# Analysis of Naval Facilities Engineering Command Military Construction Projects and the Overall Military Construction Process

by

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## DEDICATION

I would like to dedicate this thesis to all of my family. First, I want to thank my new family, the McMillan's. I appreciate all of your love and support.

To my new husband, Tiernan, who gave up a great-paying job in the Navy in part to be with me and to allow me to fulfill my career goals. I love you and look forward to spending the rest of my life with you.

And finally, I would like to dedicate this thesis to my parents who I cannot thank enough. You mean the world to me. I never could have made it this far without your love and support.

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# Abstract

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This thesis contains an in-depth analysis of 84 recently completed Naval Facilities Engineering Command (NAVFAC) Military Construction (MILCON) projects. It utilizes estimates and actual costs throughout the life of the projects to assess the general MILCON process. Furthermore, this thesis aids in the determination of trends and possible recommendations for improvement of future programming estimates, government estimates, and overall cost control for all MILCON projects.

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# Chapter 1: Introduction

Every year billions of dollars are spent on building and maintaining United States' military facilities all over the world. The Department of Defense (DoD) owns and maintains over $500 billion worth of infrastructure across 40,000 square miles of land worldwide (Else, 2002). The money used to maintain these facilities comes from American taxpayer's pockets. In fact, on October 13, 2004, the 108$^{th}$ Congress set aside $5.1 billion for Active and Reserve Military Construction projects to be used by September 30, 2009 (Military, 2004). In order to ensure taxpayer's money is being used appropriately, the United States Constitution states, "No Money shall be drawn from the Treasury, but in Consequence of Appropriations made by Law; and a regular Statement and Account of the Receipts and Expenditures of all public Money shall be published from time to time" (US Constitution, Article 1.9.7).

Unfortunately, the entire authorization and appropriation process takes years to accomplish. Currently, Fiscal Year 2007 projects are being pulled together, planned, and budgeted for in preparation of their future presentation to Congress. This presents a challenge due to the fact that needs change, projects get altered, and prices fluctuate on a highly unpredictable basis. The money is allocated so far in advance, it makes one wonder how it is possible to formulate accurate budgets and cost estimates.

This research aims at evaluating the overall Military Construction (MILCON) process and its accuracy in projecting actual costs and suitability in preventing major cost overruns. Chapter 1 explains the scope of this thesis. Chapter 2 includes an extensive Military Construction project acquisition review as well as the cause for research and objectives. Chapter 3 explains the research methodology used, summary of all data, and an explanation of various anomalies identified within the data. Chapter 4 is a discussion of the findings and perceptions. Chapter 5 includes possible solutions, a summary of contributions, and ideas for future research.

### 1.1 Thesis Scope

This thesis is an in-depth look at the most recently completed Naval Facilities Engineering Command (NAVFACENGCOM) Navy Military Construction (MCON) and Navy Reserve Military Construction (MCNR) projects. All data were collected from Naval Facilities (NAVFAC) Headquarters and includes only Navy and Marine Corps projects within the United States. Analyses were initially made regarding the trends in costs and estimates with respect to various cost indices. Further separation of data and analyses were made with regard to geographic location and project type in order to better understand the findings. The trends identified aid in determining the accuracy of the programming and estimating phases of the Navy's MILCON process. Additionally, the analyses help to discover reasons for variations from the norm and ways of improving the overall MILCON process for the entire Department of Defense.

Due to the sensitive nature of many military projects, the exact project name, number, and location will not be disclosed. All project names and numbers have been modified. The following data has been collected for 84 of the most recently completed MILCON projects and is listed in Appendix A.

1) Project Number: Random number assigned to the project for identification purposes throughout this thesis.
2) Appropriation Type: MCON or MCNR.
3) Fiscal Year (FY): The year Congress appropriated the money for use.
4) General Facility type: Housing, Maintenance Facility, Operations Facility, Piers, Runway Projects, Security, Utilities, Property Control Facilities, and Various Other Base Amenities.
5) Specific Facility Type: A more specific description of the project.
6) Engineering Field Division (EFD): Pacific, Atlantic, Southwest, or Southern. The Division responsible for the project.
7) Programmed Amount (PA): Total amount of money allotted by Congress for the project. Includes 5% set aside for contingency, 6% for supervision, inspection and overhead (SIOH), as well as escalation and area cost adjustments. The project cannot exceed 125% of the PA. All costs over this amount must be justified and authorized by Congress.
8) PA date: Date Congress authorized the money for the MILCON project.
9) Government Estimate (GE): Estimated project cost done by in-house government engineers at the respective region headquarters. Does not include any of the following: 5% contingency, 6% SIOH, follow-on contracts, Operation and Maintenance Support Information (OMSI), Certified Quality Manager (CQM), or Quality Assessment Program (QAP). The GE is the government estimator's best guess at what the low bid will be.

10) GE date: Date the Government Estimate was completed.

11) Award Current Working Estimate (ACWE): Total amount of contract award including 6% Supervision, Inspection, and Overhead (SIOH), Post Construction Award Services (PCAS), OMSI, CQM/QAP, and selected follow-on contracts where necessary. PCAS is defined as "Optional work generally performed by the architect-engineering firm that may include drawing review/approval, consultation during construction, preparation of record drawings, and construction inspection" (Department, 2003).

12) ACWE date: Date of contract award.

13) Current Working Estimate (CWE): Cumulative cost of the project to date. In this case, all projects are completed. Therefore, the CWE equals the final cost of the completed project.

14) CWE date: Date of project completion or Beneficiary Occupancy Date (BOD).

In order to better evaluate the data, similar information was collected for the last 228 awarded MILCON projects. This information is listed in Appendix B and includes the Project Number, Appropriation Type, Fiscal Year, General Facility Type, Specific Facility Type, Engineering Field Division, Programmed Amount, Award Current Working Estimate, and the Current Working Estimate. In many cases, the projects are not yet complete and therefore the dates are not included and the Current Working Estimate does not necessarily represent the final cost of the projects.

# Chapter 2: MILCON Acquisition

The following is a thorough review of the Military Construction project acquisition process. The first section includes the history and reasoning for the creation of a separate monetary appropriation for MILCON. Section 2.2 is a review of the current technologies used by the Navy for MILCON planning and estimating. Section 2.3 is an overview of the current MILCON process used by the Navy. Section 2.4 is a general explanation of the cause for research in this area. And, Section 2.5 is a list of the objectives this study aims to accomplish.

## 2.1 History of Military Construction

Military Construction (MILCON) projects are those totaling $750,000 or more and include construction of military infrastructure in the United States and overseas. In particular, the MILCON appropriations bill "provides funding for (1) military construction projects in the United States and overseas; (2) military family housing operations and construction; (3) U.S. contributions to the NATO Security Investment Program; and (4) the bulk of base realignment and closure (BRAC) costs" (Else, 2002).

MILCON includes the acquisition of land and construction of ranges, demolition, built-in equipment, and supporting facilities. [The] major categories [of MILCON] include (1) Operations and Training, (2) Quality of Life (Bachelor Enlisted Quarters (BEQs) and Community facilities), (3) Maintenance, and (4) Other (Supply and Administration)." (Cost Element, Tab 14). For the Navy, the money appropriated by

Congress is defined as MCON or MCNR. Military Construction, Navy (MCON) is "a multiyear appropriation that funds the acquisition, construction, installation, and equipping of permanent and temporary public works, naval installations, and facilities for the Navy and Marine Corps. Military Construction, Naval Reserve (MCNR) is "a multiyear appropriation that funds the construction, acquisition, expansion, rehabilitation or conversion of facilities for the training, and administration of the Reserve Components of the Navy and Marine Corps" (Cost Element, Tab 14).

Prior to 1959, military construction funding came from the annual defense and supplemental appropriations bills. Fearing nuclear attack from the Soviet Union, Congress saw the need for a separate military construction appropriations. The purpose of the bill was to ensure the proper build-up of missile silos, hardening of existing facilities, and construction of new infrastructure. MILCON appropriations, unlike other funds appropriated by Congress, must be obligated within five years and are therefore called "multiyear" (Else, 2002).

In order to ensure the taxpayer's money is spent appropriately, Congress created what is called "The Color of Money." This phrase represents the separation of money between Operations and Maintenance (O&M), Research, Development, Testing and Evaluation (RDT&E), Personnel, Military Construction (MILCON), and Procurement. It means that money can only be spent on what it is allocated for and cannot "switch colors." This policy is also known as the Misappropriations Act (U.S. House, Title 31, §1301).

In order to ensure the Navy never overspends its limits, the Anti-Deficiency Act was put in place. It states that employees of the United States Government may not promise more money than is currently appropriated for the project. The Anti-deficiency Act ensures sufficient funds are available at the time of project obligation and any time a change is made requiring additional money (U.S. House, Title 31, §1341, §1517).

Together, the Misappropriations and Anti-Deficiency acts provide checks and balances to the MILCON process. Government estimators know they are limited in their design to the Programmed Amount. Not only that, but they know they cannot get additional money from other areas of monetary allocation to cover additional expenses.

In order to receive MILCON appropriations from Congress, each branch of the military completes a DD FORM 1391 for all of their anticipated future construction needs. Congress reviews the projects and allocates the funds as they see fit. Until 1994, Congress "consistently granted significantly less budget authority to the Department of the Defense than had been requested by the [President's] Administration (Else, 2002). Even with the increase in funding since 1995, there is never enough money to fulfill all project funding requests (Advisory, 2002). Therefore, it is essential that each project is fully justified and documented to be considered competitive. In order to justify the projects each branch of the military employs various technological systems and techniques. Section 2.2 is includes a discussion of the current deficiency tracking, budget estimating, and detailed estimating technology used by the Navy for MILCON projects.

## 2.2 Current Technology

Large-scale attempts have been made to standardize the technology utilized by the United States Army Corps of Engineers (USACE), Naval Facilities (NAVFAC) Engineering Command, and the Air Force Civil Engineer Support Agency (AFCESA). In 1992, the Tri-Service (Army, Navy, and Air Force) Automated Cost Engineering System (TRACES) was created with the intention of combining all military cost engineering systems and their associated databases into one location. The TRACES agreement dictated which applications would be maintained by the respective services, thereby reducing redundancies. Today, TRACES is fully accessible through a website requiring only a login password and is available to authorized users supporting the DoD. Appendix C includes a breakdown of the currently used applications on the TRACES website.

With respect to this thesis, the most important application on the TRACES website is the Historical Cost Analysis Generator (HAG). The tri-services have successfully introduced the second version of HAG, called HII (pronounced H2). The Historical Cost Analysis Generator allows the tri-services to forecast the cost of future construction needs using the historical award amounts of MILCON projects. Since HII is completely web-based, DoD employees do not have to download it onto their computers. Instead, the data is updated on a real-time basis which means it is more accurate and timely.

Not only do the tri-services agree upon estimating software, tools, and references, they also use similar databases and techniques for tracking deficiencies, or mission shortfalls requiring new MILCON projects. From 2001 to 2003, the Navy used a program called Installation Readiness Reporting System (IRRS) from R&K Engineering. IRRS rated facilities based on a yearly list of submitted deficiencies. Facilities with a C-3 rating were considered as having serious deficiencies, while facilities with a C-4 rating were identified as unable to support the mission requirements. IRRS allowed a big-picture look at the facilities on each Navy base and a quick comparison of repair, replacement, and new construction costs.

Today, the Navy uses the Facility Readiness Evaluation System (FRES). The program does essentially the same thing as IRRS. It helps assess the current status of facilities and the installations as a whole using Navy-wide pre-set standards. This system helps the Navy prioritize and allocate its resources where needed to ensure the mission of the Navy is met. (R&K Engineering). The Army and Air Force maintain similar databases with R&K Engineering to track their deficiencies. This allows military installations to compete on a "level" basis for MILCON appropriations.

The technology used by the tri-services is continually being updated and modified to provide the most accurate information possible. TRACES plays a large role in standardizing the tri-services and ensuring they all have similar resources available to plan and prepare for necessary MILCON projects. This information provides legitimacy of this thesis towards making generalizations across the entire MILCON program and the respective military branches. If each service performed their own type of planning and programming a valid association between them would be impractical.

## 2.3 Current Navy Practices – MTP3

The Navy currently uses the MCON Team Planning and Programming Process ($MTP^3$) to prepare its MILCON projects. The entire process takes years to complete. Table 2.1 is a step-by-step breakdown of the procedure:

Table 2.1: The $MTP^3$ Process

| | |
|---|---|
| Deficiency Identification | Identification of a deficiency, through FRES, or a future mission requirement the base will be unable to fulfill. The P-80, Facility Planning Criteria, can be used to estimate quantitative facility requirements for Navy and Marine Corps shore installations. |
| Review Alternatives | Identification and evaluation of the cost of all possible alternatives from: repair/modernization of existing facilities, leasing off-base facilities, looking for existing facilities within the region, public-private venture (PPV), Unspecified Minor Construction (MC), or Military Construction (MILCON). The P-442 NAVFAC Economic Analysis Handbook assists in the performance of economic analyses of facilities investment decisions and the consistent documentation of all projects requiring Congressional approval. At this stage, the alternative with the lowest cost is chosen. |
| Activity 1391 | The command (called the "activity") requesting the project, submits a DD FORM 1391 along with a National Environmental Policy Act (NEPA) environmental checklist to the Navy Regional Command. At this level, the end user requirement must be documented and justified. A sample DD FORM 1391 is shown in Figure 2.1. |

| | |
|---|---|
| Region Team 1391 | The project scope is finalized and documentation is compiled so that it can compete with other projects at the Region level. The DD1391 Package now includes the following: A rough Plan of Action and Milestones (POA&M), environmental documentation, permits, delivery dates of equipment, a rough cost estimate based on DoD Guidance Unit Cost (GUC) data, all knowledge of the site, clean-up, NEPA mitigation, utilities, ECONPAK economic analysis report, Environmental Impact Statement (EIS), if necessary, and Environmental Assessments (EA), site approvals, site plan sketches, Anti-Terrorism/Force Protection (AT/FP) Threat Analysis, preliminary hazards list, and collateral equipment list. |
| EFD 1391 | The EFD may use the SuccessEstimator™ Parametric Cost Estimating Models (PCEM) or an A-E firm to create a 5% design effort. Additional cost calculations are prepared using the Guidance Unit Costs (GUC) or the Historical Cost Analysis Generator (HAG) and taking into effect the area cost factor, size adjustment factor, and escalation. The EFD is also responsible for the creation of a Budget Estimate Summary Sheet (BESS). This summary sheet is a breakdown of all cost associated with the project. |
| NAVFAC Final 1391 | At this stage NAVFAC collects, updates, and makes consistent with each other, all 1391 forms for projects still two years out from being authorized by Congress. |
| Budget 1391 | The 1391 is streamlined for authorization and appropriation. |
| Design Authorization | The EFD is given authorization to spend time and money on designing the project. The Navy locks in the budget two to three years out. Therefore, the Divisions know which projects they should be spending their time and effort on. |
| Design/RFP | The project team performs a Functional Analysis Concept Development (FACD) meeting composed of as many project participants as necessary to finalize any issues and reach a consensus. The FACD meetings may sometimes last up to three weeks. Following the FACD, the detailed government engineering estimate is created. In the case of Design/Build, a Request for Proposal is required instead. |

| 1. COMPONENT | FY ______ MILITARY CONSTRUCTION PROJECT DATA | 2. DATE *(YYYYMMDD)* | REPORT CONTROL SYMBOL DD-A&T(A)1610 |
|---|---|---|---|
| 3. INSTALLATION AND LOCATION | 4. PROJECT TITLE | | |
| 5. PROGRAM ELEMENT | 6. CATEGORY CODE | 7. PROJECT NUMBER | 8. PROJECT COST *($000)* 0 |

9. COST ESTIMATES

| ITEM | U/M | QUANTITY | UNIT COST | COST *($000)* |
|---|---|---|---|---|
| | | | | 0.00 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |
| | | | | 0 |

10. DESCRIPTION OF PROPOSED CONSTRUCTION

DD FORM 1391, JUL 1999 PREVIOUS EDITION IS OBSOLETE. PAGE NO.

Figure 2.1: Sample DD Form1391

The MTP[3] process flowchart provides many opportunities to clarify the scope and make necessary changes. It is important to note that once Congress approves the project and allocates the funds, the money can only be used for the exact project stated in the 1391. Changes can only be made if authorized by Congress. For example: If the project 1391 states the need for a 500-bed Bachelor Enlisted Quarters (BEQ) and the Government Estimate comes in lower than the Programmed Amount, the activity cannot add 50 more beds to the project to match the PA. However, if there is an honest need for 50 more beds and justified through Congress, the change can be made.

For Design/Bid/Build projects, if the Government Estimate is greater than the Programmed Amount, justification must be sent up the chain of command to authorize the advertisement of the work. Congress must decide if there are sufficient funds to accommodate the request. If denied, the command must reduce the scope to ensure it is within the set budget. Many times, if there is a fear of exceeding the Programmed Amount, follow-on contracts, or bid options, are created. The activity can then purchase a basic product and add any additional bid options up to their allowable budget. This ensures the client is able to spend all of their allotted money without going over. Upon receipt of bids, a meeting is set up with all parties. The Government Estimate is revealed and compared to the bids. Historically, the lowest responsible bidder is awarded the contract. The determination of "responsible" is made after an analysis of the bid and the Government Estimate. If the bid is higher or lower than the Government Estimate by 10% or more, a thorough analysis is required to compare line items. If the higher cost is justified by the contractor, the government must decide whether to accept the price or reduce the scope. If the higher cost is not justified by the contractor, the contract price is negotiated after discussions.

More recently, the focus has been on Design/Build. In this case, a request for proposals (RFP) is made by the government. Contractors wishing to bid on the project are given boundaries from which they are expected to come up with their best "solution," or design. They submit a very rough design and a bid for the work. The government compares the designs and bids and chooses the contractor providing the best value. The Design/Build process greatly decreases the amount of work for the government and is therefore being highly encouraged as an acquisition strategy.

The government has the ability to enforce the estimating systems used by contractors through the Defense Contract Audit Agency (DCAA). This agency helps to determine the adequacy of the contractor's estimating systems and can, in extreme cases, disapprove their systems (Crow, 1996). However, if the contractor's estimating system is deemed adequate and the bids are all higher than the government estimate, MILCON projects are allowed to run over the Programmed Amount by a maximum of 25%. However, this practice is not highly regarded and is avoided at all costs. If the project costs less than the Programmed Amount, the unused funds can be recaptured by Congress and reallocated to other MILCON projects requiring additional funds.

### 2.4 Initial Summary of Findings

Initial visual evaluation of the NAVFAC MILCON data resulted in a "V shape with respect to the project life for most of the projects. As shown in Figure 2.2, the average of all 84 projects' estimates and final costs form the shape of a lopsided "V." However, there was a wide variance observed throughout the project data.

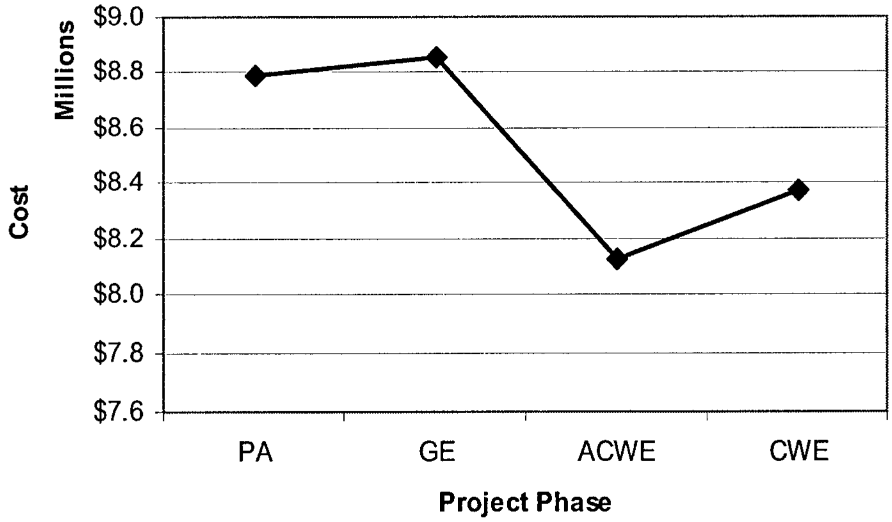


Figure 2.2: Average Cost by Project Phase for the Last 84 Completed MILCON Projects

The following is a brief description of the "V" shown in Figure 2.2 and possible explanations for each leg. Further evaluation of each section of the "V" shape will be made within Chapter 3.

The first leg of the "V" shows a slight rise from the Programmed Amount to the Government Estimate. The most basic explanation for this is the fact that government estimators and engineers know exactly how much money they can afford to spend according to the Programmed Amount. Therefore, the data seems to suggest that government estimators tend to estimate to the Programmed Amount instead of the actual project. It is anticipated that the PA and the GE are essentially equal.

The second leg of the "V" shows a sharp decrease from the Government Estimate to the Award Amount. The data seems to suggest that the government estimators routinely estimate the projects too high, or the contractors underbid the jobs in an effort to get the work. This phase seems to show the greatest room for improvement within the MILCON process.

The third and final leg of the "V" shape shows an increase from the award amount to the final cost of the project. The data seems reasonable and suggests that the projects encountered change orders and unforeseen events during the construction phase. It is anticipated that the percent change from the award amount to the final cost of the project is very close to 5% since that is the amount Congress allows for contingency.

According to these initial visual observations, the data follows a pattern forced by the workings of the overall MILCON process. In the end, it is anticipated that the MILCON process reveals a "self-leveling" trend due to the fact that Congress has a set budget and must try to use it all. If there is money left over on one project, it is shifted to another project. This decreases the cost indices of the first project and therefore increases the cost indices of the second and balances out.

### 2.5 Cause of Research

Military Construction projects are necessary to ensure the United States' military facilities remain useful and productive. However, most taxpayers want to ensure their money is being spent wisely. The motivation for the author of this thesis is twofold. As a taxpayer, the author wishes to explore the MILCON process in an effort to discover ways of ensuring the government obtains a greater value in procurement of design and construction of its Military Construction projects. And, as a military officer, the author wishes to find variances in the MILCON project data from the norm, reasons for the differences, and possible solutions to prevent the same inconsistencies in the future.

The system seems to work, but could it be improved? For example, the system currently lacks any identifiable incentive for project teams to spend less than the Programmed Amount. In fact, every incentive is provided to spend the entire amount allotted by Congress. The bid options included in contracts may sometimes be unnecessary for the command to fulfill its mission objectives. What incentives could be offered to the commands and the project teams to change these practices?

The system seems to mold each MILCON project into the observed "V" shape. However, there is still a lot of variance in the data. What changes, if any, should be made to the MILCON process to force the project lifecycles into a more appealing and less variable shape?

Chapter 3 includes analyses of the MILCON project data in an effort to identify the significance of the project lifecycle trends noted previously. Following the analyses, possible reasons for variations from the trends and possible solutions for mitigation are discussed throughout the remainder of this thesis.

### 2.6 Objectives

There are several objectives this study aims to accomplish. This thesis should identify trends in the Navy's data, explain possible reasons for the trends, explain possible reasons why projects may not always follow the trends, and recommend ways of improving the current MILCON practices. More specifically, the goal of this thesis is to identify and explain the following with respect to Navy MILCON projects:

1.) Trends in cost growth over the life-cycle of the projects.

2.) General geographic locations that do not follow the normal life-cycle trends and possible reasons for their variation.

3.) Types of projects that fall outside of the normal cost growth trends and possible reasons for their deviation from the norm.

Using the objectives listed above, an overall analysis of the Navy's MILCON process can be made. This analysis can help find ways of improving budgeting and estimating accuracy, project tracking, as well as cost control for all MILCON projects.

# Chapter 3: Observations

## 3.1 Methodology

All data used to analyze the MILCON process was obtained from NAVFAC Headquarters, NAVFAC Engineering Field Divisions (EFD), and a Navy project database called eProjects. The first set of data includes information regarding 84 completed NAVFAC MILCON projects. All of the 84 projects listed were appropriated by Congress over a three-year period from 2001 through 2003. The list only consists of projects within the United States and totals over $703.3 million in cost. The spreadsheet program used for all calculations and data accumulation was Microsoft Excel™.

The original data from NAVFACHQ did not include the Government Estimates or the dates for the PA, GE, ACWE, or CWE. Therefore, a significant amount of time was spent accumulating this data from the respective contracting offices and a NAVFAC database called eProjects. The accumulated data is listed in Appendix A. Once all data was collected, a few minor modifications needed to be made in order for the estimates and final costs to be comparable. The project data sent from NAVFACHQ could not be sufficiently compared to each other due to inclusion/exclusion of contingency and SIOH amounts. In order to make them comparable, the Programmed Amount was reduced by 5% to exclude the contingency amount and the Government Estimate was increased by 6% to include SIOH. These changes ensured that the PA, GE, ACWE, and CWE all included the same markups and could therefore be compared without giving false trends. Following these adjustments, analyses were made. Project information falling outside of the normal range was researched and all anomalies were analyzed, explained (where possible), but not removed from the data. By contacting the project manager or other project personnel, erratic costs and estimates could be explained. However, in many cases the individuals involved were no longer available for interview or comments.

The second set of data is a list of 228 projects that have been awarded; however, some of the projects have not been completed. Again, the original data from NAVFACHQ did not include the Government Estimates or the dates for the PA, GE, ACWE, or CWE. In all, the projects total over $2 Billion, were appropriated by Congress from 2001 through 2004, and are all located within the United States. The data is listed in Appendix B. This data also had to be manipulated in order to be comparable. Following the adjustments, analyses were made between the Programmed Amount and the award amount and compared to the first data sets' information to see if the data found within the 84 projects truly represents the larger population of MILCON projects.

The general methodology used for this thesis is an evaluation of the Navy's data on MILCON project costs. This thesis regards the MILCON process as uniform across the tri-services due to Constitutional and Congressional restrictions. Therefore, recommendations for improving the Navy's MILCON process will also improve the other services' MILCON processes. Figure 3.1 is a flow chart of the methodology used for this thesis.

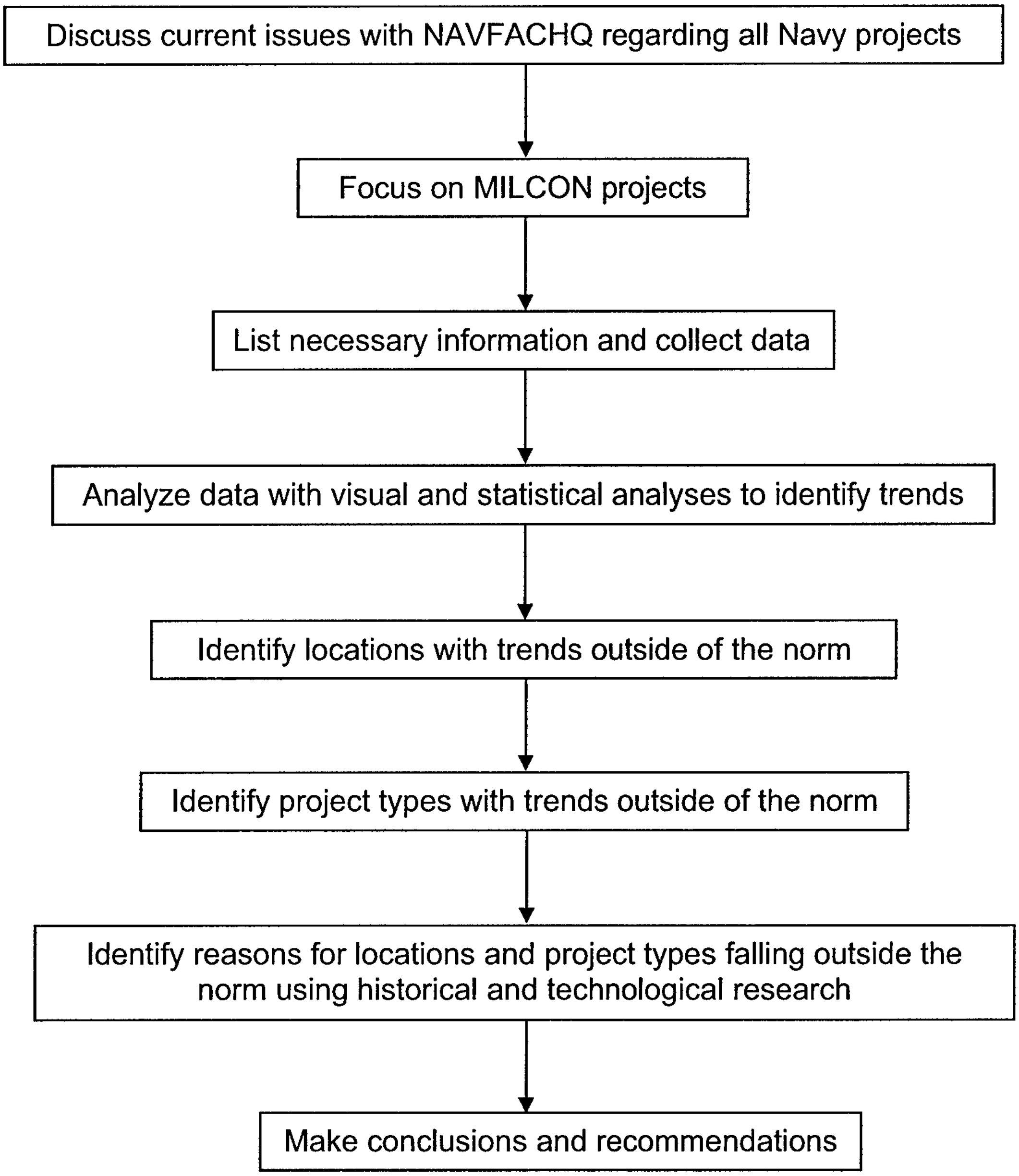


Figure 3.1: Research methodology flowchart

The following is a list of indices and their respective formulas used in analyzing the data. All formula names are made up except for Construction Cost Growth.

*Planning Cost Growth*: The percent change in the planned cost of the project from the Programmed Amount (PA) to the Government Estimate (GE). This is just one way of analyzing the Navy's budgeting and estimating practices. This index represents the first leg of the observed "V" shape in Figure 2.2.

$$\frac{(GE - PA)*100}{PA}$$

*Programming Cost Growth*: The percent change in the planned cost of the project from the Programmed Amount (PA) to the Award Current Working Estimate (ACWE), or award amount. This is the second of three ways to evaluate the Navy's budgeting and estimating practices. This index aids in determining the accuracy of the Navy's long-term programming databases such as the Historical Cost Analysis Generator (HII) since the award amount is the price entered into the HII database. Additionally, this index can be used to compare the 84 completed MILCON projects to the entire data set of 228 awarded MILCON projects.

$$\frac{(ACWE - PA)*100}{PA}$$

*Overall Cost Growth*: The percent change in the planned cost of the project from the Programmed Amount (PA) to the Current Working Estimate (CWE), or final cost of the project. This is the third way of evaluating the Navy's budgeting and estimating practices. This index aids in determining the overall accuracy of the Programmed Amount since the goal of the PA is to project the actual cost, or CWE, of the project.

$$\frac{(CWE - PA)*100}{PA}$$

*Award Cost Growth*: The percent change in the cost of the project from the Government Estimate (GE) to the Award Current Working Estimate (ACWE), or award amount. This is one of two ways of evaluating the Navy's detailed cost estimating practices for MILCON projects. This index represents the middle leg of the observed "V" shape in Figure 2.2. This index aids in determining the difference between the government estimator's estimate and the contractor's estimate.

$$\frac{(ACWE - GE)*100}{GE}$$

*Final Cost Growth*: The percent change in the cost of the project from the Government Estimate (GE) to the Current Working Estimate (CWE), or final cost of the project. This is the second way of evaluating the Navy's detailed cost estimating practices for MILCON projects. This index aids in determining the accuracy of the Government Estimate since the goal of the GE is to project the final cost, or CWE, of the project.

$$\frac{(CWE - GE)*100}{GE}$$

*Construction Cost Growth*: The percentage change in the cost of the project from the Award Current Working Estimate (ACWE), or award amount, to the Current Working Estimate (CWE), or final cost of the project. This value, along with other project details and information helps in determining the extent of cost growth for MILCON projects. This index represents the third leg of the observed "V" shape in Figure 2.2.

$$\frac{(CWE - ACWE)*100}{ACWE}$$

Using the six indices listed above, this thesis seeks to find the extent to which they are apparent in the MILCON project data. The following sections include analysis of the indices and further evaluation of the indices in relation to the project geographic locations and project types.

Due to sampling size, many of the analyses made are only represented graphically. Where there is enough data, statistical analysis was used in the form of a paired two sample for means t-test. The objective of the hypothesis testing is to determine whether the means of the two samples are equal to each other at a certain level of significance. By establishing the null hypothesis [Mean of sample 1 = Mean of sample 2: ($\overline{X_1} = \overline{X_2}$)] and alternate hypothesis [Mean of sample 1 ≠ Mean of sample 2: ($\overline{X_1} \neq \overline{X_2}$), it is possible calculate the t-test statistic and prove that the two samples are statistically similar and therefore come from the same parent population or not. The level of significance used to prove or disprove the null hypothesis is 95%. The Microsoft Excel™ Data Analysis function was used to calculate the t-values. The null hypothesis acceptance ranges at various levels of confidence for the t statistic are shown below:

99.9%: t-value from -3.416 to 3.416

99.5%: t-value from -2.887 to 2.887

99%: t-value from -2.638 to 2.638

97.5%: t-value from -2.284 to 2.284

95%: t-value from -1.989 to 1.989

90%: t-value from -1.665 to 1.665

80%: t-value from -1.293 to 1.293

**3.2 Summary of Data**

The following analyses were made in order to find trends in the data:

1.) Graphical and statistical analysis of the project cost growth indices.

2.) Graphical analysis of the average project cost growth indices in relation to the geographic location.

3.) Graphical analysis of the average project cost growth indices in relation to the type of project.

<u>3.2.1 Project Indices</u>

The first analysis of the 84 MILCON projects' data is done using the six project cost growth indices as described in Chapter 3.1. The analysis of these indices is useful in determining the extent to which the data accumulated for the 84 projects is representative of all NAVFAC MILCON projects and hopefully all MILCON projects. By identifying undeniable trends in the data, it may be possible to explain the trends or variances from the trends in an effort to better control them.

Two graphs are given for each project cost growth index. The first graph is a plot of the frequency of each percent cost growth index value calculated. This graph visually shows the average cost growth index and its associated variance. The second graph is a plot of the percent cost growth as a function of the project cost. It visually shows the cost growth trend for projects from $750,000 to $45,000,000.

3.2.3.1 Planning Cost Growth Index

The Planning Cost Growth Index represents the percent change from the PA to the GE. Figure 3.2 shows an extremely high frequency of -1% to 1% Planning Cost Growth. In fact, over 52% of the 84 projects fall within these limits. The values of Planning Cost Growth vary from -46% to 39% with a mean of -0.12%, median of 0%, and mode of 1%. The standard deviation of the sample is equal to 10%. The data shows a very wide variance; however, there are only a few outliers causing such a large standard deviation.

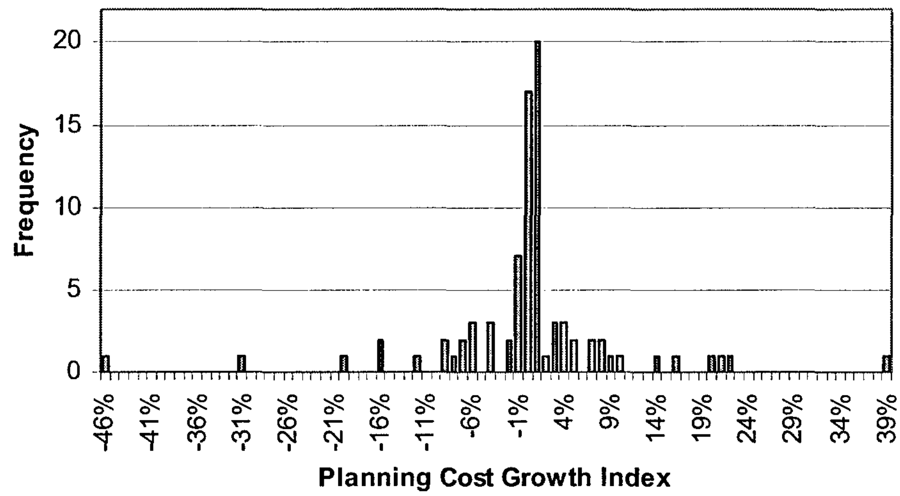


Figure 3.2: Frequency of Planning Cost Growth Indices

This information seems to suggest that either the Programmed Amount is very precise or the government estimators are trying to stay as close to the PA as possible. This fact is easily accounted for when compared to the workings of the MILCON system. Government estimators, as well as engineers, know exactly how much money they can afford to spend according to the PA. In many cases, the original amount requested on the

1391 has been cut by Congress in an effort to take on more projects at one time. The government estimators and engineers are therefore forced to use every cent in an effort to create the necessary project. In many cases, the task just cannot be done and the Government Estimate is forced to exceed the Programmed Amount. Most estimators try to stay within the budget in order to prevent the reorganization of money between projects or the need to request additional money from Congress. The difficulties and time-consumption involved with requesting more money from Congress is a deterrent from increasing project costs and acts as a sort of cost control for all MILCON projects.

Figure 3.3 is a graph of the variation in the Planning Cost Growth Indices as a function of the PA, or planned cost of the project. The graph also shows the best-fit line and the best-fit line equation for the data. For Programmed Amounts from \$750,000 to \$45,000,000, the average Planning Cost Growth Index, according to the best-fit line equation, varies only from -0.4% to 2.6% respectively.

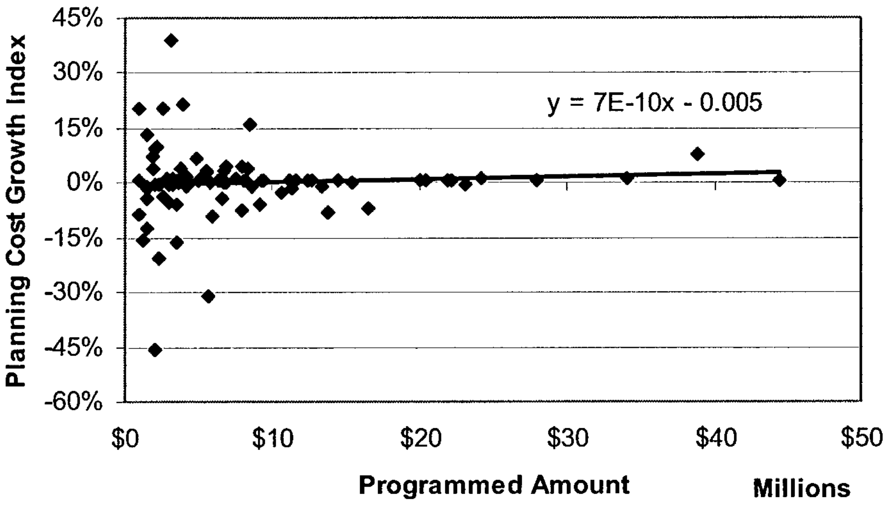


Figure 3.3: Planning Cost Growth Index as a Function of the Programmed Amount

The graph seems to suggest that there is less predictability in the Planning Cost Growth for less expensive projects. The graph also shows a slight increase in the Planning Cost Growth for more costly projects. However, this graph visually explains that no matter what the size of the MILCON project, the average Planning Cost Growth Index is expected to be near 0%. In order to test this hypothesis, further statistical analysis is necessary.

Table 3.1 is a summary of the t-test statistical analysis performed on the Planning Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.1: Summary of t-Test for Planning Cost Growth Input Variables

| | *PA* | *GE* |
|---|---|---|
| Mean | 8788753 | 8857087 |
| Variance | 8.3E+13 | 8.79E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| Df | 83 | |
| t Stat | -1.02783 | |

According to the analysis, the null hypothesis cannot be rejected with any significant confidence level. Therefore, the null hypothesis must be accepted. This means the PA and the GE are statistically similar and are therefore regarded as having the same mean and standard deviation and originating from the same parent population. The t-test statistical analysis proves that the difference between the Programmed Amount and the Government Estimate is essentially 0% for all MILCON projects, as expected.

3.2.3.2 Programming Cost Growth Index

The Programming Cost Growth Index represents the percent change in the cost of the project from the PA to the ACWE, or award amount. As previously stated in Section 3.1, this index can be used to determine the accuracy of the Historical Analysis Generator (HII) database used in formulating the PA. Figure 3.4 shows the frequencies of each Programming Cost Growth Index. The values range from -47% to 26% with a mean of -5%, median of -3%, and mode of 2%. The sample standard deviation is equal to 15%. The graph shows a very wide variance in the data and quite a few outliers.

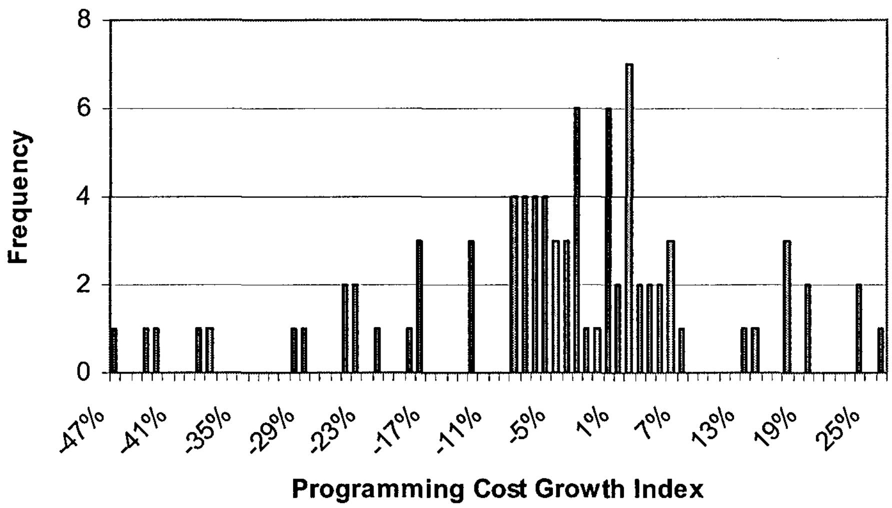


Figure 3.4: Frequency of Programming Cost Growth Indices

This data makes sense when compared to the workings of the MILCON system. Unlike the Government estimators, the contractors are unaware of the PA or the GE when preparing their bids. Additionally, due to the time lapse of up to years between the PA date and the award date, changes may have occurred in the scope of work and the expected prices of materials may be different. Therefore, it is to be expected that these values would be less predictable than the Planning Cost Growth Indices.

Figure 3.5 is a graph of the variation in the Programming Cost Growth Indices as a function of the PA. The graph also shows the least squares line and equation for the data. For Programmed Amounts from $750,000 to $45,000,000, the average Programming Cost Growth Index varies from -2.8% to -15.9% respectively. This graph suggests that there is more variability in the Programming Cost Growth of smaller projects. This graph also shows that the higher priced projects had a larger percent decrease from the Programmed Amount to the award amount. This could mean that the planners and the HII database overestimated the actual price of the projects.

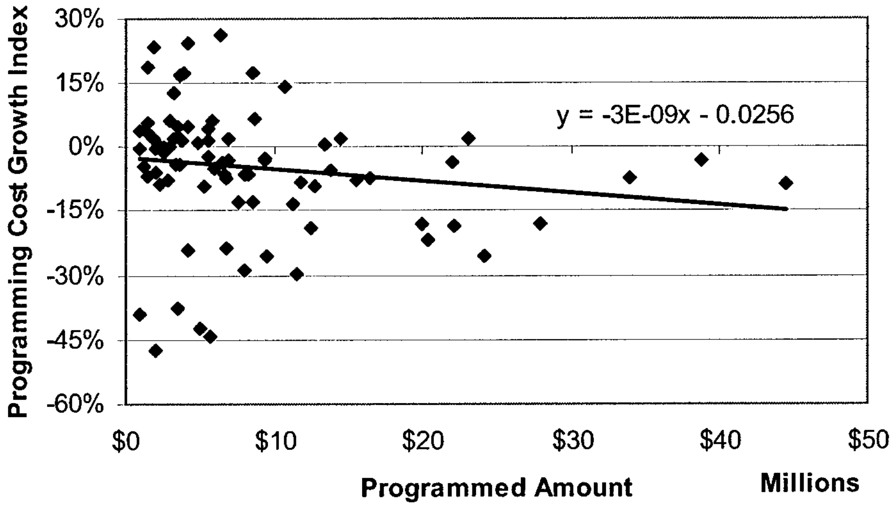


Figure 3.5: Programming Cost Growth Index as a Function of the Programmed Amount

Although the graphs suggest that this is true for the 84 projects analyzed within this thesis, further statistical analysis is necessary to test for the confidence level of this statement.

Table 3.2 is a summary of the t-test statistical analysis performed on the Programming Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.2: Summary of t-Test for Programming Cost Growth Input Variables with a Hypothesized Mean Difference Equal to 0%

| | *PA* | *ACWE* |
|---|---|---|
| Mean | 8788753 | 8123333 |
| Variance | 8.3E+13 | 6.95E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| Df | 83 | |
| t Stat | 4.293493 | |

According to the analysis, the null hypothesis must be rejected with a level of confidence equal to 99.9%. The t-test proves that the means and the standard deviations of the PA and ACWE are not equal. Therefore, they alternative hypothesis must be accepted, which is to say that there is a difference between the means of the two variables. Figure 3.5 shows the difference graphically. It displays how the Programming Cost Growth Index becomes smaller and smaller as the price of the project increases.

Additional analysis of the Programming Cost Growth Index can be made with respect to the larger data set of 144 projects (228 minus the original 84) found in Appendix B.

Table 3.3: Summary of t-test for Programming Cost Growth Indices Found in the Smaller and Larger Project Data Sets

| | *Data Appendix A* | *Data Appendix B* |
|---|---|---|
| Mean | -0.049917917 | -0.021619593 |
| Variance | 0.022271827 | 0.042867817 |
| Observations | 84 | 144 |
| Pooled Variance | 0.035303803 | |
| Hypothesized Mean Difference | 0 | |
| Df | 226 | |
| t Stat | -1.09699192 | |

According to Table 3.3, the larger project set has an average Programming Cost Growth equal to -2.2%. This closely matches the -3% median found in the 84-project data set. Table 3.3 also proves that the Programming Cost Growth found within the 84 projects is essentially the same as that of the larger MILCON project data set. According to the analysis, the null hypothesis cannot be rejected with any significant confidence level. Therefore, the null hypothesis must be accepted. This means the two data sets are statistically similar and are therefore regarded as having the same mean and standard deviation and originating from the same parent population. The t-test statistical analysis proves that a -2.2% Programming Cost Growth Index is typical for all MILCON projects.

3.2.3.3 Overall Cost Growth Index

The Overall Cost Growth Index is the percent change in the price of the project from the PA to the CWE, or the final cost of the project. This value helps to determine the accuracy of the planning estimate in forecasting the actual price of the completed construction project. As shown in Figure 3.6, the Overall Cost Growth Index values ranged widely from -43% to 29% with a mean of -1.4% and a median of 0%. There are two values for the mode since -1% and 5% both have a frequency equal to 7. The standard deviation of the sample is 16%. Again, this data shows a very wide variance and quite a few outliers.

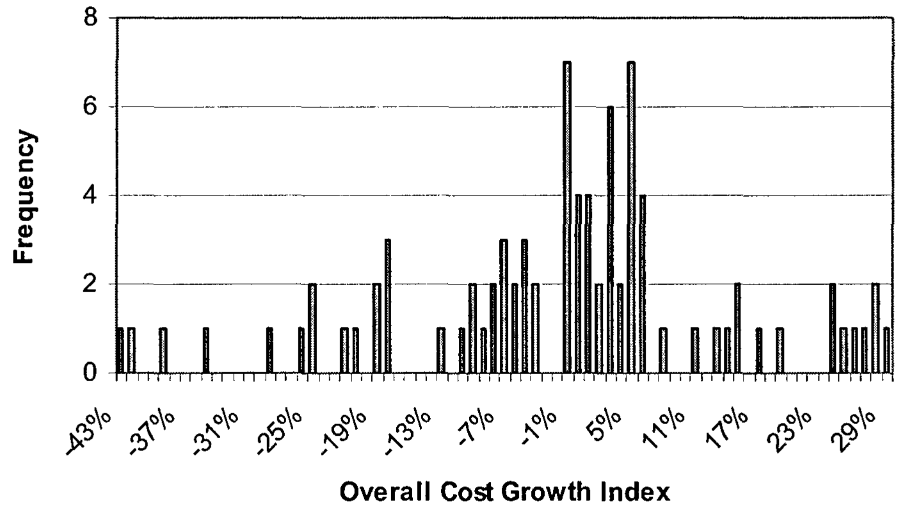


Figure 3.6: Frequency of Overall Cost Growth Indices

This data is expected to closely match the Programming Cost Growth Index. The only changes between the Programming and Overall Cost Growth Indices are the changes made during the construction phase of the project. Figure 3.7 is a graph of the variation in the Overall Cost Growth Indices as a function of the PA. The graph also shows the best-fit line and the best-fit line equation for the data. For Programmed Amounts from $750,000 to $45,000,000, the average Overall Cost Growth Index varies from 1.8% to -16.2% respectively. This graph shows that higher priced projects had a larger percent decrease from the Programmed Amount to the final cost of the project. Again, this could mean that the planners and the HII database overestimated the actual price of the projects.

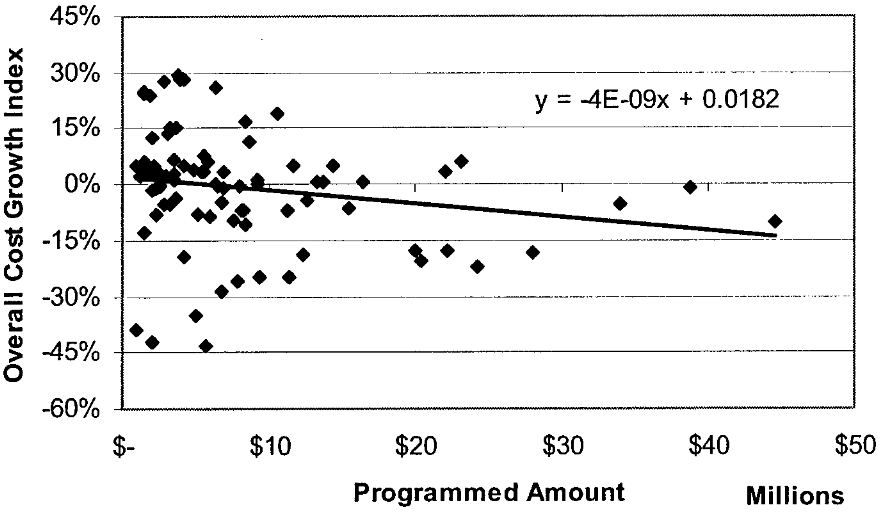


Figure 3.7: Overall Cost Growth Index as a Function of the Programmed Amount

Although the graphs suggest that this is true for the 84 projects analyzed within this thesis, further statistical analysis is necessary to test for the confidence level of this statement.

Table 3.4 is a summary of the t-test statistical analysis performed on the Overall Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.4: Summary of t-Test for the Overall Cost Growth Input Variables

| | *PA* | *CWE* |
|---|---|---|
| Mean | 8788753 | 8373453 |
| Variance | 8.3E+13 | 7.17E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| Df | 83 | |
| t Stat | 2.641882 | |

According to the analysis, the null hypothesis must be rejected with 99% confidence level. Therefore, the alternate hypothesis must be accepted. This means the

PA and the CWE are not statistically similar and are therefore regarded as having different values of mean and standard deviation. The t-test statistical analysis proves that there is a difference between the Programmed Amount and the final cost of the project. Figure 3.7 graphically shows the decrease in the Overall Cost Growth Index as the prices of the projects increase.

#### 3.2.3.4 Award Cost Growth Index

The Award Cost Growth Index represents the percent change in the cost of the project from the GE to the ACWE, or award amount. As previously stated in Section 3.1, this index can be used to compare the Navy's detailed cost estimating systems with the contractor's estimating practices. Figure 3.8 shows the frequencies of each Award Cost Growth Index. The values range from -43% to 36% with a mean of -4.9% and a median of -5%. There are essentially 3 modes for this sample since -9%, 1%, and 2% all displayed a frequency of 5. The standard deviation of the sample is equal to 14%. The graph shows a very wide variance in the data and quite a few outliers.

Visual analysis of Figure 2.2 seems to suggest the greatest change in the lifecycle of the MILCON projects lies between the Government Estimate and the Award Amount. One very surprising fact is that nearly 87% of the MILCON projects analyzed were awarded for an amount less than 10% over the Government Estimate. This means only 13% of the projects required a detailed analysis to identify the differences in cost estimates. Comparing the GE and the contractor's bid can be a very time-consuming task especially when the government estimator and the contractor have used different estimating systems. Other factors that increase the time it takes to compare estimates include the detail of the line items and the size of the project. Therefore, it behooves the government estimator to be more accurate or even over-estimate, when estimating larger projects. Again, this initial visual observation of a decrease between the GE and the award amount seems reasonable when compared to the overall MILCON system. However, it also suggests that the government estimators tend to over-estimate projects for fear of having to spend time comparing estimates at a later date.

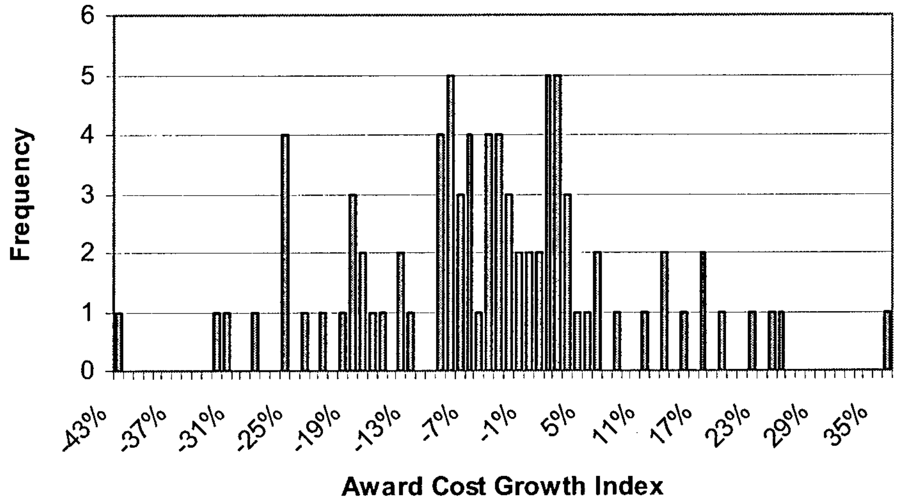


Figure 3.8: Frequency of Award Cost Growth Indices

Figure 3.9 is a graph of the variation in the Award Cost Growth Indices as a function of the GE. The graph also shows the best-fit line and the best-fit line equation for the data. For Government Estimates from \$750,000 to \$45,000,000, the average Award Cost Growth Index varies from 2.1% to -19.6% respectively. This graph shows that the higher priced projects had a larger percent decrease from the GE to the award amount. This suggests that the government estimators did over-estimate the projects, more so on costlier projects.

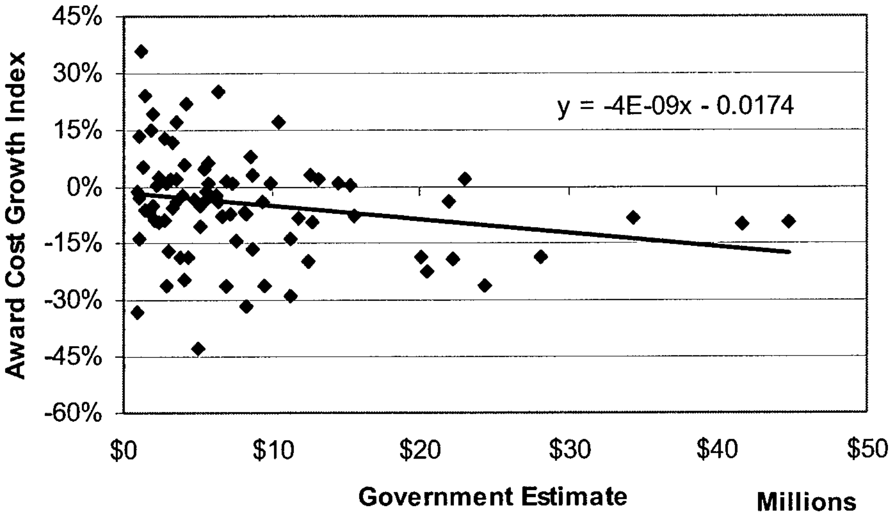


Figure 3.9: Award Cost Growth Index as a Function of the Government Estimate

Although the graphs suggest that this is true for the 84 projects analyzed within this thesis, further statistical analysis is necessary to test for the confidence level of this statement.

Table 3.5 is a summary of the t-test statistical analysis performed on the Award Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.5: Summary of t-Test for the Award Cost Growth Input Variables

| | *GE* | *ACWE* |
|---|---|---|
| Mean | 8857087 | 8123333 |
| Variance | 8.79E+13 | 6.95E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| Df | 83 | |
| t Stat | 4.368338 | |

According to the analysis, the null hypothesis must be rejected with a 99.9% significance level. Therefore, the alternative hypothesis must be accepted. This means the GE and the ACWE are not statistically similar and are therefore regarded as having different means and standard deviations. The t-test statistical analysis proves that there is a difference between the Government Estimate and the award amount of the project. Figure 3.9 graphically displays the variation between the two costs.

3.2.3.5 Final Cost Growth Index

The Final Cost Growth Index represents the percent change from the GE to the CWE. Figure 3.10 shows the frequencies of each Final Cost Growth Index. The values range from -35% to 43% with a mean of -1.1%, a median of 6%, and a mode of -7%. The standard deviation of the sample is 15%. The graph shows a very wide variance in the data and quite a few outliers.

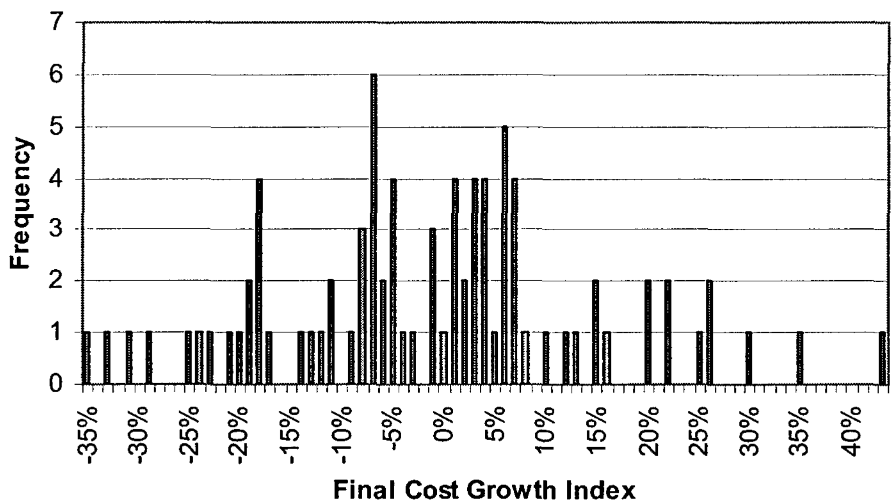


Figure 3.10: Frequency of Final Cost Growth Indices

Figure 3.11 is a graph of the variation in the Final Cost Growth Indices as a function of the GE. The graph also shows the best-fit line and the best-fit line equation for the data. For Government Estimates from $750,000 to $45,000,000, the average Final Cost Growth Index varies from 2.5% to -15.0% respectively. Again, this graph shows that higher priced projects had a larger percent decrease from the GE to the final cost. These graphs prove that the government estimators, on average, over-estimated the cost of the projects, but only by approximately 1.1%. The graphs also prove that the government estimators over-estimated more on costlier projects.

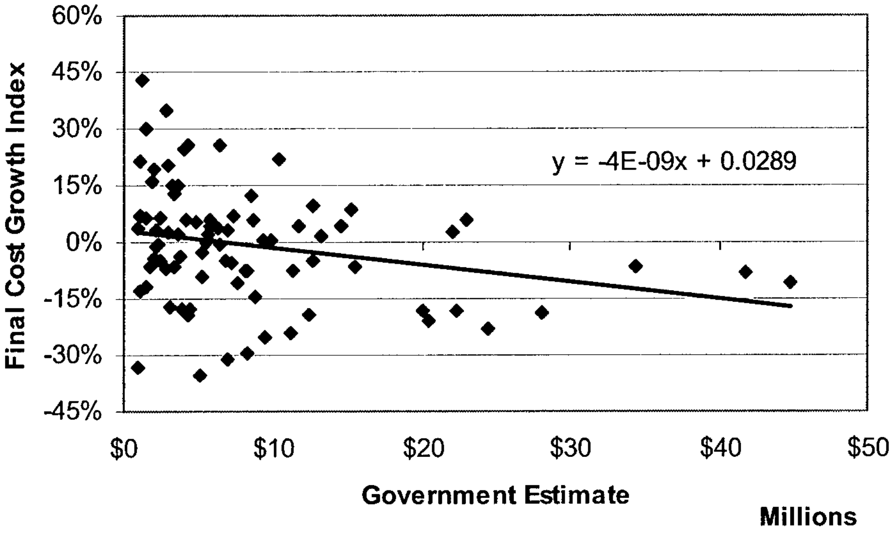


Figure 3.11: Final Cost Growth Index as a Function of the Government Estimate

Although the graphs suggest that this is true for the 84 projects analyzed within this thesis, further statistical analysis is necessary to test for the confidence level of this statement.

Table 3.6 is a summary of the t-test statistical analysis performed on the Final Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.6: Summary of t-Test for the Final Cost Growth Input Variables

| | *GE* | *CWE* |
|---|---|---|
| Mean | 8857087 | 8373453 |
| Variance | 8.79E+13 | 7.17E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| df | 83 | |
| t Stat | 2.864207 | |

According to the analysis, the null hypothesis must be rejected with a confidence level of 99%. Therefore, the alternate hypothesis must be accepted. This means the GE and the CWE are not statistically similar and are therefore regarded as having different means and standard deviations. The t-test statistical analysis proves that there is a difference between the Government Estimate and the award amount of the projects. Figure 3.11 graphically displays the difference between the two variables.

3.2.3.6 Construction Cost Growth Index

The Construction Cost Growth Index represents the percent change from the ACWE to the CWE. Figure 3.12 shows the frequencies of each Construction Cost Growth Index. The least variance, according to the 84 projects, tends to fall between the award amount and the final cost of the project. Other than one outlier, the percent change in the award to the final project cost ranged from -7% to 27% with a mean of 4.1%, median of 2%, and mode of 0%. Due to the extreme outlier, the mean is skewed to the positive side. Therefore, the median and mode are more likely to give a more correct value of the average Construction Cost Growth Index. The standard deviation of the sample is 8%.

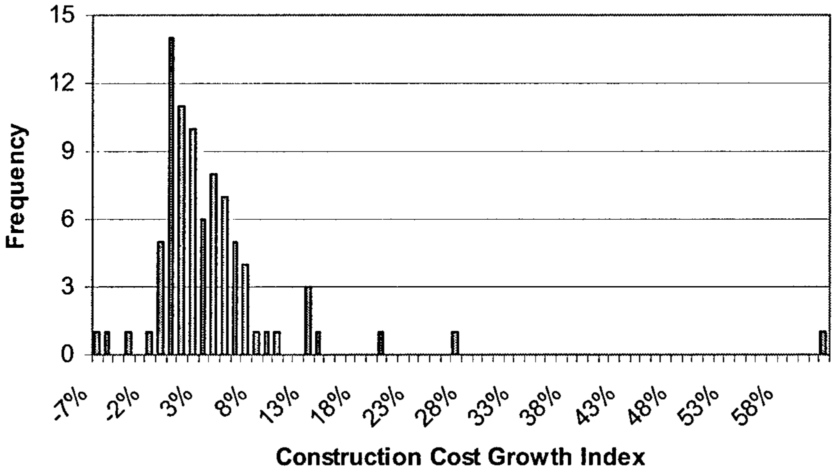


Figure 3.12: Frequency of Construction Cost Growth Indices

Figure 3.13 is a graph of the variation in the Construction Cost Growth Indices as a function of the ACWE, or the award amount. The graph also shows the best-fit line and the best-fit line equation for the data. For award amounts from $750,000 to $45,000,000, the average Construction Cost Growth Index varies from 5.0% to 1.0% respectively. This graph shows that the higher priced projects incurred lower Construction Cost Growths.

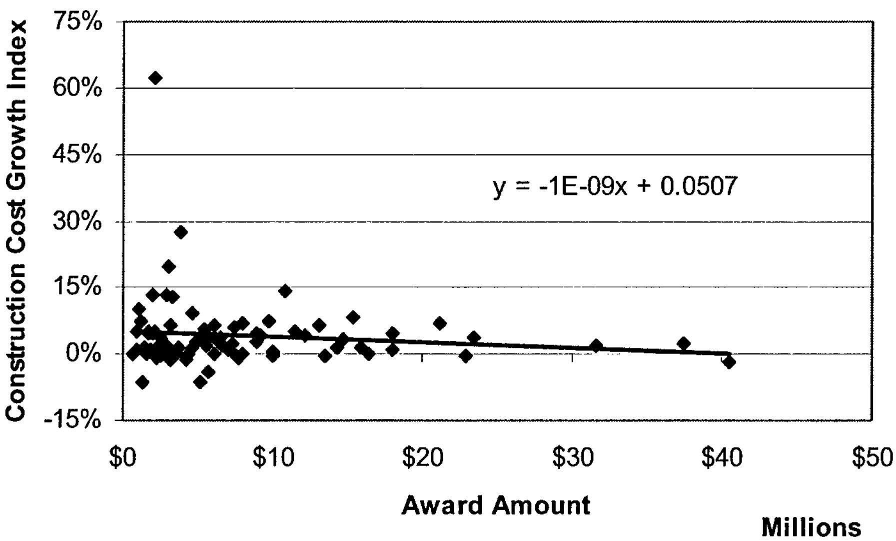


Figure 3.13: Construction Cost Growth Index as a Function of the Award Amount

The large number of Construction Cost Growth Indices less than 5% seems reasonable when compared to the MILCON process. Contractors and project personnel are aware of the 5% contingency amount allotted by Congress for unforeseen events. Therefore, if something unexpected arises, there is money to ensure that the project continues. After the 5% has been spent, it is in the best interest of the government to prevent any further changes.

Figures 3.12 and 3.13 show that no matter what the awarded price of the MILCON project, the Construction Cost Growth should not exceed the 5% allotted by Congress. Although the graphs suggest that this is true for the 84 projects analyzed within this thesis, further statistical analysis is necessary to test for the confidence level of this statement.

Table 3.7 is a summary of the t-test statistical analysis performed on the Construction Cost Growth Index variables to test whether or not they are statistically similar.

Table 3.7: Summary of t-Test for the Construction Cost Growth Input Variables

| | *ACWE* | *CWE* |
|---|---|---|
| Mean | 8123333 | 8373453 |
| Variance | 6.95E+13 | 7.17E+13 |
| Observations | 84 | 84 |
| Hypothesized Mean Difference | 0 | |
| df | 83 | |
| t Stat | -5.83684 | |

According to the analysis, the null hypothesis must be rejected with a 99.9% significance level. Therefore, the alternate hypothesis must be accepted. This means the ACWE and the CWE are not statistically similar and are therefore regarded as having different means and standard deviations. The t-test statistical analysis proves that there is a difference between the Government Estimate and the award amount of the projects. Figure 3.13 graphically shows the percent difference between the two variables.

#### 3.2.3.7 Overall Analysis of Cost Growth Indices

Overall, the "V" shape found in Figure 2.2 displays a fairly flat line from the Programmed Amount to the Government Estimate. According to statistical analysis, a Planning Cost Growth Index of approximately 0% should be true for most MILCON projects.

The second leg of the "V" shape shows an average decrease from the Government Estimate to the award amount equal to -4.6%. According to the t-test, the mean difference between the two variables is not equal to zero, which supports the idea that there is a usual decrease between them. However, the data does not provide enough evidence to prove that a -4.6% Award Cost Growth is typical for all MILCON projects. Visual observation of Figure 2.2 seems to suggest that there is usually a decrease from the Government Estimate to the award amount. However, there is quite a bit of variance within the 84 projects. In fact, the variance observed is approximately 14%.

The final leg of the "V" shape shows an average increase from the award amount to the final cost of the project equal to 4.1%. According to the t-test, the mean difference between the two variables is not equal to zero, which supports the idea that there is a usual increase between them. However, the data does not provide enough evidence to prove that a 4.1% Construction Cost Growth is typical for all MILCON projects. In fact, due to the skewed data caused by the extreme outlier, the actual average Construction Cost Growth should be somewhere around 3.4%. Figure 3.13 shows the Construction Cost Growth and how it changes according to the price of the project. The variance is low, at 8%, for the sample and can therefore be used to predict the Construction Cost Growth of future projects. This information also supports the idea that the 5% contingency supplied by Congress is sufficient to cover most changes and unforeseen situations encountered by MILCON projects from budget lock to facility completion.

Additional analysis of the Programming Cost Growth Index allowed a comparison between the smaller and larger MILCON project data sets. From this information, it was discovered that the Programming Cost Growth Indices from each were statistically similar and therefore come from the same parent population. This fact supports the idea that the information collected within the smaller data set can be used to represent the larger data pool, and therefore, all MILCON projects. This basis is used to present the following analysis of geographic location and project types.

3.2.2 Geographic Location

The second analysis of the 84 NAVFAC MILCON projects is performed by separating the data with respect to general geographic location. In this case, the analysis is based on the Engineering Field Division responsible for oversight of the project. The four Regions include Atlantic, Pacific, Southern, and Southwest. The breakdown of MILCON projects from each region is shown in Figure 3.14.

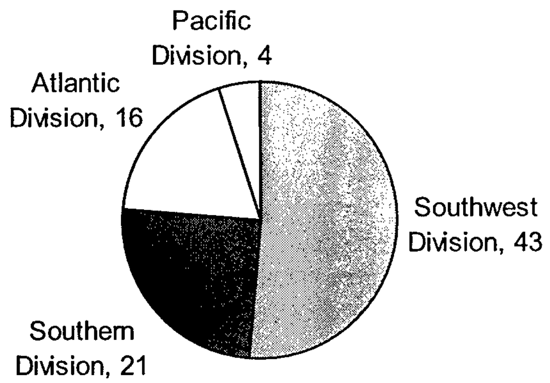


Figure 3.14: Distribution of MILCON projects within each Region

3.2.3.1 Atlantic Division

The 16 Atlantic Division MILCON projects were located within the following states: Maine, Maryland, Massachusetts, New Jersey, North Carolina, Rhode Island, and Virginia.

The Atlantic Division project estimates and actual costs as a function of project phase are displayed graphically in Figure 3.15. The average of all six Cost Growth Indices is listed in Figure 3.29. The graph visually shows the Government Estimate coming in an average of -1% below the Programmed Amount. Then, the award was made for an average of 5% over the Government Estimate (10% over the norm). The average Construction Cost Growth for MILCON projects within the Atlantic Division was 4%. In all, the Atlantic Division spent $6.6 Million, or 6.3%, over their total Programmed Amount allotted by Congress.

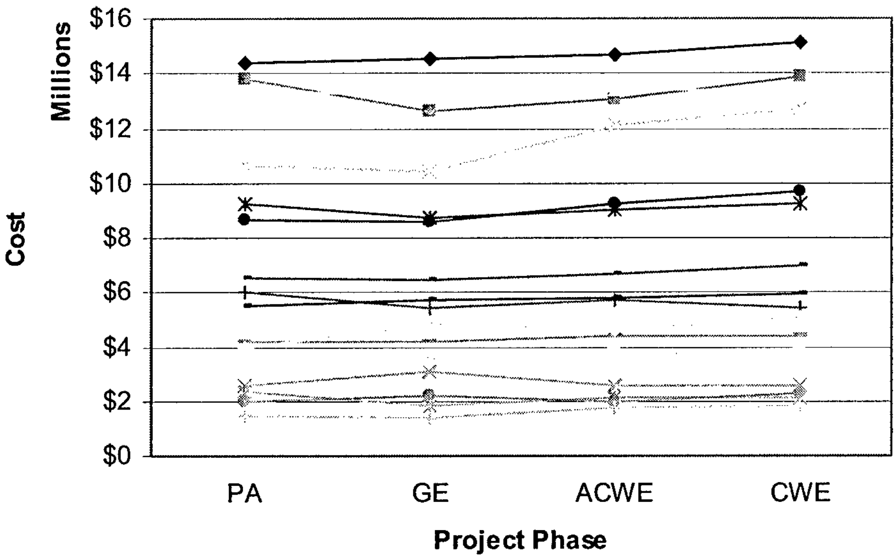


Figure 3.15: Atlantic Division Projects as a Function of Project Phase

Figure 3.16 shows the distribution of the Planning Cost Growth Indices for the Atlantic Division. Overall, their Planning Cost Growth Indices follows the 0% trend observed in Section 3.2.1.

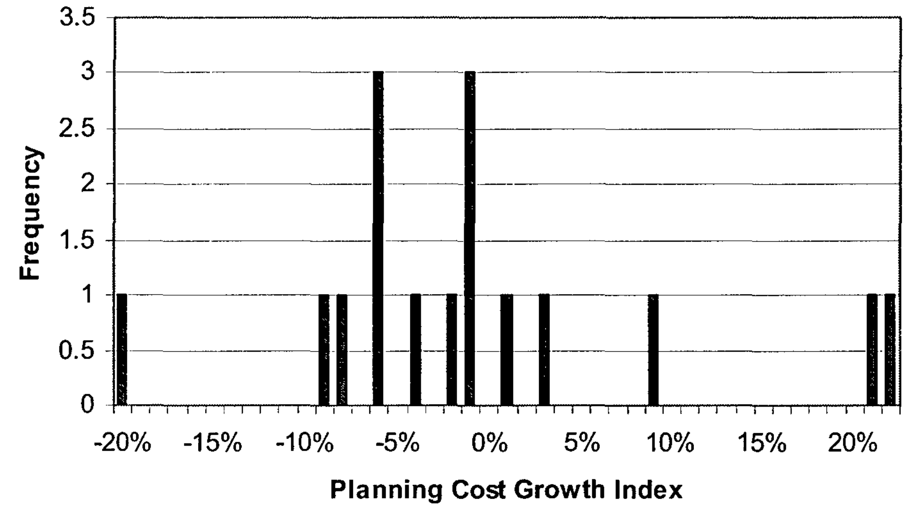


Figure 3.16: Atlantic Division Distribution of Planning Cost Growth

Figure 3.17 shows the distribution of the Construction Cost Growth Indices for the Atlantic Division. Overall, their Construction Cost Growth Index data follows the 4.1% trend observed in Section 3.2.1. In fact, only 3 projects fell outside of the norm:

- Project #17, an aircraft maintenance facility, reported a 19.8% Construction Cost Growth Index due to the change of requirements during construction leading to extremely costly change orders and redesign. Unfortunately, due to security reasons, the exact details are unavailable regarding the change of requirements.
- Project #33, which involved the renovation of an operations building, reported at 13.3% Construction Cost Growth Index because of $92,000 worth of unforeseen

requirement changes, $100,000 worth of customer requested changes, and $62,000 worth of redesign.

- Project #62, which involved airfield pavement upgrades, reported a Construction Cost Growth Index of -4.1% due to the cost savings associated with setting up a batch plant on-site and the fact that the general contractor owned most of the heavy equipment used.

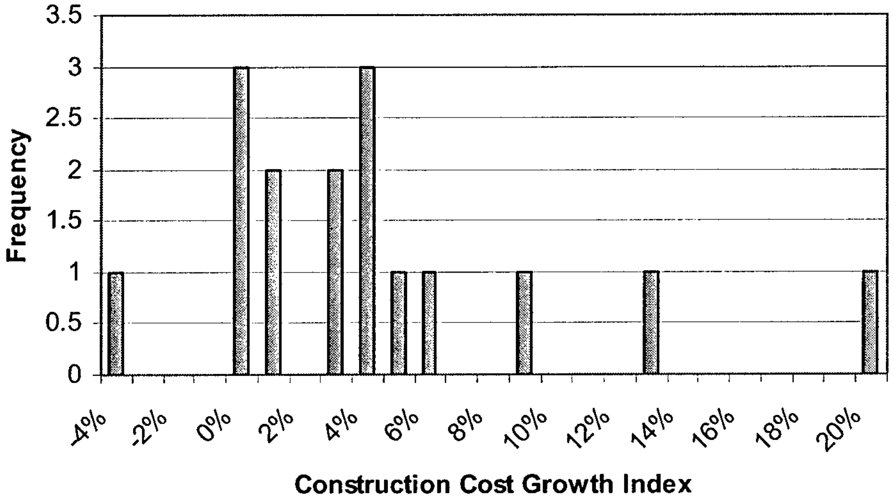


Figure 3.17: Atlantic Division Distribution of Construction Cost Growth

3.2.3.2 Pacific Division

The Pacific Division is responsible for projects in Hawaii. Due to the extremely small number of MILCON projects within the Pacific Region, a thorough analysis is very difficult to perform. In all, there were only four projects appropriated in 2001 and 2002 that have been completed. Figure 3.18 is a graphical analysis of the four projects according to project phase and Figure 3.29 provides the averages of the six Cost Growth

Indices. On average, the Government Estimates came in 9% below the Programmed Amount, the awards were made 13% below the Government Estimate, and the projects saw an average Construction Cost Growth of 5%. In all, the Pacific Division saved 10.2%, or $4.6 Million, when compared to their total allotted Programmed Amount.

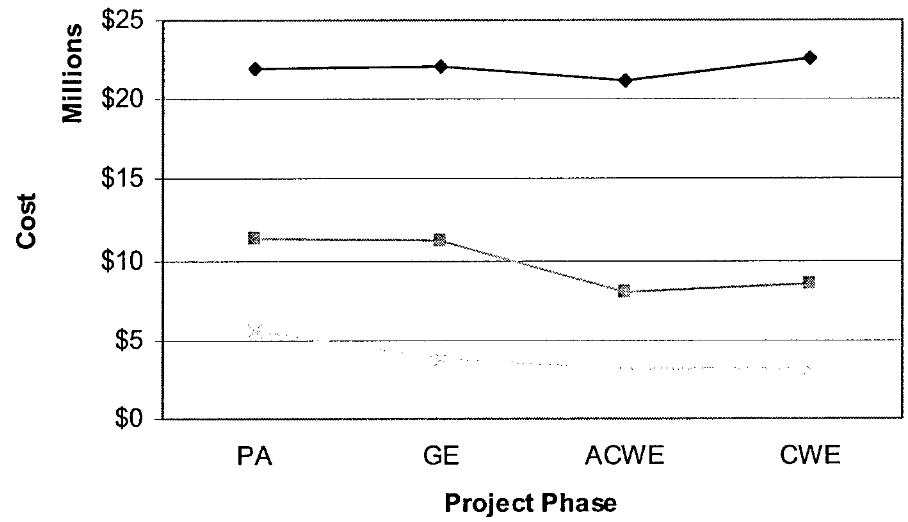


Figure 3.18: Pacific Division Projects as a Function of Project Phase

Figure 3.19 is shows the distribution of the Planning Cost Growth Indices for the Pacific Division. There was only one outlier in the data. Project #77, installation of shore power, shows a 31% decrease from the PA to the GE due to extreme scoping changes before award and reportedly good bidding climate.

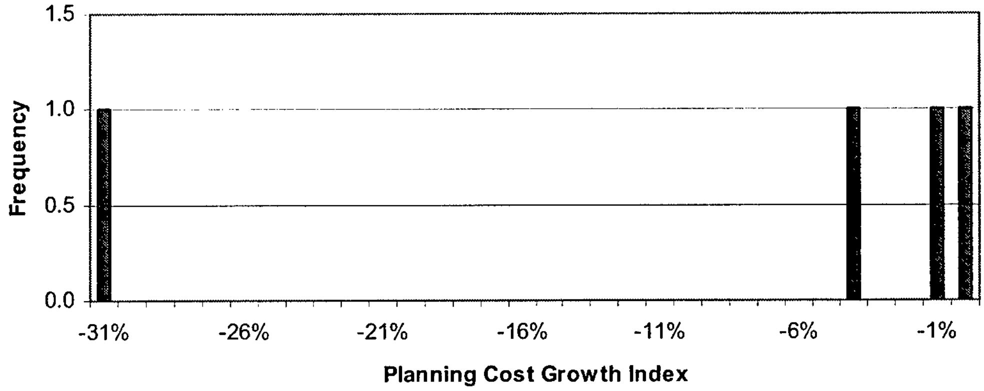


Figure 3.19: Pacific Distribution of Planning Cost Growth

Figure 3.20 shows the distribution of the Construction Cost Growth Indices for the Pacific Division. Overall, the average Construction Cost Growth came to 5%, which is close to the expected value of 4.1% from Section 3.2.1.

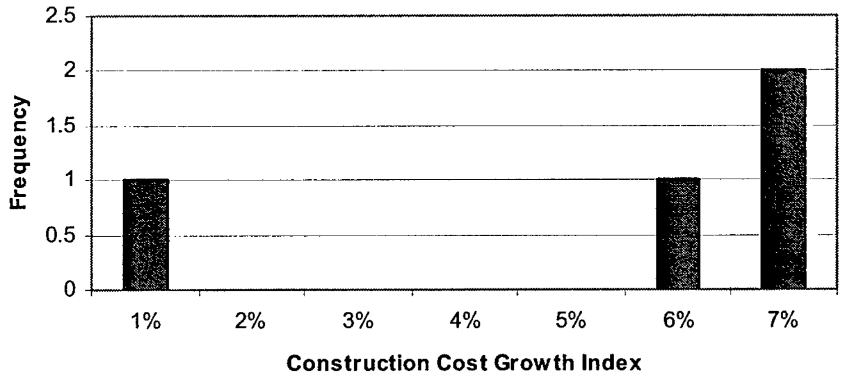


Figure 3.20: Pacific Distribution of Construction Cost Growth

3.2.3.3 Southern Division

The 21 Southern Division MILCON projects were located in the following states: Florida, Georgia, Illinois, Indiana, Louisiana, Mississippi, Missouri, Ohio, South Carolina, and Texas.

The Southern Division project data is shown graphically in Figures 3.21 and 3.22. Overall, the Government Estimates came in 1% over the Programmed Amount, the award was made for 3% below the Government Estimate, and the Construction Cost Growth average was 5%. Overall, across the entire list of 21 projects, the Southern Division spent 1.1%, or $1.6 Million, over the Programmed Amount. The six Cost Growth Indices are given in Figure 3.29.

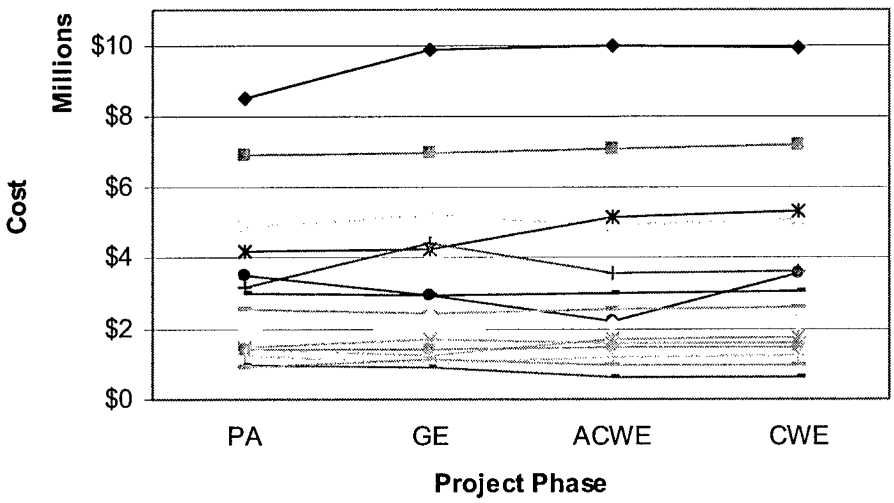


Figure 3.21: Southern Division Projects ($0 - $10 Million) as a Function of Project Phase

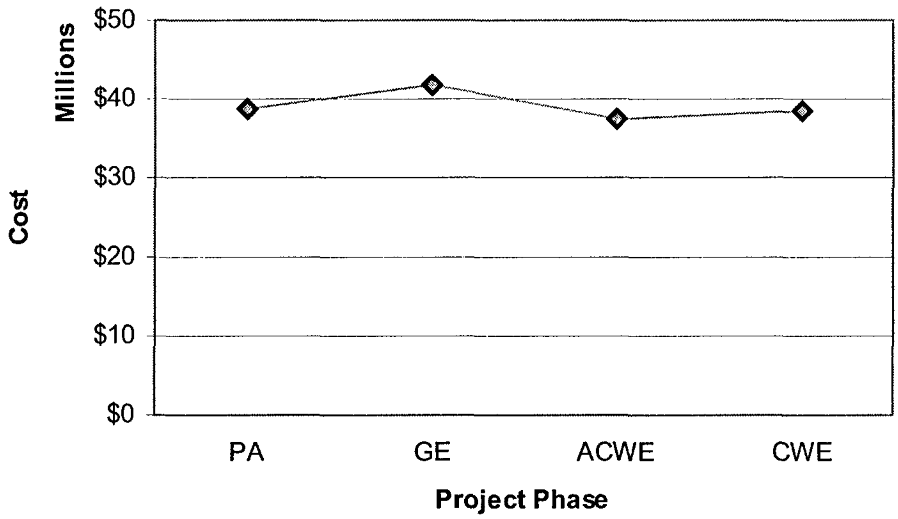


Figure 3.22: Southern Division Projects ($10 - $50 Million) as a Function of Project Phase

Figure 3.23 shows the distribution of the Planning Cost Growth Indices for the Southern Division. Overall, the average Planning Cost Growth came to 1%, which is extremely close to the 0% expected value from Section 3.2.1. The following is an explanation of two projects that fell outside of the expected range:

- Project #20, an aircraft maintenance facility, reported a Planning Cost Growth of 38.8% due to the addition of built-in furniture to the project scope and 8 modifications to the contract.
- Project #64, installation of runway lights, reported a 45.8% decrease from the PA to the GE due to the installation of a different, and less expensive, type of lighting than was originally programmed for.

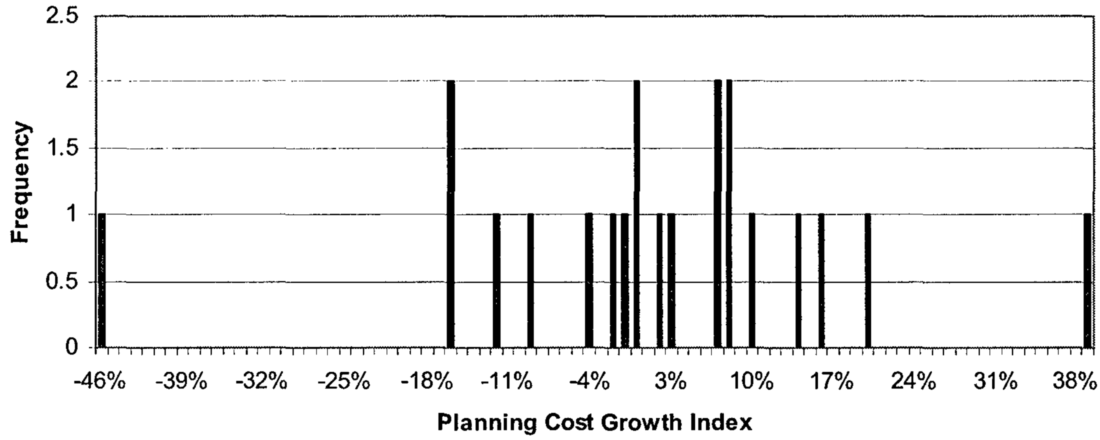


Figure 3.23: Southern Division Distribution of Planning Cost Growth

Figure 3.24 shows the distribution of the Construction Cost Growth Indices for the Southern Division. Overall, the average Construction Cost Growth came to 5%, which is close to the 4.1% expected value from Section 3.2.1. There was only one extreme outlier in the data. Project # 18 reported a 62.4% Construction Cost Growth due to a complete change in the project during the construction phase. The original project called for the renovation of one smaller aircraft hanger whereas the final project included the reconfiguration of a completely different, and much larger, aircraft hanger. Otherwise, all projects within the Southern Division fit the norm in terms of their expected Construction Cost Growth.

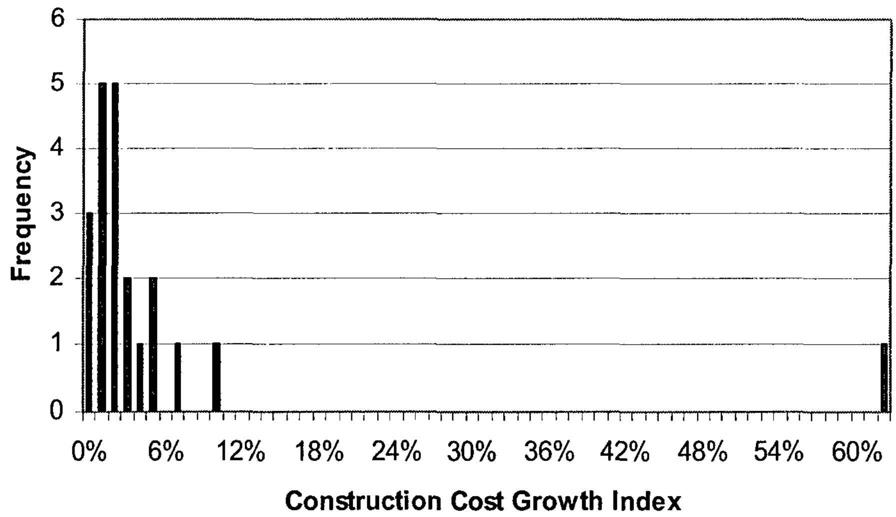


Figure 3.24: Southern Division Distribution of Construction Cost Growth

3.2.3.4 Southwest Division

The majority of the projects evaluated in this thesis came from the Southwest Division. In all, there were 43 Southwest Division MILCON projects from the following states: Arizona, California, Nevada, and Washington.

The Southwest Division data is shown graphically in Figures 3.25 and 3.26. Overall, the Government Estimates for the Southwest Division came in approximately 1% over the Programmed Amounts, the awards were made for 8% under the Government Estimates, and the Construction Cost Growths came to an average of 3%. Across the entire list of 43 projects, the Southwest Division saved 8.8%, or $38.5 Million.

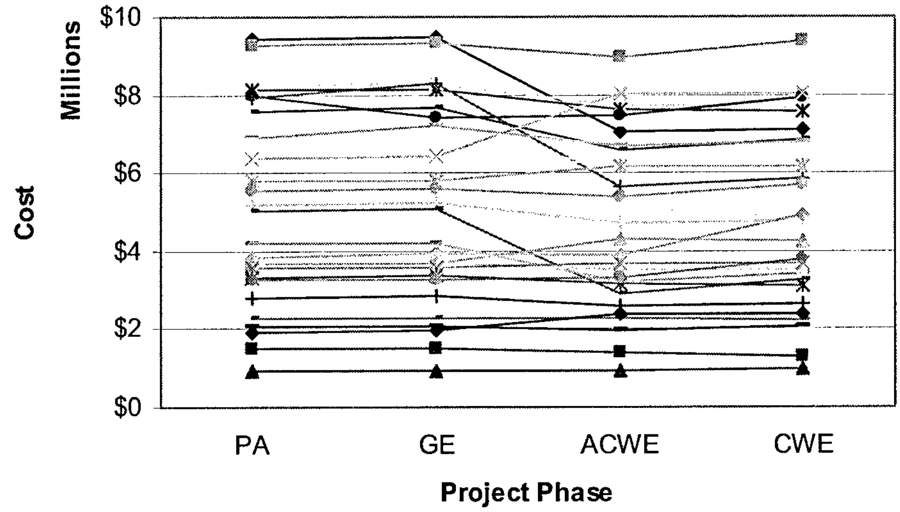


Figure 3.25: Southwest Division ($0 - $10 Million) as a Function of Project Phase

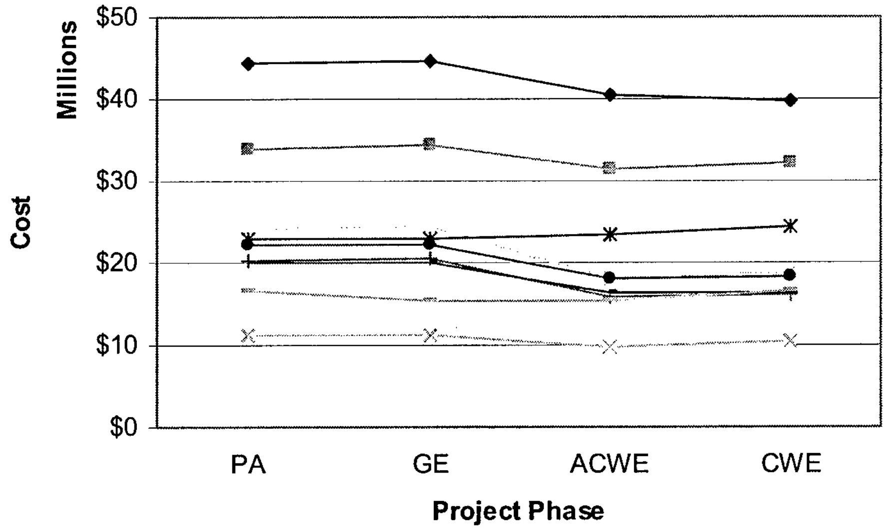


Figure 3.26: Southwest Division ($10 - $50 Million) as a Function of Project Phase

Figure 3.27 shows the distribution of the Planning Cost Growth Indices for the Southwest Division. Overall, the average Planning Cost Growth came to 1%, which is very close to the expected value of 0% found in Section 3.2.1.

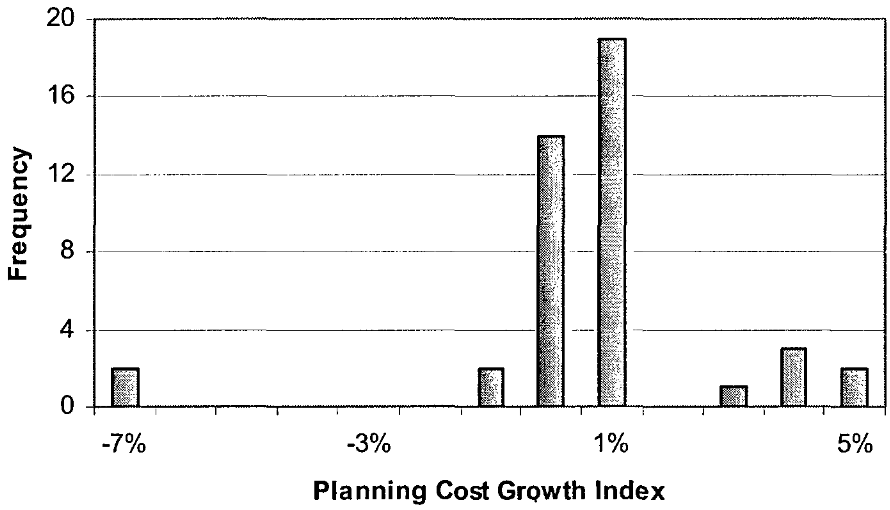


Figure 3.27: Southwest Division Distribution of Planning Cost Growth

Figure 3.28 shows the distribution of the Construction Cost Growth Indices for the Southwest Division. Overall, the average Construction Cost Growth came to 3%, which is slightly less than expected by the analysis from Section 3.2.1.

The following is a list of projects that fell outside of the normal range for the Southwest Division and the reasons the project managers attributed the Construction Cost Growth to:

- Project # 42, which included the installation of a training facility, reported a Construction Cost Growth of 27.3% due to the discovery of unexploded ordnance and erosion control problems. This caused a significant amount of regarding and re-vegetation of the site.
- Project # 44, pier improvements, reported a 14.3% Construction Cost Growth due to the unforeseen need to upgrade an electrical substation. During construction, it

was discovered that the base-wide draw was much greater than expected on the substation. Therefore, it could not handle the new demand required by the pier.

- Project #16, aircraft maintenance facility, reported a Construction Cost Growth of 12.8% due to an increase in security requirements that were not addressed until construction had begun.

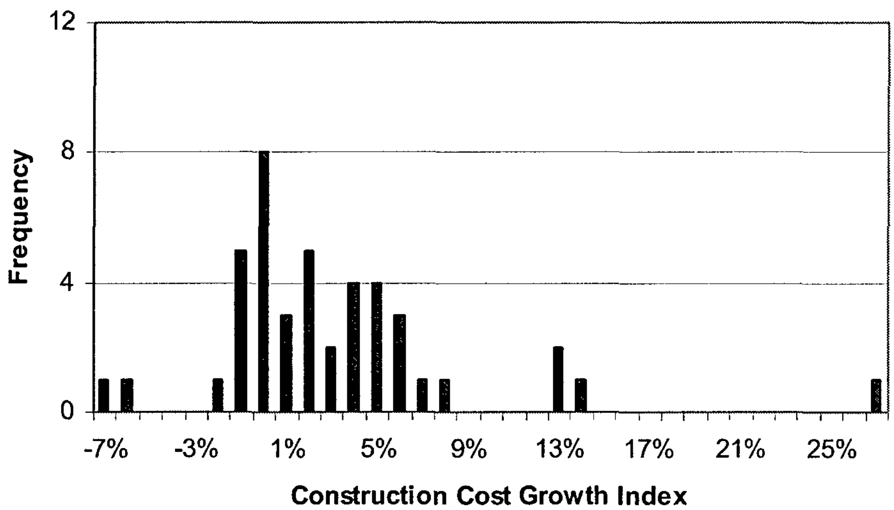

Figure 3.28: Southwest Division Distribution of Construction Cost Growth

3.2.3.5 Comparison of Divisions

The graph of Cost Growth Indices (Figure 3.29) shows the Atlantic Division falling within the normal or expected range for the Planning and Construction Cost Growths. The graph also indicates that the Atlantic Division routinely underestimates their Programmed Amounts and detailed Government Estimates by an average of 8% to 9% below actual costs. Only 3 of the 16 projects had an award or final cost lower than the Government Estimate. This information indicates that the planners' and government estimators' tools and databases used in performing estimates for the Atlantic Division are routinely under-estimating the projects. The inaccuracies could be due to a number of different factors such as unforeseen circumstances, improper projected Area Cost Factors (ACF) or escalation, insufficient designs, estimating different materials or procedures than the contractors, or human error in estimate calculations.

The graph of Cost Growth Indices (Figure 3.29) shows the Pacific Division as having a far lower final cost than the Programmed Amount and the Government Estimate. Although it is not a bad thing when costs are lower than expected, the numbers show the data used for programming and detailed estimates of electrical utilities projects in Hawaii are too high. Initial investigation into possible reasons for the drastically negative Overall and Final Cost Growth Indices leads to the idea that improper Area Cost Factors and escalation were used in estimating. Another thought was that programmers and estimators tack on, or hide, "extra" money just in case they need it since they are in a high-cost area. However, according to project personnel, there were scoping changes made before award and there were very favorable bid climates at the time of each project award. They also attribute the decreased costs for Project #74, a shore power project, to the utilization of a general contractor who was already mobilized in the area and who could perform much of the work themselves. These two facts allowed the prime contractor to reduce their mobilization and subcontractor fees and allowed them to win the contract by coming in as the low bid. Therefore, the major cause for the extremely low final costs, compared to the estimates, is due to the fact that there is an electrical contractor in Hawaii who has a strong hold of the market and can underbid all the other contractors. A more detailed analysis of costs compared to project types is made in section 3.2.2 of this thesis. The average Planning Cost Growth for the Pacific Division is equal to -9%. This is far lower than the average across the 84 MILCON projects as described in section 3.2.2.2, but is due to Project #77 that skewed the data due to extreme scoping changes before award. The average Construction Cost Growth for the Pacific Division was equal to 5% and therefore falls within the normal range for this index.

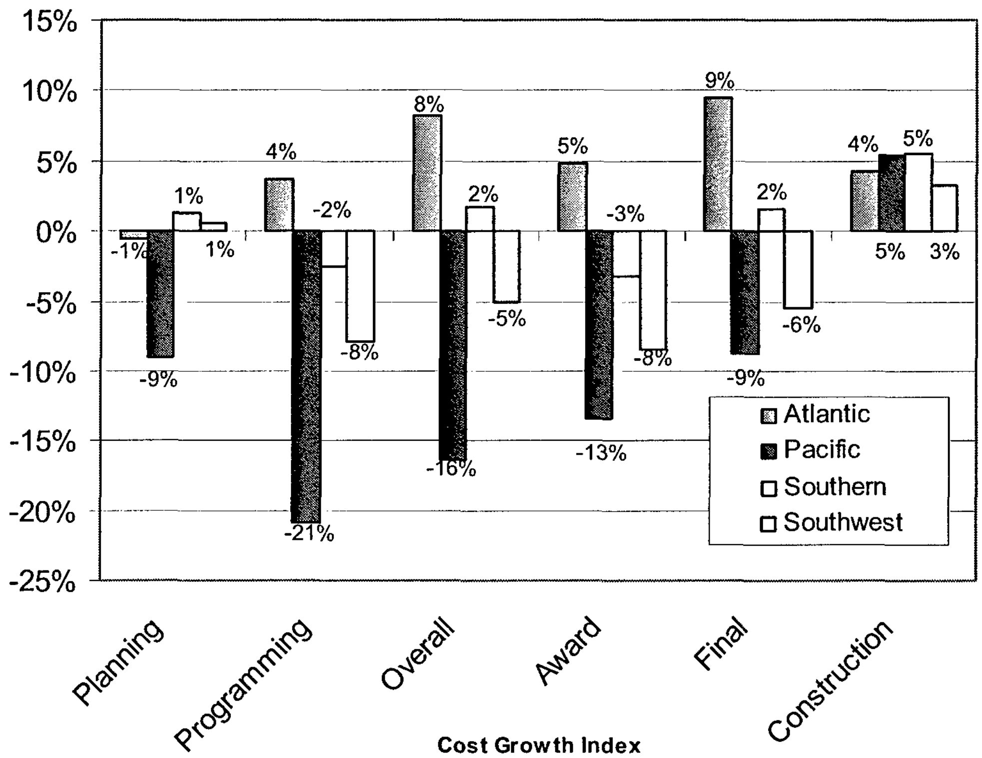


Figure 3.29: Average Cost Growth Indices per Region (84 Projects)

The Southern Division had an average of 2% increase from the PA and the GE to the CWE. Compared to the other divisions, the Southern Division seems to have the best programming and detailed estimates. The average Planning and Construction Cost Growth Indices for the Southern Division were 1% and 5% which fall near the expected values of 0% and 4.1% respectively.

The Southwest Division had an average of 5% decrease from the PA to the CWE and a 5% decrease from the GE to the CWE. This information seems to suggest that the Southwest Division over-estimates their projects. Again, the inaccuracies could be due to a number of different factors. The average Planning and Construction Cost Growths were 1% and 3% respectively, which fall near the expected values. Compared to the other divisions, the Southwest division seems to have the lowest Construction Cost Growth. This suggests that they use better cost controls or they run into less unforeseen circumstances than the other divisions.

The smaller data set, of 84 projects, suggests specific trends with respect to each region. In order investigate the extent to which these trends are seen throughout MILCON projects, it is possible to compare the Programming Cost Growth Index from the smaller data set to the same index in the larger data set.

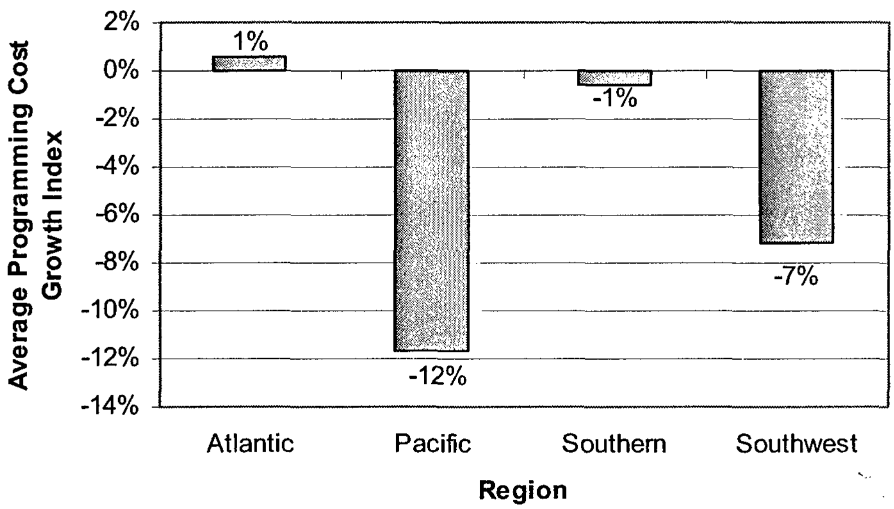


Figure 3.30: Average Programming Cost Growth Index per Region (228 Projects)

Unfortunately, the same comparison cannot be made for the other indices since the Government Estimates and final costs of the projects are unknown. Figure 3.30 is a graphical representation of the average Programming Cost Growth Index by geographical region. When compared to the smaller data set, the indices seem to mimic each other. The Atlantic Division shows a 4% increase for the smaller data set and a 1% increase for the larger data set. The Pacific Division shows a 21% decrease for the smaller data set and a 12% decrease for the larger data set. The Southern Division shows a 2% and 1% decrease respectively. And the Southwest Division shows an 8% and 7% decrease respectively. This analysis suggests that the indices from the smaller data set represent the indices found in the larger data set and, therefore, are typical of what should be expected from all MILCON projects within these regions.

The previous analysis touched slightly on possible reasons for the variations of project cost indices between the regions. However, there are many other reasons why project costs fluctuate. This thesis does not attempt to identify every possible reason why costs may increase or decrease. Further research should investigate price fluctuations due to weather, fluctuating Area Cost Factors, improper escalation, miscalculated planning and detailed estimates, and human error.

### 3.2.3 Project Type

The third analysis of the 84 MILCON projects is made by a separation of the data with respect to the general type of facility being built or upgrading. The nine project facility types are listed below. The breakdown of MILCON projects within each type is shown in Figure 3.31.

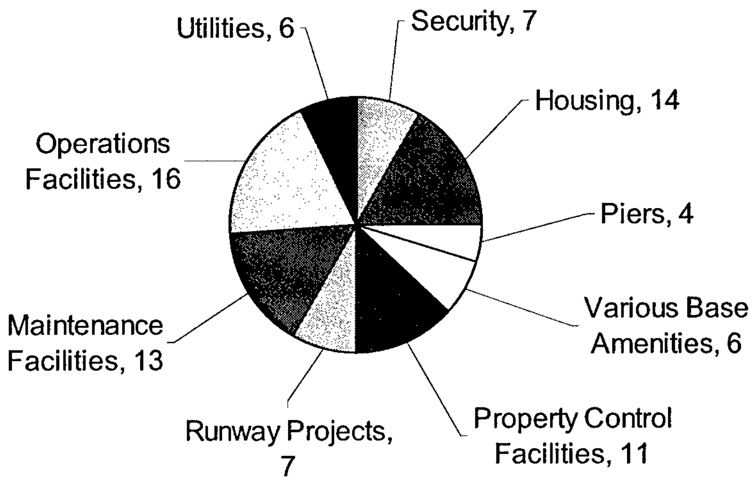


Figure 3.31: Distribution of MILCON projects within each project type

*Housing*: (14 projects) Bachelor Enlisted Quarters (BEQ), BEQ modernization, BEQ replacement, recruit barracks, and transient quarters.

*Maintenance facilities*: (13 projects) aircraft, engine, ship, and vehicle maintenance facilities.

*Operations Facilities*: (16 projects) air passenger terminals, operations towers, training and instruction facilities, Navy and Marine Corps reserve centers, and testing labs.

*Piers*: (4 projects) pier improvements, pier replacements, and berthing piers.

*Property Control Facilities*: (11 projects) armories/ordnance/ammunition facilities, hazardous material storage facilities, magazines, and warehouses.

*Runway projects*: (7 projects) lighting, aircraft parking aprons, and runway/airfield improvements.

*Security*: (7 projects) Anti-terrorism/Force-Protection (AT/FP) improvements, security support facilities, gate improvements, visitor processing centers, security fencing, and security lighting.

*Utilities*: (6 projects) shore power installations, electrical upgrades, sewer line replacements, water treatment facility upgrades, water tanks, and sewage treatment plants.

*Various Other Base Facilities*: (6 projects) bridge replacements, cut/fill disposal areas, dental clinics, fire stations, fitness centers, galleys, museums, child development centers, churches, and recreational facilities.

Table 3.8 is the breakdown of the Average Planning and Construction Cost Growth Indices according to each facility type. None of the values listed are outside of the mean and standard deviation found in Section 3.2.1 of this thesis. However, the following analysis may uncover additional trends in the data according to facility type.

Table 3.8: Average Planning, Award, and Construction Cost Growth Indices by Facility Type

| Facility Type | Average Planning Cost Growth Index | Average Award Cost Growth Index | Average Construction Cost Growth Index |
|---|---|---|---|
| Housing | 1.6% | -11.7% | 2.0% |
| Maintenance Facilities | 1.4% | -8.8% | 11.2% |
| Operations Facilities | 1.3% | -2.7% | 4.4% |
| Piers | -1.5% | -3.6% | 7.1% |
| Property Control Facilities | 1.9% | 0.9% | 3.1% |
| Runway Projects | -4.2% | -8.1% | 2.2% |
| Security | 3.0% | 0.2% | -0.2% |
| Utilities | -5.9% | -5.4% | 2.0% |
| Various Other Base Facilities | -3.7% | 1.3% | 3.3% |
| **Average** | **-0.7%** | **-4.2%** | **3.9%** |

3.2.3.1 Housing

Figure 3.32 is a graphical representation of the 14 housing projects examined in this thesis. In general, it is expected that housing projects would be the easiest to estimate since there are so many prior examples to work from. Additionally, the Navy's housing projects are comparable to the Army's and Air Forces' and even civilian hotels. According to Figure 3.32, the projects tend to follow the expected MILCON growth indices. The projects display only a 1.6% increase from the Programmed Amount to the Government Estimate and only a 2% increase from the award amount to the final cost of the project. However, there is a large decrease (-11.7% Award Cost Growth) from the GE to the ACWE. This seems to suggest that the Navy over estimates both its programming and detailed estimates for housing projects, more so than any other type of project.

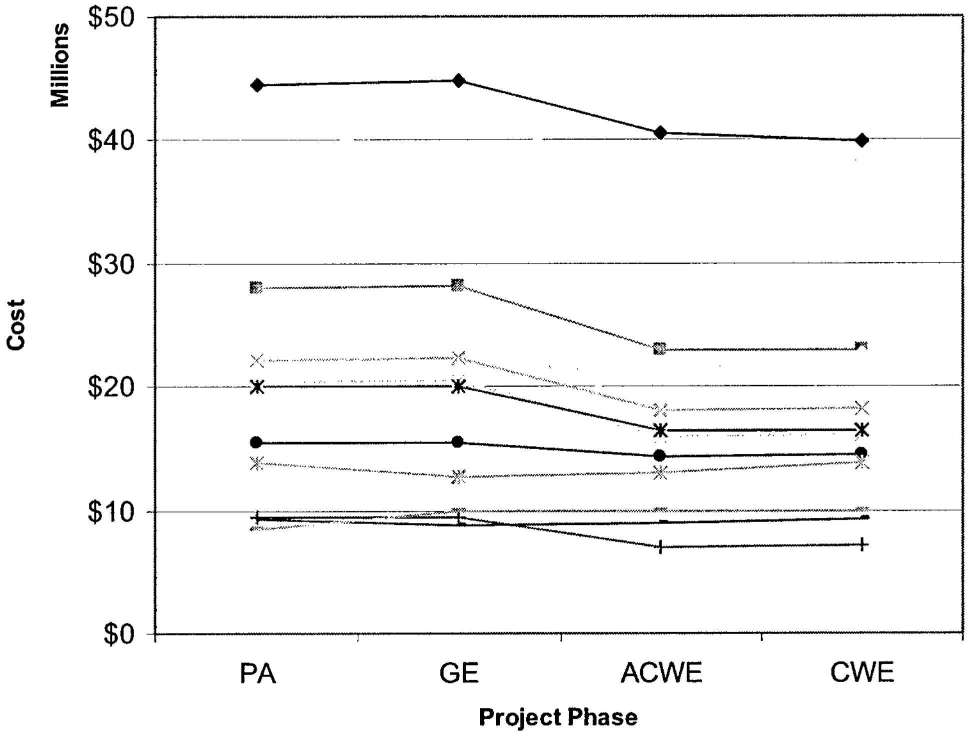


Figure 3.32: Estimates and Costs of Housing Projects

3.2.3.2 Maintenance Facilities

Figure 3.33 displays the 13 maintenance facility projects analyzed in this thesis according to their project phases. The maintenance facilities recorded an average Planning Cost Growth of 1.4% and a decrease in the Award Cost Growth, as expected. The interesting data regarding maintenance facilities is the 11.2% Construction Cost Growth Index, whereas only a maximum of 5% is expected for MILCON projects. The average Construction Cost Growth Index for maintenance facilities is the highest of all types of projects.

This fact is due to three projects in particular:

- Project #18 reported a 62.4% Construction Cost Growth due to a complete change in the project during the construction phase. The original project had previously called for the renovation of a smaller aircraft hanger whereas the final project turned into the reconfiguration of a completely different, and much larger, aircraft hanger. This extreme outlier has a very large effect on the data and skews it far to the right, or positive direction.
- Project, #17, also an aircraft maintenance facility, reported a high Construction Cost Growth of 19.8% as described in Section 3.2.2.1, due to very costly changes in requirements during construction.
- Project #16, another aircraft maintenance facility, reported a 12.8% Construction Cost Growth due to increased security requirements.

Overall, the Construction Cost Growth Index average for maintenance facilities is much higher than the expected range according to Section 3.2.1. This information seems to suggest that not enough pre-project planning is taking place on maintenance facilities, and aircraft hangar projects in particular. Unfortunately, due to security reasons, the exact change of equipment and requirements is not allowed to be released. The only information that can be extracted from these case studies is that aircraft maintenance hangars require additional thought and planning prior to construction in order to decrease the cost of changes. "Experienced managers agree the time to achieve savings and reduce changes is in the early life of the project, not at the start of construction" (Oberlender 2000).

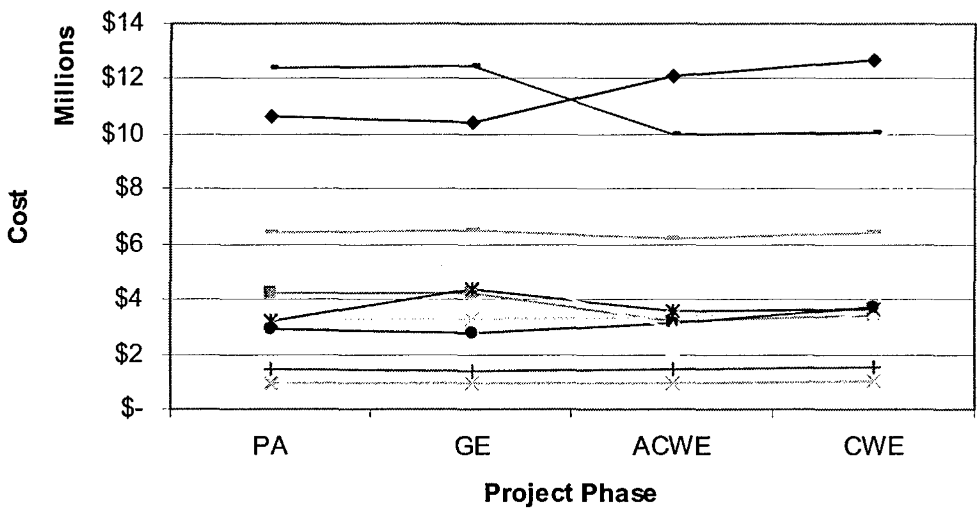


Figure 3.33: Estimates and Costs of Maintenance Facility Projects

3.2.3.3 Operations Facilities

Figure 3.34 shows the 16 operations facilities' costs as a function of project phase. Overall, the data seems to mimic what is expected from the previous analysis in Section 3.2.1. There were only 2 projects out of 16 that did not fit the norm. Project #42, which included the construction of a training facility, saw a 27.3% Construction Cost Growth due to the discovery of unexploded ordnance and erosion control problems. And, Project #33, the renovation of an operations building, saw a Construction Cost Growth of 13.3% due to the need for unforeseen changes, customer requested changes, and redesign.

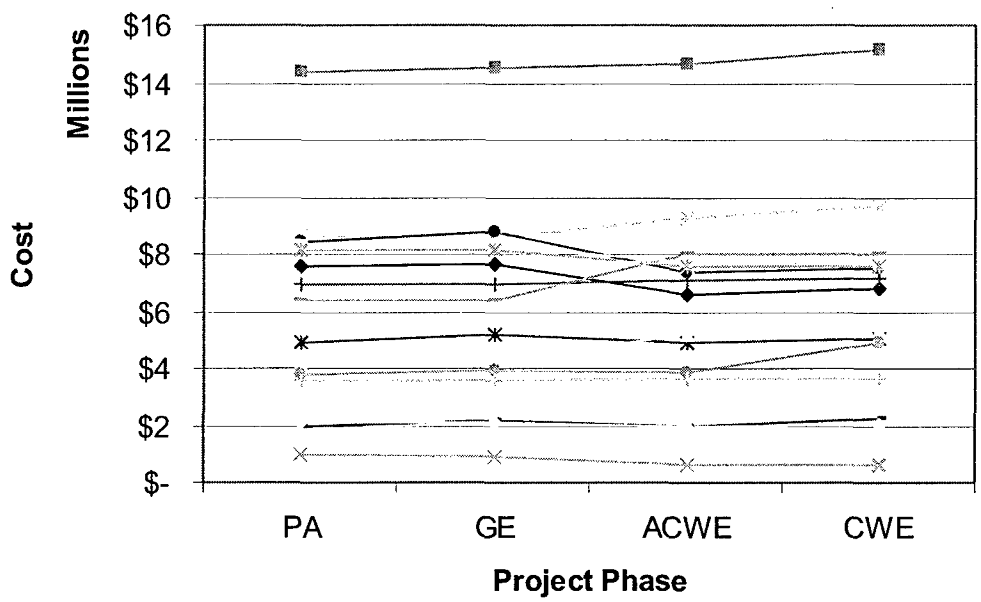


Figure 3.34: Estimates and Costs of Operations Facility Projects

Overall, most projects within this category followed the expected trends for MILCON projects. For example, project #29, a training facility, reported Planning, Award, and Construction Cost Growths of 0.8%, 1%, and 3.2% respectively. When asked, the Project Manager accounted for the "ideal" conditions by stating that they had "a good market, good contractors, no major changes, and very few unforeseen problems."

3.2.3.4 Piers

Figure 3.35 is the graphical representation of the estimates and costs for the pier projects as a function of project phase. There were only 4 projects within this category and all were located in the Southwest Division. In fact, until recently, there were not enough pier projects listed within the HII database to allow the forecasting of costs. The pier projects reported indices within the expected ranges, but displayed a slightly higher than expected average Construction Cost Growth due to one project in particular. Project # 44, pier improvements, reported a 14.3% Construction Cost Growth due to the need to upgrade the electrical distribution system. This requirement was not identified until after the award.

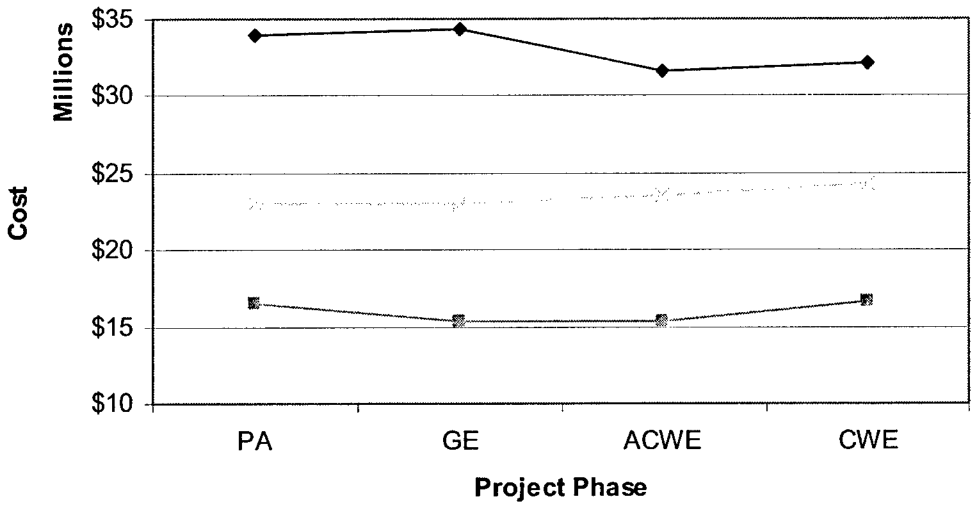


Figure 3.35: Estimates and Costs of Pier Projects

3.2.3.5 Property Control Facilities

Figure 3.36 is the graphical representation of the estimates and costs for the property control facility projects as a function of project phase. There were 11 projects within this category.

According to Table 3.8, these types of facilities indices' fall into the normal range of what is expected for MILCON projects. A Property Control Facility, which is a fancy name for a warehouse, is the most basic type of facility the Navy or any military service acquires at the MILCON level. Due to this fact, it is expected that this type of facility be the easiest to estimate both in long-range planning and detailed estimating.

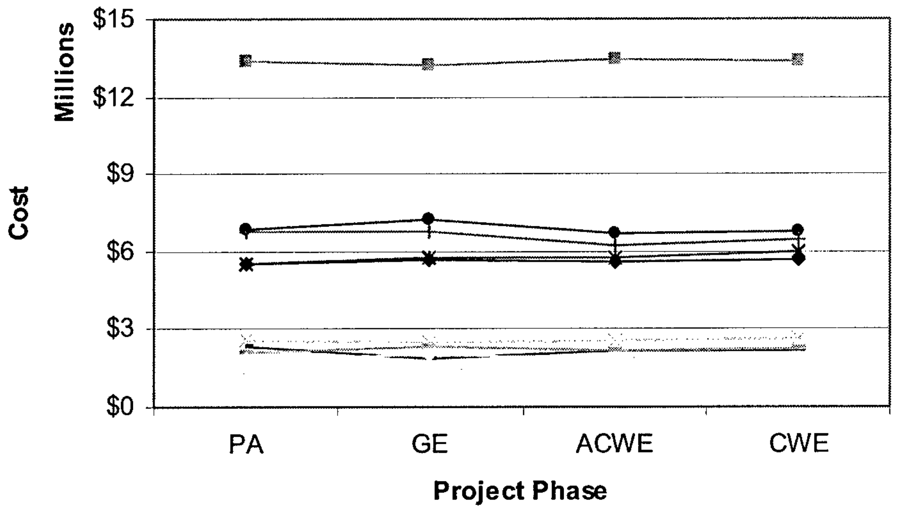


Figure 3.36: Estimates and Costs of Warehouse Facility Projects

3.2.3.6 Runway Projects

Figure 3.37 is the graphical representation of the estimates and costs for the runway projects as a function of project phase. There were a total of 7 projects within this category. The average Planning, Award, and Construction Cost Growth Indices for this category were all below the norm. This suggests that these types of projects are over-estimated.

Project #64, in particular, displayed a 45.8% decrease in the Planning Cost Growth due to the installation of a different type of runway lighting than was originally programmed for, as described previously in Section 3.2.2.3. The 1391 for this project was based on the replacement of the same (existing) runway lighting. During the design phase, a new and improved lighting system was identified for use instead. The new lighting required less electrical equipment, cabling, and duct work, resulting in lowered costs. It also required a significantly smaller building (vault) and used less energy. The final cost came out lower than the Programmed Amount set aside for the project years beforehand even though a redesign was necessary to accommodate the new lighting system.

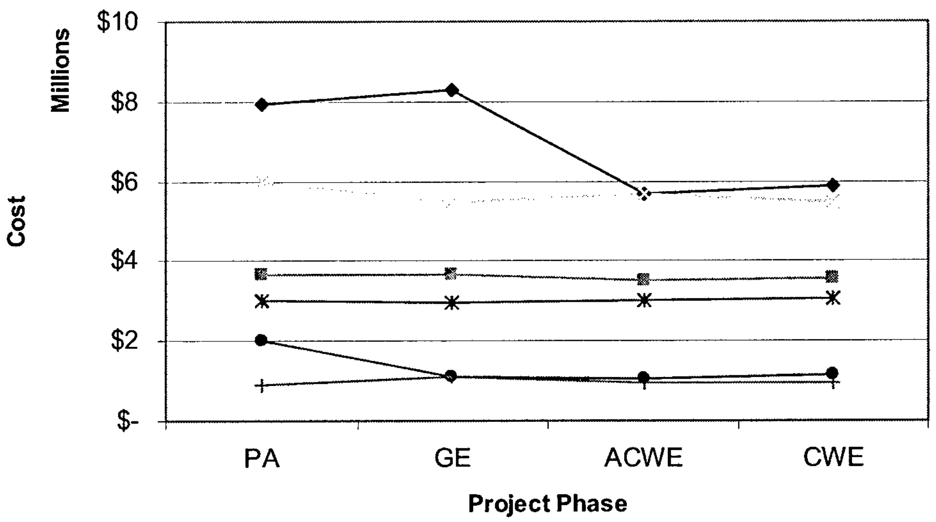


Figure 3.37: Estimates and Costs of Runway Projects

3.2.3.7 Security

Figure 3.38 is the graphical representation of the estimates and costs for the security projects as a function of project phase. There were a total of 7 projects within this category. Security projects recorded the highest average Planning Cost Growth Index, at 3%, and the lowest average Construction Cost Growth Index, at -0.2%.

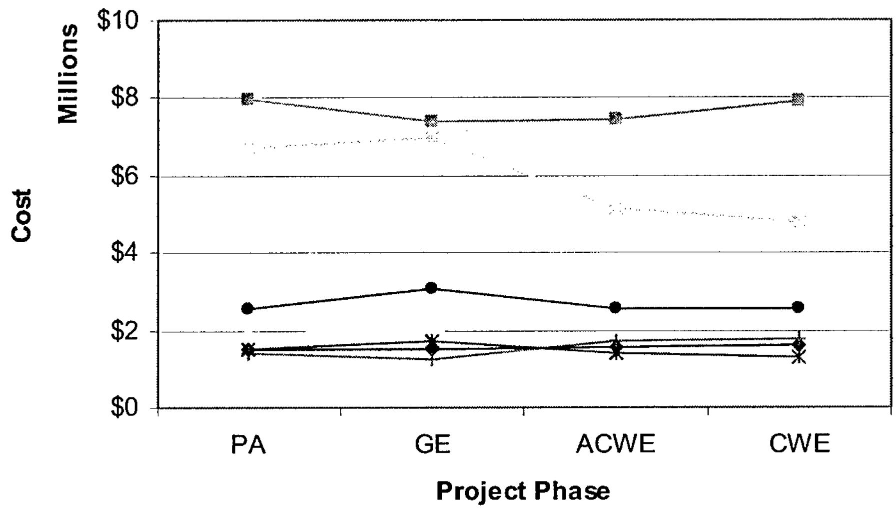


Figure 3.38: Estimates and Costs of Security Projects

This information seems to suggest that the proper pre-project planning took place between the programming and the detailed estimates. This would account for the extremely low average Construction Cost Growth for security projects.

3.2.3.8 Utilities

Figure 3.39 is the graphical representation of the estimates and costs for the utilities projects as a function of project phase. There were a total of 6 projects within this category. Utilities projects recorded the most negative Planning Cost Growth out of all the project types, at -5.9%. Additionally, utilities projects reported another decrease from the Government Estimate to the award amount. This seems to suggest, once again, that these types of projects are overestimated on a regular basis.

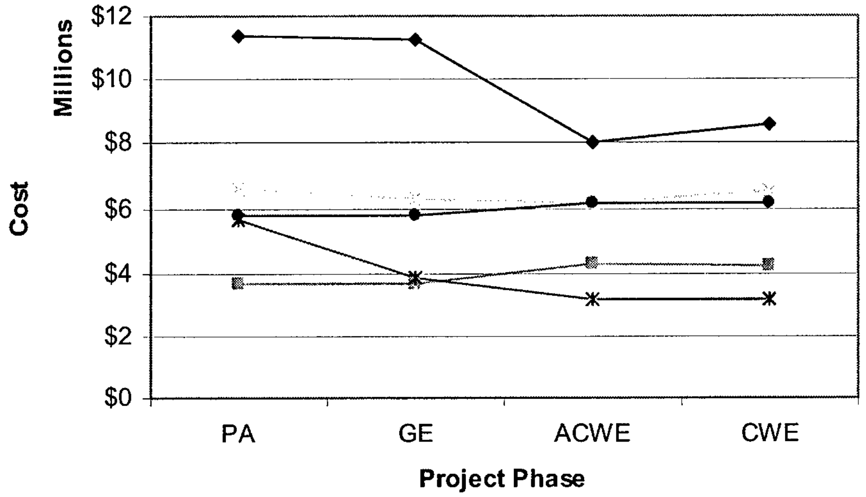


Figure 3.39: Estimates and Costs of Utilities Projects

3.2.3.9 Various Other Base Facilities

Figure 3.40 is the graphical representation of the estimates and costs for the various other base facility projects as a function of project phase. There were a total of 6 projects within this category. Overall, the trends observed in this category follow the expected MILCON indices.

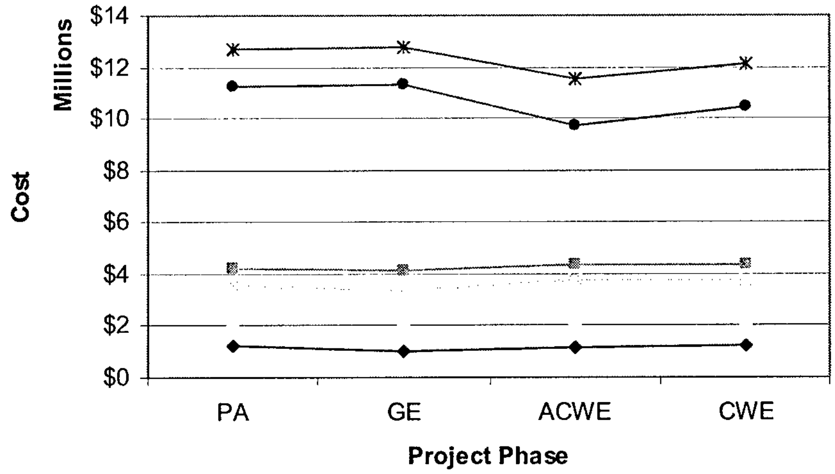


Figure 3.40: Estimates and Costs of Various Other Base Facility Projects

3.2.3.10 Comparison of Project Types

Figure 3.41 shows the average Programming Cost Growth Indices for both the small and large data sets found in Appendix A and B. According to this figure, the average Programming Cost Growth Indices for each project type follow the same trends in both the large and small data sets. Again, this comparison shows how the smaller data set can be used to represent the larger data set and, therefore all MILCON projects.

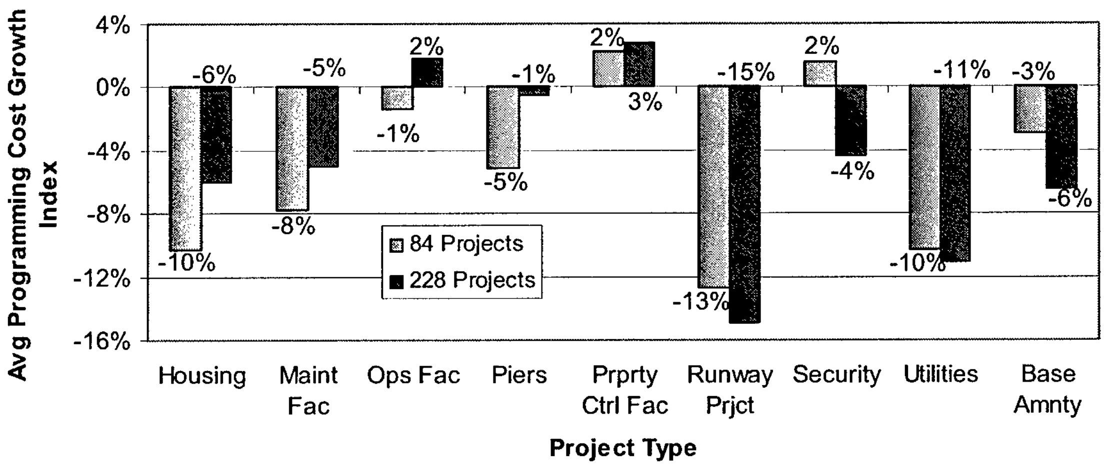


Figure 3.41: Comparison of Average Programming Cost Growth Index for Both Small (84 Projects) and Large (228 Projects) Data Sets

In general, housing, maintenance, runway, and utilities projects were all overestimated in both their programming and detailed estimates. However, the maintenance facilities then required major changes during construction which cost a great deal more than if the changes had been made earlier in the project lifecycle.

The operations, property control, security, and various other facilities were all fairly ideal in their indices. Security projects, in particular, displayed the greatest change between the PA and the GE and a very slight increase (0.2%) in their Construction Cost Growth. This suggests that the proper pre-project planning took place and produced the lowest average Construction Cost Growth Index of all project types.

# Chapter 4: Conclusions

## 4.1 Findings

The purpose of this thesis was to identify undeniable trends in MILCON project data in an effort to find reasons for why all projects do not follow the trends and possible ways of correcting this. The first analysis was done through the calculation of various project cost indices. The second analysis was done through a division of the projects by geographic location. Finally, the third analysis was done through a division of the projects by type. The following is a summary of the findings.

### 4.1.1 Project Index Findings

According to the 84 completed projects, a 0% Planning Cost Growth Index is expected for all MILCON projects. This was proven using a t-test between the Programmed Amount and the Government Estimate. The results concluded that the two estimates had approximately the same mean and standard deviation and therefore come from the same parent population. This finding matches the idea that the Government Estimators do not estimate around the project. Rather, they estimate the project around the Programmed Amount.

The Programming Cost Growth Index yielded a mean of 5% and a median of -3% from the Programmed Amount to the Award Amount. It was found that higher priced projects resulted in a lower Programming Cost Growth. However, there was not enough statistical evidence to prove the exact percent that should be expected for all MILCON projects without further analysis. Project data for an additional 144 awarded MILCON projects was compared to the original 84 completed MILCON projects to see if their Programming Cost Growth Indices were statistically similar. The t-test proved that they do, in fact, have similar means and standard deviations and therefore come from the same parent population. According to this test, the average Programming Cost Growth for all MILCON projects is expected to be near -2.2%. This means that the HII database and other long-term estimators are very accurate in predicting the award amount of the projects.

The average Overall Cost Growth Index across the 84 completed projects was found to be -1.4%. However, there was not enough statistical evidence to prove that this is standard for all MILCON projects. From graphical analysis, it was discovered that the higher priced projects reported a more negative Overall Coat Growth Index. This means that the HII database and other long-range estimating tools slightly overestimated the price of MILCON projects (more so on expensive projects greater than $10 Million).

The average Award Cost Growth Index was found to be -4.9%. Once again, there was not enough statistical evidence to prove that this is standard for all MILCON projects. However, from graphical analysis, it was found that most projects (63%) reported a negative Award Cost Growth Index and higher priced projects reported a more negative Award Cost Growth Index than lower priced projects. This means that the detailed government estimators and the tools they use tend to overestimate MILCON projects (more so on larger projects greater than $10 Million).

The average Final Cost Growth Index was found to e -1.1%. There was not enough statistical evidence to prove that this percent is standard for all MILCON projects. Graphical analysis does indicate that higher priced projects resulted in a more negative Final Cost Growth Index. Again, this means that the detailed government estimators and the tools they use tend to slightly overestimate MILCON projects.

The average Construction Cost Growth Index was found to be 4.1%. There was not enough statistical evidence to prove that this percent is standard for all MILCON projects. However, the analysis does indicate that the Construction Cost Growth Index is almost always positive and less than 5%. This coincides with the idea that the contractor and project team members all know they are allotted only 5% contingency. This means they are willing to accept changes up to that amount, but reluctant to go beyond. Since 73% of the MILCON projects within this thesis fall below the 5% limit, this leads to the conclusion that the contingency amount set aside by Congress is a reasonable and sufficient amount to account for unexpected and unforeseen costs from the budget lock to the facility completion.

### 4.1.2 Project Location Findings

The Atlantic Division's Planning and Construction Cost Growth Indices fell within the expected range. However, it was discovered that their planners and government estimators routinely underestimate the PA and GE by approximately 9% below actual costs.

The Pacific Division displayed a -9% Planning Cost Growth Index due to scoping changes made before award. Additionally, final costs were far below the estimates due to a favorable bid climate during award. The average Construction Cost Growth for the Pacific Division was 5% which fell within the expected range for this index.

The Southern Division displayed an average increase of 2% from the PA and the GE to the CWE. Compared to the other divisions, the Southern Division has the best programming and detailed estimates. The average Planning and Construction Cost Growth Indices for the Southern Division fell within the normal, or expected, ranges.

The Southwest Division displayed an average 5% decrease from the PA to the CWE and a 5% decrease from the GE to the CWE. This information shows that the Southwest Division overestimates their MILCON projects. The average Planning and Construction Cost Growths fell near the expected ranges for these indices. Compared to the other divisions, the Southwest division has the lowest Construction Cost Growth. This means they use better cost controls and run into less unforeseen circumstances than the other divisions.

An overall analysis of the Programming Cost Growth Indices for each region using both the small (84 completed MILCON projects) and large (228 awarded MILCON projects) data sets shows the similarities between them. This analysis confirms that the indices from the smaller data set represent the indices found in the larger data set and, therefore, are typical of what should be expected from all MILCON projects within these regions.

### 4.1.3 Project Type Findings

Overall, the housing, maintenance, runway, and utilities projects were overestimated. In addition, the aircraft maintenance facilities produced too many changes after award and resulted in extremely high Construction Cost Growths.

The operations, property control, security, and various other facilities projects produced the expected average indices. Security projects, in particular, displayed cost growth indices which suggest the proper pre-project planning took place and produced an extremely low average Construction Cost Growth Index.

## 4.2 Perceptions

The following is a list of perceptions and suggestions based upon the findings of this thesis. Further ideas for their implementation are presented in Chapter 5.

- The MILCON process needs to incorporate various incentives to encourage lower programming and detailed estimates. In particular, the government estimators need to have incentives to estimate around the actual project requirements rather than the Programmed Amount.
- The Historical Cost Analysis Generator, HII, and other long-range planning tools used by NAVFAC are very good at forecasting actual costs. The use of such tools should be encouraged throughout the tri-services.
- Government estimators overestimate MILCON projects on a regular basis. However, this is to be expected based on the current workings of the system and

cannot be changed without altering laws. Additionally, the MILCON process is self-leveling and therefore produces the necessary results.

- The 5% contingency set aside by Congress is a reasonable and sufficient amount to assist with unforeseen circumstances.
- The Southern Division has the best programming and detailed estimates. Their estimating practices should be evaluated and presented to the other divisions.
- The Southwest Division overestimates their projects, but has the lowest Construction Cost Growth. Their cost control techniques should be evaluated and presented to the other divisions.
- Aircraft Hangar Maintenance Facility projects require much more pre-project planning than is currently being performed.

# Chapter 5: Recommendations

## 5.1 Possible Solutions

From the research performed within this thesis, suggestions for improving the MILCON process have been made. These suggestions will not only decrease costs, but can also assist in creating a more accurate, predictable, and reliable MILCON system.

The following is a list of ways to implement the suggestion presented in Section 4.2 of this thesis.

The first suggestion for improving the MILCON process is to add incentives to keep costs low. Currently, money not spent on a project can be recalled by Congress for re-allocation to other MILCON projects. The MILCON process should be changed to automatically allow the divisions to self-allocate a percentage of any savings within their own divisions. For example, if a MILCON project only costs 90% of the PA, then only 5% could be recalled by Congress and the other 5% could be re-allocated to another MILCON project within that region if needed. This type of change would encourage the divisions to perform detailed designs and estimates around the needed project, rather than the amount of money they have to work with. Additionally, it will assist in lowering the Construction Cost Growth of MILCON projects.

Another finding and suggestion from this thesis is that the Historical Cost Analysis Generator (HII) and other long-range planning tools used by NAVFAC are very effective in projecting actual costs and should therefore be kept in use and up to date. It is important that all MILCON data for the tri-services be entered into these databases in a timely manner to facilitate the most accurate cost estimates possible. There will always be individuals and offices that refuse to input such information into these databases. Therefore, their use should be considered mandatory and enforced by the tri-services.

Another observation made through the analysis within this thesis is that the 5% contingency amount set aside by Congress is sufficient to cover unforeseen circumstances. However, the average Construction Cost Growth is only 4.1%. This suggests that if the contingency amount were reduced to 4%, it may be possible to encourage an even lower average Construction Cost Growth Index in future projects.

Through the analysis of the four NAVFAC divisions, it was discovered that the Southern Division had the best programming and detailed estimates, while the Southwest Division had the lowest Construction Cost Growth Index. This suggests that these divisions' practices should be evaluated and presented to the other divisions. While each division is presented with similar tools, it is best to evaluate those that are actually being used and their usefulness. Without a feedback loop, past experience and knowledge will be lost.

According to NAVFAC, because the Southern Division has shown the best track record for cost estimating, they have been designated as the "Chair" on a new Cost Consistency Review Board. The review board began in the fall of 2004 and is composed of the lead cost estimating experts at each of the Divisions and Headquarters. The purpose of the board is to ensure "like facilities are being estimated in a similar manner using similar cost estimating tools, correct historical cost data, appropriate area cost factors, and reasonable judgment where unique requirements or unknowns are 'guestimated'"(Viohl, 2005). Through this new Cost Consistency Review Board, the hope is that the Southern Division's exceptional estimating practices can be identified and disseminated to the other Divisions.

Through the analysis of the nine facility types, it was discovered that the Aircraft Maintenance Facilities, in particular, need more pre-project planning. According to NAVFAC, new meetings have been created to handle these types of complex projects in a proactive manner. One meeting, called the Function Analysis Concept Development (FACD), requires all parties involved in a project to meet for one to two weeks to discuss the project in detail. The project is presented and then modified (iterative process) until it is satisfactorily complete to the parties involved. The hope is to have a 35% design at the end of the FACD meeting. The process was started in 1996 by the Pacific Division and has since spread through the tri-services even though it was never enacted into official policy.

More recently, the Southern Division has created a similar meeting called the Functional Analysis Requirements Definition (FARD). The idea behind the FARD is essentially the same as the FACD, yet it is utilized at an earlier stage of the project development. The FARD is used to set the budget for the necessary design instead of creating a design for the allotted budget. This results in a more accurate and less "padded" design. NAVFAC has decided to include the FARD as official policy in their new corporate business procedures.

The use of FACD and FARD meetings should be encouraged and enforced for aircraft maintenance facilities and any other projects which are complex due to requirements or the number of participants involved.

Using the suggestions for implementation listed above, it is possible to improve the MILCON process and ensure less variability in estimates and costs. The following is a summary of contributions and suggestions for future research surrounding the MILCON process.

### 5.2 Summary of Contributions

This thesis aimed at evaluating the accuracy of the Military Construction process in projecting actual costs and its suitability in preventing major cost overruns. Project data from the last 84 completed and 228 awarded NAVFAC MILCON projects was evaluated on the basis of cost indices, project geographic location, and project type. Following these analyses, variations from the norm were identified and suggestions were made for improvement of the MILCON process.

The suggestions made include: providing incentives to project team members for keeping costs low; enforcing the use of HII and other estimating databases; decreasing the contingency amount allotted by Congress to 4%; evaluating the estimating practices of the Southern Division; evaluating the cost control techniques used by the Southwest Division; and encouraging the use of FACD meetings for complex projects.

### 5.3 Future Research

This thesis merely touches on a few of the possible changes that could be made to improve the MILCON process. In order to continue improving, it is important that future research continues to explore the MILCON process across the tri-services.

Future research in this area should examine incentives offered in the civilian construction industry that could be modified and utilized on MILCON projects. Additional research should identify all estimating and tracking tools (including those found within TRACES), and the extent to which they are being used in performing programming and detailed estimates across the tri-services. From this research, it would also be useful to know which tools are more accurate in projecting actual costs.

This thesis touched on the differences between the geographic locations and MILCON project types. However, future research should evaluate time as a possible factor of increased costs once projects have been accumulated in a single database over the course of 10 years or more.

# Appendix A: Collected Data on 84 Completed MILCON Projects

| # | APPR | FY | EFD | GENERAL | SPECIFIC |
|---|---|---|---|---|---|
| 1 | MCON | 2002 | S | Housing | BEQ |
| 2 | MCON | 2002 | R | Housing | BEQ |
| 3 | MCON | 2002 | L | Housing | BEQ |
| 4 | MCON | 2002 | R | Housing | BEQ |
| 5 | MCON | 2002 | R | Housing | BEQ |
| 6 | MCON | 2002 | R | Housing | BEQ |
| 7 | MCON | 2003 | R | Housing | BEQ |
| 8 | MCON | 2002 | R | Housing | BEQ |
| 9 | MCON | 2002 | S | Housing | BEQ |
| 10 | MCON | 2002 | P | Housing | BEQ Modernization |
| 11 | MCON | 2002 | S | Housing | Recruit Barracks |
| 12 | MCON | 2002 | S | Housing | Recruit Barracks |
| 13 | MCON | 2002 | R | Housing | Transient BEQ |
| 14 | MCON | 2002 | L | Housing | Transient BEQ |
| 15 | MCON | 2002 | R | Maint Fac | Aircraft Maint Fac |
| 16 | MCON | 2002 | R | Maint Fac | Aircraft Maint Fac |
| 17 | MCON | 2002 | L | Maint Fac | Aircraft Maint Fac |
| 18 | MCNR | 2002 | S | Maint Fac | Aircraft Maint Fac |
| 19 | MCON | 2002 | L | Maint Fac | Aircraft Maint Fac |
| 20 | MCON | 2002 | S | Maint Fac | Aircraft Maint Fac |
| 21 | MCNR | 2003 | S | Maint Fac | Engine Maint Shop |
| 22 | MCON | 2002 | R | Maint Fac | Maint Fac |
| 23 | MCON | 2003 | R | Maint Fac | Maint Fac |
| 24 | MCON | 2002 | R | Maint Fac | Maint Fac |
| 25 | MCON | 2003 | R | Maint Fac | Vehicle Maint Fac |
| 26 | MCNR | 2002 | R | Maint Fac | Vehicle Maint Fac |
| 27 | MCON | 2002 | R | Maint Fac | Vehicle Maint Fac |
| 28 | MCON | 2003 | R | Ops Fac | Air Passenger Trmnl |
| 29 | MCON | 2002 | L | Ops Fac | Instruction Facility |
| 30 | MCON | 2002 | R | Ops Fac | Instruction Facility |
| 31 | MCNR | 2002 | S | Ops Fac | Marine Crps Rsrv Ctr |
| 32 | MCNR | 2001 | L | Ops Fac | Marine Crps Rsrv Ctr |
| 33 | MCON | 2001 | L | Ops Fac | Operations Building |
| 34 | MCON | 2001 | R | Ops Fac | Operations Building |
| 35 | MCON | 2002 | S | Ops Fac | Operations Building |
| 36 | MCON | 2003 | R | Ops Fac | Operations Tower |
| 37 | MCON | 2002 | R | Ops Fac | Operations Tower |
| 38 | MCNR | 2002 | S | Ops Fac | Reserve Center |
| 39 | MCON | 2002 | R | Ops Fac | Reserve Center |
| 40 | MCNR | 2003 | S | Ops Fac | Reserve Center |
| 41 | MCON | 2002 | R | Ops Fac | Training Facility |
| 42 | MCON | 2001 | R | Ops Fac | Training Facility |
| 43 | MCON | 2002 | R | Ops Fac | Training Facility |
| 44 | MCON | 2002 | R | Piers | Pier Improvements |

| # | APPR | FY | EFD | GENERAL | SPECIFIC |
|---|---|---|---|---|---|
| 45 | MCON | 2002 | R | Piers | Pier Replacement |
| 46 | MCON | 2001 | R | Piers | Berthing Pier |
| 47 | MCON | 2002 | R | Piers | Berthing Pier |
| 48 | MCON | 2002 | S | Prprty Ctrl Fac | Ammunitions Facility |
| 49 | MCON | 2001 | L | Prprty Ctrl Fac | Armory |
| 50 | MCON | 2003 | L | Prprty Ctrl Fac | Armory |
| 51 | MCNR | 2003 | S | Prprty Ctrl Fac | HAZMAT Storage |
| 52 | MCON | 2002 | L | Prprty Ctrl Fac | Magazines |
| 53 | MCON | 2002 | R | Prprty Ctrl Fac | Ordnance Facility |
| 54 | MCON | 2003 | R | Prprty Ctrl Fac | Ordnance Facility |
| 55 | MCON | 2002 | S | Prprty Ctrl Fac | Warehouse |
| 56 | MCON | 2002 | L | Prprty Ctrl Fac | Warehouse |
| 57 | MCON | 2002 | L | Prprty Ctrl Fac | Warehouse |
| 58 | MCON | 2002 | L | Prprty Ctrl Fac | Warehouse |
| 59 | MCON | 2003 | R | Runway Prjct | Aircraft Parking |
| 60 | MCON | 2002 | R | Runway Prjct | Aircraft Parking |
| 61 | MCON | 2003 | R | Runway Prjct | Aircraft Parking |
| 62 | MCON | 2002 | L | Runway Prjct | Airfield Improvements |
| 63 | MCON | 2001 | S | Runway Prjct | Airfield Improvements |
| 64 | MCON | 2002 | S | Runway Prjct | Runway Lights |
| 65 | MCON | 2003 | S | Runway Prjct | Runway Lights |
| 66 | MCON | 2003 | S | Security | Gate Improvements |
| 67 | MCON | 2003 | R | Security | Security Fencing |
| 68 | MCON | 2003 | R | Security | Security Fencing |
| 69 | MCON | 2003 | R | Security | Security Lighting |
| 70 | MCON | 2003 | R | Security | Security Lighting |
| 71 | MCNR | 2003 | S | Security | Visitor Processing Ctr |
| 72 | MCON | 2003 | L | Security | Visitor Processing Ctr |
| 73 | MCON | 2003 | R | Utilities | Electrical Upgrades |
| 74 | MCON | 2002 | P | Utilities | Electrical Upgrades |
| 75 | MCON | 2002 | R | Utilities | Electrical Upgrades |
| 76 | MCON | 2001 | P | Utilities | Sewer |
| 77 | MCON | 2002 | P | Utilities | Shore Power |
| 78 | MCON | 2002 | R | Utilities | Wtr Trtmnt Fac Upgrd |
| 79 | MCNR | 2002 | S | Base Amnty | Bridge Replacement |
| 80 | MCON | 2002 | L | Base Amnty | Cut/Fill Area |
| 81 | MCON | 2003 | R | Base Amnty | Dental Clinic |
| 82 | MCON | 2002 | L | Base Amnty | Fire Station |
| 83 | MCON | 2002 | R | Base Amnty | Fitness Center |
| 84 | MCON | 2002 | R | Base Amnty | Galley |

| # | PA | PA DATE | GE | GE DATE |
|---|---|---|---|---|
| 1 | $8,914,000 | Nov-01 | $9,400,716 | May-02 |
| 2 | $20,973,000 | Dec-01 | $19,115,200 | Jan-02 |
| 3 | $9,705,000 | Oct-01 | $8,310,000 | Jul-01 |
| 4 | $21,369,000 | Dec-01 | $19,479,200 | Jan-02 |
| 5 | $9,903,000 | Nov-01 | $9,027,200 | Jan-02 |
| 6 | $46,734,000 | Dec-01 | $42,608,800 | Jan-02 |
| 7 | $25,354,000 | Dec-02 | $23,244,000 | Jan-03 |
| 8 | $29,357,000 | Dec-01 | $26,769,600 | Jan-02 |
| 9 | $16,244,000 | Nov-01 | $14,763,000 | Mar-02 |
| 10 | $23,050,000 | Dec-01 | $21,000,000 | Sep-01 |
| 11 | $40,690,000 | May-02 | $39,700,000 | Jul-01 |
| 12 | $40,690,000 | May-02 | $39,700,000 | Jul-01 |
| 13 | $23,268,000 | Dec-01 | $21,216,000 | Jan-02 |
| 14 | $14,463,000 | Dec-02 | $12,048,000 | Aug-01 |
| 15 | $4,422,000 | Dec-01 | $4,020,000 | Jan-02 |
| 16 | $3,433,000 | Dec-01 | $3,110,000 | Jan-02 |
| 17 | $3,067,000 | Oct-01 | $2,628,300 | Jan-02 |
| 18 | $3,702,000 | Nov-01 | $2,820,000 | Jan-01 |
| 19 | $11,179,000 | Dec-01 | $9,900,000 | Nov-01 |
| 20 | $3,334,000 | Oct-00 | $4,196,000 | Nov-00 |
| 21 | $1,500,000 | Jun-02 | $1,337,067 | Dec-02 |
| 22 | $6,747,000 | Dec-01 | $6,146,400 | Jan-02 |
| 23 | $5,805,000 | Dec-02 | $5,324,800 | Jan-03 |
| 24 | $13,019,000 | Dec-01 | $11,866,400 | Jan-02 |
| 25 | $5,451,000 | Oct-02 | $5,002,400 | Jan-03 |
| 26 | $989,000 | Nov-01 | $904,800 | Jan-02 |
| 27 | $5,303,000 | Dec-01 | $4,836,000 | Jan-02 |
| 28 | $7,940,000 | Oct-02 | $7,280,000 | Jan-03 |
| 29 | $15,126,000 | Oct-01 | $13,835,929 | Mar-02 |
| 30 | $9,754,000 | Dec-01 | $8,892,000 | Jan-02 |
| 31 | $5,141,000 | Sep-99 | $4,970,000 | Sep-00 |
| 32 | $9,100,000 | Oct-00 | $8,175,000 | Mar-01 |
| 33 | $2,100,000 | Dec-00 | $2,080,464 | Jan-01 |
| 34 | $8,860,000 | Oct-00 | $8,360,000 | Nov-00 |
| 35 | $7,281,000 | Nov-01 | $6,628,000 | Jan-02 |
| 36 | $2,191,000 | Dec-02 | $1,976,000 | Jan-03 |
| 37 | $6,678,000 | Dec-01 | $6,094,400 | Jul-02 |
| 38 | $4,376,000 | Dec-01 | $4,050,000 | Jan-02 |
| 39 | $8,666,000 | Dec-01 | $7,904,000 | Jan-02 |
| 40 | $1,040,000 | Oct-02 | $860,000 | Nov-02 |
| 41 | $3,740,000 | Nov-01 | $3,411,200 | Jan-02 |
| 42 | $4,000,000 | Oct-00 | $3,770,000 | Nov-00 |
| 43 | $8,518,000 | Dec-01 | $7,768,800 | Jan-02 |
| 44 | $12,267,000 | Nov-01 | $11,180,000 | Jan-02 |

| # | PA | PA DATE | GE | GE DATE |
|---|---|---|---|---|
| 45 | $24,198,000 | Dec-01 | $21,693,132 | Jan-02 |
| 46 | $35,700,000 | Oct-00 | $32,700,000 | Nov-00 |
| 47 | $17,313,000 | Dec-01 | $14,433,962 | Jan-02 |
| 48 | $5,758,000 | Jan-02 | $5,368,200 | Apr-02 |
| 49 | $14,000,000 | Oct-00 | $12,568,000 | Oct-00 |
| 50 | $4,166,000 | Aug-00 | $4,593,400 | Jan-02 |
| 51 | $2,690,000 | Jul-02 | $2,346,556 | Dec-02 |
| 52 | $5,817,000 | Oct-01 | $5,455,000 | Aug-01 |
| 53 | $7,083,000 | Dec-01 | $6,440,000 | Jan-02 |
| 54 | $7,221,000 | Dec-02 | $6,853,600 | Jan-03 |
| 55 | $1,939,000 | Nov-01 | $1,890,000 | Feb-00 |
| 56 | $2,244,000 | Oct-02 | $2,244,000 | Feb-03 |
| 57 | $2,463,000 | Dec-01 | $1,777,000 | Nov-01 |
| 58 | $1,543,000 | Dec-01 | $1,341,000 | Nov-01 |
| 59 | $8,313,000 | Oct-02 | $7,893,600 | Jan-03 |
| 60 | $3,868,000 | Dec-01 | $3,510,000 | Jan-02 |
| 61 | $2,952,000 | Dec-02 | $2,714,400 | Jan-03 |
| 62 | $6,292,000 | Jun-01 | $5,200,000 | Apr-01 |
| 63 | $3,140,000 | Jul-00 | $2,830,000 | Jan-01 |
| 64 | $2,117,000 | Dec-01 | $1,040,991 | May-02 |
| 65 | $974,000 | Apr-03 | $1,061,181 | Jan-03 |
| 66 | $1,574,000 | Oct-02 | $1,621,000 | Mar-03 |
| 67 | $8,368,000 | Dec-02 | $6,975,030 | Jan-03 |
| 68 | $2,012,000 | Oct-02 | $1,892,800 | Jan-03 |
| 69 | $7,073,000 | Dec-02 | $6,635,200 | Jan-03 |
| 70 | $1,574,000 | Dec-02 | $1,414,400 | Jan-03 |
| 71 | $1,500,000 | Oct-02 | $1,191,278 | Feb-02 |
| 72 | $2,680,000 | Oct-02 | $2,931,000 | Aug-02 |
| 73 | $3,473,000 | Oct-02 | $3,192,800 | Jan-03 |
| 74 | $11,970,000 | Dec-01 | $10,724,000 | Jan-02 |
| 75 | $3,858,000 | Dec-01 | $3,500,000 | Jan-02 |
| 76 | $6,900,000 | Oct-00 | $6,000,000 | Apr-04 |
| 77 | $5,936,000 | Dec-01 | $3,700,000 | Dec-02 |
| 78 | $6,084,000 | Dec-01 | $5,520,000 | Jan-02 |
| 79 | $1,285,000 | Aug-00 | $979,362 | Jun-02 |
| 80 | $4,400,000 | Dec-01 | $3,951,880 | Apr-02 |
| 81 | $2,380,000 | Dec-02 | $2,152,800 | Apr-02 |
| 82 | $3,749,000 | Dec-01 | $3,200,000 | Oct-01 |
| 83 | $13,316,000 | Dec-01 | $12,147,200 | Jan-02 |
| 84 | $11,802,000 | Dec-01 | $10,764,000 | Jan-02 |

| # | ACWE | ACWE DATE | CWE | CWE DATE |
|---|---|---|---|---|
| 1 | $9,951,955 | Jan-03 | $9,928,229 | May-04 |
| 2 | $16,396,580 | Mar-02 | $16,377,967 | Jul-04 |
| 3 | $8,999,692 | Jan-02 | $9,259,769 | Jan-04 |
| 4 | $15,905,906 | Jun-02 | $16,157,804 | Jun-04 |
| 5 | $7,027,295 | Feb-02 | $7,089,910 | Jun-03 |
| 6 | $40,596,176 | Jul-02 | $39,856,727 | Oct-04 |
| 7 | $18,018,480 | Dec-02 | $18,814,726 | Apr-04 |
| 8 | $22,963,460 | Apr-02 | $22,903,458 | Jan-04 |
| 9 | $14,293,400 | Aug-02 | $14,471,104 | Aug-04 |
| 10 | $21,201,540 | Jan-02 | $22,634,380 | Nov-04 |
| 11 | $37,457,866 | May-02 | $38,390,171 | Jan-04 |
| 12 | $37,457,866 | May-02 | $38,383,312 | Mar-04 |
| 13 | $18,066,400 | Mar-02 | $18,258,808 | Sep-03 |
| 14 | $13,045,000 | Jan-02 | $13,870,005 | May-04 |
| 15 | $3,192,640 | Jan-02 | $3,396,133 | Mar-03 |
| 16 | $3,332,192 | Jan-02 | $3,759,861 | Aug-03 |
| 17 | $3,106,879 | Mar-02 | $3,722,957 | May-03 |
| 18 | $2,192,716 | Sep-02 | $3,560,840 | Mar-04 |
| 19 | $12,137,540 | Dec-01 | $12,670,553 | Sep-03 |
| 20 | $3,578,952 | Mar-01 | $3,615,372 | May-03 |
| 21 | $1,475,649 | Mar-03 | $1,497,718 | May-04 |
| 22 | $6,193,400 | May-02 | $6,418,953 | Sep-03 |
| 23 | $5,409,272 | Apr-03 | $5,710,389 | Aug-04 |
| 24 | $10,024,282 | Aug-02 | $10,055,546 | Apr-04 |
| 25 | $4,704,280 | Apr-03 | $4,762,378 | Nov-04 |
| 26 | $939,160 | Sep-02 | $987,148 | Mar-04 |
| 27 | $2,903,621 | Jan-02 | $3,286,290 | Oct-02 |
| 28 | $6,574,152 | Jan-03 | $6,816,536 | Aug-04 |
| 29 | $14,673,685 | Jan-02 | $15,143,512 | Apr-02 |
| 30 | $8,985,901 | Feb-02 | $9,402,495 | Sep-03 |
| 31 | $4,941,777 | Feb-02 | $5,079,730 | Mar-04 |
| 32 | $9,253,800 | Sep-01 | $9,653,974 | Oct-03 |
| 33 | $1,991,282 | May-02 | $2,255,213 | May-03 |
| 34 | $7,356,819 | Dec-01 | $7,524,512 | Mar-04 |
| 35 | $7,068,780 | Aug-02 | $7,180,632 | Feb-04 |
| 36 | $1,965,933 | Apr-03 | $2,056,406 | May-04 |
| 37 | $8,018,263 | Jun-02 | $8,032,314 | May-04 |
| 38 | $5,177,130 | Sep-02 | $5,343,481 | Jan-04 |
| 39 | $7,719,027 | Mar-02 | $7,671,966 | Jun-03 |
| 40 | $603,417 | Dec-02 | $603,417 | Dec-03 |
| 41 | $3,654,101 | Aug-02 | $3,664,906 | Jan-04 |

| # | ACWE | ACWE DATE | CWE | CWE DATE |
|---|---|---|---|---|
| 42 | $3,871,358 | Aug-01 | $4,929,143 | Jun-04 |
| 43 | $7,592,093 | Feb-02 | $7,547,768 | Aug-03 |
| 44 | $10,738,330 | Aug-02 | $12,268,791 | Mar-04 |
| 45 | $23,479,720 | Jan-02 | $24,377,941 | May-03 |
| 46 | $31,557,177 | Jul-01 | $32,177,903 | Feb-04 |
| 47 | $15,308,860 | Jan-02 | $16,575,804 | Feb-04 |
| 48 | $5,570,689 | Jun-02 | $5,669,826 | May-04 |
| 49 | $13,446,540 | Apr-01 | $13,387,295 | May-03 |
| 50 | $4,657,350 | Apr-02 | $5,088,754 | Jan-04 |
| 51 | $2,529,017 | Mar-03 | $2,627,832 | Jul-04 |
| 52 | $5,769,876 | Oct-01 | $5,977,252 | Mar-04 |
| 53 | $6,238,100 | Feb-02 | $6,428,355 | Feb-04 |
| 54 | $6,665,731 | Jan-03 | $6,795,127 | Jan-04 |
| 55 | $1,880,000 | Feb-02 | $1,894,370 | Mar-04 |
| 56 | $2,137,880 | Apr-03 | $2,242,314 | Mar-04 |
| 57 | $2,141,864 | Jan-02 | $2,162,291 | May-03 |
| 58 | $1,746,138 | Jan-02 | $1,827,061 | May-03 |
| 59 | $5,658,556 | Jan-03 | $5,854,658 | Dec-03 |
| 60 | $3,532,820 | Jan-02 | $3,547,375 | Aug-02 |
| 61 | $2,591,700 | Dec-02 | $2,655,639 | Dec-03 |
| 62 | $5,698,441 | Jun-01 | $5,465,195 | Nov-04 |
| 63 | $2,990,522 | May-01 | $3,054,058 | Apr-04 |
| 64 | $1,059,691 | Aug-02 | $1,167,751 | Oct-03 |
| 65 | $964,356 | Feb-03 | $973,073 | Apr-04 |
| 66 | $1,588,340 | Apr-03 | $1,588,580 | Jul-04 |
| 67 | $7,466,529 | Apr-03 | $7,915,780 | Jan-05 |
| 68 | $2,366,637 | Sep-03 | $2,375,978 | Aug-04 |
| 69 | $5,140,800 | Mar-03 | $4,805,692 | Aug-04 |
| 70 | $1,393,200 | Mar-03 | $1,307,955 | Jul-04 |
| 71 | $1,696,000 | Mar-03 | $1,783,760 | Jan-04 |
| 72 | $2,555,275 | Aug-03 | $2,543,382 | Nov-04 |
| 73 | $3,171,531 | Dec-02 | $3,131,860 | Jun-03 |
| 74 | $8,003,073 | Sep-02 | $8,575,235 | Aug-04 |
| 75 | $4,291,693 | Mar-02 | $4,233,648 | Feb-03 |
| 76 | $6,142,565 | Apr-01 | $6,532,705 | May-04 |
| 77 | $3,164,000 | Jan-02 | $3,200,425 | Oct-03 |
| 78 | $6,150,000 | Jun-02 | $6,150,000 | Jun-02 |
| 79 | $1,166,000 | Sep-02 | $1,250,800 | Sep-03 |
| 80 | $4,387,157 | Sep-02 | $4,387,157 | Sep-05 |
| 81 | $2,267,790 | Jun-03 | $2,246,620 | Aug-04 |
| 82 | $3,745,338 | Dec-01 | $3,795,816 | Aug-03 |
| 83 | $11,531,051 | Feb-02 | $12,119,742 | Mar-04 |
| 84 | $9,749,880 | Apr-02 | $10,459,780 | Feb-04 |

# Appendix B: Collected Data on 228 Awarded MILCON Projects

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 85 | MNR | 2003 | S | Housing | BEQ |
| 86 | MCON | 2001 | R | Housing | BEQ |
| 87 | MCON | 2002 | S | Housing | BEQ |
| 88 | MNR | 2002 | S | Housing | BEQ |
| 89 | MCON | 2002 | R | Housing | BEQ |
| 90 | MCON | 2003 | S | Housing | BEQ |
| 91 | MCON | 2002 | L | Housing | BEQ |
| 92 | MCON | 2001 | L | Housing | BEQ |
| 93 | MCON | 2001 | L | Housing | BEQ |
| 94 | MCON | 2002 | S | Housing | BEQ |
| 95 | MCON | 2002 | L | Housing | BEQ |
| 96 | MCON | 2001 | P | Housing | BEQ |
| 97 | MCON | 2001 | L | Housing | BEQ |
| 98 | MCON | 2001 | P | Housing | BEQ |
| 99 | MCON | 2002 | R | Housing | BEQ |
| 100 | MCON | 2002 | R | Housing | BEQ |
| 101 | MCON | 2001 | R | Housing | BEQ |
| 102 | MCON | 2002 | L | Housing | BEQ |
| 103 | MCON | 2003 | R | Housing | BEQ |
| 104 | MCON | 2002 | R | Housing | BEQ |
| 105 | MCON | 2002 | R | Housing | BEQ |
| 106 | MCON | 2002 | L | Housing | BEQ Modernization |
| 107 | MCON | 2002 | P | Housing | BEQ Modernization |
| 108 | MCON | 2002 | L | Housing | BEQ Replacement |
| 109 | MCON | 2002 | S | Housing | BEQ Replacement |
| 110 | MCON | 2002 | P | Housing | BEQ Replacement |
| 111 | MCON | 2004 | S | Housing | Recruit Barracks |
| 112 | MCON | 2004 | S | Housing | Recruit Barracks |
| 113 | MCON | 2001 | S | Housing | Recruit Barracks |
| 114 | MCON | 2001 | S | Housing | Recruit Barracks |
| 115 | MCON | 2002 | S | Housing | Recruit Barracks |
| 116 | MCON | 2002 | S | Housing | Recruit Barracks |
| 117 | MCON | 2002 | L | Housing | Transient BEQ |
| 118 | MCON | 2002 | R | Housing | Transient BEQ |
| 119 | MCON | 2001 | L | Maint Fac | Aircraft Maint Fac |
| 120 | MCON | 2001 | L | Maint Fac | Aircraft Maint Fac |
| 121 | MCON | 2002 | L | Maint Fac | Aircraft Maint Fac |
| 122 | MCON | 2002 | S | Maint Fac | Aircraft Maint Fac |
| 123 | MCON | 2002 | R | Maint Fac | Aircraft Maint Fac |
| 124 | MNR | 2002 | L | Maint Fac | Aircraft Maint Fac |
| 125 | MNR | 2002 | S | Maint Fac | Aircraft Maint Fac |
| 126 | MCON | 2002 | R | Maint Fac | Aircraft Maint Fac |
| 127 | MCON | 2001 | S | Maint Fac | Aircraft Maint Fac |
| 128 | MCON | 2001 | R | Maint Fac | Aircraft Maint Fac |

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 129 | MCON | 2001 | L | Maint Fac | Aircraft Maint Fac |
| 130 | MCON | 2003 | R | Maint Fac | Aircraft Maint Fac |
| 131 | MCON | 2002 | L | Maint Fac | Aircraft Maint Fac |
| 132 | MCON | 2001 | L | Maint Fac | Aircraft Maint Fac |
| 133 | MNR | 2003 | S | Maint Fac | Engine Maint Shop |
| 134 | MNR | 2002 | S | Maint Fac | Maint Fac |
| 135 | MCON | 2001 | S | Maint Fac | Maint Fac |
| 136 | MCON | 2001 | S | Maint Fac | Maint Fac |
| 137 | MCON | 2001 | S | Maint Fac | Maint Fac |
| 138 | MCON | 2001 | L | Maint Fac | Maint Fac |
| 139 | MCON | 2001 | R | Maint Fac | Maint Fac |
| 140 | MCON | 2003 | R | Maint Fac | Maint Fac |
| 141 | MCON | 2001 | R | Maint Fac | Maint Fac |
| 142 | MCON | 2002 | R | Maint Fac | Maint Fac |
| 143 | MNR | 2003 | S | Maint Fac | Maint Fac |
| 144 | MCON | 2001 | L | Maint Fac | Maint Fac |
| 145 | MCON | 2002 | R | Maint Fac | Maint Fac |
| 146 | MCON | 2003 | R | Maint Fac | Maint Fac |
| 147 | MCON | 2001 | L | Maint Fac | Ship Maint Fac |
| 148 | MCON | 2002 | P | Maint Fac | Ship Maint Fac |
| 149 | MCON | 2002 | R | Maint Fac | Ship Maint Fac |
| 150 | MNR | 2002 | R | Maint Fac | Vehicle Maint Fac |
| 151 | MNR | 2002 | S | Maint Fac | Vehicle Maint Fac |
| 152 | MCON | 2003 | R | Maint Fac | Vehicle Maint Fac |
| 153 | MNR | 2003 | S | Maint Fac | Vehicle Maint Fac |
| 154 | MCON | 2002 | R | Maint Fac | Vehicle Maint Fac |
| 155 | MNR | 2001 | S | Ops Fac | Air Passenger Trmnl |
| 156 | MCON | 2003 | R | Ops Fac | Air Passenger Trmnl |
| 157 | MCON | 2002 | R | Ops Fac | Instruction Facility |
| 158 | MCON | 2002 | L | Ops Fac | Instruction Facility |
| 159 | MNR | 2002 | S | Ops Fac | Marine Crps Rsrv Ctr |
| 160 | MNR | 2001 | L | Ops Fac | Marine Crps Rsrv Ctr |
| 161 | MCON | 2001 | P | Ops Fac | Operations Building |
| 162 | MCON | 2001 | L | Ops Fac | Operations Building |
| 163 | MNR | 2002 | L | Ops Fac | Operations Building |
| 164 | MCON | 2001 | L | Ops Fac | Operations Building |
| 165 | MCON | 2002 | S | Ops Fac | Operations Building |
| 166 | MCON | 2002 | L | Ops Fac | Operations Building |
| 167 | MCON | 2001 | R | Ops Fac | Operations Building |
| 168 | MCON | 2001 | S | Ops Fac | Operations Building |
| 169 | MCON | 2002 | S | Ops Fac | Operations Building |
| 170 | MCON | 2001 | R | Ops Fac | Operations Building |
| 171 | MCON | 2002 | L | Ops Fac | Operations Building |
| 172 | MCON | 2001 | R | Ops Fac | Operations Building |

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 173 | MCON | 2001 | P | Ops Fac | Operations Building |
| 174 | MCON | 2002 | P | Ops Fac | Operations Building |
| 175 | MCON | 2003 | R | Ops Fac | Operations Tower |
| 176 | MCON | 2002 | R | Ops Fac | Operations Tower |
| 177 | MNR | 2002 | S | Ops Fac | Reserve Center |
| 178 | MNR | 2003 | S | Ops Fac | Reserve Center |
| 179 | MNR | 2002 | S | Ops Fac | Reserve Center |
| 180 | MNR | 2003 | S | Ops Fac | Reserve Center |
| 181 | MNR | 2001 | R | Ops Fac | Reserve Center |
| 182 | MNR | 2003 | S | Ops Fac | Reserve Center |
| 183 | MNR | 2002 | S | Ops Fac | Reserve Center |
| 184 | MNR | 2001 | S | Ops Fac | Reserve Center |
| 185 | MNR | 2001 | S | Ops Fac | Reserve Center |
| 186 | MNR | 2003 | R | Ops Fac | Reserve Center |
| 187 | MNR | 2001 | S | Ops Fac | Reserve Center |
| 188 | MNR | 2001 | S | Ops Fac | Reserve Center |
| 189 | MCON | 2002 | R | Ops Fac | Reserve Center |
| 190 | MCON | 2001 | S | Ops Fac | Reserve Center |
| 191 | MCON | 2002 | L | Ops Fac | Testing Lab |
| 192 | MCON | 2001 | L | Ops Fac | Testing Lab |
| 193 | MCON | 2001 | L | Ops Fac | Testing Lab |
| 194 | MCON | 2001 | R | Ops Fac | Testing Lab |
| 195 | MCON | 2003 | R | Ops Fac | Testing Lab |
| 196 | MCON | 2001 | R | Ops Fac | Testing Lab |
| 197 | MCON | 2002 | L | Ops Fac | Testing Lab |
| 198 | MCON | 2001 | L | Ops Fac | Testing Lab |
| 199 | MCON | 2001 | L | Ops Fac | Testing Lab |
| 200 | MCON | 2001 | L | Ops Fac | Testing Lab |
| 201 | MNR | 2001 | S | Ops Fac | Training Facility |
| 202 | MCON | 2001 | R | Ops Fac | Training Facility |
| 203 | MCON | 2001 | S | Ops Fac | Training Facility |
| 204 | MNR | 2001 | S | Ops Fac | Training Facility |
| 205 | MCON | 2002 | R | Ops Fac | Training Facility |
| 206 | MCON | 2001 | R | Ops Fac | Training Facility |
| 207 | MCON | 2003 | S | Ops Fac | Training Facility |
| 208 | MCON | 2001 | R | Ops Fac | Training Facility |
| 209 | MCON | 2003 | S | Ops Fac | Training Facility |
| 210 | MCON | 2002 | R | Ops Fac | Training Facility |
| 211 | MCON | 2001 | S | Ops Fac | Training Facility |
| 212 | MCON | 2001 | R | Ops Fac | Training Facility |
| 213 | MCON | 2001 | P | Ops Fac | Training Facility |
| 214 | MCON | 2001 | S | Piers | Berthing Pier |
| 215 | MCON | 2001 | R | Piers | Berthing Pier |
| 216 | MCON | 2001 | R | Piers | Berthing Pier |

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 217 | MCON | 2002 | R | Piers | Berthing Pier |
| 218 | MCON | 2001 | R | Piers | Pier Improvements |
| 219 | MCON | 2001 | L | Piers | Pier Improvements |
| 220 | MCON | 2001 | L | Piers | Pier Improvements |
| 221 | MCON | 2001 | S | Piers | Pier Improvements |
| 222 | MCON | 2001 | P | Piers | Pier Improvements |
| 223 | MCON | 2002 | R | Piers | Pier Improvements |
| 224 | MCON | 2002 | R | Piers | Pier Replacement |
| 225 | MCON | 2002 | R | Piers | Pier Replacement |
| 226 | MCON | 2002 | L | Piers | Pier Replacement |
| 227 | MCON | 2003 | L | Piers | Pier Replacement |
| 228 | MCON | 2001 | R | Piers | Pier Replacement |
| 229 | MNR | 2001 | R | Piers | Seawall |
| 230 | MNR | 2001 | S | Prprty Ctrl Fac | Armory |
| 231 | MCON | 2001 | R | Prprty Ctrl Fac | Armory |
| 232 | MCON | 2003 | L | Prprty Ctrl Fac | Armory |
| 233 | MCON | 2001 | L | Prprty Ctrl Fac | Armory |
| 234 | MNR | 2003 | S | Prprty Ctrl Fac | HAZMAT Storage |
| 235 | MCON | 2002 | L | Prprty Ctrl Fac | Ordnance Facility |
| 236 | MCON | 2002 | S | Prprty Ctrl Fac | Ordnance Facility |
| 237 | MCON | 2002 | R | Prprty Ctrl Fac | Ordnance Facility |
| 238 | MCON | 2003 | R | Prprty Ctrl Fac | Ordnance Facility |
| 239 | MNR | 2001 | S | Prprty Ctrl Fac | Warehouse |
| 240 | MCON | 2001 | S | Prprty Ctrl Fac | Warehouse |
| 241 | MCON | 2002 | L | Prprty Ctrl Fac | Warehouse |
| 242 | MCON | 2004 | L | Prprty Ctrl Fac | Warehouse |
| 243 | MCON | 2002 | S | Prprty Ctrl Fac | Warehouse |
| 244 | MNR | 2002 | S | Prprty Ctrl Fac | Warehouse |
| 245 | MCON | 2002 | L | Prprty Ctrl Fac | Warehouse |
| 246 | MCON | 2001 | L | Prprty Ctrl Fac | Warehouse |
| 247 | MCON | 2001 | L | Prprty Ctrl Fac | Warehouse |
| 248 | MCON | 2001 | L | Prprty Ctrl Fac | Warehouse |
| 249 | MCON | 2001 | S | Runway Prjct | Aircraft Parking |
| 250 | MCON | 2003 | R | Runway Prjct | Aircraft Parking |
| 251 | MCON | 2002 | R | Runway Prjct | Aircraft Parking |
| 252 | MCON | 2001 | S | Runway Prjct | Aircraft Parking |
| 253 | MCON | 2003 | R | Runway Prjct | Aircraft Parking |
| 254 | MCON | 2001 | R | Runway Prjct | Aircraft Parking |
| 255 | MCON | 2003 | R | Runway Prjct | Aircraft Parking |
| 256 | MCON | 2001 | L | Runway Prjct | Airfield Improvements |
| 257 | MCON | 2001 | S | Runway Prjct | Airfield Improvements |
| 258 | MCON | 2001 | L | Runway Prjct | Airfield Improvements |
| 259 | MCON | 2002 | L | Runway Prjct | Airfield Improvements |
| 260 | MCON | 2001 | L | Runway Prjct | Airfield Improvements |

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 261 | MCON | 2003 | S | Runway Prjct | Runway Lights |
| 262 | MCON | 2003 | L | Runway Prjct | Runway Lights |
| 263 | MCON | 2002 | S | Runway Prjct | Runway Lights |
| 264 | MCON | 2003 | L | Security | AT/FP |
| 265 | MCON | 2003 | S | Security | Gate Improvements |
| 266 | MCON | 2003 | S | Security | Gate Improvements |
| 267 | MCON | 2003 | S | Security | Gate Improvements |
| 268 | MCON | 2003 | S | Security | Gate Improvements |
| 269 | MNR | 2003 | S | Security | Security Fencing |
| 270 | MCON | 2003 | R | Security | Security Fencing |
| 271 | MCON | 2003 | R | Security | Security Fencing |
| 272 | MCON | 2003 | R | Security | Security Lighting |
| 273 | MCON | 2003 | R | Security | Security Lighting |
| 274 | MCON | 2003 | P | Security | Security Lighting |
| 275 | MCON | 2001 | R | Security | Security Support Fac |
| 276 | MNR | 2003 | S | Security | Visitor Processing Ctr |
| 277 | MCON | 2003 | L | Security | Visitor Processing Ctr |
| 278 | MCON | 2003 | R | Utilities | Electrical Upgrades |
| 279 | MCON | 2002 | R | Utilities | Electrical Upgrades |
| 280 | MCON | 2002 | P | Utilities | Electrical Upgrades |
| 281 | MCON | 2002 | L | Utilities | Electrical Upgrades |
| 282 | MCON | 2002 | L | Utilities | Electrical Upgrades |
| 283 | MCON | 2002 | R | Utilities | Sewage Trtmt Plant |
| 284 | MCON | 2001 | P | Utilities | Sewer |
| 285 | MCON | 2002 | P | Utilities | Sewer |
| 286 | MCON | 2002 | P | Utilities | Shore Power |
| 287 | MCON | 2002 | S | Utilities | Water Tank |
| 288 | MCON | 2002 | R | Utilities | Wtr Trtmnt Fac Upgrd |
| 289 | MCON | 2001 | R | Utilities | Wtr Trtmnt Fac Upgrd |
| 290 | MCON | 2002 | P | Utilities | Wtr Trtmnt Fac Upgrd |
| 291 | MNR | 2002 | S | Base Amnty | Bridge Replacement |
| 292 | MCON | 2001 | R | Base Amnty | Child Development Ctr |
| 293 | MCON | 2001 | L | Base Amnty | Child Development Ctr |
| 294 | MCON | 2002 | S | Base Amnty | Child Development Ctr |
| 295 | MNR | 2001 | S | Base Amnty | Church |
| 296 | MCON | 2002 | L | Base Amnty | Cut/Fill Area |
| 297 | MCON | 2003 | R | Base Amnty | Dental Clinic |
| 298 | MCON | 2002 | S | Base Amnty | Fire Station |
| 299 | MCON | 2002 | L | Base Amnty | Fire Station |
| 300 | MCON | 2002 | S | Base Amnty | Fire Station |
| 301 | MCON | 2004 | L | Base Amnty | Fitness Center |
| 302 | MNR | 2001 | S | Base Amnty | Fitness Center |
| 303 | MCON | 2001 | S | Base Amnty | Fitness Center |
| 304 | MCON | 2003 | L | Base Amnty | Fitness Center |

| # | APPR | FY | EFD | General | Specific |
|---|---|---|---|---|---|
| 305 | MCON | 2001 | R | Base Amnty | Fitness Center |
| 306 | MCON | 2001 | L | Base Amnty | Fitness Center |
| 307 | MCON | 2002 | R | Base Amnty | Fitness Center |
| 308 | MCON | 2001 | S | Base Amnty | Fitness Center |
| 309 | MCON | 2002 | R | Base Amnty | Galley |
| 310 | MCON | 2001 | L | Base Amnty | Museum |
| 311 | MNR | 2001 | S | Base Amnty | Recreational Facility |
| 312 | MCON | 2001 | R | Base Amnty | Recreational Facility |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 85 | $6,730,000 | $6,517,840 | $6,531,576 |
| 86 | $8,260,000 | $7,903,704 | $8,076,009 |
| 87 | $8,914,000 | $9,951,955 | $9,928,229 |
| 88 | $8,958,000 | $8,731,220 | $8,848,541 |
| 89 | $9,903,000 | $7,027,295 | $7,089,910 |
| 90 | $10,460,000 | $10,117,878 | $10,473,155 |
| 91 | $13,405,000 | $12,388,571 | $12,521,744 |
| 92 | $14,300,000 | $13,882,840 | $13,807,468 |
| 93 | $16,100,000 | $16,944,676 | $17,574,948 |
| 94 | $16,244,000 | $14,293,400 | $14,448,842 |
| 95 | $16,353,000 | $15,064,929 | $15,250,260 |
| 96 | $16,500,000 | $15,118,385 | $15,395,943 |
| 97 | $17,197,000 | $17,974,915 | $19,196,503 |
| 98 | $18,400,000 | $17,538,446 | $18,013,592 |
| 99 | $20,973,000 | $16,396,580 | $16,377,837 |
| 100 | $21,369,000 | $15,905,906 | $16,152,018 |
| 101 | $21,770,000 | $14,304,164 | $15,270,182 |
| 102 | $22,388,000 | $20,468,820 | $19,990,598 |
| 103 | $25,354,000 | $18,018,480 | $18,798,391 |
| 104 | $29,357,000 | $22,963,460 | $22,900,495 |
| 105 | $46,734,000 | $40,596,176 | $39,850,856 |
| 106 | $14,572,000 | $12,711,200 | $13,681,711 |
| 107 | $23,050,000 | $21,201,540 | $22,634,958 |
| 108 | $9,705,000 | $8,999,692 | $9,260,560 |
| 109 | $14,147,000 | $12,093,900 | $12,340,480 |
| 110 | $17,115,000 | $14,506,255 | $15,991,697 |
| 111 | $31,600,000 | $30,163,344 | $30,852,225 |
| 112 | $34,130,000 | $31,670,240 | $31,540,022 |
| 113 | $37,000,000 | $31,970,929 | $33,154,658 |
| 114 | $37,700,000 | $32,575,313 | $33,734,665 |
| 115 | $40,690,000 | $37,457,866 | $38,419,048 |
| 116 | $40,690,000 | $37,457,866 | $38,652,334 |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 117 | $14,463,000 | $13,045,000 | $13,879,252 |
| 118 | $23,268,000 | $18,066,400 | $18,248,002 |
| 119 | $800,000 | $700,000 | $743,373 |
| 120 | $2,450,000 | $2,587,054 | $2,603,659 |
| 121 | $3,067,000 | $3,106,879 | $3,726,208 |
| 122 | $3,334,000 | $3,578,952 | $3,619,004 |
| 123 | $3,433,000 | $3,332,192 | $3,759,712 |
| 124 | $3,673,000 | $3,264,217 | $3,654,898 |
| 125 | $3,702,000 | $2,192,716 | $3,418,523 |
| 126 | $4,422,000 | $3,192,640 | $3,395,795 |
| 127 | $4,700,000 | $4,434,054 | $4,304,358 |
| 128 | $6,280,000 | $6,794,570 | $7,593,989 |
| 129 | $8,480,000 | $7,130,511 | $7,669,775 |
| 130 | $9,031,000 | $8,468,225 | $8,709,202 |
| 131 | $11,179,000 | $12,137,540 | $12,669,151 |
| 132 | $11,800,000 | $11,297,328 | $13,375,043 |
| 133 | $1,500,000 | $1,475,649 | $1,497,718 |
| 134 | $643,000 | $536,360 | $545,847 |
| 135 | $1,230,000 | $1,169,840 | $1,226,693 |
| 136 | $2,420,000 | $2,650,485 | $2,661,762 |
| 137 | $3,900,000 | $4,555,000 | $4,586,983 |
| 138 | $4,150,000 | $3,900,225 | $4,367,778 |
| 139 | $4,340,000 | $2,768,088 | $3,034,310 |
| 140 | $5,451,000 | $9,262,280 | $4,758,072 |
| 141 | $6,660,000 | $6,089,844 | $6,217,659 |
| 142 | $6,747,000 | $5,720,284 | $6,412,806 |
| 143 | $8,850,000 | $4,580,595 | $4,867,843 |
| 144 | $9,500,000 | $9,199,766 | $9,566,649 |
| 145 | $13,019,000 | $10,024,282 | $10,050,049 |
| 146 | $5,805,000 | $5,409,272 | $5,710,389 |
| 147 | $3,100,000 | $2,922,406 | $3,086,135 |
| 148 | $7,815,000 | $4,855,617 | $5,129,103 |
| 149 | $11,852,000 | $7,841,101 | $10,170,933 |
| 150 | $989,000 | $939,160 | $987,148 |
| 151 | $1,473,000 | $1,505,904 | $1,823,112 |
| 152 | $3,497,000 | $2,915,000 | $2,934,995 |
| 153 | $4,140,000 | $2,549,978 | $2,641,663 |
| 154 | $5,303,000 | $2,903,621 | $3,286,138 |
| 155 | $590,000 | $1,262,425 | $717,313 |
| 156 | $7,940,000 | $6,574,152 | $6,742,469 |
| 157 | $9,754,000 | $8,985,901 | $9,402,495 |
| 158 | $15,126,000 | $14,673,685 | $14,918,929 |
| 159 | $5,141,000 | $4,941,777 | $5,086,830 |
| 160 | $9,100,000 | $9,253,800 | $9,653,974 |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 161 | $2,100,000 | $2,125,059 | $2,295,391 |
| 162 | $2,100,000 | $1,991,282 | $2,264,667 |
| 163 | $2,106,000 | $1,361,473 | $1,441,179 |
| 164 | $2,830,000 | $3,762,543 | $3,772,661 |
| 165 | $4,630,000 | $4,512,840 | $4,647,347 |
| 166 | $5,045,000 | $4,290,350 | $4,675,424 |
| 167 | $5,280,000 | $5,457,087 | $5,603,263 |
| 168 | $6,950,000 | $5,695,400 | $5,908,280 |
| 169 | $7,281,000 | $7,068,780 | $7,174,284 |
| 170 | $8,860,000 | $7,356,819 | $7,523,947 |
| 171 | $8,993,000 | $7,932,200 | $8,129,706 |
| 172 | $11,400,000 | $12,205,900 | $12,677,870 |
| 173 | $35,600,000 | $33,985,864 | $37,526,022 |
| 174 | $37,178,000 | $33,011,586 | $36,669,877 |
| 175 | $2,191,000 | $1,965,933 | $2,054,067 |
| 176 | $6,678,000 | $8,018,263 | $8,030,552 |
| 177 | $2,946,000 | $2,510,342 | $2,653,519 |
| 178 | $1,040,000 | $350,995 | $860,115 |
| 179 | $1,048,000 | $1,137,960 | $1,146,931 |
| 180 | $1,240,000 | $768,868 | $740,468 |
| 181 | $1,420,000 | $1,144,195 | $1,227,341 |
| 182 | $1,450,000 | $1,230,170 | $1,230,170 |
| 183 | $4,376,000 | $5,177,130 | $5,352,426 |
| 184 | $4,730,000 | $4,504,762 | $4,993,898 |
| 185 | $5,200,000 | $4,950,000 | $4,295,954 |
| 186 | $5,905,000 | $4,029,000 | $4,065,289 |
| 187 | $7,000,000 | $7,166,400 | $7,276,059 |
| 188 | $7,080,000 | $6,688,121 | $7,263,661 |
| 189 | $8,666,000 | $7,719,027 | $7,667,987 |
| 190 | $11,700,000 | $12,379,243 | $14,491,899 |
| 191 | $2,236,000 | $2,260,000 | $2,315,456 |
| 192 | $3,300,000 | $3,773,433 | $3,951,631 |
| 193 | $6,570,000 | $6,253,945 | $6,728,340 |
| 194 | $9,400,000 | $11,060,526 | $10,956,800 |
| 195 | $10,061,000 | $9,998,856 | $9,995,765 |
| 196 | $10,200,000 | $10,296,000 | $10,833,062 |
| 197 | $10,655,000 | $12,362,500 | $12,523,587 |
| 198 | $10,680,000 | $7,567,888 | $7,790,558 |
| 199 | $11,300,000 | $10,524,000 | $10,970,294 |
| 200 | $12,390,000 | $13,245,225 | $13,644,000 |
| 201 | $1,769,000 | $1,661,532 | $1,742,314 |
| 202 | $2,100,000 | $1,708,002 | $1,917,225 |
| 203 | $2,660,000 | $3,074,906 | $3,221,474 |
| 204 | $3,570,000 | $4,053,000 | $4,185,714 |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 205 | $3,740,000 | $3,654,101 | $3,663,649 |
| 206 | $4,000,000 | $3,871,358 | $4,924,541 |
| 207 | $4,981,000 | $4,753,840 | $4,867,440 |
| 208 | $5,500,000 | $4,832,541 | $4,937,453 |
| 209 | $7,290,000 | $7,406,222 | $7,547,463 |
| 210 | $8,518,000 | $7,592,093 | $7,548,188 |
| 211 | $9,960,000 | $7,667,760 | $8,019,150 |
| 212 | $10,000,000 | $9,474,706 | $11,411,937 |
| 213 | $14,200,000 | $15,285,483 | $16,166,481 |
| 214 | $3,570,000 | $4,186,000 | $4,114,555 |
| 215 | $12,800,000 | $10,213,725 | $11,077,498 |
| 216 | $35,700,000 | $31,557,177 | $32,177,553 |
| 217 | $17,313,000 | $15,308,860 | $16,575,804 |
| 218 | $1,400,000 | $1,196,640 | $1,102,992 |
| 219 | $4,700,000 | $4,550,813 | $5,804,495 |
| 220 | $4,960,000 | $4,798,850 | $5,418,646 |
| 221 | $6,830,000 | $6,112,000 | $6,379,402 |
| 222 | $12,000,000 | $13,202,460 | $13,881,353 |
| 223 | $12,267,000 | $10,738,330 | $12,267,536 |
| 224 | $13,583,000 | $12,190,000 | $15,384,326 |
| 225 | $24,198,000 | $23,479,720 | $24,352,623 |
| 226 | $27,908,000 | $28,479,679 | $29,038,470 |
| 227 | $32,979,000 | $31,923,809 | $32,185,265 |
| 228 | $38,000,000 | $35,279,000 | $38,436,903 |
| 229 | $950,000 | $887,095 | $902,476 |
| 230 | $3,490,000 | $2,899,089 | $2,996,237 |
| 231 | $4,100,000 | $3,882,013 | $4,053,059 |
| 232 | $4,166,000 | $4,657,350 | $5,172,042 |
| 233 | $14,000,000 | $13,446,540 | $13,282,708 |
| 234 | $2,690,000 | $2,529,017 | $2,627,832 |
| 235 | $5,817,000 | $5,769,876 | $5,977,252 |
| 236 | $5,758,000 | $5,570,689 | $5,661,288 |
| 237 | $7,083,000 | $6,238,100 | $6,425,395 |
| 238 | $7,221,000 | $6,665,731 | $6,788,891 |
| 239 | $800,000 | $782,880 | $774,059 |
| 240 | $1,100,000 | $1,252,835 | $1,240,808 |
| 241 | $1,543,000 | $1,746,138 | $1,827,061 |
| 242 | $1,550,000 | $1,245,178 | $1,252,650 |
| 243 | $1,939,000 | $1,880,000 | $1,894,374 |
| 244 | $2,244,000 | $2,137,880 | $2,232,600 |
| 245 | $2,463,000 | $2,141,864 | $2,162,291 |
| 246 | $3,650,000 | $3,507,120 | $3,583,351 |
| 247 | $6,430,000 | $6,634,000 | $6,913,825 |
| 248 | $7,400,000 | $8,504,690 | $9,245,520 |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 249 | $2,670,000 | $1,558,434 | $1,581,016 |
| 250 | $2,952,000 | $2,591,700 | $2,655,639 |
| 251 | $3,868,000 | $3,532,820 | $3,544,490 |
| 252 | $4,850,000 | $4,462,000 | $4,659,826 |
| 253 | $6,651,000 | $3,637,698 | $4,304,616 |
| 254 | $8,200,000 | $7,934,100 | $8,171,333 |
| 255 | $8,313,000 | $5,658,556 | $5,851,946 |
| 256 | $1,670,000 | $1,211,614 | $1,233,555 |
| 257 | $3,140,000 | $2,990,522 | $3,054,058 |
| 258 | $5,250,000 | $5,443,000 | $5,536,851 |
| 259 | $6,292,000 | $5,698,441 | $5,465,195 |
| 260 | $6,350,000 | $5,787,565 | $6,247,793 |
| 261 | $974,000 | $964,356 | $973,073 |
| 262 | $1,967,000 | $1,211,815 | $1,257,785 |
| 263 | $2,117,000 | $1,039,402 | $1,167,751 |
| 264 | $11,412,000 | $10,673,480 | $10,741,955 |
| 265 | $1,574,000 | $1,588,340 | $1,583,580 |
| 266 | $1,883,000 | $1,739,108 | $1,760,677 |
| 267 | $2,192,000 | $2,014,357 | $2,075,371 |
| 268 | $2,670,000 | $2,439,852 | $2,595,472 |
| 269 | $1,510,000 | $1,350,223 | $1,505,025 |
| 270 | $2,012,000 | $2,366,637 | $2,375,479 |
| 271 | $8,368,000 | $7,466,529 | $7,902,805 |
| 272 | $7,073,000 | $5,140,800 | $4,805,116 |
| 273 | $1,574,000 | $1,393,200 | $1,306,898 |
| 274 | $4,184,000 | $2,054,372 | $2,219,497 |
| 275 | $4,600,000 | $3,975,189 | $4,592,324 |
| 276 | $1,500,000 | $1,696,000 | $1,765,559 |
| 277 | $2,680,000 | $2,555,275 | $2,585,068 |
| 278 | $3,473,000 | $3,171,531 | $3,131,249 |
| 279 | $3,858,000 | $4,291,693 | $4,199,919 |
| 280 | $11,970,000 | $8,003,073 | $8,577,837 |
| 281 | $12,762,000 | $9,875,100 | $9,598,768 |
| 282 | $15,453,000 | $14,754,000 | $16,719,585 |
| 283 | $1,550,000 | $1,550,000 | $1,261,027 |
| 284 | $6,900,000 | $6,142,565 | $6,532,705 |
| 285 | $16,719,000 | $11,238,511 | $11,590,561 |
| 286 | $5,936,000 | $3,164,000 | $3,197,937 |
| 287 | $3,858,000 | $3,021,800 | $3,082,070 |
| 288 | $6,084,000 | $6,150,000 | $6,150,000 |
| 289 | $6,600,000 | $5,255,000 | $7,006,270 |
| 290 | $13,949,000 | $12,313,858 | $12,923,500 |
| 291 | $1,285,000 | $1,166,000 | $1,250,800 |
| 292 | $3,790,000 | $3,436,742 | $4,331,969 |

| # | PA | ACWE | CWE |
|---|---|---|---|
| 293 | $4,420,000 | $4,083,940 | $4,125,143 |
| 294 | $5,995,000 | $5,718,880 | $5,896,405 |
| 295 | $1,830,000 | $1,511,173 | $1,284,421 |
| 296 | $4,400,000 | $4,387,157 | $4,387,157 |
| 297 | $2,380,000 | $2,267,790 | $2,243,780 |
| 298 | $3,660,000 | $4,325,232 | $4,512,426 |
| 299 | $3,749,000 | $3,745,338 | $3,816,535 |
| 300 | $5,372,000 | $5,500,004 | $5,853,514 |
| 301 | $1,970,000 | $1,773,427 | $1,757,435 |
| 302 | $2,650,000 | $2,643,380 | $2,598,610 |
| 303 | $2,950,000 | $3,272,081 | $3,137,979 |
| 304 | $5,284,000 | $4,240,326 | $4,458,575 |
| 305 | $6,390,000 | $3,454,147 | $4,456,034 |
| 306 | $8,590,000 | $9,781,000 | $9,980,336 |
| 307 | $13,316,000 | $11,531,051 | $12,114,273 |
| 308 | $35,000,000 | $32,673,000 | $33,402,646 |
| 309 | $11,802,000 | $9,749,880 | $10,456,904 |
| 310 | $2,450,000 | $2,439,065 | $3,021,857 |
| 311 | $1,670,000 | $1,411,040 | $1,489,942 |
| 312 | $1,930,000 | $1,124,420 | $1,564,434 |

# Appendix C: Current Technology Available Through the TRACES Website

| | |
|---|---|
| Micro Computer Assisted Cost Engineering System (MII) | Formerly called MCACES. MII is a detailed cost estimating module based upon labor rates, equipment rates, crews, material pricing information, productivity rates and markups maintained by the USACE with assistance from Project Time & Cost, Inc. |
| Historical Cost Analysis Generator (HII) | Formerly called HAG. HII is a collection of historical costs for awarded MILCON projects. The program allows the tri-services to forecast the cost of future construction needs. The system is maintained by Project Time & Cost, Inc. |
| ECONPAK | Economic analysis software package maintained by the USACE |
| Parametric Cost Estimating System (PACES) | Used for preparing programming estimates for MILCON projects. Created by the USAF in conjunction with EarthTech. |
| SuccessEstimator™ | SuccessEstimatorTM is a cost estimating program maintained by the Navy in conjunction with U.S. Cost. The program includes Parametric Cost Estimating Models (PCEM) and a Unit Price Book (UPB). |
| Life Cycle Costing (LCC) System | Assists in the estimates of costs for the lifecycle of the facility |
| CostRisk | Contingency calculator maintained by the USACE |
| PC Cost | Budgetary estimating module |
| Guidance Unit Costs (GUC) | Provides costs for various facilities based per unit (size, quantity). |
| Size Adjustment Factors | Aids in more accurate cost estimates for varying sizes of facilities based off historical data. |
| Area Cost Factors (ACF) | ACF based off the Office of the Under Secretary of Defense (OSD) |

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# VITA

Lauren Ashley McMillan was born in Phoenix, Arizona on May 1, 1979, the daughter of Joan Carol Jacobson and Steven Douglas Jacobson. She attended Moon Valley High School in Phoenix for one semester before moving to Sheridan, Wyoming where she attended Sheridan High School. Upon completion of high school, in 1997, she entered the United States Naval Academy in Annapolis, Maryland. She received the degree of Bachelor of Science in Mathematics in May, 2001 along with her commission in the United States Navy Civil Engineer Corps. During the following years she served one tour at Naval Air Station Jacksonville, Florida at the Public Works Center as the Assistant Production Officer. In January 2004, she entered The Graduate School at University of Texas.

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