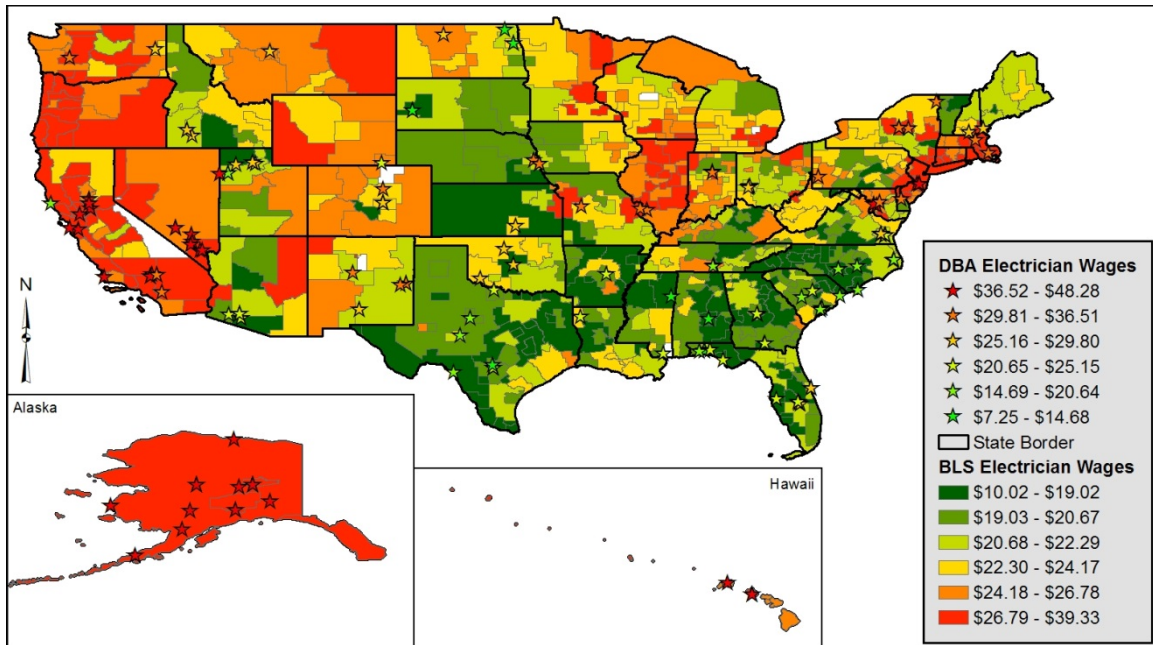


Figure 10: DBA & BLS Electrician Wage Rate Combined Map

Limitations

Due to the availability of data and method of analysis there are limitations to the conclusions drawn from this geospatial analysis. Conclusions drawn from this analysis do not apply to specially funded realignment projects such as the Guam Realignment Fund. Additionally, although both Davis-Bacon and BLS wage rates exist for trades other than carpenters and electricians these were the only trades analyzed. This means this research can be used to show that wage rates differ and contribute to cost premiums, but cannot be used to specify an exact amount DBA prevailing wage rates add to construction projects. Furthermore, the DBA analysis did not account for any fringe benefit pay since these benefits may be included in private industry pay but the BLS does not quantify them. In addition, any Davis-Bacon wage determinations with multiple categories, such as over/under \$1.5M, were averaged to represent USAF projects of both MILCON and unspecified minor construction scope. Finally, this analysis treats all

USAF locations the same. This means radar sites and test ranges have the same weighting as major installations with a greater volume of construction. This limitation makes it impossible to quantify exactly how much extra money the USAF spends due to Davis-Bacon prevailing wage rates. This analysis focuses on general additional costs rather than an exact quantity.

Summary and Conclusions

This analysis showed that the Davis-Bacon wage rates are not accurately representing industry wages for USAF bases. This misrepresentation results in easily quantifiable type one waste for federal construction. Specifically, 64% of USAF bases have higher DBA prevailing wage rates for carpenters, 83% of the bases have higher rates for electricians, and 60% of the bases have higher prevailing wage rates for both trades. However, at bases with prevailing wage rates below the surrounding area's wage rates, contractors may increase the wage rate paid or bring in labor from outside the local area; either of these options hurt the government by violating the premise of the DBA and increasing construction costs. Additionally, this analysis confirms the House of Representatives Subcommittee belief that any fidelity lost through the use of BLS wage rates would be regained by not using statewide data for prevailing wage rates (112th Congress 2011a). By demonstrating that the BLS and DBA wage rates agree with each other for regions with higher or lower wage rates, this study lends additional validation toward the subcommittee's thought that fidelity would not be lost by changing to BLS statistical regions.

This research demonstrated graphically and statistically that the Davis-Bacon Act method of prevailing wage determination does not accurately reflect market conditions for carpenters and electricians, two major construction trades. Therefore, the use of DBA results in type one waste and costs the taxpayers additional money for construction on USAF installations. Adapting DBA wage rates to match local prevailing wages in geospatial breakdown as well as hourly rates would reduce USAF, and all federal, construction costs while still supporting local contractors and crafts persons and not removing any value from a construction project. The federal government could address this inefficiency, i.e., type one waste, as the first step in implementing lean construction practices to address budgetary concerns.

Disclaimer

The views expressed in this article are those of the writers and do not reflect the official policy or position of the U.S. Air Force, Department of Defense, the U.S. Government, or the Air Force Institute of Technology.

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V. Conclusions and Recommendations

This chapter briefly summarizes the results presented in the white paper, two scholarly articles, and their supporting appendices. While the scholarly articles each contain their own, in-depth, conclusions and recommendations, this chapter combines and simplifies the recommendations. This chapter also addresses the overarching research problem and each of the research objectives. Recommendations for future research follow the synopsis of conclusions and recommendations for addressing MILCON cost premiums.

Research Objectives Addressed

The overarching research objective was to determine if military construction (MILCON) costs exceed private industry costs, thereby reducing the cost performance and effectiveness of United States Air Force (USAF) construction, and if so, discover the causes of the MILCON cost premiums. Four objectives, which directly relate to the four phases of research, addressed the broad objective. The first objective related to confirming the existence of MILCON cost premiums. This research confirmed the belief that MILCON cost premiums exist through an extensive literature review as well as expert interviews and surveys. This confirmation of the existence of MILCON cost premiums addressed the first half of the overall research problem and set the baseline assumption for the remainder of the MILCON cost premium research.

Factors Causing MILCON Cost Premiums

This section addresses the second secondary objective by summarizing the factors shown to cause or influence MILCON cost premiums. While the expert survey identified 43 possible factors, and half of which at least moderately effect MILCON cost premiums (Chapter III, Table 8), this section sticks to broad categories of cost premium causes. Table 13 lists the major cost premium factors and where additional information can be found relating to each factor. Additionally, Table 13 identifies whether the factors are under the control of the Department of Defense (DoD) (internal), outside DoD control (external), or a combination of both. The factors listed are general categories; some factors, such as schedule and submittal development, have many additional factors within them. The chapters listed contain details relating to the individual factors. Overall, this research found that although factors outside of the USAF or DoD control cause cost premiums, internal policies cause further cost premiums. This research expands the body of knowledge related to these controllable cost premium factors rather than passing blame onto factors outside the span of control of the USAF or DoD. While Table 13 lists many factors shown to cause cost premiums, it should not be considered all-encompassing; other factors, some of which are included in Chapter IV, can influence MILCON cost premiums based on the specific project, location, or execution method.

Table 13: Broad summary of factors causing MILCON cost premiums

Cost Premium Factor	Internal/ External Control	Supporting Chapter(s)		
		II	III	IV
Development of overly restrictive statements of work or requirements	Internal	✓	✓	
Failure to balance risk between all parties	Both	✓	✓	
Stifling or not applying innovation	Internal	✓	✓	
Unique attributes/requirements for MILCON projects	Both	✓		
Parameterization of the construction execution method	Internal	✓	✓	
Selection of construction specifications	Internal	✓	✓	
Schedule and submittal development and management policies	Internal	✓	✓	
Perception of MILCON construction agents	Internal	✓	✓	
Anti-terrorism/force protection requirements	Both	✓		
Federal Acquisition Regulations	External	✓	✓	✓
Socioeconomic laws and policies including the Davis-Bacon Act (DBA)	External	✓		✓

Factor Analysis and Mitigation

The third and fourth research objectives related to analyzing the factors shown to cause cost premiums and develop mitigation strategies where appropriate. Analysis of cost premium factors under the span of control of the USAF or DoD found disconnects between different entities and agencies involved. When contractors and government agencies disagree on whether or not a given factor results in cost premiums, the contractor is most likely adding to the cost while the government is not looking to address the contractor’s concerns and thereby reduce costs. The overarching result of this research is that the USAF needs to better partner with its construction agents such as United States Army Corps of Engineers (USACE) and Naval Facilities Engineering Command (NAVFAC) in order to begin addressing MILCON cost premiums. Additionally, partnering or alliancing with contractors will allow cost premium causes to

be mitigated through the synergy of new perspectives and experience. This research found that 80% of the cost premium causing factors mentioned in Table 13 can be directly mitigated by USAF or DoD entities. Mitigation of the remaining 20% will require an act of Congress. This research also quantitatively demonstrated that DBA wage rates are higher than the local area wage rates and addressed the DBA wage rate administrator's concern that the Bureau of Labor Statistics' (BLS) geospatial breakdown did not offer enough fidelity. This information can allow the DoD to bring concerns regarding prevailing wage rates to Congress to begin to address the remaining 20% of the cost premium factors.

Overall Conclusions

This research confirmed the anecdotal belief that MILCON costs more than similar private industry construction. Additionally, this research found that internal DoD policies and actions cause many of these cost premiums. Previous MILCON research focused on how public law and the Federal Acquisition Regulations (FAR) restrict the ability to procure construction similarly to the private sector. However, this research demonstrated that while those conclusions are true, there are many cost premium factors that the USAF can address independently to lower MILCON costs without impacting, or even improving, facility performance. All parties involved with MILCON procurement and construction need to cooperate to help each other meet the user's needs. An attitude of cooperation, adaptation of contract templates to correctly reflect practices implemented in name only, and a focus on the required end-result rather than methods

applied will allow the USAF to reduce MILCON cost premiums and achieve more with fewer construction dollars.

Opportunities for Future Research

This research can act as a baseline for many additional research endeavors into MILCON cost premiums. This research has provided a list of factors shown to cause increased MILCON costs above expected levels. Future academic inquiries can address any number of these factors. The following list contains specific topics that have emerged where additional investigation can benefit USAF MILCON procurement.

1. Specific, all-encompassing, quantitative Davis-Bacon Act wage rate analysis. The geospatial statistical study carried out for this research effort focused on only carpenter and electrician trades. In order to quantify the cost premiums associated with DBA wage rates, a researcher should investigate all trades and associate the cost premiums for each based to the amount of money expended on construction. This would allow an exact dollar figure to be placed on the DBA wage rate cost premium.
2. Survey and interview regarding MILCON cost premiums with a larger sample size. The requirement for knowledge regarding the JBER weather shelter case study limited the number of survey participants for this research. Additional insight could be gained by surveying a large sample size and using inferential statistics to associate a specific “level of influence” with each factor shown to cause cost premiums.
3. Quantitative MILCON cost premium research. This research would require a long term investment from AFCEC which involves tracking additional cost information. Additionally, contractors would have to be willing to share quantitative cost data for projects similar in scope to MILCON facilities. To do a full investigation, this future research would have to investigate more than just historical square footage costs.
4. Undocumented scope changes that occur based on fixed programmed amounts. It appears that when bids are too far above the programmed amount, engineers reduce scope by removing components of MILCON facilities. Research into what changes to reduce the bids, and any performance losses, could help quantify the need to reduce cost premiums due to the loss of performance. This investigation would require AFCEC

to track additional information regarding changes to scope from project inception to bid acceptance.

5. A comparison between private and government execution process, specifically design-build. James Rosner (2008) also proposed this topic for additional research in his thesis related to MILCON DB execution. This research endeavor demonstrated the need to remedy DoD implementation of DB in order to gain the benefits seen in private industry. Further investigation should compare each design and construction agent's policies and management guides against private sector implementation of DB. This future research could help MILCON execution align more properly to industry standard execution methods.
6. Look into innovative construction materials and methods not currently used in MILCON. Design and construction agencies restrict the use of certain methods and materials for MILCON execution. An investigation into the reasons why certain materials, such as flexible plastic water pipes rather than copper, are not allowed and what risk the government would be accepting by allowing new industry standards in MILCON could help validate the need to allow innovation. This investigation could also focus on whether or not the end result requirements or user preferences drive restrictions and limitations.
7. Experiment during MILCON execution. AFCEC should coordinate with researchers to implement suggested cost mitigation strategies from this research or private industry practices and then analyze the results. By partnering with a researcher, changes could be thoroughly documented and analyzed in an academically rigorous way without taxing AFCEC's limited resources.

Appendix A. MILCON Case Study Supporting Information

Chapters II and III contain most of the results and analysis as it relates to the JBER weather shelter case study. This appendix contains further methodology details including information about the database used. Additionally, the final section of this appendix contains raw content exported from the case study contract requirement differences database. All conclusions based on the data in this appendix are documented in Chapters II and III.

Analysis Process Details

Four broad data sources were available for this case study. Both the USACE and CEG provided the RFPs (contract documents), including the SOW and specifications, which contractors used to bid on the weather shelter projects. Additionally, CEG and USACE personnel were available for interviews whenever questions arose about the projects. Also, the construction agents provided quantitative data such as the programming estimate, actual cost of construction, and schedule information. Finally, AARs written by personnel from the CEG, USACE, and Air Force Audit Agency were obtained. The synthesis of all the information provided results in a database of contract requirement differences.

The programming documentation sets the initial, macro, project requirements. The first step of the case study was to ensure the two weather shelters had the same macro requirements. Once it was demonstrated that the same requirements existed for both facilities the analysis of contract requirement differences could begin. For this study, the contract documents provided an unbiased baseline of requirement differences.

The USACE RFP was considered the standard since it represents the majority of USAF MILCON. For each requirement listed or defined in the USACE RFP, a search was made for an equivalent requirement in the CEG RFP. Any differences in requirements, or lack of a requirement, was codified and entered in the database. After the analysis of the contract documents, the AARs were used to ensure no requirement differences were missed. Finally, any discrepancies or oddities were validated by asking project managers what was meant by the statement and how each contractor interpreted the statement. There were very few discrepancies noted during the case study research. Once the database was populated with all the contract requirement differences, they were associated with existing, interview developed, survey questions or turned into new survey questions. Finally, all the contract requirement differences were associated with contract line item numbers (CLIN). By utilizing a variety of biased and unbiased sources, the single case study was able to ensure a thorough analysis of contract requirement differences and thereby discover any factor that could cause cost premiums.

Case Study Database

The development of a database that organizes all the data collected during the case study is critical to successful analysis (Yin 2009). The use of a database with set parameters on what was documented for each contract difference helped establish a chain of evidence and thereby mitigate some threats to construct validity (Yin 2009). Construct validity is validity that relies on both subjective judgments and empirical data, in this case the subjective judgment is that of the researcher (Patten 2009). The use of a database, rather than a single data sheet, ensured data from different sources could be

linked together for analysis. A Microsoft Access data stored all the survey and case study data. Table 14 documents the case study database structure.

Table 14: Case Study Database Structure

Database Name	Name	Type	Description
ID	ID	Integer	Auto populated by Access
ShortName	Requirement Short Name	Text	Simple identifier of the requirement
USACE-doc	USACE Containing Document	Text	Which USACE provided document contains the requirement
USACE-sec	USACE Section/Page	Text	Which section or page of the USACE document contain the requirement
USAF-doc	CEG Containing Document	Text	Which CEG provided document contains the requirement
USAF-sec	CEG Section/Page	Text	Which section of page of the CEG document contains the requirement
Diff	Difference	Number	1 = Similar requirement exists but not the exact same 2 = The requirement does not exist in one of the contracts
DiffMag	Level of Difference	Text	L = little difference in requirement M = difference in requirement H = extreme difference in requirement (required for Diff=2)
DiffSide	More Stringent Agency's Requirement	Text	A = CEG specified a more stringent requirement C = USACE specified a more stringent requirement
Notes	Notes	Rich Text	Notes describing the difference between CEG and USACE projects
Survey	Survey Question Number	Number	Populated with the survey question number if directly linked to a survey question.
USACE-CLIN	Link to USACE CLIN	Text	USACE CLIN (cost id) containing this requirement. Comma delimit if more than one.
USAF-CLIN	Link to CEG CLIN	Text	CEG CLIN (cost id) containing this requirement. Comma delimit if more than one.

Case Study Raw Data

This section contains the raw case study information. The first part lists the CLIN cost information. The remaining parts present the raw contract requirement differences. The data has been sorted into five sections, four representing the level of influence, and the remaining section containing contract difference requirements not associated with a survey question.

CLIN Costs

The CEG and USACE projects used different CLINs. Additionally, the USACE project included costs for work not completed on the CEG project; these costs are included in the CLIN list by construction agent but are not included in the pair analysis or the case study results. Table 15 contains the USACE CLIN identifiers, descriptions, and costs. Table 16 contains the CEG CLIN identifiers, descriptions, and costs. Finally, Table 17 contains the linked cost data including broad descriptions.

Table 15: USACE Shelter Costs by CLIN

CLIN	Description	Cost
0001	Design/Construct Site Work (outside 5')	\$3,637,966
0002	Design Wx Shelter (within 5')	\$2,135,132
0003	Construct 5-bay Weather Shelter	\$16,941,440
0012AA	Mod Option Item 0012AA	\$50,000
0013	Offsite treatment contaminated soil	\$5,000
0015	Construct Bay 6 & 7	\$4,991,227
0016	Provide/install 270V DC Power (7-bay)	\$683,668
0017	Provide/install 480VAC, 3 Phase, 4 Pole (7-bay)	\$490,678
0018	Provide/install compressed air system (7-bay)	\$225,879
0019	Hangar Floor Coating	\$206,072
0020	Interior Painting	\$143,440

Table 16: CEG Shelter Costs by CLIN

CLIN	Description	Cost
0001AA	Purchase Pre-fabricated 7-Bay Weather Shelter Hangar	\$1,232,685
0001AB	Freight for 7-Bay Weather Shelter Hangar	\$397,990
0001AC	Provide Ancillary Services	\$890,478
0001AD	Provide Installation & Site Preparation	\$14,457,911
0001AF	270 V DC Power System	\$461,267
0001AG	480 V AC Power System	\$604,988
0001AH	Compressed Air System	\$144,665
0001AJ	Hangar Floor Treatment	\$193,837
0001AK	Hangar Bay Interior Painting	\$142,730
0001AL	Builder's Risk Insurance Deductible	\$350,000

Table 17: Matched CLINs and Shelter Costs

CEG CLIN(s)	USACE CLIN(s)	Description	CEG Cost	USACE Cost
1AA, 1AB, 1AD	0003, 0015	Shelter Construction & Site Work	\$16,088,586	\$21,932,667
1AC, 1AL	0002	Design Services & Insurance	\$1,240,478	\$2,135,132
1AF	0016	270V DC Power	\$461,267	\$683,668
1AG	0017	480V AC Power	\$604,988	\$490,678
1AH	0018	Compressed Air System	\$144,665	\$225,879
1AJ	0019	Hangar Floor Coating	\$193,837	\$206,072
1AK	0020	Interior Painting	\$142,730	\$143,440

Largely Influential Contract Requirement Differences

- Name: Exterior Wall Systems
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 46 - 2.3.13)
 - CEG Source (Section): FY09F-22AWS - SOW (B5.2)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USAF
 - Linked Survey Question: 36
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USAF specified the use of insulated metal panels for the exterior. USACE just specified the use of metal panels.
- Name: Hangar Bay Electrical
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 110- 2.6.6)
 - CEG Source (Section): FY09F-22AWS - SOW (D5.1)

- Level of Difference: Similar requirement, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 39
- USACE CLIN(s): 0002, 0001, 0003, 0015, 0016, 0017
- CEG CLIN(s): 0001AC, 0001AD, 0001AF, 0001AG
- Notes: USACE required electrical in the hangar be hazard rated per NEC requirements. USAF allowed for hazard rated or a de-energized circuit IAW AFOSH 91-100. USACE was very prescriptive with the type of receptacles and controls required; USAF required meeting NEC and applicable ETLs.

Both USAF and USACE specified the type of equipment that would be connected to the 270V and 480V power systems.

- Name: Roof System
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 43 2.3.10)
 - CEG Source (Section): FY09F-22AWS - SOW (B5.3)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 35
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specifies a low-slope BUR, 2-ply modified hot-mopped in place. USACE specifies exact roofing material requirements. USACE required interior roof drains. USACE required 20-year warranty. USACE required 2 roof access hatches.

USAF required a low-slope metal panel assembly that does not shed snow. USAF allowed a gutter system. USAF required 25-year warranty. USAF required 1 roof access hatch.

Moderately Influential Contract Requirement Differences

- Name: 100% Design submittal
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 27 Part 6)
 - CEG Source (Section): Specification - General Req ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 44
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AA

- Notes: USACE prescribed exact requirements and comments for the 100% design submittal. USAF specified broad requirements not necessarily for a 100% design.
- Name: 65% Design Submittal
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 10-18 Part 4)
 - CEG Source (Section): Specification - General Req ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 44
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AA
 - Notes: USACE prescribed the expectations of a 65% design to include what each discipline has to have complete.

USAF did not specify 65% design submittal or requirements.

- Name: 95% Design Submittal
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 18-27)
 - CEG Source (Section): Specification - General Req ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 44
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AA
 - Notes: COE prescribed exact requirements for the 95% design submittal summed up as “complete and buildable”. USAF did not specify. Includes requirements for each discipline. USAF only mentioned drawings and analysis requirements in broad terms.
- Name: Acceptable Building System Types
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 64)
 - CEG Source (Section): FY09F-22AWS - SOW (B50)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specifically allowed: cast in place concrete foundations, concrete slabs on grade, structural steel columns, braces and beams, engineered metal trusses, roof assemblies with tributary dead loads. USAF did not specify building systems.

- Name: Additional References
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 2)
 - CEG Source (Section): FY09F-22AWS - SOW (2.4)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 16
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 001AD
 - Notes: USACE specifies many additional ETLs, TOs, AFIs, AFMs than USAF. However, USAF says the list may not be all inclusive of all requirements that must be met for DoD projects. Differences include ETL 03-1 Storm water construction standards, ETL 03-3 - Air Force Carpet Standard
- Name: Antiterrorism Requirements
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 5)
 - CEG Source (Section): FY09F-22AWS - SOW (2.3.5)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 31
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USAF weather shelter was planned to be low occupancy and therefore exempted from many AT/FP requirements. USACE required the building to be considered inhabited but not a primary facility.
- Name: Ceiling Finish
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 52 2.3.24)
 - CEG Source (Section): FY09F-22AWS - SOW (C3.4)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0020
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE prescribed a suspended ceiling. USAF allowed suspended ceiling or a hard lid.
- Name: Civil Scope
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 15)
 - CEG Source (Section): FY09F-22AWS - SOW (G30)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA

- Notes: USACE is extremely prescriptive required a licensed civil engineer whereas USAF specifies civil objectives.
- Name: Communication Room Criteria Sheet
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 682-683)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specified areas and heights, USAF said “as required”. Rest the same
- Name: Compaction Tests
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 32-33)
 - CEG Source (Section): FY09F-22AWS - SOW (A1.4)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE is very prescriptive with compaction tests. USAF required appropriate compaction but did not specify testing. In the general specifications USAF required the contractor to have an approved quality control plan.
- Name: Contractor Quality Control
 - USACE Source (Section): RFP-ELM288-FINAL (01 45 04.00 10)
 - CEG Source (Section): Specification - General Req (01 45 04.00 29)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USAF requires the control to develop and implement a quality control plan in coordination with the government.

USACE specifies exact requires the contractor's quality control plan must meet including:- Exactly what content must be included in the quality control plan including formatting- A design quality control plan- How many personnel it takes to manage a quality control plan- Exact requirements for QC personnel (mainly graduate school or many years of

experience)- Phases of the quality control plan (including development)-
A list of all tests and inspections

- Name: Corridor Room Criteria Sheet
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 686-687)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE very prescriptive specifying corridor height, area, and width. USAF specified what must be able to transit and fit in corridor. USAF specified exterior access; USACE did not. USACE required walk off mats at entries.
- Name: Design Reviews
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 3-4 1.2)
 - CEG Source (Section): Specification - General Req (01 33 00)
 - Level of Difference: Requirement only in one contract, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 44
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s):
 - Notes: USACE requires the contractor to print all comments and responses in Dr. Checks system and bring 35 copies. USAF has no similar requirement. Additionally, contractor must furnish a hard copy and annotated in Dr. Checks action taken against each comment.
- Name: Design Submittal Requirement
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 5-7)
 - CEG Source (Section): Specification - General Req (01 33 00 1.11)
 - Level of Difference: Similar requirement, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AA, 0001AC
 - Notes: USACE requires 41 hard copies of the 65%, 95%, and 100% designs. USAF appears to only specify 3 copies of any submittal.
- Name: Design Submittal Review
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 3 1.2)
 - CEG Source (Section): Specification - General Req ()
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12

- USACE CLIN(s): 0001, 0002
- CEG CLIN(s): 0001AC
- Notes: USACE requires the contractor to use Dr. Checks Review System and respond to comments on the design. Following those comment a review meeting will be held. The Government has 30 days to review and comment on the 65% and 95% design submittals.

USAF requires submittals via an AF Form 3000 (submittal attached) and does not specify a time required to review and return.

- Name: Door Roof Covers
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 45)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 15
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s):
 - Notes: USACE specified sloped standing seam metal roof for canopies over each exterior door.
- Name: Dust Control
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 14)
 - CEG Source (Section): FY09F-22AWS - SOW (G1.1.4)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s): 0001AC
 - Notes: USACE is prescriptive on how dust will be controlled (water mist, temp enclosures, or other suitable methodology). USAF says contractor shall provide dust controls.
- Name: Electrical Room Criteria Sheet
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 680-681)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specified heights and areas; USAF said as required. USAF required rubber base at the walls, USACE did not specify. Rest the same.
- Name: Environmental Protection Execution

- USACE Source (Section): RFP-ELM288-FINAL (01 57 20.00 10 Page 9 Part 3)
- CEG Source (Section): Specification - General Req (01 57 20.00 10)
- Level of Difference: Requirement only in one contract, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 32
- USACE CLIN(s): 0001, 0003, 0015
- CEG CLIN(s): 0001AD
- Notes: USACE specifies the exact way that the environment shall be protected including fencing off areas not to be disturbed and physically limiting the work area. USACE sets specific requirements for how the environment shall be protected (required to be built in to the environmental protection plans).

USAF left the execution of environmental protection to the contractor.

- Name: Evaluation Rating System
 - USACE Source (Section): RFP-ELM288-FINAL (00 22 11 Basis for Award Part IV. (pg 43))
 - CEG Source (Section): Tech Eval R1 (Volume II)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AA, 0001AC, 0001AD
 - Notes: COE and USAF evaluated the RFP using different ratings. However, the differences should not affect the outcome.
- Name: FAR Clauses
 - USACE Source (Section): RFP-ELM288-FINAL (pg 47-61)
 - CEG Source (Section): GSA Schedules (N/A)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 18
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: The COE RFP is required to include all FAR clauses referenced. The GSA Schedules process takes care of some of the clauses so 3 CES personnel did not have to include those in the SOW.

Any cost differences based on this are more on the government administration side rather than the contractor side.

- Name: FAR Clauses Differences
 - USACE Source (Section): RFP-ELM288-FINAL (00700)

- CEG Source (Section): Atch 2 (RFP Section I, pg 170)
- Level of Difference: Requirement only in one contract, Different
- More Stringent Agency: USACE
- Linked Survey Question: 21
- USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
- CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
- Notes: The following 38 FAR clauses are included in the USACE project but not the USAF project
 - 52.211-10 - Commencement, Prosecution and completion of work
 - 52.211-12 - Liquidated Damages
 - 52.211-15 - Defense priority and allocation requirements
 - 52.211-18 - Variation in Estimated Quantity
 - 52.215-11 - Price reduction for defective cost or pricing data modifications
 - 52.215-13 - subcontractor cost or pricing date-modifications
 - 52.215-21 - requirements for cost or pricing data or information other than cost or pricing data- modifications
 - 52.217-7 - Option for increase quantity-separately priced line item
 - 52.219-4 - Notice of price evaluation preferences for Hubzone small business concerns
 - 52.219-16 - Liquidated Damages--subcontracting plan
 - 52.219-25 - Small disadvantaged business participation program - disadvantaged status and reporting
 - 52.222-1 - Notice to the government of labor disputes
 - 52.222-23 - Notice of requirement for affirmative action to ensure equal employment opportunity for construction (covered by 52.222-27)
 - 52.222-39 – Notifications of employee rights concerning payment of union dues or fees
 - 52.223-3 - Hazardous Material Identification and Material Safety Data (included in OSHA and EM 385-1-1)
 - 52.223-13 - Certification of Toxic Chemical Release Reporting
 - 52.225-11 - Buy American Act - Construction Materials Under Trade Agreement
 - 52.231-5000 - Equipment ownership and operating expense schedule
 - 52.232-5000 - Payment for materials delivered off-site
 - 52.236-1 - Performance of work by the contractor
 - 52.236-4 – Physical data
 - 52.236-25 - Requirements for registration of designers
 - 52.244-6 - Subcontracts for commercial items
 - 52.246-12 - Inspection of construction (covered in -1 and -13)
 - 52.247-64 - Preference for privately owned US-flagged commercial vessels
 - 52.249-5000 - Basis for settlement of proposals

52.201-7000 – Contracting officer’s representative
252.204-7000 - Disclosure of information
252.215-7000 - Pricing adjustments
252.219-7003 - Small business subcontracting plan
252.222-7000 - Restrictions on employment of personnel
252.223-7001 – Hazard warning labels
252.223-7004 - Drug free work force
252.227-7023 - Drawings and other data to become property of government
252.227-7024 - Notice and approval of restricted designs
252.236-7001 - Contract drawings, maps and specifications
252.236-7008 - Contract prices-bidding schedules
252.247-7023 – Transportation of supplies by sea

The following clauses are included in the USAF project but not USACE:

52.216-7 - Allowable cost and payment
52.222-50 – Combating trafficking in persons
252.225-7012 – Preference for certain domestic commodities
252.225-7014 – Preference for domestic specialty metals
252.225-7016 – Restriction on acquisition of ball and roller bearings
252.232-7003 – Electronic submissions of payment requests and receiving reports
252.244-7000 – Subcontracts for commercial items and commercial components (DoD contracts)

- Name: FAR Clauses Full Text
 - USACE Source (Section): RFP-ELM288-FINAL (Section 00700 pg 62-192)
 - CEG Source (Section): GSA Schedule, Specification - General Req ()
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 21
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: Both GSA and COE contracting are required to meet FAR and DFAR requirements. COE lists all of the FAR contract clauses while the USAF was not required to list all of the clauses since some are covered by the GSA process. Additionally, when listed the USAF removed elements of the clauses that did not apply.

Overall there are likely additional contractor administrative costs due to the inclusion of the full-text of all FAR clauses including the portions that do not apply to this contract. For example clause 52.203-10 included all

the different type of awards (cost-plus-fixed, cost-plus-incentive, etc.) even though this contract is a fixed price contract.

- Name: Field Testing
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 32-40)
 - CEG Source (Section): FY09-F-22AWS-SOW (All)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE specified the exact testing to occur for each piece of equipment while also specifying that equipment shall be tested IAW industry codes and standards. USAF solely specified testing IAW industry codes and standards.
- Name: Fire Alarm System
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 135-138 2.7.8)
 - CEG Source (Section): FY09-F-22AWS-SOW (D4.1)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 42
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE required the fire alarm system to include a 50% expansion capability and a minimum of 2 additional releasing zones. USACE also specified an outside strobe facing the tower. USACE also prescribed the features of the fire alarm whereas USAF specified a Monaco or equivalent system.

USAF specified the system required and required a NFPA Class A addressable fire alarm system (but not including expansion).

- Name: Fire Protection Design Coordination
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 128 2.7.4)
 - CEG Source (Section): FY09F-22AWS - SOW (D40)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 10
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE requires the fire protection engineer (FPE) to meet with Elmendorf fire protection authorities to review all fire protection aspects

prior to the 65% submittal. USAF required an FPE to be integral to the design team and only prescribes coordination with Elmendorf fire protection for the location of a Knox-Box.

- Name: Fire Protection Manufacture's Rep
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 129 2.7.4)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0003, 0015
 - CEG CLIN(s):
 - Notes: USACE required the manufacture's representative for major fire protection components to lead testing at the project site. USAF did not set this requirement.
- Name: Fire Protection Quality Control Inspections
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 129 2.7.4)
 - CEG Source (Section): Specification - General Req (01 45 04.00 29 3.2 (Page 37))
 - Level of Difference: Similar requirement, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0003, 0015
 - CEG CLIN(s): 0001AC
 - Notes: USACE prescribed that the FPE shall conduct and document QC inspections at least monthly. Additionally the FPE must be present for final acceptance, inspection and testing. The USAF required the contractor to develop their own QC plan.
- Name: Fire Protection System Prohibited Items
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 130)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 26
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE provided a list of prohibited items that would impact proposal evaluation.
- Name: Fire provisions for masonry
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 41)

- CEG Source (Section): ()
- Level of Difference: Requirement only in one contract, Extremely Different
- More Stringent Agency:
- Linked Survey Question: 16
- USACE CLIN(s): 0002, 0003, 0015
- CEG CLIN(s): 0001AA, 0001AD
- Notes: USACE specifies the use of ETL 02-15 A1.1.1.2.1 a minimum of 1-hour fire-rated masonry wall. Both USACE and USAF require the use of the same ETLs and NFPA requirements but USACE specified masonry requirements whereas USAF left it open to the D-B contractor to decide material type.
- Name: Fire Sprinkler Piping Requirements
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 132)
 - CEG Source (Section): FY09F-22AWS - SOW (D4.3)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USAF required a sprinkler system IAW NFPA, UFC, and ELT requirements. USACE required the same but then prescribed the exact piping, fittings, valves, and gaskets to be utilized in the system.
- Name: Firms Who May Submit
 - USACE Source (Section): RFP-ELM288-FINAL (00 22 11 Part II)
 - CEG Source (Section): Atch 2 - Technical Analysis (Section 2)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 19
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE specifies an unrestricted and open competition for both large and small business. USAF specified the use of the GSA Schedules Program.

This difference meant the USACE RFP is significantly longer to specify all the contracting requirements. These are not required for the USAF project since the contractor is already in the GSA Schedules Program.

- Name: Hangar Floor
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 19)
 - CEG Source (Section): FY09F-22AWS - SOW (A1.4)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE

- Linked Survey Question: 32
- USACE CLIN(s): 0002, 0003, 0015
- CEG CLIN(s): 0001AD
- Notes: USAF gives the requirements based on loading (F22) which matches USACE. USAF then references the appropriate AFIs, UFCs, and ETLS. USACE goes further to reference all references but then prescribe mixtures for concrete.
- Name: Hangar Heating
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 84-85)
 - CEG Source (Section): FY09F-22AWS - SOW (D3.2)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE was very prescriptive on how the hangar shall be heated. USAF required hangar heating based on natural gas and forbid flames or glowing elements open to the atmosphere in the hangar areas. USACE specified a 3 hour timeframe to return to design temperatures; USAF did not specify.
- Name: Hangar Transition and Floor Slabs
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 21)
 - CEG Source (Section): FY09F-22AWS - SOW (A1.4 (page 38))
 - Level of Difference: Similar requirement, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USAF allowed the hangar floor to be constructed with varying thicknesses (NLT 6") based on where the aircraft would actually be located whereas USACE required the entire floor to be at least 12" thick.
- Name: Hangar Ventilation (including APU)
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 83)
 - CEG Source (Section): FY09F-22AWS - SOW (D30)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USAF required mechanical ventilation at a rate of at least 1000cfm to maintain indoor air quality IAW ASHRAE standard 62.1 - ventilation for acceptable indoor air quality. USACE prescribed exactly how the air

shall be ventilated as at least 3000cfm. USACE then requires a separate ventilation system for the APU. USAF required APU and hangar area to be ventilated in order to maintain air quality but did not specify a method. Both agencies required tempered make up air when the APU exhaust system is operating.

- Name: HVAC Building Controls
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 99-103)
 - CEG Source (Section): FY09F-22AWS - SOW (D3.4)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 38
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE prescribes extensive direct digital control (DDC) units that integrate to the energy monitoring and control system (EMCS). USACE specifies that the DDC must serve the entire facility. USAF determined that requirement impractical and only required DDC for monitoring boilers and collecting utility metering data due to mission requirements (hangar doors opening and closing).

COE specified a laptop containing a modem and floppy disk drive.

- Name: Interior Floor Finish
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 51 2.3.22)
 - CEG Source (Section): FY09F-22AWS - SOW (C3.2)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE required the use of linoleum flooring. USAF required resilient flooring that can resist tool cart traffic. USAF is willing to accept finished concrete.
- Name: Interior Wall Finishes
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 51 2.3.23)
 - CEG Source (Section): FY09F-22AWS - SOW (C3.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0020
 - CEG CLIN(s): 0001AA, 0001AD, 0001AK

- Notes: USACE specified exactly what the walls should be covered with in different rooms. USAF requested contractor give consideration to room requirements and specified a finish level.
- Name: Interior wall partitions
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 47)
 - CEG Source (Section): FY09F-22AWS - SOW (C1.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0020
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE is much more prescriptive on walls compared to USAF. However the end result is the same. USACE specifies the steel runner size whereas USAF requires gypsum board walls on metal studs.
- Name: Interior Wall Systems
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 47 2.3.14)
 - CEG Source (Section): FY09F-22AWS - SOW (C1.2)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USAF
 - Linked Survey Question: 16
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specified walls would be masonry or concrete with 1-hour fire rating for walls and 45 minutes for openings. USAF specified CMU or fire-rated insulated metal panels. Required fire rating is 3 hours for walls and openings.
- Name: Janitor's Closet Room Criteria
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 692-693)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE prescribed size, resilient flooring, and ceramic tile wainscoting. USAF set "as required", sealed concrete, and some sort of wainscoting.
- Name: LEED Documentation
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 29)
 - CEG Source (Section): FY09-F-22AWS-SOW (2.3.1)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 46

- USACE CLIN(s): 0002
- CEG CLIN(s): 0001AC, 0001AA
- Notes: The USAF requires the contractor to show calculations used for LEED credits. The USACE dedicates a section of specifications to how LEED will be documented. The end results are similar but the path to get there varies.
- Name: Lighting Equipment
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 109)
 - CEG Source (Section): FY09F-22AWS - SOW (D5.3)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD, 0001AF, 0001AG
 - Notes: USAF specified interior lighting intensities and ASHREA 90.1 requirements as well as giving consideration to LEED-NC requirements. USACE specified exact fixtures and lamps to be utilized as well as lighting intensities.

USAF specified that exterior lights should face away from areas that interfere with flying operations.
- Name: Mechanical Room Criteria Sheet
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 678-679)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 2
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specified area as 1200ft; USAF specified as “as required”. Rest same between agencies.
- Name: Mechanical Specifics
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 92-99)
 - CEG Source (Section): FY09F-22AWS - SOW (D30)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE has prescribed exact requirements for each and every type of heating system. USAF references industry standards. Cost differences are likely due to administrative requirements vs. actual HVAC equipment and installation.

USACE specified use of DOE Buying Energy Efficient Products Recommendations or Energy Star. USAF specified energy efficient.

- Name: Men's and Women's Restroom Criteria
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 688-689)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 15
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE required: ceramic tile wainscot; USAF did not specify type. USACE required countertop mounted sinks, USAF required a wall mounted. USACE required occupancy switched lights; USAF prescribed locally switched. USACE required resilient flooring, USAF desired sealed concrete. USAF required 2 women's water closets vs. USACE single.
- Name: Non-government borrow sources
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 30.00 29 Page 6)
 - CEG Source (Section): Specification - General Req (Page 8 1.15)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE has specific requirements for the testing of non-government borrow sources including an engineer with 3 years of experience performing the tests. USAF specifies testing of non-government borrow sources.
- Name: Non-Hangar Bay Concrete
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 62 2.4.8)
 - CEG Source (Section): FY09F-22AWS - SOW (A1.3)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015, 0001
 - CEG CLIN(s): 0001AD, 0001AE
 - Notes: USACE is extremely prescriptive on concrete design and specs. USAF references ACI 302.1R and UFC requirements.
- Name: Plumbing Installations
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 71)
 - CEG Source (Section): FY09F-22AWS - SOW (D20)
 - Level of Difference: Similar requirement, Different

- More Stringent Agency: USACE
- Linked Survey Question: 32
- USACE CLIN(s): 0002, 0003, 0015
- CEG CLIN(s): 0001AA, 0001AD
- Notes: USACE is very prescriptive on how all plumbing will be installed (9 pages). USAF states the plumbing must meet industry standards such as the International Plumbing Code. USACE goes into specifics such as “reduction of pipe sizes shall be made with reducing tees or reducing fittings”. Likely cost differences due administrative requirements vs. plumbing material and labor.
- Name: Preconstruction Submittals
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 2)
 - CEG Source (Section): Specification - General Req (01 33 00)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AA, 0001AC
 - Notes: USACE specifies additional submittals above and beyond USAF requirements. Additionally, USACE specifies them as “preconstruction” whereas USAF specifies them as submittal requirements.- Certificates of insurance- Surety bonds- Construction progress schedule- Schedule of prices
- Name: Quality Control System Software Requirement
 - USACE Source (Section): RFP-ELM288-FINAL (01 45 02.00 10)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE specifies exactly what will exist in a quality control system (QCS). USAF has no such requirements beyond using a quality control system as part of the quality control plan.

The USACE QCS system must be able to transfer data to the government include administration data, finances, QC, submittal monitoring, and scheduling. USACE has developed QCS software that the contractor must utilize.

- Name: Quality Objectives
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 7)
 - CEG Source (Section): ()

- Level of Difference: Requirement only in one contract, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 16
- USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
- CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
- Notes: USACE specifies that the facility shall be constructed with an anticipated life of 50 years with refurbishment at 20 years. USAF does not specify.
- Name: RFP Evaluation Process
 - USACE Source (Section): RFP-ELM288-FINAL (00 22 11 Part III)
 - CEG Source (Section): Tech Eval R1 (All)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 18
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE evaluates: experience, past performance, schedule, design solution & drawings, and organization and management. USAF evaluates: compliance with SOW and specs, management capabilities and approach, schedule, past performance, and price.
- Name: Roof Drainage
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 23 2.2.11)
 - CEG Source (Section): FY09F-22AWS - SOW (G3.4)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 34
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE extremely prescriptive. USAF: “Roof drainage shall be collected and discharged into the manhole. USACE specifies rainfall intensity, size of infiltration basins, monitoring tubes.
- Name: Schedule Activity Coding
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 8)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC

- Notes: USACE requires scheduling use the activity coding structured defined in the Standard Data Exchange Format in ER1-1-11 Appendix A. The structure must be used even if some fields are not used.
- Name: Schedule Critical Activities
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page4-5 3.3.2.4)
 - CEG Source (Section): Specification - General Req (01 32 01.00 10 3.3.2.4)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE requires the following additional critical activities be scheduled:- Submission of the testing and air balance review report- Submission and approval of testing and balancing of HVAC plus commissioning plans and data- Air and water balance dates- HVAC commissioning dates- Controls testing plan- Controls testing- Performance verification testing- Other systems testing, if required
- Name: Schedule Requirements
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002, 0003, 0015
 - CEG CLIN(s): 0001AC
 - Notes: The following elements of the schedule are required by USACE and not the USAF:- Government activities (approvals, submittals, design reviews, etc.)- Responsibility (which party is responsible for performing the work)- Work areas (identify work area where activity occurs)- Modification or claim number (include mod/claim in in schedule)- Bid item (identify each activity's bid item number)- Phase of work- Category of work- Feature of work- Project start date- Constraint of last activity (calculated by critical path)- Early Project Completion (which activities were accelerated to complete the project early)- Interim completion dates- Start Phase X- End Phase X- Phase X (identify which phase activity is in)- Default progress data disallowed- Out-of-sequence progress (disallowed unless contracting officer specifically approves)- Negative lags disallowed
- Name: Schedule Submission Requirements

- USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 8-9 3.5)
- CEG Source (Section): Specification - General Req (01 33 00 Submittal Procedures)
- Level of Difference: Similar requirement, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 12
- USACE CLIN(s): 0001, 0002
- CEG CLIN(s): 0001AC
- Notes: USAF requires the schedule be submitted and the use of an industry standard program. USACE has specific submittal requirements including:- 3 copies- 2 disks (floppy unless otherwise approved) with labels- specific file naming conventions- narrative reports- approved changes verification- schedule reports (activity numbers, description, etc.)- activity reports (list of all activities)- Logic report (preceding and succeeding activities)- Total float report- Earnings report (by bid item)- Network diagram- Continuous flow diagrams- Project milestone dates- Banding (grouping of activities)- S-curves of earnings
- Name: Schedule: Critical Path Method
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 4 3.3.1)
 - CEG Source (Section): Specification - General Req (01 32 01.00 10 3.3.1)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE requires the critical path method project schedule be in the precedence diagram method. USAF only requires the use of the critical path method.
- Name: Schedule: Directed changes
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 13 3.8)
 - CEG Source (Section): ()
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 21
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE specifies procedures for directed changes. USAF only references FAR requirements.
- Name: Schedule: Ownership of float

- USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 13 3.9)
- CEG Source (Section): ()
- Level of Difference: Requirement only in one contract, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 23
- USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
- CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
- Notes: USACE specifies that schedule float is not for the exclusive use of the contractor or government. USAF does not specify.
- Name: Schedule: Requests for time extensions
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 12-13 3.7)
 - CEG Source (Section): ()
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE specifies procedures and submittals required for requests for time extensions. USAF only references FAR requirements.
- Name: Schedule: Standard Data Exchange Format
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Appendix A)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 23
 - USACE CLIN(s): 0002, 0001
 - CEG CLIN(s): 0001AC
 - Notes: USACE requires the use of the specific non-proprietary protocol called standard data exchange format for its schedule. USAF does not specify.
- Name: Site Drainage
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Pages 22-23)
 - CEG Source (Section): FY09F-22AWS - SOW (G3.4)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:

- Linked Survey Question: 32
- USACE CLIN(s): 0002, 0003, 0015, 0001
- CEG CLIN(s): 0001AD, 0001AE
- Notes: USACE is very prescriptive on storm drainage including specifics on culverts, infiltration basins, and drain rock. USAF references the international plumbing code and UFC-3-260-02.
- Name: Specification: Airfields and heavy-duty concrete pavement
 - USACE Source (Section): RFP-ELM288-FINAL (32 13 13.03)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE included additional specifications for airfields and heavy-duty concrete pavement including specific mixtures, how to tie-in, weather limitations. USAF solely required the following of the UFC and IBC.

USACE required government approval of concrete design (mix, ratio, etc.).

- Name: Sprinkler System Design
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 132-133)
 - CEG Source (Section): FY09F-22AWS - SOW (D4.2 & D4.3)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USAF required a sprinkler system that meets all NFPA and UFC requirements. USACE prescribed exact elements of the sprinkler system to include color, deconfliction, and signage. Additionally USACE specifies that the location of sprinklers and routing of pipes is subject to approval of the USACE Contracting Officer.
- Name: Standard Hangar Bay Room Criteria
 - USACE Source (Section): RFP-ELM288-FINAL (Pg 675)
 - CEG Source (Section): FY09F-22AWS - SOW (Ch 5)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015, 0019, 0020
 - CEG CLIN(s): 0001AA, 0001AD, 0001AJ, 0001AK
 - Notes: USAF specified a height of 27 ft. USACE specified height as required for clearance. USAF required additional equipment.

USACE required an exterior personnel door and cable portal in the hangar aircraft door; USAF did not. USACE required the walls to be painted CMU, USAF required painted CMU or metal panels.

- Name: Storm Water Protection Plan Inspection
 - USACE Source (Section): RFP-ELM288-FINAL (01 57 34.00 29)
 - CEG Source (Section): Specification - General Req (01 57 34.00 29)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 11
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s):
 - Notes: USACE specifies the qualifications that a storm water protection plan inspector as meeting federal standard requirements. USAF does not specify beyond requiring the contractor to meet federal standard requirements.
- Name: Structural Steel
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 63)
 - CEG Source (Section): FY09F-22AWS - SOW (B5.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 32
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE is very prescriptive to include specifying types of indicators to be used and primer color. USAF references industry standards.
- Name: Submittal Classification
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 4 1.3)
 - CEG Source (Section): Specification - General Req (01 33 00)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE specifies that submittals are classified as government approved or information only. USAF requires the contractor coordinate with the government to determine submittal requirements.
- Name: Submittal Packages
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 8-)
 - CEG Source (Section): Specification - General Req (01 33 00 1.1.2)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12

- USACE CLIN(s): 0001, 0002
- CEG CLIN(s): 0001AA, 0001AC
- Notes: USACE is very prescriptive in the formatting of specifications, designs, and color prints received. USAF required similar drawings, designs, and catalog cuts but did not specify a hard copy format.

Note: Both USAF and USACE have the same electronic drawing requirements.

- Name: Submittal procedures
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 6 1.11)
 - CEG Source (Section): Specification - General Req (01 33 00 1.11)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE requires 6 copies of submittals for government approval and 3 for information only. USAF only requires 3 copies of submittals.
- Name: Submittal Stamps
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 6-8 1.15)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE requires the use of a stamp by the contractor on submittal data to certify the submittal meets contract requirements. USAF has no such requirement.
- Name: Submittal Transmittal form
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 5-6 1.10)
 - CEG Source (Section): Specification - General Req (01 33 00 1.10)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 12
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK

- Notes: USACE requires the use of an ENG Form 4025. USAF requires the use of an AF Form 3000.
- Name: Submittal: Scheduling
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 5 1.9)
 - CEG Source (Section): Specification - General Req (01 33 00 1.9)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 13
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AC
 - Notes: USAF did not have a scheduling requirement for submittals. USACE specifies that submittals forming a system or interrelated items shall be submitted concurrently with adequate time allowed (14+ days) allowed for approval.
- Name: Submittal: Withhold of payment
 - USACE Source (Section): RFP-ELM288-FINAL (01 33 00 Page 5 1.6)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 12
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE specifies that payment will be withheld for materials used without approval. USAF does not specify beyond FAR requirements.
- Name: Sustainable Design
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 7)
 - CEG Source (Section): FY09F-22AWS - SOW (2.3.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - Linked Survey Question: 46
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specifies the shelter should be able to be LEED “certified” while USAF specifies the project must meet as many prerequisites and credits as practical for LEED-NC.
- Name: Telecommunications Requirements
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 115-117 2.6.11)
 - CEG Source (Section): FY09F-22AWS - SOW (D5.4)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 32
 - USACE CLIN(s): 0001, 0002, 0003, 0015

- CEG CLIN(s): 0001AA, 0001AD
- Notes: USACE prescribed communications configurations meeting and exceeding Elmendorf standards. USAF required contractor meet Elmendorf Communication Installation Standards. USACE also set minimum contractor qualifications including years of experience (3 years).
- Name: Test Hangar Floor Area
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 21)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 33
 - USACE CLIN(s): 0003
 - CEG CLIN(s):
 - Notes: USACE required the construction of a 3m by 12m test slab with 4 different surface textures. Then a decision would be made regarding the final selected texture. USAF did not have this requirement.
- Name: Work Prior to 100% design
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 28 6.4)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 2
 - USACE CLIN(s): 0001, 0003, 0015, 0016, 0017, 0018, 0019, 0020
 - CEG CLIN(s):
 - Notes: USACE did not allow any field or construction work without 100% design approval. This could be waived if a contractor identifies fast-track portions of the project at the start of design work. Review of the 100% design can take 14 days.
- Name: Year 2000 Compliance
 - USACE Source (Section): RFP-ELM288-FINAL (00800-159 SCR-38)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - Linked Survey Question: 21
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s):
 - Notes: USACE uses an additional contract requirement to reference FAR 39.106 requiring Y2K compliance. The USAF does not include a special clause for this.

Limited Influence Contract Requirement Differences

- Name: Bathroom Accessories
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 53)
 - CEG Source (Section): FY09F-22AWS - SOW (C1.4.2)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 37
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE is very prescriptive on bathroom accessories with exact specifications for each item (including toilet tissue dispenser, tampon receptacle, waste receptacle, etc.). USAF just required the item itself.
- Name: Closeout Submittals - Warranty Management
 - USACE Source (Section): RFP-ELM288-FINAL (01 78 02.00 10 1.3)
 - CEG Source (Section): Specification - General Req (01 78 02.00 10 1.3)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 49
 - USACE CLIN(s): 0003, 0015, 0016, 0017, 0018
 - CEG CLIN(s):
 - Notes: USACE specifies a requirement for performance bond, pre-warranty conference, and a contractor's response to construction warranty service requirements. Both USAF and USACE require a warranty management plan and warranty tags.
- Name: Conference Meeting Records
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 3 Part 1.1)
 - CEG Source (Section): Specification - General Req (Page 8 1.16)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0001, 0002, 0003, 0015
 - CEG CLIN(s): 0001AC
 - Notes: USACE requires the contractor to prepare meeting minutes and provide within 10 working days. USAF does not set a time table for meeting minutes.
- Name: Environmental Protection Plans
 - USACE Source (Section): RFP-ELM288-FINAL (01 57 20.00 10 Part 1)
 - CEG Source (Section): Specification - General Req (01 57 20.00 10 Part 1)

- Level of Difference: Requirement only in one contract, Extremely Different
- More Stringent Agency: USACE
- Linked Survey Question: 22
- USACE CLIN(s): 0001, 0003, 0015
- CEG CLIN(s): 0001AD
- Notes: USACE requires the following environmental protection plans that USAF does not:- Non-hazardous solid waste disposal plan- air pollution control plan- contaminant presentation plan- waste water management plan- A historical, archaeological, cultural resources, biological resources and wetlands plan- pesticide treatment plan
- Name: Fire Protection System Training
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 130 2.7.4.F)
 - CEG Source (Section): FY09F-22AWS - SOW (D40)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 40
 - USACE CLIN(s): 0003, 0015
 - CEG CLIN(s): 0001AC
 - Notes: USACE required an 8-hour training session for fire protection operations and another 8-hour session for fire protection system maintenance. USAF required a single 8-hour session on all elements of the fire protection system.
- Name: Fire Protection System Warranty Maintenance
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 130 2.7.4.G)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 41
 - USACE CLIN(s): 0003, 0015
 - CEG CLIN(s):
 - Notes: USACE required that one month prior to fire protection system's warranty expiration the equipment distributor perform all recommended annual maintenance. Additionally the equipment distributor must replace any defective or damaged parts, modify software as required, and re-certify the system.
- Name: Government Field Office
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 30.00 29 Page 5 1.10)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different

- More Stringent Agency: USACE
- Linked Survey Question: 45
- USACE CLIN(s): 0001, 0003, 0015
- CEG CLIN(s):
- Notes: USACE required a government field office be furnished with office furniture and four laptop computers with base stations. USAF did not have requirement.
- Name: Independent design review
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 20.00 29 Page 4-5 1.6)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 43
 - USACE CLIN(s): 0001, 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE requires the contractor to have an independent (not associated with the design) engineer/architect in each discipline review and certify the design and calculations as being correct and meeting the RFP requirements. This must be done for 65%, 95%, and 100% designs.
- Name: Progress Meeting Contents
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 11-12 3.6.3)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0001, 0002, 0003, 0015
 - CEG CLIN(s): 0001AC, 0001AD
 - Notes: USACE specifies what content is required at progress meetings including: start and finish dates, time completion, cost completion, logic changes, and other changes.
- Name: Red Zone Meeting
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 30.00 29 Page 8 1.20)
 - CEG Source (Section): Specification - General Req (Page 8 1.16)
 - Level of Difference: Requirement only in one contract, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK

- Notes: USACE requires a specific red zone meeting at 75% completion. USAF does not specify a specific red zone meeting but does discuss punch lists and weekly meetings.
- Name: RFP: Technical Solution, Organization and Management
 - USACE Source (Section): RFP-ELM288-FINAL (00 22 11 Part V 2, Tab B and C (pg 21-23))
 - CEG Source (Section): Tech Eval R1 (All)
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0002
 - CEG CLIN(s): 0001AC
 - Notes: USACE prescribes exactly how technical solutions will be given as part of the RFP as well as exactly what information and what format it shall be in for evaluating organization and management. USAF does not prescribe the format.
- Name: Safety and Occupational Health Requirements
 - USACE Source (Section): RFP-ELM288-FINAL (01 35 29 Part 1)
 - CEG Source (Section): Specification - General Req (01 35 29)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 47
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: Both projects require the use of EM 385-1-1 however USACE also has additional specifications goes further into specifying exact submittals required. The difference ends up being that the USACE requires government approval of accident prevention plans, activity hazard analysis, crane critical lift plans, and proof of qualifications for crane operators whereas USAF requires those items exist per OSHA and EM but not government approval.

Additionally, USACE includes definitions in their specifications whereas those definitions also exist in OSHA and EM 385-1-1. Overall, USACE just includes requirements out of EM 385-1-1 in their RFP.

- Name: Submittal Procedures
 - USACE Source (Section): RFP-ELM288-FINAL (00800-156 (SCR-8))
 - CEG Source (Section): Specification - General Req (01 33 00)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - Linked Survey Question: 22
 - USACE CLIN(s): 0002, 0001

- CEG CLIN(s): 0001AC, 0001AD
- Notes: USAF specifies the use of an AF Form 3000; USACE requires the use of a ENG Form 4288. Both require the form in triplicate. USACE specifies they need at least 30 days to review any submittal; USAF does not specify.

Based on interviews the long process can increase construction time and thereby increase construction cost.

- Name: Update submission following progress meeting requirement
 - USACE Source (Section): RFP-ELM288-FINAL (01 32 01.00 10 Page 11 3.6.2)
 - CEG Source (Section): Specification - General Req (01 32 01.00 10 Page 14 3.6.2)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0001, 0002, 0003, 0015
 - CEG CLIN(s): 0001AC, 0001AD
 - Notes: USACE specifies that an updated schedule is submitted 4 days after the meeting. USAF requires an updated schedule be submitted before the next meeting.
- Name: Videotaping of Tests & O&M Training
 - USACE Source (Section): RFP-ELM288-FINAL (01 78 02.00 10 1.6)
 - CEG Source (Section): Specification - General Req ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 22
 - USACE CLIN(s): 0003, 0015, 0016, 0017, 0018
 - CEG CLIN(s):
 - Notes: USACE required that all training and tests be videotapes and provided to the government. USAF did not have this requirement.
- Name: Windows
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 50-51 2.3.21C)
 - CEG Source (Section): FY09F-22AWS - SOW (G5.4.4)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency: USACE
 - Linked Survey Question: 41
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE required 5 year warranty; USAF did not specify. Cost differences negligible with this project due to lack of windows.

Not Influential Contract Requirement Differences

- Name: Air Force Project Sign
 - USACE Source (Section): RFP-ELM288-FINAL (01 58 23.00 29)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - Linked Survey Question: 48
 - USACE CLIN(s): 0003
 - CEG CLIN(s):
 - Notes: USACE requires a specifically formatted project sign for the construction site. The cost of the sign is incidental to the project.

Contract Requirement Differences Not Linked to the Survey

- Name: Demolition Work
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 13)
 - CEG Source (Section): FY09F-22AWS - SOW (G10)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency: USACE
 - USACE CLIN(s): 0001
 - CEG CLIN(s): 0001AE
 - Notes: The demolition of existing taxiway was not included or required for the USAF project. Both projects did require similar earthwork for building construction. For cost comparisons the demolition performed on the USACE project should be removed.
- Name: Emergency Eye Wash/Showers
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 86)
 - CEG Source (Section): FY09F-22AWS - SOW (D2.1.6)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE specified that water tempering system cannot be one per emergency fixture; USAF did not specify. Otherwise requirements the same.
- Name: Excavation and Handling of Contaminated Material
 - USACE Source (Section): RFP-ELM288-FINAL (02 61 13)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different

- More Stringent Agency: USACE
- USACE CLIN(s): 0001, 0003, 0015, 0013
- CEG CLIN(s):
- Notes: USACE included a specification on the excavation and handling of contaminated material. USAF did not include specifications.
- Name: Field Screen Testing of Soils for POL Contamination
 - USACE Source (Section): RFP-ELM288-FINAL (31 09 20.00 29)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - USACE CLIN(s): 0001, 0003, 0015, 0013
 - CEG CLIN(s):
 - Notes: USACE included specifications for field screen testing of soils for POL contamination. USAF did not include such specification. Requirements specified in code.

USACE contractor is required to field screen all excavated soils.

- Name: Foam Alert System
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 140 2.7.8)
 - CEG Source (Section): FY09-F-22AWS-SOW (D40)
 - Level of Difference: Requirement only in one contract, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: COE specified blue beacon alarms for foam system; USAF did not specify.
- Name: Hangar Doors
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 47-48 2.3.16)
 - CEG Source (Section): FY09F-22AWS - SOW (B5.4.3)
 - Level of Difference: Similar requirement, Different
 - More Stringent Agency:
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: Both USAF and USACE specified vertical doors. USACE allow steel panels or fabric. USAF required fabric.

Note: USAF could use GSA Selection door without markup.

- Name: HVAC Heating/Cooling Set Points
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 77-78)
 - CEG Source (Section): FY09F-22AWS - SOW (D30)
 - Level of Difference: Similar requirement, Little Difference

- More Stringent Agency: USACE
- USACE CLIN(s): 0002, 0003, 0015
- CEG CLIN(s): 0001AA, 0001AD
- Notes: USACE required a winter set point of 68oF, USAF required a set point of 65oF for the hangar bay. All other areas were the same.
- Name: Low Level High Expansion Foam Systems
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 134 2.7.7)
 - CEG Source (Section): FY09-F-22AWS-SOW (D40)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE is more prescriptive in the foam requirements by calling out specific ETL criteria as well as specifying the exact pipes and valves to be utilized. USAF just required foam system to meet requirements. End result is the very similar.
- Name: Proposed Schedule
 - USACE Source (Section): RFP-ELM288-FINAL (00 22 11 Part V 2, Tab A (pg 20))
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - USACE CLIN(s): 0002, 0001
 - CEG CLIN(s): 0001AC
 - Notes: The USAF did not specify a schedule time. USACE specified a max duration of 540 days unless an alternate schedule optimizes costs in which case 750 days is allowed. However, both USACE and USAF must follow FAR 52.211-10 which specifies a maximum time.
- Name: Restroom Hardware
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 52 2.3.26)
 - CEG Source (Section): FY09F-22AWS - SOW (C1.4.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0002, 0003
 - CEG CLIN(s): 0001AA, 0001AD
 - Notes: USACE required chrome plated hardware. USAF specified heavy-duty stainless steel hardware.

- Name: Site Electrical
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 118-120 2.6.14,15)
 - CEG Source (Section): FY09F-22AWS - SOW (G40)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0002, 0001, 0003, 0015, 0016, 0017
 - CEG CLIN(s): 0001AC, 0001AD, 0001AF, 0001AG
 - Notes: USACE is more prescriptive than USAF but not by much for transformers and connections. Both require metering and connection to existing base power.

USACE is very prescriptive on conduit and raceway while still requiring meeting NEC.
- Name: Sources for Reference Publication
 - USACE Source (Section): RFP-ELM288-FINAL (01 42 00)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency:
 - USACE CLIN(s): 0001, 0002, 0003, 0012AA, 0013, 00015, 00016, 0017, 0018, 0019, 0020
 - CEG CLIN(s): 0001AC, 0001AD, 0001AA, 0001AF, 0001AG, 0001AH, 0001AJ, 0001AK
 - Notes: USACE includes a list of sources for reference materials. USAF does not.
- Name: Temporary Construction Facilities Specifications
 - USACE Source (Section): RFP-ELM288-FINAL (01 50 02.00 10)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s): 0001AD
 - Notes: USACE included specific requirements for temporary construction facilities. USAF did not include any requirements.
- Name: Utility Stairs
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 54 2.3.28)
 - CEG Source (Section): ()
 - Level of Difference: Requirement only in one contract, Extremely Different
 - More Stringent Agency: USACE
 - USACE CLIN(s): 0002, 0003, 0015
 - CEG CLIN(s):

- Notes: USACE specified exact requirements for utility stairs. USAF did not specify.
- Name: Water Line Upgrade
 - USACE Source (Section): RFP-ELM288-FINAL (01 19 10.00 29 Page 26)
 - CEG Source (Section): FY09F-22AWS - SOW (G3.1)
 - Level of Difference: Similar requirement, Little Difference
 - More Stringent Agency:
 - USACE CLIN(s): 0001, 0003, 0015
 - CEG CLIN(s): 0001AD, 0001AE
 - Notes: USACE project required upgrading an 8" water line to 10". USAF project did not require upgrade but did require a 10" water line.

Appendix B. Survey and Interview Supporting Information

This appendix contains supporting information for interviews and surveys carried out in support of research documented in Chapter II and Chapter III. The first section contains further information on the development of the survey. The second and third sections contain the sample characteristics and further detail on survey interpretation. The fourth and fifth sections contain the actual survey and interview questions. The final section contains statistical analysis of all survey responses. In order to maintain the anonymity of the respondents, the raw open-ended survey question and interview responses have not been documented in this thesis. The author may be contacted for further information.

Survey Development

The survey consisted of two overarching questions. Both questions ask the respondents to rate the level of influence factors have on the cost of MILCON projects; however, the first question asks for a comparison between MILCON and private industry construction while the second question requires a comparison between the CEG and USACE weather shelters. Each of these two overarching questions had a series of cost premium factors listed underneath that required a Likert-style response.

The cost premiums factors were developed by synthesizing contract requirement differences from the weather shelter case study with literature review and interview results. In total 102, or 87%, of the contract requirement differences linked to factors in the survey. All ten of the block two questions were developed based on contract requirement differences that could not be answered with a general comparison between

MILCON and private industry. Additionally, 22 of the 33 block one questions directly linked to contract requirement differences. In order to limit the survey length, factors quantitatively known to cause cost premiums, such as Davis-Bacon Act wage rates, were left out of the survey. However, the FAR drives many of these quantitative factors, so they were included in a general form. Although these factors were purposely not included many respondents mentioned the additional requirements in the open-ended response at the end of the survey.

Follow on research, with the goal of using inferential statistics, will need a much larger sample size. There are multiple barriers to success that could not be overcome for this study. First, the requirement for knowledge related to the JBER case study greatly reduced the population of available experts. A more broadly distributed survey would not be able to ask questions about specific MILCON projects. Second, contractors and government employees are hesitant to answer questions or provide additional data because it can directly affect their organization's performance. For example, a contractor who provides information about why MILCON costs more could end up losing money if the Government improved its MILCON process and reduced costs. However, many contractors pointed out that improving the process could increase their profits since many additional burdens could be removed. Additionally, some government employees are hesitant to blame their own organization. Finally, a larger survey would require full Institutional Review Board (IRB) approval and an Air Force survey control number. Both of these elements take additional time to obtain, and the Air Force is hesitant to inundate personnel with surveys; thus, it is difficult to obtain a control number. The

survey implemented supported the goals of this study; however, the lessons learned and understood can help future research.

Institutional Review Board

The AFIT Institutional Review Board (IRB) reviewed the interview and survey. The IRB granted the survey and interview an exemption from human experimentation requirements (32 CFR 219, DoDD 3216.2, and AFI 40-402) on 15 October 2012. This study qualified for an exemption because no sensitive data was collected and respondent anonymity was maintained through the use of broad demographic information.

Sample Characteristics

A purposeful sample was utilized for both the surveys and interviews. The purposive sample ensured all respondents were experts in the engineering, construction, and contracting fields with knowledge of private industry and MILCON or direct knowledge of the case study projects (Patten 2009). Additionally, snowball sampling occurred with the survey when contractors and USACE provided additional points of contact. Although snowball and purposive sampling bring can add additional bias to the study, the use of unbiased source documents mitigated this bias. The sample involved three demographics. The USAF personnel demographic contains engineers and contracting officers currently or previously assigned to the 3rd Civil Engineer Squadron, 673d Civil Engineer Group, or 673d Contracting Squadron. The USACE demographic contains engineers and contracting personnel assigned to USACE Alaska District. Finally, the contractor demographic contains engineers and contract specialists with private industry and MILCON experience. In each demographic certain respondents did

not answer all of the survey questions. This outcome was expected since all respondents were asked not to answer questions where they did not have experience or knowledge. The sample used for the survey and interviews provided knowledge, both broad and specific, that helped validate MILCON cost premiums and provide external validity to the case study findings.

Survey Interpretation

The limited population, and therefore limited sample size, resulted in the use of descriptive statistics rather than inferential statistics. Descriptive statistics include using histograms, the mean median or mode, as well as qualitative descriptions of data (Neter et al. 1996). The small sample size required the use of these statistics were utilized because the responses did reflect a standard distribution. However, the use of descriptive statistics does not invalidate the results and even helps avoid issues with the Likert scale using ordinal data in a continuous manner (Carifio and Perla 2007). Non-parametric statistics were used to rank each factors level of influence relative to one another for each demographic. Additionally the responses were average for each demographic for each factor. Finally, an overall weighted average was determined based on the response averages from each demographic. All of these values were utilized to compare cost premium factors individually as well as in between demographics.

Survey Given

The survey given to USAF civil engineers and contracting personnel, USACE Alaska District, and contractors is shown in Table 18. The survey was distributed electronically to all respondents.

Table 18: Electronically Distributed Survey

Directions: Please place an x in the appropriate box rating the influence of each factor.

<p>Research has shown that MILCON projects cost more than equivalent private industry construction. For the factors below it is given that MILCON projects costs more than private industry construction. If you have no experience with one of the factors please leave it blank. The second block of questions relate specifically to the Army Corp of Engineers (standard) MILCON 7-bay weather shelters compared to the USAF GSA procured weather shelters. While this survey focuses on cost, the research team understands that in some instances the additional cost is merited.</p>					
Demographic Information					
Please select (by bolding) the entity you associate with:	USAF	USA			
	Engineering	Engineering			
	USAF	Contractor			
	Contracting	Contractor			
Questions Block 1					
Please rate the level of influence each factor below has on the cost of MILCON projects above private industry construction costs.	Factor influence on MILCON cost premiums				
	Not at all	To a limited extent	To a moderate extent	To a large extent	To a very large extent
USAF implementation of design-build execution					
USACE implementation of design-build execution					
Design-build rather than design-bid-build					
Contracting method: Firm fixed price					
Fixed programmed amounts (allowed project cost) early in project development					
Oversight on contractor by local CE squadron					
Oversight on contractor by AFCEE					
Oversight on contractor by USACE/NAVFAC					
Quality control requirements set by the government					
Submittal process (administration/# of submittals)					
Submittal timeline (time for approval/rejection)					
Unique attributes of USAF project vs private industry with similar end-use requirements					
Military design standards/specifications					
Contract requirements for PEs (professional engineers)					
Federal Acquisition Regulations (FAR)					

FAR: 8A/small-business policies					
FAR: Restrictions on government-contractor alliancing/partnering					
FAR: Administrative requirements					
Non-FAR related administrative requirements					
Restrictions placed on designs					
Restrictions placed on construction methods					
USAF project through USACE					
USAF project through AFCEE					
Prescriptive design requirements rather than code references					
O&M training for government personnel					
Warranty requirements					
Requirement for a non-government independent design review					
Design review process					
Contractor provided government field office					
LEED for new construction requirements					
Safety requirements (OSHA & EM 385-1-1)					
Project signage requirements					
Requirement for warranty performance bonds					
Questions Block 2					
Please rate the level of influence each <u>factor</u> below has on the cost of the USACE weather shelter (standard) above USAF GSA-procured weather shelter costs.	Factor influence on MILCON cost premiums				
	Not at all	To a limited extent	To a moderate extent	To a large extent	To a very large extent
Schedule management requirements required by USACE versus CE squadron					
Inhabited vs low-occupancy anti-terrorism/force protection standards requirements					
Requirement to develop test hangar concrete slabs					
Internal roof drains versus gutters					
Built up low slope roof versus metal panels					
CMU vs insulated metal panels for hangar bay walls					
Acquisition of specified bathroom accessories versus requirement for non-specific bathroom accessories					

Direct digital controls for all HVAC components					
100% hazard rated electrical systems in the hangar bays versus a de-energized system					
Additional capacity required in fire alarm system above and beyond current building scope					
Additional Comments					
Please feel free to provide comments for any of the factors, especially factors which you rated as having no influence or a strong influence on MILCON cost premiums.					

In addition to the survey the following text was included in the email to ensure all respondents understood their rights as they relate to the survey, the purpose of the research, and to comply with the guidelines of the IRB exemption:

Purpose:

The United States Air Force continually searches for methods to reduce construction costs and improve performance. This research attempts to determine what factors cause military construction to cost more than private industry. In order to validate and determine the influence of factors shown to cause increased costs, experts such as you are being surveyed. The open ended and/or Likert style questions provide a deeper understanding of factors affecting the costs of military construction above standard private industry costs. All answers are anonymous and cannot be traced back to you.

Participation:

Your participation in this data collection effort is greatly appreciated and desired. Though your participation is beneficial to this research, please remember that it is COMPLETELY VOLUNTARY. Whether you decide to participate or withdraw from the survey or interview process will have no impact up your relationship with the researcher, the United States Air Force, or the Department of Defense.

Confidentiality:

Demographic data regarding the status of the interviewee is collected solely to allow the data to be interpreted more specifically. All answers are ANONYMOUS and do not include name or organization.

Instructions:

- Base all of your responses on your own personal experiences, thoughts, or desires
- For open ended questions please ensure your answers are as clear as possible. If more background information is required feel free to provide that information to the researched.
- There is no “right” answer to the survey or open ended questions. Please select the option you feel is most correct.
- If you believe you do not have the experience to truthfully answer a question please leave it blank.

Contact Information:

If you have any questions, comments, or concerns about this survey or interview, please contact Capt Daniel Blomberg using the information below.

AFIT/ENV BLDG 640/Room 104A
2950 Hobson Way
Wright Patterson AFB OH 45433-7765
Email: daniel.blomberg@afit.edu
Advisor: paul.cotelleso@afit.edu
Advisor: alfred.thal@afit.edu
Phone: DSN 785-3636 x7401, commercial (937) 255-6565 x7401

Interview Questions

The following open-ended interview questions were asked to the government employees and contractors surveyed. Questions two and three were only asked of contractors and question five was only asked of government employees.

1. In your expert opinion, do you believe MILCON costs more than private industry construction? If so, what are the causes of MILCON cost premiums compared to private industry construction?
2. (Contractor Only) What is your overall experience working on MILCON projects compared to private industry construction?
3. (Contractor Only) What, if any, additional factors are included for MILCON projects that are not included for private industry construction?

Additionally, do these factors vary by executing agent such as USACE, AFCEE, or the local civil engineer squadron?

4. What is your opinion on the implementation of Air Force MILCON design-build processes compared to private industry implementation and the traditional Air Force MILCON design-bid-build execution?
5. (Government Only) Have you seen any policies that either cause additional cost premiums or have worked to remove cost premiums? If so, what are the policies and can they be controlled or influenced by the USAF?

Survey Response Data

This section contains the survey response data for all questions. Table 20 contains the general MILCON cost premium factors (Block 1 in Table 18) while Table 21 contains cost premium factors directly related to the JBER weather shelter projects (Block 2 in Table 18). Figure 11 shows the color key for the demographic data as depicted in each distribution. Table 19 contains the cost premium identification numbers that link the survey question to a cost premium theme in the survey results table.

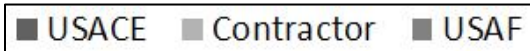


Figure 11: Distribution Key for Survey Demographics

Table 19: Cost Premium Theme IDs

#	Cost Premium Theme
1	Selection of Construction Specifications
2	Misapplication of Execution Process
3	Stifling or Not Applying Innovation
4	Failing to Balance Risk
5	Additional Public-sector Requirements

Table 20: Survey Response Data - General MILCON Cost Premium Factors

Question & Statistical Information	Distribution																								
<p>USAF implementation of design-build execution</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 3.05 • N_{USACE}: 8 Avg_{USACE}: 3.75 • N_{USAF}: 5 Avg_{USAF}: 2.4 • N_{Contractor}: 3 Avg_{Contractor}: 3 • # of kt differences linked: 0 • Cost Premium Themes: 2, 3, 4 • Overall influence: Moderate 	<table border="1"> <caption>USAF Distribution Data</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey Count</th> <th>Light Grey Count</th> <th>Total Count</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>4</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>Large Extent</td> <td>4</td> <td>1</td> <td>5</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> </tbody> </table>	Response Category	Dark Grey Count	Light Grey Count	Total Count	Not At All	1	0	1	A Limited Extent	2	4	6	Moderate Extent	0	1	1	Large Extent	4	1	5	Extremely Large Extent	2	1	3
Response Category	Dark Grey Count	Light Grey Count	Total Count																						
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A Limited Extent	2	4	6																						
Moderate Extent	0	1	1																						
Large Extent	4	1	5																						
Extremely Large Extent	2	1	3																						
<p>USACE implementation of design-build execution</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.43 • N_{USACE}: 9 Avg_{USACE}: 2.89 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 4 Avg_{Contractor}: 4.00 • # of kt differences linked: 7 • Cost Premium Themes: 1, 2, 3, 4 • Overall influence: Moderate 	<table border="1"> <caption>USACE Distribution Data</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey Count</th> <th>Light Grey Count</th> <th>Total Count</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>0</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>3</td> <td>2</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>4</td> <td>5</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> </tbody> </table>	Response Category	Dark Grey Count	Light Grey Count	Total Count	Not At All	1	0	1	A Limited Extent	4	0	4	Moderate Extent	3	2	5	Large Extent	1	4	5	Extremely Large Extent	1	2	3
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Large Extent	1	4	5																						
Extremely Large Extent	1	2	3																						
<p>Design-build rather than design-bid-build</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 2.32 • N_{USACE}: 9 Avg_{USACE}: 2.56 • N_{USAF}: 5 Avg_{USAF}: 2.40 • N_{Contractor}: 4 Avg_{Contractor}: 2.00 • # of kt differences linked: 0 • Cost Premium Themes: • Overall influence: Limited 	<table border="1"> <caption>Design-build Distribution Data</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey Count</th> <th>Light Grey Count</th> <th>Total Count</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>3</td> <td>7</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>4</td> <td>6</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey Count	Light Grey Count	Total Count	Not At All	1	2	3	A Limited Extent	4	3	7	Moderate Extent	2	4	6	Large Extent	2	0	2	Extremely Large Extent	0	0	0
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Extremely Large Extent	0	0	0																						
<p>Contracting method: Firm fixed price</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 2.30 • N_{USACE}: 7 Avg_{USACE}: 2.00 • N_{USAF}: 5 Avg_{USAF}: 2.40 • N_{Contractor}: 4 Avg_{Contractor}: 2.50 • # of kt differences linked: 0 • Cost Premium Themes: • Overall influence: Limited 	<table border="1"> <caption>Firm fixed price Distribution Data</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey Count</th> <th>Light Grey Count</th> <th>Total Count</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>4</td> <td>7</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey Count	Light Grey Count	Total Count	Not At All	2	1	3	A Limited Extent	3	4	7	Moderate Extent	2	3	5	Large Extent	0	1	1	Extremely Large Extent	0	0	0
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Question & Statistical Information	Distribution																								
<p>Fixed programmed amounts (allowed project cost) early in project development</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 2.53 • N_{USACE}: 9 Avg_{USACE}: 2.67 • N_{USAF}: 4 Avg_{USAF}: 3.25 • N_{Contractor}: 3 Avg_{Contractor}: 1.67 • # of kt differences linked: 0 • Cost Premium Themes: • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Fixed programmed amounts</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Bottom)</th> <th>Light Grey (Top)</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>3</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey (Bottom)	Light Grey (Top)	Total	Not At All	2	1	3	A Limited Extent	3	3	6	Moderate Extent	2	1	3	Large Extent	2	0	2	Extremely Large Extent	2	0	2
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<p>Oversight on contractor by local CE squadron</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 2.06 • N_{USACE}: 8 Avg_{USACE}: 2.38 • N_{USAF}: 5 Avg_{USAF}: 1.80 • N_{Contractor}: 3 Avg_{Contractor}: 2.00 • # of kt differences linked: 0 • Cost Premium Themes: 4 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Oversight on contractor by local CE squadron</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Bottom)</th> <th>Light Grey (Top)</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>5</td> <td>8</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Category	Dark Grey (Bottom)	Light Grey (Top)	Total	Not At All	2	2	4	A Limited Extent	3	5	8	Moderate Extent	2	1	3	Large Extent	0	0	0	Extremely Large Extent	1	0	1
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<p>Oversight on contractor by AFCEE</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 2.43 • N_{USACE}: 8 Avg_{USACE}: 2.75 • N_{USAF}: 5 Avg_{USAF}: 2.20 • N_{Contractor}: 3 Avg_{Contractor}: 2.33 • # of kt differences linked: 0 • Cost Premium Themes: 4 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Oversight on contractor by AFCEE</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Bottom)</th> <th>Light Grey (Top)</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>4</td> <td>6</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey (Bottom)	Light Grey (Top)	Total	Not At All	2	2	4	A Limited Extent	2	2	4	Moderate Extent	2	4	6	Large Extent	0	0	0	Extremely Large Extent	2	0	2
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<p>Oversight on contractor by USACE/NAVFAC</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.39 • N_{USACE}: 9 Avg_{USACE}: 2.67 • N_{USAF}: 5 Avg_{USAF}: 4.00 • N_{Contractor}: 4 Avg_{Contractor}: 3.50 • # of kt differences linked: 1 • Cost Premium Themes: 4 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Oversight on contractor by USACE/NAVFAC</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Bottom)</th> <th>Light Grey (Top)</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>0</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>4</td> <td>0</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> </tbody> </table>	Response Category	Dark Grey (Bottom)	Light Grey (Top)	Total	Not At All	1	1	2	A Limited Extent	4	0	4	Moderate Extent	2	2	4	Large Extent	4	0	4	Extremely Large Extent	1	3	4
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<p>Quality control requirements set by the government</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.41 • N_{USACE}: 9 Avg_{USACE}: 3.33 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 4 Avg_{Contractor}: 3.50 • # of kt differences linked: 9 • Cost Premium Themes: 4 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Quality Control Requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>1</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	0	0	0	A Limited Extent	3	1	4	Moderate Extent	2	3	5	Large Extent	2	2	4	Extremely Large Extent	2	2	4
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<p>Submittal process (administration/# of submittals)</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.11 • N_{USACE}: 9 Avg_{USACE}: 2.44 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 4 Avg_{Contractor}: 3.50 • # of kt differences linked: 14 • Cost Premium Themes: 2, 4 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Submittal Process</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	2	0	2	A Limited Extent	4	2	6	Moderate Extent	1	3	4	Large Extent	1	2	3	Extremely Large Extent	1	2	3
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<p>Submittal timeline (time for approval/rejection)</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 2.97 • N_{USACE}: 9 Avg_{USACE}: 2.22 • N_{USAF}: 5 Avg_{USAF}: 3.20 • N_{Contractor}: 4 Avg_{Contractor}: 3.50 • # of kt differences linked: 1 • Cost Premium Themes: 2, 4 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Submittal Timeline</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>3</td> <td>0</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	3	0	3	A Limited Extent	4	2	6	Moderate Extent	1	3	4	Large Extent	1	1	2	Extremely Large Extent	1	2	3
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<p>Unique attributes of USAF project vs private industry with similar end-use requirements</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 3.47 • N_{USACE}: 9 Avg_{USACE}: 4.33 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 3 Avg_{Contractor}: 2.67 • # of kt differences linked: 2 • Cost Premium Themes: 3, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Unique Attributes</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>4</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>6</td> <td>0</td> <td>6</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	1	0	1	Moderate Extent	1	4	5	Large Extent	1	3	4	Extremely Large Extent	6	0	6
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Question & Statistical Information	Distribution																								
<p>Military design standards/specifications</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.26 • N_{USACE}: 9 Avg_{USACE}: 3.78 • N_{USAF}: 5 Avg_{USAF}: 3.00 • N_{Contractor}: 4 Avg_{Contractor}: 3.00 • # of kt differences linked: 4 • Cost Premium Themes: 1, 3, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Military design standards/specifications</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>6</td> <td>8</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>4</td> <td>0</td> <td>4</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	0	1	1	A Limited Extent	2	0	2	Moderate Extent	2	6	8	Large Extent	1	2	3	Extremely Large Extent	4	0	4
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<p>Contract requirements for PEs (professional engineers)</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 2.14 • N_{USACE}: 9 Avg_{USACE}: 1.67 • N_{USAF}: 5 Avg_{USAF}: 3.00 • N_{Contractor}: 4 Avg_{Contractor}: 1.75 • # of kt differences linked: 0 • Cost Premium Themes: 4 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Contract requirements for PEs</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>5</td> <td>1</td> <td>6</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>5</td> <td>8</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	5	1	6	A Limited Extent	3	5	8	Moderate Extent	2	0	2	Large Extent	1	0	1	Extremely Large Extent	1	0	1
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<p>Federal Acquisition Regulations (FAR)</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 2.76 • N_{USACE}: 8 Avg_{USACE}: 3.13 • N_{USAF}: 5 Avg_{USAF}: 2.40 • N_{Contractor}: 4 Avg_{Contractor}: 2.75 • # of kt differences linked: 2 • Cost Premium Themes: 2, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Federal Acquisition Regulations (FAR)</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>1</td> <td>4</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	2	1	3	A Limited Extent	1	4	5	Moderate Extent	1	2	3	Large Extent	2	2	4	Extremely Large Extent	2	0	2
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<p>FAR: 8A/small-business policies</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 3.18 • N_{USACE}: 8 Avg_{USACE}: 3.13 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 3 Avg_{Contractor}: 3.00 • # of kt differences linked: 1 • Cost Premium Themes: 2, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for FAR: 8A/small-business policies</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Moderate Extent</td> <td>4</td> <td>4</td> <td>8</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	0	0	0	A Limited Extent	2	1	3	Moderate Extent	4	4	8	Large Extent	1	3	4	Extremely Large Extent	1	0	1
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<p>FAR: Restrictions on government-contractor alliancing/partnering</p> <ul style="list-style-type: none"> • N: 15 Avg_{Weighted}: 2.49 • N_{USACE}: 7 Avg_{USACE}: 2.00 • N_{USAF}: 5 Avg_{USAF}: 2.80 • N_{Contractor}: 3 Avg_{Contractor}: 2.67 • # of kt differences linked: 0 • Cost Premium Themes: 2, 5 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for FAR: Restrictions on government-contractor alliancing/partnering</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>3</td> <td>0</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Moderate Extent</td> <td>3</td> <td>4</td> <td>7</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	3	0	3	A Limited Extent	1	2	3	Moderate Extent	3	4	7	Large Extent	1	0	1	Extremely Large Extent	0	0	0
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<p>FAR: Administrative requirements</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 3.06 • N_{USACE}: 8 Avg_{USACE}: 2.88 • N_{USAF}: 5 Avg_{USAF}: 2.80 • N_{Contractor}: 4 Avg_{Contractor}: 3.50 • # of kt differences linked: 4 • Cost Premium Themes: 4, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for FAR: Administrative requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>3</td> <td>7</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>3</td> <td>4</td> <td>7</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	0	0	0	A Limited Extent	4	3	7	Moderate Extent	1	2	3	Large Extent	3	4	7	Extremely Large Extent	0	0	0
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<p>Non-FAR related administrative requirements</p> <ul style="list-style-type: none"> • N: 15 Avg_{Weighted}: 2.41 • N_{USACE}: 7 Avg_{USACE}: 2.57 • N_{USAF}: 5 Avg_{USAF}: 3.00 • N_{Contractor}: 3 Avg_{Contractor}: 1.67 • # of kt differences linked: 8 • Cost Premium Themes: 2, 4 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Non-FAR related administrative requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>4</td> <td>8</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>1</td> <td>1</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	0	1	1	A Limited Extent	4	4	8	Moderate Extent	2	2	4	Large Extent	1	0	1	Extremely Large Extent	0	1	1
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Large Extent	1	0	1																						
Extremely Large Extent	0	1	1																						
<p>Restrictions placed on designs</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.05 • N_{USACE}: 9 Avg_{USACE}: 2.89 • N_{USAF}: 5 Avg_{USAF}: 3.00 • N_{Contractor}: 4 Avg_{Contractor}: 3.25 • # of kt differences linked: 1 • Cost Premium Themes: 1, 3 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Restrictions placed on designs</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>3</td> <td>3</td> <td>6</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	0	0	0	A Limited Extent	4	2	6	Moderate Extent	2	3	5	Large Extent	3	3	6	Extremely Large Extent	0	0	0
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
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A Limited Extent	4	2	6																						
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Large Extent	3	3	6																						
Extremely Large Extent	0	0	0																						

Question & Statistical Information	Distribution																								
<p>Restrictions placed on construction methods</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.10 • N_{USACE}: 9 Avg_{USACE}: 2.89 • N_{USAF}: 5 Avg_{USAF}: 3.40 • N_{Contractor}: 4 Avg_{Contractor}: 3.00 • # of kt differences linked: 0 • Cost Premium Themes: 1, 3 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Restrictions placed on construction methods</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>3</td> <td>4</td> <td>7</td> </tr> <tr> <td>Large Extent</td> <td>3</td> <td>2</td> <td>5</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	2	2	4	Moderate Extent	3	4	7	Large Extent	3	2	5	Extremely Large Extent	1	0	1
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
Not At All	1	0	1																						
A Limited Extent	2	2	4																						
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Large Extent	3	2	5																						
Extremely Large Extent	1	0	1																						
<p>USAF project through USACE</p> <ul style="list-style-type: none"> • N: 16 Avg_{Weighted}: 4.05 • N_{USACE}: 9 Avg_{USACE}: 2.56 • N_{USAF}: 5 Avg_{USAF}: 4.60 • N_{Contractor}: 2 Avg_{Contractor}: 5.00 • # of kt differences linked: 0 • Cost Premium Themes: 4 • Overall influence: Large 	<table border="1"> <caption>Distribution Data for USAF project through USACE</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>5</td> <td>0</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>5</td> <td>6</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	5	0	5	Moderate Extent	1	0	1	Large Extent	1	2	3	Extremely Large Extent	1	5	6
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
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<p>USAF project through AFCEE</p> <ul style="list-style-type: none"> • N: 12 Avg_{Weighted}: 3.14 • N_{USACE}: 6 Avg_{USACE}: 2.67 • N_{USAF}: 4 Avg_{USAF}: 2.75 • N_{Contractor}: 2 Avg_{Contractor}: 4.00 • # of kt differences linked: 0 • Cost Premium Themes: 4 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for USAF project through AFCEE</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>2</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	3	2	5	Moderate Extent	1	1	2	Large Extent	1	1	2	Extremely Large Extent	1	1	2
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
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Large Extent	1	1	2																						
Extremely Large Extent	1	1	2																						
<p>Prescriptive design requirements rather than code references</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 3.31 • N_{USACE}: 9 Avg_{USACE}: 3.67 • N_{USAF}: 5 Avg_{USAF}: 3.00 • N_{Contractor}: 4 Avg_{Contractor}: 3.25 • # of kt differences linked: 23 • Cost Premium Themes: 1 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Prescriptive design requirements rather than code references</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>3</td> <td>2</td> <td>5</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	2	2	4	Moderate Extent	2	3	5	Large Extent	2	1	3	Extremely Large Extent	3	2	5
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
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Extremely Large Extent	3	2	5																						

Question & Statistical Information	Distribution																								
<p>O&M training for government personnel</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 2.15 • N_{USACE}: 9 Avg_{USACE}: 1.78 • N_{USAF}: 5 Avg_{USAF}: 2.00 • N_{Contractor}: 3 Avg_{Contractor}: 2.67 • # of kt differences linked: 1 • Cost Premium Themes: 5 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for O&M training for government personnel</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>4</td> <td>1</td> <td>5</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>4</td> <td>8</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	4	1	5	A Limited Extent	4	4	8	Moderate Extent	2	1	3	Large Extent	1	0	1	Extremely Large Extent	0	0	0
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Extremely Large Extent	0	0	0																						
<p>Warranty requirements</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 2.23 • N_{USACE}: 9 Avg_{USACE}: 1.89 • N_{USAF}: 5 Avg_{USAF}: 1.80 • N_{Contractor}: 3 Avg_{Contractor}: 3.00 • # of kt differences linked: 2 • Cost Premium Themes: • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Warranty requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>3</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	4	2	6	A Limited Extent	3	3	6	Moderate Extent	1	2	3	Large Extent	1	1	2	Extremely Large Extent	0	0	0
Response Category	Dark Grey	Light Grey	Total																						
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Large Extent	1	1	2																						
Extremely Large Extent	0	0	0																						
<p>Requirement for a non-government independent design review</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 2.41 • N_{USACE}: 8 Avg_{USACE}: 2.13 • N_{USAF}: 5 Avg_{USAF}: 2.60 • N_{Contractor}: 4 Avg_{Contractor}: 2.50 • # of kt differences linked: 1 • Cost Premium Themes: • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Requirement for a non-government independent design review</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>A Limited Extent</td> <td>6</td> <td>4</td> <td>10</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	1	1	2	A Limited Extent	6	4	10	Moderate Extent	1	1	2	Large Extent	1	2	3	Extremely Large Extent	0	0	0
Response Category	Dark Grey	Light Grey	Total																						
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Large Extent	1	2	3																						
Extremely Large Extent	0	0	0																						
<p>Design review process</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 2.74 • N_{USACE}: 9 Avg_{USACE}: 2.67 • N_{USAF}: 5 Avg_{USAF}: 2.80 • N_{Contractor}: 4 Avg_{Contractor}: 2.75 • # of kt differences linked: 4 • Cost Premium Themes: 2, 3 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Design review process</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>5</td> <td>9</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	1	0	1	A Limited Extent	4	5	9	Moderate Extent	2	2	4	Large Extent	1	1	2	Extremely Large Extent	2	0	2
Response Category	Dark Grey	Light Grey	Total																						
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Extremely Large Extent	2	0	2																						

Question & Statistical Information	Distribution																								
<p>Contractor provided government field office</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 1.99 • N_{USACE}: 9 Avg_{USACE}: 2.11 • N_{USAF}: 5 Avg_{USAF}: 2.20 • N_{Contractor}: 3 Avg_{Contractor}: 1.67 • # of kt differences linked: 1 • Cost Premium Themes: • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Contractor provided government field office</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>4</td> <td>3</td> <td>7</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	4	3	7	A Limited Extent	2	3	5	Moderate Extent	2	1	3	Large Extent	1	0	1	Extremely Large Extent	1	0	1
Response Category	Dark Grey	Light Grey	Total																						
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A Limited Extent	2	3	5																						
Moderate Extent	2	1	3																						
Large Extent	1	0	1																						
Extremely Large Extent	1	0	1																						
<p>LEED for new construction requirements</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 2.90 • N_{USACE}: 9 Avg_{USACE}: 2.89 • N_{USAF}: 5 Avg_{USAF}: 2.80 • N_{Contractor}: 3 Avg_{Contractor}: 3.00 • # of kt differences linked: 2 • Cost Premium Themes: • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for LEED for new construction requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>3</td> <td>5</td> <td>8</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	0	0	0	A Limited Extent	4	2	6	Moderate Extent	3	5	8	Large Extent	1	1	2	Extremely Large Extent	1	0	1
Response Category	Dark Grey	Light Grey	Total																						
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Extremely Large Extent	1	0	1																						
<p>Safety requirements (OSHA & EM 385-1-1)</p> <ul style="list-style-type: none"> • N: 18 Avg_{Weighted}: 1.96 • N_{USACE}: 9 Avg_{USACE}: 2.33 • N_{USAF}: 5 Avg_{USAF}: 1.80 • N_{Contractor}: 4 Avg_{Contractor}: 1.75 • # of kt differences linked: 1 • Cost Premium Themes: 5 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Safety requirements (OSHA & EM 385-1-1)</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>3</td> <td>2</td> <td>5</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>7</td> <td>11</td> </tr> <tr> <td>Moderate Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	3	2	5	A Limited Extent	4	7	11	Moderate Extent	0	0	0	Large Extent	0	0	0	Extremely Large Extent	2	0	2
Response Category	Dark Grey	Light Grey	Total																						
Not At All	3	2	5																						
A Limited Extent	4	7	11																						
Moderate Extent	0	0	0																						
Large Extent	0	0	0																						
Extremely Large Extent	2	0	2																						
<p>Project signage requirements</p> <ul style="list-style-type: none"> • N: 17 Avg_{Weighted}: 1.29 • N_{USACE}: 9 Avg_{USACE}: 1.33 • N_{USAF}: 5 Avg_{USAF}: 1.20 • N_{Contractor}: 4 Avg_{Contractor}: 1.33 • # of kt differences linked: 1 • Cost Premium Themes: • Overall influence: Not at all 	<table border="1"> <caption>Distribution Data for Project signage requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>7</td> <td>6</td> <td>13</td> </tr> <tr> <td>A Limited Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey	Light Grey	Total	Not At All	7	6	13	A Limited Extent	1	2	3	Moderate Extent	1	0	1	Large Extent	0	0	0	Extremely Large Extent	0	0	0
Response Category	Dark Grey	Light Grey	Total																						
Not At All	7	6	13																						
A Limited Extent	1	2	3																						
Moderate Extent	1	0	1																						
Large Extent	0	0	0																						
Extremely Large Extent	0	0	0																						

Question & Statistical Information	Distribution												
<p>Requirement for warranty performance bonds</p> <ul style="list-style-type: none"> • N: 14 Avg_{Weighted}: 1.83 • N_{USACE}: 8 Avg_{USACE}: 1.50 • N_{USAF}: 3 Avg_{USAF}: 1.67 • N_{Contractor}: 3 Avg_{Contractor}: 2.33 • # of kt differences linked: 1 • Cost Premium Themes: 4 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data</caption> <thead> <tr> <th>Response Category</th> <th># of responses</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>8</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> </tr> <tr> <td>Large Extent</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> </tr> </tbody> </table>	Response Category	# of responses	Not At All	8	A Limited Extent	4	Moderate Extent	1	Large Extent	0	Extremely Large Extent	1
Response Category	# of responses												
Not At All	8												
A Limited Extent	4												
Moderate Extent	1												
Large Extent	0												
Extremely Large Extent	1												

Table 21: Survey Response Data - Specific to Weather Shelters MILCON Cost Premium Factors

Question & Statistical Information	Distribution																								
<p>Schedule management requirements required by USACE versus CE squadron</p> <ul style="list-style-type: none"> • N: 13 Avg_{Weighted}: 2.92 • N_{USACE}: 7 Avg_{USACE}: 2.00 • N_{USAF}: 4 Avg_{USAF}: 2.75 • N_{Contractor}: 2 Avg_{Contractor}: 4.00 • # of kt differences linked: 2 • Cost Premium Themes: 2, 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Schedule management requirements</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>3</td> <td>0</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>5</td> <td>0</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	3	0	3	A Limited Extent	5	0	5	Moderate Extent	1	1	2	Large Extent	1	0	1	Extremely Large Extent	1	1	2
Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)																						
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Large Extent	1	0	1																						
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<p>Inhabited vs low-occupancy anti-terrorism/force protection standards requirements</p> <ul style="list-style-type: none"> • N: 12 Avg_{Weighted}: 2.81 • N_{USACE}: 6 Avg_{USACE}: 2.17 • N_{USAF}: 4 Avg_{USAF}: 2.75 • N_{Contractor}: 2 Avg_{Contractor}: 3.50 • # of kt differences linked: 1 • Cost Premium Themes: 5 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Inhabited vs low-occupancy anti-terrorism/force protection standards</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>0</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>1</td> <td>1</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	2	1	3	A Limited Extent	4	0	4	Moderate Extent	1	1	2	Large Extent	0	1	1	Extremely Large Extent	1	1	2
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<p>Requirement to develop test hangar concrete slabs</p> <ul style="list-style-type: none"> • N: 12 Avg_{Weighted}: 2.69 • N_{USACE}: 6 Avg_{USACE}: 1.83 • N_{USAF}: 4 Avg_{USAF}: 2.75 • N_{Contractor}: 2 Avg_{Contractor}: 3.50 • # of kt differences linked: 1 • Cost Premium Themes: • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Requirement to develop test hangar concrete slabs</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>3</td> <td>0</td> <td>3</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>3</td> <td>4</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	3	0	3	A Limited Extent	2	1	3	Moderate Extent	1	3	4	Large Extent	1	1	2	Extremely Large Extent	0	0	0
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<p>Internal roof drains versus gutters</p> <ul style="list-style-type: none"> • N: 12 Avg_{Weighted}: 2.86 • N_{USACE}: 6 Avg_{USACE}: 2.83 • N_{USAF}: 4 Avg_{USAF}: 2.75 • N_{Contractor}: 2 Avg_{Contractor}: 3.00 • # of kt differences linked: 1 • Cost Premium Themes: 1 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Internal roof drains versus gutters</caption> <thead> <tr> <th>Response Category</th> <th>Dark Grey (Count)</th> <th>Light Grey (Count)</th> <th>Total (Count)</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>1</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>3</td> <td>1</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Response Category	Dark Grey (Count)	Light Grey (Count)	Total (Count)	Not At All	1	0	1	A Limited Extent	2	2	4	Moderate Extent	2	1	3	Large Extent	3	1	4	Extremely Large Extent	0	0	0
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Question & Statistical Information	Distribution																								
<p>Built up low slope roof versus metal panels</p> <ul style="list-style-type: none"> • N: 12 AvgWeighted: 3.67 • N_{USACE}: 6 Avg_{USACE}: 3.50 • N_{USAF}: 4 Avg_{USAF}: 3.50 • N_{Contractor}: 2 Avg_{Contractor}: 4.00 • # of kt differences linked: 1 • Cost Premium Themes: 1, 3 • Overall influence: Large 	<table border="1"> <caption>Distribution Data for Built up low slope roof versus metal panels</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>1</td> <td>0</td> <td>1</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>3</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	0	0	0	A Limited Extent	1	0	1	Moderate Extent	2	3	5	Large Extent	2	2	4	Extremely Large Extent	1	1	2
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<p>CMU vs insulated metal panels for hangar bay walls</p> <ul style="list-style-type: none"> • N: 12 AvgWeighted: 4.06 • N_{USACE}: 6 Avg_{USACE}: 3.17 • N_{USAF}: 4 Avg_{USAF}: 4.50 • N_{Contractor}: 2 Avg_{Contractor}: 4.50 • # of kt differences linked: 1 • Cost Premium Themes: 1 • Overall influence: Large 	<table border="1"> <caption>Distribution Data for CMU vs insulated metal panels for hangar bay walls</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> <td>0</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>1</td> <td>2</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	0	0	0	A Limited Extent	2	0	2	Moderate Extent	2	0	2	Large Extent	1	1	2	Extremely Large Extent	1	1	2
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<p>Acquisition of specified bathroom accessories versus requirement for non-specific bathroom accessories</p> <ul style="list-style-type: none"> • N: 12 AvgWeighted: 2.33 • N_{USACE}: 6 Avg_{USACE}: 2.00 • N_{USAF}: 4 Avg_{USAF}: 2.00 • N_{Contractor}: 2 Avg_{Contractor}: 3.00 • # of kt differences linked: 1 • Cost Premium Themes: 1 • Overall influence: Limited 	<table border="1"> <caption>Distribution Data for Acquisition of specified bathroom accessories versus requirement for non-specific bathroom accessories</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>2</td> <td>2</td> <td>4</td> </tr> <tr> <td>A Limited Extent</td> <td>3</td> <td>2</td> <td>5</td> </tr> <tr> <td>Moderate Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Extremely Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	2	2	4	A Limited Extent	3	2	5	Moderate Extent	0	0	0	Large Extent	1	2	3	Extremely Large Extent	0	0	0
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Extremely Large Extent	0	0	0																						
<p>Direct digital controls for all HVAC components</p> <ul style="list-style-type: none"> • N: 12 AvgWeighted: 3.14 • N_{USACE}: 6 Avg_{USACE}: 2.67 • N_{USAF}: 4 Avg_{USAF}: 3.25 • N_{Contractor}: 2 Avg_{Contractor}: 3.50 • # of kt differences linked: 1 • Cost Premium Themes: 1 • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Direct digital controls for all HVAC components</caption> <thead> <tr> <th>Extent</th> <th>Dark Grey</th> <th>Light Grey</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> <td>2</td> <td>6</td> </tr> <tr> <td>Moderate Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> <tr> <td>Large Extent</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>Extremely Large Extent</td> <td>1</td> <td>2</td> <td>3</td> </tr> </tbody> </table>	Extent	Dark Grey	Light Grey	Total	Not At All	0	0	0	A Limited Extent	4	2	6	Moderate Extent	1	2	3	Large Extent	0	0	0	Extremely Large Extent	1	2	3
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Question & Statistical Information	Distribution												
<p>100% hazard rated electrical systems in the hangar bays versus a de-energized system</p> <ul style="list-style-type: none"> • N: 12 Avg_{Weighted}: 4.00 • N_{USACE}: 6 Avg_{USACE}: 3.50 • N_{USAF}: 4 Avg_{USAF}: 4.00 • N_{Contractor}: 2 Avg_{Contractor}: 4.50 • # of kt differences linked: 1 • Cost Premium Themes: 1, 3 • Overall influence: Large 	<table border="1"> <caption>Distribution Data for Question 1</caption> <thead> <tr> <th>Response Category</th> <th># of responses</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>0</td> </tr> <tr> <td>A Limited Extent</td> <td>0</td> </tr> <tr> <td>Moderate Extent</td> <td>5</td> </tr> <tr> <td>Large Extent</td> <td>4</td> </tr> <tr> <td>Extremely Large Extent</td> <td>3</td> </tr> </tbody> </table>	Response Category	# of responses	Not At All	0	A Limited Extent	0	Moderate Extent	5	Large Extent	4	Extremely Large Extent	3
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Moderate Extent	5												
Large Extent	4												
Extremely Large Extent	3												
<p>Additional capacity required in fire alarm system above and beyond current building scope</p> <ul style="list-style-type: none"> • N: 11 Avg_{Weighted}: 3.00 • N_{USACE}: 5 Avg_{USACE}: 3.00 • N_{USAF}: 4 Avg_{USAF}: 3.00 • N_{Contractor}: 2 Avg_{Contractor}: 3.00 • # of kt differences linked: 1 • Cost Premium Themes: • Overall influence: Moderate 	<table border="1"> <caption>Distribution Data for Question 2</caption> <thead> <tr> <th>Response Category</th> <th># of responses</th> </tr> </thead> <tbody> <tr> <td>Not At All</td> <td>1</td> </tr> <tr> <td>A Limited Extent</td> <td>4</td> </tr> <tr> <td>Moderate Extent</td> <td>2</td> </tr> <tr> <td>Large Extent</td> <td>2</td> </tr> <tr> <td>Extremely Large Extent</td> <td>2</td> </tr> </tbody> </table>	Response Category	# of responses	Not At All	1	A Limited Extent	4	Moderate Extent	2	Large Extent	2	Extremely Large Extent	2
Response Category	# of responses												
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Survey Response Results

This section contains a synopsis of the survey response data. This data is used and referenced throughout the thesis. Table 22 (next page) contains each factor, its weighted average, qualitative level of influence on cost premiums, rank based on each demographic, and overall rank based on the weighted average. The table is sorted based on factor cost premium influence from most to least influential factors, and highlights difference ranks between demographics.

Table 22: Survey Results Including Ranked Level of Influence

Applies To	Factor	Influence on Cost Premiums	Weighted Avg. Value	Rank by Demographic			Overall Rank
				USACE	USAF	Contractor	
Specific	CMU vs insulated metal panels for hangar bay walls	Large	4.06	8	2	2	1
General	USAF project through USACE	Large	4.05	25	1	1	2
Specific	100% hazard rated electrical systems in the hangar bays versus a de-energized system	Large	4.00	5	3	2	3
Specific	Built up low slope roof versus metal panels	Large	3.67	5	5	4	4
General	Unique attributes of USAF project vs private industry with similar end-use requirements	Moderate	3.47	1	6	29	5
General	USACE implementation of design-build execution	Moderate	3.43	12	6	4	6
General	Quality control requirements set by the government	Moderate	3.41	7	6	8	7
General	Oversight on contractor by USACE/NAVFAC	Moderate	3.39	19	3	8	8
General	Prescriptive design requirements rather than code references	Moderate	3.31	4	15	16	9
General	Military design standards/specifications	Moderate	3.26	2	15	18	10
General	FAR: 8A/small-business policies	Moderate	3.18	9	6	18	11
General	USAF project through AFCEE	Moderate	3.14	19	25	4	12
Specific	Direct digital controls for all HVAC components	Moderate	3.14	19	12	8	12
General	Submittal process (administration/# of submittals)	Moderate	3.12	27	6	8	14
General	Restrictions placed on construction methods	Moderate	3.10	12	6	18	15
General	FAR: Administrative requirements	Moderate	3.06	16	21	8	16
General	USAF implementation of design-build execution	Moderate	3.05	3	31	18	17
General	Restrictions placed on designs	Moderate	3.05	12	15	16	18

Applies To	Factor	Influence on Cost Premiums	Weighted Avg. Value	Rank by Demographic			Overall Rank
				USACE	USAF	Contractor	
Specific	Additional capacity required in fire alarm system above and beyond current building scope	Moderate	3.00	11	15	18	19
General	Submittal timeline (time for approval/rejection)	Moderate	2.97	30	14	8	20
Specific	Schedule management requirements required by USACE versus CE squadron	Moderate	2.92	34	25	4	21
General	LEED for new construction requirements	Moderate	2.90	12	21	18	22
Specific	Internal roof drains versus gutters	Moderate	2.86	17	25	18	23
Specific	Inhabited vs low-occupancy anti-terrorism/force protection standards requirements	Moderate	2.81	31	25	8	24
General	Federal Acquisition Regulations (FAR)	Moderate	2.76	9	31	27	25
General	Design review process	Moderate	2.74	19	21	27	26
Specific	Requirement to develop test hangar concrete slabs	Moderate	2.69	39	25	8	27
General	Fixed programmed amounts (allowed project cost) early in project development	Moderate	2.53	19	12	40	28
General	FAR: Restrictions on government-contractor alliancing/partnering	Limited	2.49	34	21	29	29
General	Oversight on contractor by AFCEE	Limited	2.43	18	35	34	30
General	Non-FAR related administrative requirements	Limited	2.41	24	15	40	31
General	Requirement for a non-government independent design review	Limited	2.41	32	30	32	32
Specific	Acquisition of specified bathroom accessories versus requirement for non-specific bathroom accessories	Limited	2.33	34	37	18	33
General	Design-build rather than design-bid-build	Limited	2.32	25	31	36	34
General	Contracting method: Firm fixed price	Limited	2.30	34	31	32	35
General	Warranty requirements	Limited	2.23	38	39	18	36

Applies To	Factor	Influence on Cost Premiums	Weighted Avg. Value	Rank by Demographic			Overall Rank
				USACE	USAF	Contractor	
General	O&M training for government personnel	Limited	2.15	40	37	29	37
General	Contract requirements for PEs (professional engineers)	Limited	2.14	41	15	38	38
General	Oversight on contractor by local CE squadron	Limited	2.06	28	39	36	39
General	Contractor provided government field office	Limited	1.99	33	35	40	40
General	Safety requirements (OSHA & EM 385-1-1)	Limited	1.96	29	39	38	41
General	Requirement for warranty performance bonds	Limited	1.83	42	42	34	42
General	Project signage requirements	Not at all	1.29	43	43	43	43

Appendix C. Davis-Bacon Wage Rate Analysis Supporting Information

This appendix includes additional information that supports Chapter IV. Journal Article: A Geospatial Statistical Analysis of . This appendix provides additional background information, more detailed methodology, and more exhaustive results than could be included in the journal article.

Additional Literature Review

Quantitative Spatial Analysis

Spatial analysis requires all data to be attributed to a location in space. However, it is possible to take non-spatial raw data and relate it to known spatial points. Raw data can either be imported into a geographic information system (GIS) as data with arbitrary X-Y points or with unique identifiers that can be related to other data containing geographic attributes (Old 2000). The arbitrary X-Y points can either relate to geographic points on earth or be relative to each other without regard for the true location on earth. These two methods allow for visualization and statistical analysis of data points relative to each other or relative to true geographic locations (Old 2000). The analysis of wage rates relates attributes of the raw non-spatial data to data containing geographic locations.

When spatial data is available for singular points, but analysis requires a congruent surface, GIS applications allow for the generation of a surface. Software performs interpolation on the voids between data points to generate a surface. In ESRI ArcInfo four surface interpolation methods exist: trend surface, inverse distance weighted (IDW), triangulation, and Kriging (Hu 1995). Triangulation generates surfaces

represented by irregularly spaced points (TIN) while the other methods' surfaces are represented by equally spaced data points, or grids. The trend surface interpolation method uses least-squares polynomial regression with observed data points to generate the surface. While this method is easy to understand, it is highly affected by uneven data point distribution and extreme values. The IDW method weights observed points so "the influence of one point relative to another declines with distance from the new point" (Hu 1995). The advantages of this method include the speed and reasonable results. The disadvantages include the possibility of ambiguity when the characteristics of the underlying surface are unknown and inaccuracies caused by uneven data point distribution. Triangulation generates data from existing surfaces and data points. Due to this ability, triangulation can offer more accurate surfaces when the attributes of existing surfaces are known. Also, triangulation is more accurate than any grid method because known data points are located exactly on the surface rather than only being honored occasionally. However, surfaces generated by triangulation are generally not smooth and may have discontinuous slopes around edges and data points. Also, triangulation is usually unable to extrapolate beyond the observed data points' domain. Finally, surfaces generated by Kriging are based on the weighted moving averaging method. The main assumption of the Kriging method is a statistically homogenous dataset. The Kriging method uses semivariograms, based on the data variance, to weight data and generate a smooth surface. Additionally, this method utilizes clustering by weighting a series of nearby points with a singular value located at the centroid of the cluster. While the Kriging method provides a smooth interpolated surface, its weaknesses include the fact that original data points are seldom honored, and the estimation of the semivariogram

may not correctly relate to the spatial correlation of the existing, known, data. In order to validate the correct method was utilized, the distribution of the interpolated data can be validated against the distribution of the existing data (Hu 1995). ArcInfo allows for the utilization of a variety of surface generation methods which can be used to generate data where observations do not exist.

Detailed Methodology

This section provides additional details regarding the methodology used to analyze the effects of the Davis-Bacon Act on USAF construction.

Data Utilized

Analyzing the impacts of the DBA prevailing wage rate involved acquiring, merging, and analyzing spatial and quantitative data from a variety of government agencies. The following agencies provided data used for the DBA wage rate analysis:

- U.S. Census Bureau – The Census Bureau provides spatial data including state and county boundaries as well as metropolitan and micropolitan statistical areas. Additionally, the Census Bureau provides place names that can be used for spatial analysis. The 2011 Tiger data were used. (U.S. Census Bureau 2011)
- Wage Determinations OnLine Program – The MHD provides DBA wage determinations via its WDOL.gov site. The data are raw and non-spatial. WDOL.gov is the official repository for DBA prevailing wage acts. The May 2012 data were used.(Wage Determinations OnLine 2012)
- Bureau of Labor Statistics – The BLS provides tables of employment and wage data that are matched to statistical areas provided by the Census Bureau. The BLS also provides area definitions of nonmetropolitan areas. The May 2011 data were used. (Bureau of Labor Statistics 2011; Bureau of Labor Statistics 2011)

Office of Secretary of Defense (OSD) – The OSD provides GIS data for all base locations via data.gov. The January 2010 data were used. (Department of Defense Installations & the Environment 2010)

Geospatial Analysis

This section provides an overview of the steps taken to perform spatial analysis comparing DBA prevailing wage rates to BLS survey wage rates. A spatial analysis is the most appropriate methodology because both the BLS survey wage rates and the DBA prevailing wages vary by geographic location. Additionally, the spatial analysis allows a quantitative analysis of data across geographic boundaries. The analysis required four main steps with a multitude of sub-operations. Appendix D contains a detailed procedure log of all manipulations. All procedures listed were carried out in Microsoft Excel or ESRI ArcMap.

1. First, all shapefiles, excel worksheets, and DBA text files were downloaded from sources listed previously. The dates of files downloaded provide a static look, a snapshot in time, at DBA wage rates compared to BLS wage surveys since both the DBA and BLS data are updated frequently.
2. Next, spatial data were created based on the non-spatial data provided. Specifically, the DBA wage data are not spatial data that can be directly loaded into ArcMap.
 - a. Create the boundary data for the BLS data based on metropolitan and non-metropolitan statistical areas. This is accomplished by focusing on metropolitan statistical areas and matching the nonmetropolitan statistical areas to county data. However, due to inconsistencies between the Census Bureau and BLS MSAs some IDs must be changed. Table 27 in Appendix D summarizes the changes that must be made to the BLS data to ensure data integrity, continuity, and accuracy.
 - b. For the BLS information, the data were limited to the electrician and carpenter trade codes, 47-2111 and 47-2031 respectively. The data were joined to the boundary information thereby creating one set of spatial data for BLS survey wage rates.

- c. The applicable USAF bases were extracted from the DoD installations spatial file. This analysis focused on active duty Air Force bases as well as joint bases under Air Force command. The joint bases analyzed include: Joint Base Elmendorf-Richardson, Joint Base Charleston, Joint Base Andrews-Naval Air Facility Washington, Joint Base McGuire-Dix-Lakehurst, Joint Base Langley-Eustis, and Joint Base San Antonio.
 - d. For the DBA data, the zone(s) each USAF base resides in was determined and the extracted information was merged with the USAF base information. Table 23 lists the applicable DBA wage rate files based on USAF installation location. Only these wage rates were used for this analysis.
 - e. For the DBA data only the electrician and carpenter wages for each required zone were extracted. If two hourly wage rates were listed, the average was utilized to encompass the entire range of USAF construction.
3. The BLS data were analyzed as a standalone entity. A quantitative analysis of the carpenter and electrician BLS data was performed to determine statistically significant metrics such as mean, median, mode, and type of distribution. Additionally, the data were spatially visualized to determine how the wage rates vary across the country.
 4. The DBA data were also analyzed as a standalone entity. A quantitative analysis of the carpenter and electrician DBA data was performed to determine statistically significant metrics such as mean, median, mode, and the type of distribution at USAF bases. Additionally, the data were spatially visualized to determine how the wage rates vary across USAF bases throughout the country.
 5. Finally, the DBA data were compared to the BLS data.
 - a. The two spatial datasets were visually compared to determine if there were similar trends. This comparison was done by comparing the standardized wages rates to each other.
 - b. The quantitative percentage and dollar wage rate difference were computed. These differences were compared statistically and visually.
 - c. Geostatistical analyst was used to map the wage rate difference across the entire United States. The use of Kriging surface generation is appropriate due to the geographic nature of the data provided as well as the limited DBA availability. DBA data were limited since it was only processed for each USAF base whereas the BLS data provided coverage of the entire United States.

Table 23: DBA Wage rate files analyzed

AL58	CA29	FL18	HI1	MS90	NH13	NC65	PA1	TX2	VA115
AK1	CA23	FL29	ID10	MO12	NJ27	NC62	PR1	TX61	VA118
AZ1	CA29	FL64	IL7	MO51	NJ39	NC47	SC29	TX266	VA134
AR132	CA9	FL35	IN2	MT63	NM40	NC41	SC30	TX267	WA38
CA31	CO2	FL36	KS7	NE64	NM23	ND3	SC33	TX218	WA42
CA33	CO6	FL70	LA9	NE66	NM32	ND7	SC23	TX268	WY23
CA5	DE4	GA173	MD77	NV1	NM34	ND5	SC37	UT18	
CA9	DC2	GA203	MD82	NV4	NY76	OH12	SD4	UT7	
CA36	FL7	GA204	MA1	NV10	NY31	OH29	SD3	UT10	
CA9	FL1	GA208	MI135	NV1	NY13	OK14	TN37	UT16	
CA37	FL56	GU1	MS119	NH12	NC25	OK32	TN41	VA112	

The spatial analysis of the DBA and BLS data provided quantitative and visual results. Although the use of only two craftsman trades limited the analysis, the results can be utilized to validate existing literature and reports related to the cost of Davis-Bacon prevailing wages.

Statistical Analysis

The software solution JMP v10.0 was used for all MANOVA and t-test analysis. The data were provided to JMP by exporting the tables of carpenter and electrician wage rate data from ArcGIS. JMP was used to determine the following additional information: the wage rate if DBA wages could not be lower than BLS wages, the difference and percent difference if the wage rate could not be lower than BLS wages, and the normalized DBA and BLS wage rates. Equation 2 shows the formula used to determine a base’s wage rate if the wage rate could not be below the BLS wage rates.

$$if \left(\begin{matrix} DBA \text{ Wage Rate} < BLS \text{ WageRate} \rightarrow BLS \text{ WageRate} \\ else \rightarrow DBA \text{ Wage Rate} \end{matrix} \right) \quad (2)$$

Additionally, Equation 3 presents the formula used to standardize the wage rates (Neter et al. 1996). Data for the entire population of USAF bases are available; therefore, the population statistical variables are used rather than sample variables. Both the DBA and BLS wage rates were standardized to allow for comparison of the high and low value by location.

$$Z = \frac{X - \mu}{\sigma} \quad (3)$$

Where:

X = the wage rate

μ = the average of all the wage rates

σ = the standard deviation of all wage rates

MANOVA and matched-pairs t-tests were used to determine if the differences in wage rates were statistically significant. For all tests, a 95% confidence interval ($\alpha=0.05$) was applied. A MANOVA was performed on the standardized wage rates in order to test whether the DBA and BLS wage rates track similarly to each other, high and low values in the same geographic locations. A MANOVA was performed on the wage rates in order to test the hypothesis that the DBA wage rates vary from the BLS wage rates. Additionally, in order to get expected dollar differences a matched-pairs t-test was used to determine the 95% confidence interval. These statistical tests help validate the visual data presented by ArcGIS.

Detailed Results

This section contains additional results information not contained in Chapter IV. The additional results include statistical details for each test performed as well figures for data mentioned but not provided in Chapter IV.

Statistical Results

This section contains figures illustrating the wage distributions as well as the detailed results of the MANOVA and t-tests. Figure 12 shows the distribution for BLS carpenter wage rates. As shown, the skewed right distribution shows that few regions are paying the highest wage rates. The wage rates vary between \$8.81 and \$34.26 with an average of \$20.61. Figure 13 shows the BLS electrician wage rate distribution. The wage rates vary between \$10.02 and \$39.33 with an average rate of \$24.69. Figure 14 shows the multi-modal DBA wage rate distribution for carpenters. The wage rates vary between \$7.25 and \$43.59 with an average of \$24.16. Finally, Figure 15 illustrates the distribution of electrician DBA wage rates. The wage rates vary between \$7.25 and \$48.28 with an average of \$29.33. The BLS wage rates distributions are shaped similarly for Air Force bases and wage rates across the entire United States.

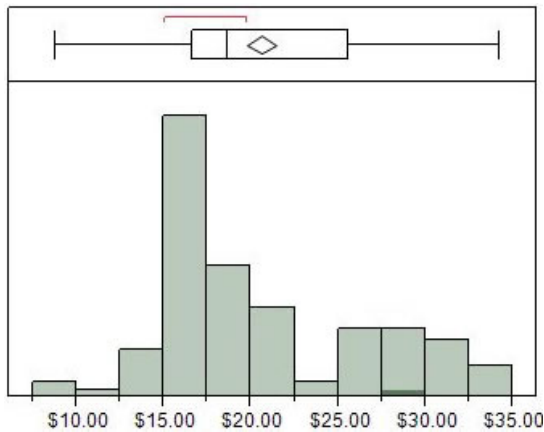


Figure 12: Frequency Distribution of BLS Carpenter Wage Rates

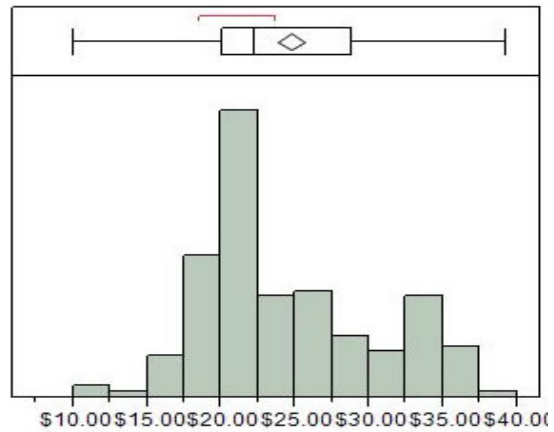


Figure 13: Frequency Distribution of BLS Electrician Wage Rates

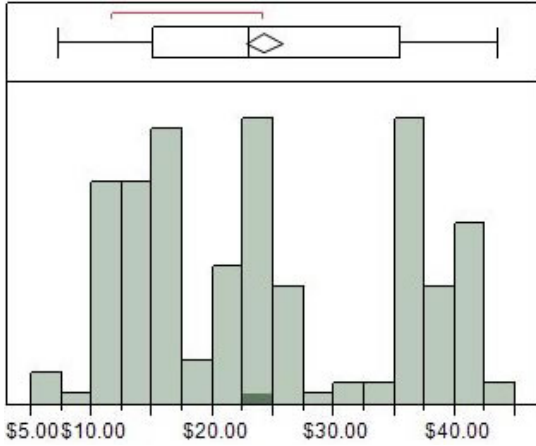


Figure 14: Frequency Distribution of DBA Carpenter Wage Rates

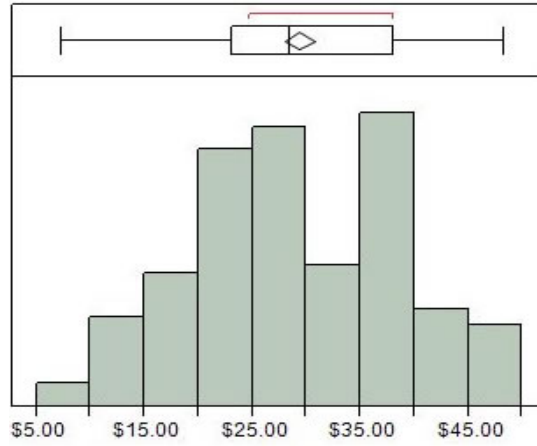


Figure 15: Frequency Distribution of DBA Electrician Wage Rates

The following tables contain the detailed results of all statistical analysis performed on the wage rate data. Table 24 provides the MANOVA data for the standardized wage rates. The following two tables (Table 25, Table 26) provide matched pairs and MANOVA data for the carpenter and electrician trades.

Table 24: MANOVA Analysis of Standardized Wage Rates

<p>Carpenter: F Test Value: 0.0017804 Exact F: 0.3347 NumDF: 1 DenDF: 188 Prob>F (p-value): 0.5636</p>	<p>Electrician: F Test Value: 0.0001171 Exact F: 0.0220 NumDF: 1 DenDF: 188 Prob>F (p-value): 0.8822</p>
---	---

Table 25: Carpenter Wage Rate Detailed Statistical Results

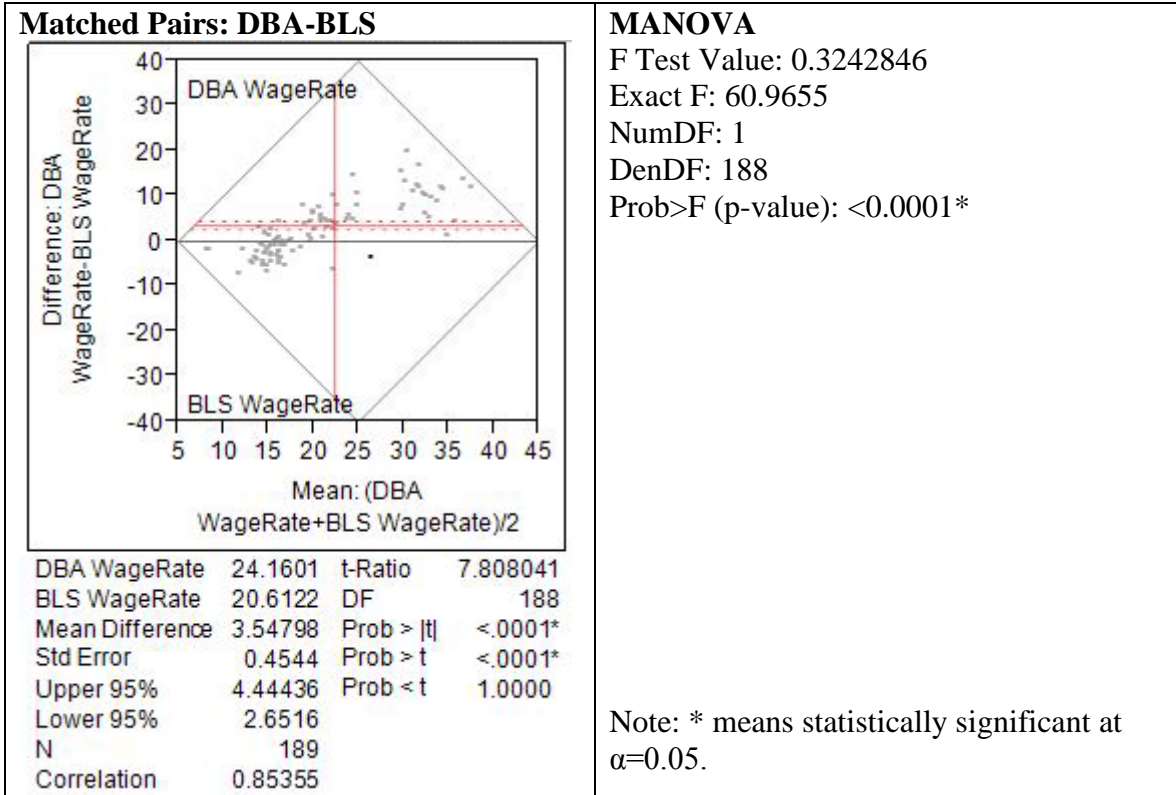


Table 26: Electrician Wage Rate Detailed Statistical Results

Matched Pairs: DBA-BLS				MANOVA	
				F Test Value: 0.5780305	
				Exact F: 108.6697	
				NumDF: 1	
				DenDF: 188	
				Prob>F (p-value): <0.0001*	
DBA WageRate	29.33	t-Ratio	10.42448		
BLS WageRate	24.694	DF	188		
Mean Difference	4.63597	Prob > t	<.0001*		
Std Error	0.44472	Prob > t	<.0001*		
Upper 95%	5.51325	Prob < t	1.0000		
Lower 95%	3.75869				
N	189				
Correlation	0.77971				
				Note: * means statistically significant at $\alpha=0.05$.	

Appendix D. Davis-Bacon Wage Rate Analysis Procedure Log

This appendix contains a detailed procedure log for analysis presented in Chapter IV and Appendix C. This appendix details the data preparation and creation, visualization of the data, and statistical procedures used. Microsoft Excel, JMP, and ESRI ArcMap were used for data creation, manipulation, and analysis. Any names of files presented can change based on the year of data download but the methodological processes remain the same.

Data Preparation/Creation

This section contains procedural instructions for preparing and creating the required data. Specific data sources are detailed in Appendix C.

Bureau of Labor Statistics Data Preparation (Spatial)

In this section the data is prepared for use with BLS data by creating the nonmetropolitan statistical areas from county data and separating the metropolitan statistical areas. These areas are used for BLS' wage rate surveys.

Non-Metropolitan and Metropolitan Statistical Areas

This section contains the procedures used to create geospatial non-metropolitan statistical areas.

1. Using ArcMap load the U.S. states (tl_2011_us_state) and counties (tl_2011_us_county) and symbolize to show the borders only.
2. Add the Metropolitan/micropolitan statistical areas to the map (tl_2011_us_cbsa).
3. Start Editor on the MSAs.

4. Use *select by attributes* to select all areas where MEMI equals 2. This will select all micropolitan areas.
5. Delete these areas. This should leave 374 MSAs.
6. Stop editing and save the edits.
7. Now use the clip tool to clip the counties by MSA.
8. Create a copy of the counties file; call this file counties_no_msa
9. Now *select by location* all counties in counties_no_msa that are within the source layer of MSAs
10. Start editor and delete these counties.
11. Stop editing and save the edits. The counties_no_msa will be used to create the nonmetropolitan statistical areas.
12. Open area_definitions_m2011.xls in Excel.
13. Create a new column called Non-MSA and use the following formula in it:
=IF(LEN(TRIM(C2))=7,"Y","")
This will use the MSA code to determine if it's a MSA/non-MSA based on its code length.
14. Delete all rows that do not have a Y for Non-MSA
15. Change the heading names to no longer have spaces, dashes, or parentheses
16. Create a new column called StateCountyCode
17. Use this formula and repeat it all the way down: =CONCATENATE(A2,"-",H2)
This will join the state code and county code so there is a unique value for joining.
18. Save and close Excel.
19. In ArcMap add the area_definitions excel file
20. Open the attribute table for counties_no_msa and add a new text column called state_county
21. Use the *field calculator* to set state_county to [STATEFP] &"-" & [COUNTYFP]

22. *Join* the excel file to counties_no_msa linked by state_county and StateCountyCode
23. *Dissolve* county_no_msa into a file called Non_MSAs with MSACode with division code as the dissolve field.
24. *Join* Non_MSAs with the excel file by the MSA code with divisions
25. Use editor and delete the 1 <Null> value in Non_MSA. This is an area not tracked by the BLS.
26. *Export* the joined Non_MSA as NonMSA and delete the old Non_MSA. This is done to ensure all the data is in one location and doesn't require the join to function.

BLS Geospatial Areas

This section details how to combine the MSA and non-MSAs together to create one file containing the BLS geospatial breakdown.

1. Use the *merge* function to combine MSA and nonMSA.
2. The output file should be BLSAreas
3. Remove all outputs in the field map except Non_MSA
4. Add a new output called AreaCode and the inputs should be MSAs.CBSAFP and NonMSA.MSACode_with_divisions; remove the inputs from the field map.
5. Add a new output called FullName (len of 150) and the inputs should be MSAs.NAME_SAD and NonMSA.MSAname_with_MSA_divisions.
6. Add a new output called ShortName (len of 150) and the input should be MSAs.NAME and NonMSA.MSAname_with_MSA_divisions.

Military Bases (Spatial)

The procedures in this section limit the bases to just USAF active duty installations.

1. Add MILITARY_INSTALLATIONS_RANGES_TRAINING_AREAS_BND to the map.

2. Do the transformation to ensure proper analysis however it is unlikely to change anything since NAD83 and WGS84 are extremely similar.
3. *Select by attributes* from the base area with this query: "COMPONENT" = 'AF Active' OR "JOINT_BASE" = 'Joint Base Charleston' OR "JOINT_BASE" = 'Joint Base Elmendorf - Richardson' OR "JOINT_BASE" = 'Joint Base Andrews - Naval Air Facility Washington' OR "JOINT_BASE" = 'Joint Base McGuire - Dix - Lakehurst' OR "JOINT_BASE" = 'Joint Base McGuire-Dix-Lakehurst' OR "JOINT_BASE" = 'Joint Base Langley - Eustis' OR "JOINT_BASE" = 'Joint Base San Antonio'
This will select all active duty USAF bases and joint bases where the USAF is the lead agency.
4. *Export* this selection to a new file called USAF_bases.
5. To make it easier to visualize the bases on future maps, convert the polygons to points using the *Feature to Point* tool.
6. Save the point file as USAF_bases_points

Davis-Bacon Wage Data Preparation (Spatial)

This section details the procedures used to prepare a spatial file for linking with the Davis-Bacon Act wage determination information. The result of this series of steps is a file containing each Air Force base and its correct Davis-Bacon Act wage data file lookup.

1. Load states, counties, and USAF bases in ArcMap
2. Now *select by location* the counties that intersect USAF bases
3. *Export* the selection to a new shapefile
4. Use Excel to open the DBF file and extract the following columns to a new sheet: STATEFP, COUNTYFP, COUNTYNS, GEOID, NAME, NAMELSAD
5. Create new columns for the DVB FileCode and LookUp
6. For each county on pull the FileCode and download the DVB file from Wage Determinations Online

7. For counties with multiple DVB files open the file and see which is applicable to the Air Force Base in the county. For example FL1 applies to Brevard County Air Force Bases while FL8 applies to the rest of the county. Also, NV1 is for Nellis AFB while NV4 is for the ranges.
8. For the LookUp column run this formula for all rows of data:
=CONCATENATE(A2,"-",B2)
9. With the shapefile of counties intersecting USAF bases clip the files to just the bases (if this was done with all counties ArcMap may have been overloaded).
10. Since some bases span multiple counties it is best to know which base is in the county. Use *spatial join* to join the USAF bases to the clipped county file into a file called USAF_base_with_county.
11. In USAF_base_with_county add a new field called StateCounty.
12. Use the *field calculator* to set StateCounty to [STATEFP] &"-" & [COUNTYFP]
13. Add the excel sheet with Davis-Bacon Wage file information to ArcMap
14. *Join* the excel information to USAF_base_with_county by StateCounty to LookUp
15. *Export* the joined file as USAF_base_DBA_file.
16. To handle Nellis AFB and its ranges select the Nellis area bases in Clark County and extract them from the USAF base file.
17. *Join* the Nellis bases in Clark County to the Davis-Bacon wage spatial data. This will give four unique bases rather than the one "base" joined. This is required because not all the Clark County bases have the same Davis-Bacon wage determination.
18. Use editor to delete the existing Nellis area bases in Clark County in the DBA file.
19. Use *append* to combine the new Nellis base information with the rest of the DBA file.
20. Edit Nellis Air Force Range to have a file code of NV4.
21. Stop editing and save the edits.

Davis-Bacon Wage Data Preparation (Non-Spatial)

This section summarizes the process used to create excel files with the proper Davis-Bacon Act wage information and identifiers.

1. Copy the applicable FileCodes from the excel file used to create the spatial Davis-Bacon data for each USAF base to a new file called DBA-data.
2. Remove all non-unique FileCodes
3. Create other columns called “WageType”, “OccupationCode”, “OccupationTitle”, “WageRate”, and “FringeRate”
4. For each FileCode there will be two rows, one for OccupationTitle = “Electrician” with OccupationCode = “47-2111” and another for OccupationTitle = “Carpenter” with OccupationCode = “47-2031”. WageType will be “DBA”
5. Fill in the required data from the .dvb files. The dvb files can be opened in Notepad or any text editor. For any dual wage rates average the categories. For Davis-Bacon wage determinations set by county, check which county the USAF base(s) is/are in and average or choose accordingly.
6. Now split the carpenter data into a separate sheet and electrician data into another separate sheet.

Bureau of Labor Statistics Data Preparation (Non-Spatial)

This section summarizes the process used to create a singular excel file containing all the BLS data.

1. Open oes_data_2011.xlsx.
2. Due to some inconsistencies between the Census Bureau MSAs and BLS, Table 27 lists the AREA ids that must be changed
3. Create a new excel sheet called BLS_data
4. Create two sheets in the excel file, one called electrical and one called carpenter.
5. Copy the field descriptions sheet from oes_data_2011 to the new sheet.
6. Copy row 1 from oes_data_2011 to the electrical and carpenter sheets.

7. Rename GROUP to GRP in the carpenter and electrical sheets
8. Filter oes_data_2011 to code area_type 4 and 6
9. Filter oes_data_2011 to OCC_CODE equals 47-2111
10. Copy the data to electrical
11. Filter oes_data_2011 to OCC_CODE equals 47-2031
12. Copy the data to carpenter
13. Save the BLS_data file

Table 27: BLS MSA ID corrections

Old ID	New ID	Old ID	New ID
79600	49340	76450	35980
78100	44140	74650	30340
71650	14460	76750	38860
76600	38340	73450	25540
71950	14860	74950	31700
75700	35300	72400	15540
70750	12620	66	6600001 (also change area type to 6)
70900	12700	78	7800001 (also change area type to 6)
77200	39300		

Combine the Spatial and Non-Spatial BLS Data (Spatial)

This section details the procedures used to combine the spatial and non-spatial BLS data. The final output is two GIS files, one for each trades' BLS wage rates.

1. Start ArcMap and add the BLSAreas file.
2. Add the BLS_data excel file.
3. *Join* BLSAreas to BLS_data's carpenter sheet by AREA to AreaCode
4. *Export* the data as BLS_Carpenter_Wages
5. *Join* BLSAreas to BLS_data's electrical sheet by AREA to AreaCode

6. *Export* the data as BLS_Electrician_Wages

Combine the Spatial and Non-Spatial DBA Wage Data (Spatial)

This section details the procedures used to combine the spatial and non-spatial DBA data. The final output is two GIS files, one for each trades' DBA wage rates.

1. Start ArcMap and add the USAF_base_DBA_file, counties, and states.
2. Add the DBA-data excel sheet.
3. *Join* USAF_base_DBA_file to DBA-data's carpenter sheet by FileCode to FileCode
4. Export the data as DBA_Carpenter_Wages
5. *Join* USAF_base_DBA_file to DBA-data's electrician sheet by FileCode to FileCode
6. Export the data as DBA_Electrician_Wages

Carpenter and Electrician Wage Rate Data (Spatial)

This section explains the procedures used to create a single GIS file for each trade which contains the DBA and BLS wage rates.

1. In ArcMap add BLS_Carpenter_Wages, BLS_Electrician_Wages, DBA_Carpenter_Wages, and DBA_Electrician_Wages
2. Run *intersect* with BLS_electrician_wages and DBA_electrician_wages. Call the output Electrician_Wages_Intersect.
3. Run *intersect* with BLS_carpenter_wages and DBA_carpenter_wages. Call the output Carpenter_Wages_Intersect.
4. Add a new column to both intersect files called WageDiff with the type as float.
5. Use the *field calculator* on the WageDiff column with this formula: [WageRate] - [H_MEAN]
6. Add a new column to both intersect files called WageDiffPercent
7. Use the *field calculator* on the WageDiffPercent column with this formula: ([WageRate] / [H_MEAN]) *100

8. Convert both intersect files to points for visualization and surface generation using *Feature to Point*. Call the carpenter file Carpenter_Wages_Intersect_Pt. Call the electrician file Electrician_Wages_Intersect_Pt.

Visualization/Analysis

This section of the procedure log details steps taken to visualize and analyze the data.

Compare Wage Rate Differences

This section describes the procedures used to test the hypothesis that BLS and DBA wage rates are different.

Graphical Representation

This section details how to visualize the wage rate differences. The key to visualization is the generation of a surface based on wage rate difference point data.

1. Load Carpenter_Wages_Intersect_Pt, Electrician_Wages_Intersect_Pt, and States in a map in ArcMap
2. Open the *Geostatistical Wizard* in the Geostatistical Analyst toolbar.
3. Under geostatistical methods select Kriging / CoKriging
4. For the source dataset select Carpenter_Wages_Intersect_Pt
5. For the data field select WageDiff
6. For overlapping data points select “use mean”
7. In step 4, select covariance as the variable because it results in less predicted error.
8. In step 4, click the button to have ArcMap automatically optimize the model
9. In step 5 move the searching neighborhood into the center of the United States since that is where the data points are

10. Click finish. This has generated a surface representing the wage rate differences for the carpenter trade.
11. Repeat steps 2 through 10 for the Electrician_Wages_Intersect_Pt file
12. *Clip* the two surfaces to the United States using either the clip command or the clip function in the data frame properties

Statistical Tests

This section details how statistical tests were performed on the GIS data in JMP.

1. In ArcMap open the attribute table for Carpenter_Wages_Intersect_Pt and Electrician_Wages_Intersect_Pt
2. Export each attribute table as a text file
3. Import each attribute table's text file into an Excel worksheet; the text file is comma delimited and has headings
4. Open the excel file for each wage rate in JMP
5. Perform a MANOVA between H_MEAN and WageRate by selecting *Fit Model* in the analyze menu.
6. Add H_MEAN and WageRate to the Y box
7. Change the personality to MANOVA
8. Run the model
9. Run a matched pairs test on the wage rates to determine the average difference and its confidence interval
10. Select *Matched Pairs* from the analyze menu.
11. Add H_MEAN and WageRate to each axes box
12. Run the test, the resulting p-value and confidence interval address the wage rate difference hypothesis

Compare Geographic Breakdown Fidelity

This section describes the procedures used to test the hypothesis that BLS and DBA wage rates had high and low values in the same areas.

Graphical Comparison

This section details how to use ArcMap to visualize the high and low values for each wage type of a single map.

1. Add States, Counties, DBA_Carpenter_Wages, and BLS_Carpenter_Wages, to ArcMap
2. Symbolize the DBA wages as relatively large stars for easy visualization
3. Symbolize the BLS_Carpenter_Wages with graduated colors with the value as H_MEAN with classification as quantile with 6 classes
4. Symbolize the DBA points as stars with the same graduated colors according to the wage rate with classification as natural breaks (jenks) with 6 classes. Jenks is used in this case because quantiles did not make sense based on the histogram.
5. The colors of the stars and the BLS polygons should be the same in the same areas if they hypothesize that the high and low values of the wage rates are in the same location is true
6. Repeat the above steps with DBA_Electrician_Wages and BLS_Electrician_Wages

Statistical Comparison

This section details how statistical tests based on GIS data were performed in JMP to support the comparison of the geographic breakdown of the wage rates.

1. Use the same excel files used for the statistical analysis
2. Start with the carpenter wage rate information
3. Create a new column with the type of float for each wage type. Call the column DBAStandardized and BLSStandardized
4. Use the formula *Col Standardize(DBA WageRate)* to get the standardized DBA wage rates
5. Use the formula *Col Standardize(BLS WageRate)* to get the standardized BLS wage rates
6. Perform a MANOVA between the two standardized wage rates by selecting *Fit Model* in the analyze menu.

7. Add the two standardized columns to the Y box
8. Change the personality to MANOVA
9. Run the model
10. The F-test p-value will describe the statistical significance of the difference between the standardized wage rates
11. Repeat these steps for the electrician wage rate information

Additional Analysis Options

JMP can be used to perform additional mathematical operations that can then be imported back into Excel. For example, this research investigated how the cost premiums would change if the DBA prevailing wage rate could not be lower than the BLS wage rate for the area. By using an if then statement in JMP (Equation 2, Appendix C) these new wage rates can be determined. The following steps state how to export the data from JMP and import it into ArcMap for analysis.

1. Perform any additional mathematical operations in JMP
2. Export the table from JMP as an Excel file
3. Open the excel file and delete all the existing columns except OBJECTID. This should leave you with an OBJECTID column and any of the new columns created in JMP.
4. Add the excel file to ArcMap
5. *Join* the excel table to the electrician or carpenter intersect file by connecting the two OBJECTID columns.
6. Geospatial analysis can now be carried out based on the new outputs from JMP

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14. ABSTRACT Military construction (MILCON) represents 40% of the federal government's \$30 billion construction budget. The federal budget is fixed; therefore, any cost overages likely affect project scope or requirements. This study investigated if MILCON procurement costs more than private industry construction and if so, what causes the cost premiums. A combination of in-depth literature review, expert interviews, a unique case study, expert surveys, and geospatial statistical analysis answered the research question. The case study evaluated two nearly identical projects to determine how internal factors affect MILCON cost premiums. This study confirmed the existence of MILCON cost premiums. Additionally, 11 major cost premium themes emerged: overly restrictive statements of requirements, failing to balance risk, stifling or not applying innovation, unique MILCON requirements, parameterization of the execution process, selection of construction specifications, schedule and submittal policies, perception of MILCON construction agents, anti-terrorism/force protection requirements, Federal Acquisition Regulations, and socioeconomic laws and policies. Additionally, in spite of contract requirement similarities, the studied projects differed by over a year of construction time and \$7 million. Research frequently cites federal laws and policies as the primary cost premium driver; however, this research demonstrated internal construction policies, which the military can control, also cause increased cost premiums.				
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