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Cost Analysis Reform: Where Do We Go From Here? A Delphi Study of Views of Leading Experts

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COST ANALYSIS REFORM: WHERE DO WE GO FROM HERE?
A DELPHI STUDY OF VIEWS OF LEADING EXPERTS

THESIS

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DEPARTMENT OF THE AIR FORCE
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THESIS

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Degree of Master of Science in Cost Analysis

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Abstract

The Department of Defense (DOD) has faced many fiscal challenges in recent years, and these challenges have driven cost saving initiatives across all services and career fields. Many improvement initiatives or new policies aimed at better estimating, controlling, and reducing costs have been initiated to meet fiscal challenges. The senior leaders within the cost analysis workforce are faced with the challenge of managing change within their organizations to improve cost analysis processes and practices, while continuing to provide key decision support in the form of ongoing quality cost estimates.

This purpose of this research is to generate applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories. The Delphi Method was used in conjunction with Grounded Theory to produce a qualitative study that built a consensus among expert participants. The consensus that emerged from the data was then developed into a ranked priority list that can be used by senior leaders within the cost analysis field, and by AFIT students for future research.

Acknowledgments

More matter with less art.

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COST ANALYSIS REFORM: WHERE DO WE GO FROM HERE?

A DELPHI STUDY OF VIEWS OF LEADING EXPERTS

I. Introduction

General Issue

Budgetary challenges in the Department of Defense (DOD) have driven cost saving initiatives across all services and career fields. Many cost saving initiatives are focused within the financial accounting and cost-estimating workforce of the United States Air Force. Several improvement initiatives or new policies such as the Financial Improvement and Audit Readiness Initiative, Will-Cost and Should-Cost Management, Better Buying Power, and Life Cycle Cost management are in use across the DOD. The intent of the programs above and many others are to generate more accurate cost estimates, and to control costs through the lifecycle of a product.

Identifying areas of improvement or topics of research within the cost analysis and financial management career fields could be beneficial in enacting improvement initiatives throughout the force. The Weapon Systems Acquisition Reform Act of 2009 (WSARA) is a major Department of Defense initiative to improve cost estimating within the cost analysis and acquisition arms of the DOD. WSARA is indicative of the efforts to implement change within the cost and acquisition community. However, like many other such efforts it mandated processes and areas of concern to address without specifically providing a ranked priority list of applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories that are ranked by importance and ease of implementation. Congress, through WSARA, appointed a

director of Cost Assessment and Program Evaluation (CAPE). The CAPE director

reports directly to the Secretary of Defense. Statute 1706 of the law instructs the director

of CAPE to lead the development of improved analytical skills. Additionally, the law

directs CAPE to improve cost analysis tools, decrease cost overruns, and increase the

accuracy of cost estimates within the Department of Defense. WSARA broadly focused

on improving the acquisition and cost career field, but lacked a list of research thrust

initiatives, training emphasis areas, policy change recommendations, and cost analysis

theories that are most important to senior leaders in the cost field. With no list, it is

possible that the field lacks commonality of effort across the force, with each

organization concentrating on different areas to improve.

Problem Statement

The purpose of this study is to generate applicable research thrust initiatives,

training emphasis areas, policy change recommendations, and cost analysis theories. The

current fiscal environment within the Department of Defense has placed emphasis on

improving processes within the cost and acquisition community, and senior leaders are

focusing on implementing cost saving changes. Increased awareness of cost analysis

issues among senior Air Force leadership has created an environment that necessitates the

creation of an index of cost analysis priorities. Dwindling resources coupled with more

severe budgetary restraints has led to a higher demand for decision support from the cost

analysis community. Decision support is a service the many program, cost, and finance

offices throughout the Department of Defense provide, but these offices have limited

personnel and time. The increased workload coupled with a shortage of personnel has

led to a need for the community to prioritize its efforts in all areas including improvement of processes, research, training, and policy implementation/change.

The creation of a set of ranked priorities, based on senior leadership consensus, would enable the cost analysis community to focus resources on the topics of research or areas of improvement that matter the most. To achieve the optimal benefits, senior leaders would support the dissemination and use of potential improvement areas and topics of research to the cost analysis field. This list would allow the community to conduct research and improvement efforts with the knowledge that the rest of the cost analysis community is moving forward in the same direction. Ideally, unity of effort in research and improvement would lead to cost savings, improved cost analysis, and improved process execution within the defense acquisition system.

Required Resources

This study required three major resources. First, the study required research participants who met all entrance criteria, which we discuss in the methodology section. These participants completed multiple rounds of questionnaires, and we asked them to provide feedback on questions posed.

Second, the assistance of a sufficiently high-ranking official was required to obtain sufficient participation within the cost analysis field. A high-ranking official did provide support for the research by providing the researchers with contact information for participant candidates.

Third, the researchers used the Air Force Institute of Technology Web Survey Information Retrieval System (WEBSIRS) to create and administer the questionnaires to participants.

Investigative Questions

This research relied on an inductive approach to analyzing the data gathered from study participants. Specifically we used grounded theory, which is used to identify emerging themes in qualitative data (Glaser & Strauss, 1967; Douglas, 2003; Locke, 2001). Dr. David Douglas states:

> The process of generating grounded theory involves data being systematically collected through field observations, interview, meetings, and the inspection of documentation where appropriate or possible. The researcher is often confronted with a flood of textually rich data. Coding for emerging concepts (from those data) is done by scrutiny, with intention of developing core categories that account for most of the variance in data (Douglas, 2003).

Grounded Theory is a methodology that is used to inductively generate theory (Paton, 1990). The use of grounded theory as explained above allowed us to use inductive theory building to conduct our research and build our questionnaires. The Delphi Method provided a vehicle to conduct our inductive theory building within this study. We provided the questions found in Figure 1 to the participants in round one of the study's questionnaire process. We hoped our questions would prompt the participants, and allow them to provide feedback, which would enable the construction of successive rounds of questionnaires.

The initial five investigative questions were meant to allow participants to identify their ideas, ineffective/effective initiatives, ineffective/effective regulations and policies, education/skills opportunities, and any ideas the participants believed do not fall within the scope of the five questions. The researchers, using the initial feedback from participants, formulated further questions for use in later questionnaires. The process continued until we established a consensus based on the feedback collected throughout the study.

Methodology

Due to the nature of the research questions, the researchers chose to use the Delphi Method, which constructs an expert consensus (Helmer, 1967; Linstone & Turoff, 2002; Loo, 2002; Rowe, Wright, & Bolger, 1991). The expected result of this consensus would be a ranked list of applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories. Initially, the researchers used participant eligibility criteria to identify potential participants. The entrance criteria of the study required participants to fall within a seniority band defined by both rank and years of service within the cost analysis field. The military participants held a rank of O-5 or higher and civilian participants held a rank of GS-14 or higher. Military and civilian participants had experience within the cost analysis or acquisition field of two or more assignments. Next, we invited potential qualified participants to participate in the Delphi study.

Participants received the first questionnaire, designated as round one, requesting that they provide feedback detailing the areas of improvement or topics of research they

view as important. The researchers collected the data obtained from questionnaire one

and refined the feedback using grounded theory coding and integrated our findings into

specific questions that we distributed to all participants in the second round of questions.

The first set of questions is below in Table 1.

Table 1: Round 1 Investigative Questions

#	Questions
1	What cost estimation improvement or acquisition reform initiatives do you believe have been most effective and why?
2	What cost estimation improvement or acquisition reform initiatives do you believe have been least effective and why?
3	What cost estimation improvement or acquisition reform initiatives (e.g. changes to DoD/USAF regulations or policies) would you recommend and why?
4	What areas of education/training would be most beneficial to the cost estimation workforce and why?
5	What other important questions should this research address and why?

Next, the researchers provided questionnaire two to participants. The objective of

questionnaire two was to further narrow the responses of the participants into a clear

picture of what issues seem to be most important. We refined the responses once more to

identify questions to use to produce final topics for questionnaire round three.

Finally, we split the questions developed for round three into the categories: 1)

applicable research thrust initiatives, 2) training emphasis areas, 3) policy change

recommendations, and 4) cost analysis theories. The researchers used rating scales for

the first three categories with a short response section for further thoughts from

participants. The cost analysis theories section contained a list of twenty-five tools,

theories, and models and the participants chose which items were most useful in their

opinion. This final section also contained a short response section for participants to

provide any further thoughts. The researchers used the questionnaire responses to build a ranked list of cost analysis areas of concern based upon senior leader feedback.

Assumptions/Limitations

There are three assumptions associated with the Delphi Method. The first assumption is that the participants in the study are experts based upon the selection criterion of the study (Helmer, 1967; Linstone & Turoff, 2002; Rowe et al., 1991). The second assumption is that participants are anonymous (to each other) and will not discuss their involvement in the Delphi study or feedback on questionnaires with any other participants. The third assumption is that participants will respond to early rounds with areas of concern or topics of research, and participant responses could subsequently be used to build further questionnaires.

A limitation associated with this research is the difficulty obtaining appropriate study participants. The researchers conducted this study with volunteer participants meeting set criteria for participation. Since the career field itself is small, and the members of the career field meeting the entrance criteria smaller still, it was difficult to obtain the desired level of participation.

Another potential limitation of the study is the difficulty of maintaining proper anonymity. The Delphi Method requires complete anonymity to be successful (Hallowell & Gambatese, 2010; Linstone & Turoff, 2002; Rowe et al., 1991). However, the cost analysis field has a limited number of senior leaders, and they may discuss their involvement or feedback with other participants. The possibility of participants recognizing the originator of the topic of a questionnaire question exists, because many

participants will be familiar with the concerns and areas of concentration of other senior leaders. We strove to maintain anonymity as much as possible by controlling the flow of questionnaires and the solicitation of participation to prevent participants from discovering the identities of one another.

Implications

The expected result of this research --a list of applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories --would greatly benefit the United States Air Force cost analysis career field. This prioritized list should provide improvement and resource allocation vectors for organizations seeking to implement studies or change initiatives, and provide future researchers with valuable guidance for future efforts. Additionally, a unified approach to improving the cost and acquisition career field could lead to cost savings down the road, and lead to a more unified knowledge base within the cost analysis field.

II. Literature Review

Chapter Overview

The purpose of this chapter is to examine current initiatives implemented across the Department of Defense related to the improvement of cost estimates, describe the Delphi Method process, Grounded Theory, and organizational change. This thesis's scope includes the entirety of the cost analysis field within the United States Air Force with respect to generating improved cost estimates. This broad scope encompasses a large number of initiatives that warrant review. Included in this chapter are several initiatives our experts identified. The initiatives identified include The Weapon Systems Acquisition Reform Act of 2009 (WSARA), Better Buying Power (BBP), Will-Cost and Should-Cost Management, Earned Value Management (EVM) initiatives, and the Delphi Method.

The Delphi Method

The Delphi Method was created to build a consensus among a group of experts (Hallowell & Gambatese, 2010; Linstone & Turoff, 2002; Skulmoski & Hartman, 2007). The Delphi Method implements a series of questionnaires that continually refine and narrow expert responses. The researchers achieve the final state of the Delphi Study when the participants all agree on the same course of action. To accomplish a Delphi Method study, four steps are required. First, they must protect the anonymity of participants. This is important because "…anonymity of Delphi participants allows the participants to freely express their opinions without undue social pressures to conform from others in the group" (Skulmoski & Hartman, 2007). Second, iteration of the

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questionnaire process must occur. This is necessary to refine questions in the process of moving toward building a consensus. According to Linestone & Turoff (2002), the iteration process consists of six phases: specifically, the formulation of issues, exposing of options, determination of initial positions, exploration and obtaining reasons for disagreements, evaluation-underlying reasons for position, and the reevaluation of options (Linstone & Turoff, 2002). Third, controlled feedback occurs. Controlled feedback consists of refining the participant answers and informing them of other participants' perspectives. The iterative rounds allow participants to alter their responses or views.

Finally, the last step of the process is statistical aggregation of the participants' responses. The aggregation of participant scoring enables the researcher to conduct a quantitative analysis of the data. (It is also possible to conduct a qualitative analysis of the data instead). The researcher used the scales described below for the analysis of data. There are four scales, often called "voting dimensions" that represent a policy type (Linstone & Turoff, 2002). The four scales are desirability, feasibility, importance, and confidence in the validity of premise. Each scale has four different levels ranging from best to least with two middle scores. By choosing the level within each scale, participants are clearly communicating to researchers how strongly they feel about an issue. Applying these scales will allow a researcher to determine how each participant ranks a question within each scale category and will allow for aggregation of scores. It is also possible to conduct a qualitative study, which requires a researcher to refine the questions asked until all experts agree on one answer. Upon completion of the analysis,

the researcher will report his results but ensure the anonymity of the participants remains

intact.

Grounded Theory

Grounded Theory is a method of qualitative research, which we used for this

research. Dr. Joseph explains this method by stating "this theory is "grounded" in the

actual data collected, in contrast to theory that is "developed conceptually and then

simply tested against empirical data"(Maxwell, 2005). The point made by Dr. Maxwell

is important because it leaves little confusion that Grounded Theory develops from

qualitative data and is not a method that will compare its findings to hard empirical data.

Grounded Theory, pioneered by Dr. Barney Glaser and Dr. Anselm Strauss, is explained

in the book *The Discovery of Grounded Theory: Strategies for qualitative research.*

Glaser and Strauss state:

> We address ourselves to the equally important enterprise of how the discover of
>
> theory from data-systematically obtained and analyzed in social research-can be
>
> furthered. We believe that the discovery of theory from data-which we call
>
> grounded theory-is a major task confronting sociology today, for as we shall try to
>
> show, such a theory fits empirical situations, and is understandable to sociologists,
>
> and layman alike (Glaser & Strauss, 1967).

An integral element of this theory known as theoretical sampling is paramount to

conducting a successful study using this method. Theoretical sampling is defined as "the

process of data collection for generating theory whereby the analyst jointly collects,

codes, and analyzes his data and decides what data to collect next and where to find them,

in order to develop his theory as it emerges" (Glaser & Strauss, 1967). The process begins with selecting a partial list of concepts or ideas within the realm of study to begin the research (Glaser & Strauss, 1967; Locke, 2001). Using this sampling method, a researcher can determine the themes, subject matters, and trends emerging during the research process. The identification process allowed the researchers in this study to develop subsequent questionnaires and helped them determine in what direction the research should continue.

The use of grounded theory allows a researcher to collect and analyze qualitative data based on a pre-conceived research concept. The researcher will identify and code the themes, subject matter, and trends that emerge during the theoretical sampling portion of the study. The identified factors allow researchers to identify the concepts that answer their initial research questions partially, positively, or negatively.

Weapon Systems Acquisition Reform Act of 2009

WSARA highlights many areas of improvement for cost analysis personnel including acquisition organization and policy. Specifically, WSARA targets acquisition policy as a means of improving cost estimates. The law states "The Secretary of Defense shall ensure that mechanisms are developed and implemented to require consideration of trade-offs among cost, schedule, and performance objectives" (Congress, 2009). Specifically the 2366 process emerged from our expert responses as a prominent theme. WSARA mandated changes to the 2366 process, which ensured that programs were conducing appropriate independent cost estimates, and ensured that programs which exceeding original cost estimates were presented to Congress. These requirements, along

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with other clarifications of the 2366 process within WSARA, ensured greater oversight

and that a minimum level of analysis is completed. Congress uses WSARA to inform the

cost community that they must balance cost against schedule and performance concerns,

but does not demonstrate a clear priority of which element should be the most important.

WSARA highlights many areas of improvement, but does not specifically identify which

areas are most important to improve in a ranked list. However, the law does provide the

cost estimation field with a mandate to improve processes and policy, which have led to

several initiatives such as the topics reviewed below.

Better Buying Power

The key concept of BBP, according to Secretary of Defense Ashton Carter, is to

deliver capabilities to the war fighter while reducing waste and increasing savings. BBP

focuses on improving efficiency in many different areas to realize savings, while

increasing warfighter capabilities. Carter states that the objective *of better buying power*

is to "obtain 2-3% net annual growth in war fighting capabilities without commensurate

budget increase by identifying and eliminating unproductive or low-value-added

overhead and transfer savings to war fighting capabilities" (Carter, 2010). He continues

to identify areas of improvement such as leveraging competition, reducing non-value

added costs, increasing the skills of DOD employees, and adopting Should-Cost and

Will-Cost Management. BBP focuses on the reduction of non-value added costs by

targeting processes and bureaucracy. Specifically, the need to identify low-value

processes that impede the acquisition process were identified (Carter, 2010 p. 4). The

elimination of unnecessary and counterproductive overhead should lead to lower costs

and better cost estimating. Furthermore, an evaluation regarding the overhead costs of six Nunn-McCurdy reports computes the costs of current regulations. One study found "the estimates for these six evaluations exceeded ten million dollars and ninety-five thousand hours of overhead labor" (Carter, 2010). The study found that very little knowledge beyond the knowledge available before the studies was gained. An examination of the above evaluation demonstrates the cost savings possible if existing policy changed. The recommendation, after evaluating the cost of 719 congressional reports, is to reduce the volume and cost of internal and congressionally mandated reports by half. Carter stated, "a conservative cost estimate of the resources consumed in producing the 719 congressional reports is $350 million annually" (Carter, 2010).

Additionally, the improvement of skills among DOD personnel is a key part of BBP. Primarily, BBP advocates the adoption of a uniform standard for services. No uniform standard exists, and the lack of standard has led to each service valuing contracts differently across the DOD. The different processes across the DOD lend confusion to the cost estimation process when calculating the cost of similar contracts. By ensuring consistency, it is possible that cost savings may be realized by ensuring similar contracts receive similar pricing and eliminating unfavorable contracts charging much higher than the average price across the DOD. Ideally, BBP leverages the initiatives above, and many discussed below, to help lower costs and improve cost estimating within the DOD.

Will-Cost and Should-Cost Management

Will Cost and Should Cost Management is the process of forecasting what a program should cost and then comparing this to the actual, or will cost, of the program.

According to Carter, "I will require the manager of each major program to conduct a Should Cost analysis justifying each element of program cost and showing how it is improving year by year or meeting other relevant benchmarks for value" (Carter, 2010). The above requirement in practice lowers the Will Cost price of programs by giving cost estimators a tool to conduct analysis, in conjunction with contract negotiations, to achieve lower contract costs. The lower contract costs should ideally be closer to what the contract should have cost. The use of this method across the DOD could lead to significant cost savings during contract negotiations and life cycle cost estimating. It is possible that using Should Cost estimates leads to performance improvement within DOD programs. Buren states "The estimates will be designed to drive productivity improvements in our programs" (Woods, 2011). Increased productivity, wrought by the Should Cost estimates, should lead to the spread of best practices and increased productivity across programs. A cost analysis workforce using Would Cost and Should Cost Management can catalog best practices and disseminate them across the DOD.

Earned Value Management

The Defense Contract Management Agency (DCMA) defines EVM as "A program management tool that integrates the technical, cost, and schedule parameters of a contract" (Ernst, 2006). Essentially a program possesses a baseline, which assigns projected resources to the planned cost, schedule, and work through the life of the project. The computed earned value is the work performed measured against the established plan. "Specifically, risk is measured in EVM as any deviations from the original baseline. That is, risk is anything that results in a variance"(Smoker, 2016).

Using earned value, we can calculate cost and schedule variance in time and dollars and thus a programs current risk. Using calculated earned value metrics, a program can effectively track performance and make corrections during the program's life. According to Ernst (2006), EVM helps identify future delays/ problems, and help determine how to fix the problem once discovered (p. 26). Ideally, EVM use provides real time reports on performance, as well as the technical accomplishment of contractors. The EVM system allows program managers to make decisions based upon real-time data. If used correctly, the decisions made using EVM allow a program manager to effectively manage a program while controlling cost and schedule variance using corrective actions. The DOD practices EMV to help programs manage their resources more effectively.

Organizational Change

The purpose of this study is to generate applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories. However, to affect the policies and changes we discover in this research will require great effort within an organization the size of the Department of Defense. Dr. Terry Cooke-Davis writes "it is virtually impossible for organizations to implement their chosen strategies without undertaking the kinds of strategic initiatives that inevitably require substantial behavioral and cultural changes" (Cooke-Davies, Cabrey, & Haughey, 2014). The difficulty in managing change and changing behaviors in amplified when operating within the Department of Defense. This increased difficulty will require an even greater emphasis on leadership and organizational culture. Many experts agree that to implement real changes within an organization, there must be strong leadership and a change in the

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organization culture ((Cooke-Davies et al., 2014; Junge et al., 2006; Kahn, n.d.). If the recommendations of this research are to be realized, senior leaders must help lead the effort in changing the culture from within the cost workforce.

Summary

The background of the Delphi Study and Grounded Theory was discussed in Chapter II, and the implementation of these theories will be discussed in the following chapter. The initiatives presented above emerged as the prominent initiatives within expert responses collected as the result of the initial questionnaire. The Methodology implemented in this study will be discussed in Chapter III.

III. Methodology

Chapter Overview

This chapter presents the methods and procedures used in this research to determine what initiatives or areas of research are of interest to cost analysis experts, and how important each interest is in their collective opinion. This chapter discusses the Delphi method, scaled scoring, the institutional review board, and how these were utilized in this research effort. We will provide an example of the coding process used to identify common response themes, present the responses for each round of questionnaires. We discuss the results of our research in the next chapter.

The Delphi Method

The Delphi Method is "a systematic and interactive research technique for obtaining the judgment of a panel of independent experts on a specific topic" (Hallowell & Gambatese, 2010). Ultimately, this method of qualitative research is used to build a consensus among recognized experts, who have participated in the Delphi Study and provided feedback on an iterative basis until the consensus is reached (Hallowell & Gambatese, 2010; Linstone & Turoff, 2002; Rowe et al., 1991; Skulmoski & Hartman, 2007). The researcher builds a consensus by conducting multiple rounds of questionnaires with the study participants, while the researcher continues refining feedback until the experts agree. The findings of this research are the result of the consensus built by the researchers, based on the questionnaire feedback gained from the participants. Figure 1 displays the Delphi Study process.
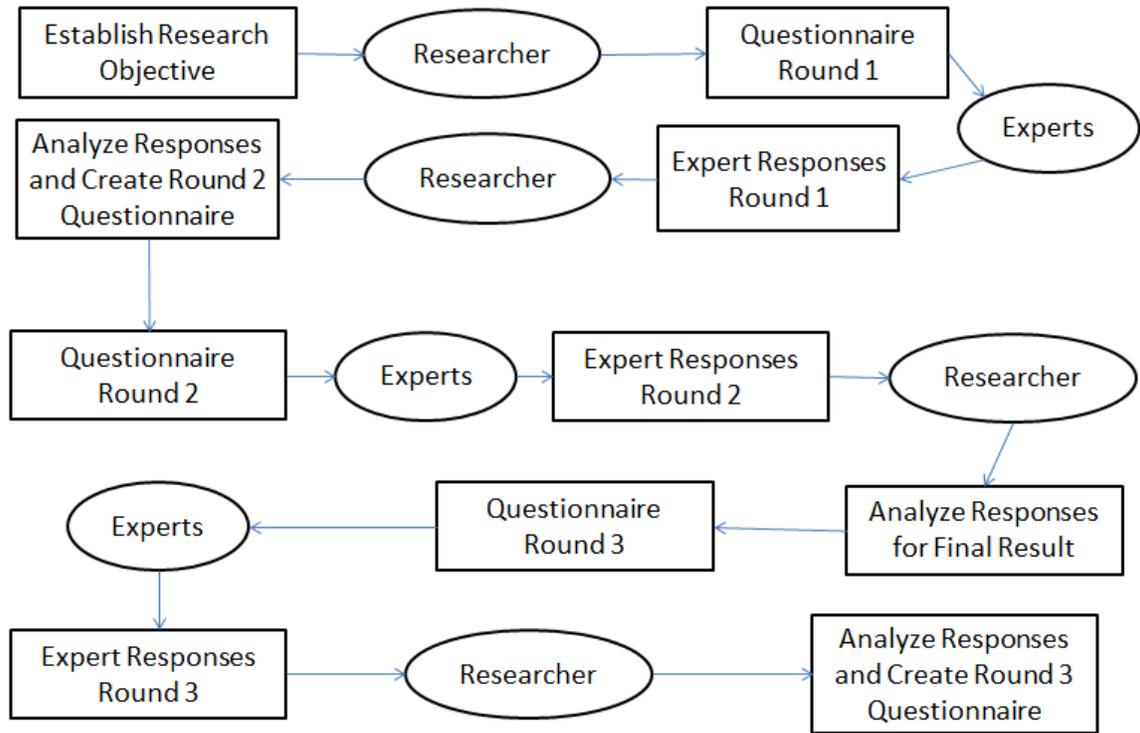
Figure 1: The Delphi Method Process Based On (Chang & Yang, 2011)

The Delphi Process

The Delphi Method is a multi-step procedure that involves an iterative process to obtain participant feedback used to build a consensus. Figure 1 displays the process graphically. First, the researcher identifies the research problem. We chose the lack of a definitive list, derived from senior leaders, of areas for improvement or topics of research within the cost analysis community as our research problem. The researchers predicated the problem on the fact that while there is research into improving the cost analysis community, our research could provide a clearer picture of applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis

theories. The prioritized list of the subjects discussed above will be ranked by the

importance found based on the findings of the research.

Second, the criteria for the selection of study participants were established.

Participants should possess expertise in the field of study examined. There are four

requirements for expertise according to Skulmoski (2007):

1. Knowledge and experience with the issues under investigation
2. Capacity and willingness to participate
3. Sufficient time to participate in the Delphi Study
4. Effective communication skills

For this research the requirement of knowledge and experience was met by ensuring the

participants held a military rank of O-6 or higher or a civilian rank of GS-14 or higher.

Additionally, military and civilian participants were required to possess experience

within the cost analysis or acquisition field of at least two assignments. The participants

must have been willing and able to commit their time to the study, and we assumed the

experts possessed the necessary communication skills to participate based on their rank.

Eventually eight experts participated in this study.

The Delphi Method is particularly useful in qualitative research. Hallowell states:

In contemporary research, the Delphi method is particularly useful when

objective data are unattainable, there is a lack of empirical evidence,

experimental research is unrealistic or unethical, or when the

heterogeneity of the participants must be preserved to assure validity of

the results. (Hallowell & Gambatese, 2010).

The following steps indicate how we applied the process depicted in Figure 1 to this

study.

First, we completed the identification, selection, and verification of potential experts. The researchers identified experts by using the participation criteria seen in Table 2.

Table 2: Participant Eligibility Criteria

Participant Eligibility Criteria	
Rank	O-5+/GS-14+
Experience	2+ assignments in Cost Analysis/Acquisition

We generated a list of individuals eligible for selection, and forwarded a solicitation for participation through electronic mail to the potential participants using a letter. This letter outlined the purpose of the study and explained the commitment each participant would be incurring with participation. Finally, we logged the participants' demographic information including rank and experience to ensure they met all participant entrance criteria.

Second, the researchers generated a list of initial investigative questions. These questions were intentionally broad and allowed study participants to provide their own ideas for the next round of questionnaires. Figure 1 displays the initial investigative questions. Third, we collected and evaluated the feedback provided by each participant. The first questionnaire feedback consisted of responses to the initial investigative questions. We analyzed the responses using grounded theory coding to identify emerging themes. After we established commonality between participants, we designed new questions to further investigate the commonalities. We next distributed the second round of questionnaires.

Finally, the third and final round of questionnaires was distributed, and portioned into categories consisting of applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories. We used scaled scoring for the first three categories with a short response section for further thoughts from participants. For each question, we asked participants to select a score that reflects how important something is as well as the ease of implementation for each item. Examples of these scales can be seen in Appendix A: Figure 22 (for importance) and Figure 23 (for ease of implementation). The cost analysis theories section contained a list of twenty-five tools, theories, and models and we asked the participants to choose which items were most useful in their opinion. This final section had a short response section for participants to provide any further thoughts.

Grounded Theory Coding Process

As discussed in Chapter III, grounded theory requires the expert responses to be coded to help the researchers identify common trends to formulate further questions and produce results. The coding discovered is the result of discovering trends amongst expert feedback. The researcher then creates distinctions between codes and produces dimensions and sub-dimensions amongst these codes ((Patton, 2003, p. 49). The codes are merely labels assigned by the researcher to major categories that emerge from the data. The initial coding process requires detailed analysis in which the researcher evaluates responses line by line. This analysis allows the researcher to codify every piece of data received and is an indicator of what ideas or categories the researcher should pursue. The codes provide a framework for aggregation into core concepts. These core

concepts represent the larger trends emerging from the data. The different code

categories can be then analyzed individually or jointly to discover any further trends in

the data. It is important to note that the development of conceptual categories and their

properties is the conceptual interpretation of the data by the researcher to create the

grounded theory (Glaser & Strauss, 1967; Patton,2003). It is also important to note that

more than one code may be assigned to a line of text. Each line may represent more than

one concept and the researcher may apply multiple codes to evaluate what ideas the

respondents are discussing in their responses. These multiple codes can be combined

under major core codes to allow the researcher to further identify top-level themes to

guide further research. It is important to note that a major limitation of coding is the idea

that the researcher assigned may not be reliable. The codes assigned by the researcher

may miss important categories or not contain the data needed for future questionnaires.

The issue of reliability is managed by using inter-rater reliability testing. This process

consists of the researcher coding the data and then providing the same data to a second

researcher for coding. The two results are then compared to assess if the same codes

emerged from the data. Inter-rater reliability tests were not accomplished for every round

of this study. However, the researcher provided round two results to a second researcher

who did compare their results to the primary researcher's results. The two separately

formulated coding documents did vary, and both researchers conducted further coding

and comparison until the two researchers codes agreed. An example of the coding

process is below in Table 3.

Table 3: Grounded Theory Coding Example

Round	Question	Respondent	Code 1	Code 2	Code 3	Text
2	2	Masked	2366A/B requirements	Cost Field	Revitalization	A careful look back to the way we used to do things.
2	2	Masked	2366A/B requirements	Technology	Procedure/Process Change	Then re-visualize with an eye to where technology changes displace procedure or process of old.
2	2	Masked	2366A/B requirements	Cost Field	Revitalization	Otherwise| we used to do this well we need to go forward to the past.

Institutional Review Board

The use of the Delphi Method necessitates interaction with experts in the field in the form of questionnaires. To ensure the safety of these participants and to safeguard protected individuals, it is required that an Institutional Review Board review the research being done. The Institutional Review Board conducted a review of this research and granted a waiver allowing the researcher to disseminate questionnaires to participants.

Summary

The application of the Delphi Method required the development of initial questionnaires and the use of scaled scoring. The research conducted using these methods was reviewed by AFIT and disseminated to senior leaders and the responses used to build a consensus that is presented in the results in Chapter IV.

IV. Analysis and Results

Chapter Overview

This chapter discusses the analysis and results found by the research team during this study. Each question asked will be presented, along with the response subjects, which emerged from the gathered expert responses. Finally, we will explain the results of all scoring and consensus building.

Round One Questionnaire

We distributed the first round of questionnaires to individuals who met the entrance criteria. Six participants responded and the researchers used these responses to establish common themes for each initial investigative question. For example, the topics discussed by participants in response to the first question appear in Table 4 below. Note that the right column in each table contains the number of experts that had responses that were coded the same as the response displayed. It is important to note that this is not the number of respondents that responded to the question, but rather the number of responses that were coded the same.

Table 4: Response Subjects Question 1.1

What cost estimation improvement or acquisition reform initiatives do you believe have been most effective and why?	
Response	**# Experts**
WASARA 2366A/B certification requirements	3
WASARA emphasis on life cycle operation and support costs	2
Reinvigoration of the organic cost analysis service capability	1
AFPD 65-5 update requiring annual program non-advocate cost assessments	3
Increase emphasis to provide cost estimates that support POM submission process	2

The responses shown in Table 3 point to several initiatives that participants believe were most effective in improving cost estimating. Experts mentioned the direct effects of WASARA twice. We used the specific initiatives linked to WASARA shown above to formulate questions for round two that we will discuss later. Participants also mentioned the reinvigoration of the workforce in responses to both questions one and two. These responses centered on the opinion that a reduction in the organic cost workforce within the last twenty years was a mistake. The participants tended to agree that this reduction led to multiple issues such as lost knowledge, degradation of skills, and the loss of valuable data. The responses to question one tend to indicate that the recent reinvigoration of the workforce is seen as a positive step forward. Additionally, participants identified the increased emphasis on providing cost estimates that support the Program Objective Memorandum (POM) submission process as an effective initiative.

Table 5 below presents the responses to question two, which focused on identifying what initiatives or improvement programs have been *least* effective within the cost community. The first initiative the researchers identified, using the participants' responses, is a belief that the trade-off analysis process is ineffective. Next, we identified that respondents agreed that the Should Cost process is a composition of processes already accomplished in other cost programs. An idea that the Should Cost process already exists and should not be required emerged from the data.

Table 5: Response Subjects Question 1.2

What cost estimation improvement or acquisition reform initiatives do you believe have been least effective and why	
Response	**# Experts**
Trade-off analysis need to be improved to ensure the correct cost trade-offs are being conducted. Cost drivers must be better identified using data to accomplish.	2
Reducing the acquisition workforce was disastrous and led to cost growth.	2
Acquisition reforms in 1990's have resulted in less data availability which have negatively impacted cost analysts	1
The should cost process is a composition of things that are already being done	2

Table 6 below displays the responses collected from question three detailing the improvement or reform initiatives recommended by experts. Participants identified several different subjects to include scheduling analysis, earned value, and data collection and standardization. Specifically, several experts agreed that scheduling analysis skill sets need to be instilled in the government acquisition workforce through training, or, alternatively, through increased emphasis on schedule analysis within program estimates. Multiple experts identified earned value data as an area of policy to improve. These experts believe that the oversight of earned value belongs to the services to bolster program management, and they wished to disseminate earned value practices more widely through the acquisition community.

Table 6: Response Subjects Question 1.3

What cost estimation improvement or acquisition reform initiatives (e.g. changes to DoD/USAF regulations or policies) would you recommend and why?	
Response	**# Experts**
Scheduling Analysis skill need to be instilled back in government acquisition workforce	2
Earned value expertise need to be restored in the cost community	3
Data must be collected and standardized across programs to assist in generating CER's	3
Earned value oversight should be transferred back to the services to bolster program analysis	1

Table 7 below contains the feedback gathered for question four which ask experts what training or education would be most beneficial to the cost estimation workforce. The responses to this question identified several areas of education and training that experts want to address. As in the second question responses, experts tended mention the need for improved schedule analysis skills training in their responses. Much like the response found in question three, experts believe that the cost workforce could benefit greatly by increasing training in the area of schedule analysis. Additionally, experts identified risk and uncertainty analysis as an area of training to address in the future. The idea of expanding the AFIT Cost Analysis Master's Program was addressed as well. Finally, the idea of utilizing real world data to give new estimators practice that is more realistic was put forth by an expert as a means of improving overall estimating skills.

Table 7 : Response Subjects Question 1.4

What areas of education/training would be most beneficial to the cost estimation workforce and why?	
Response	**# Experts**
The workforce would benefit from further training in schedule analysis	2
The workforce would benefit from further training in risk and uncertainty analysis	2
The Air Force Institute of Technology program should be expanded	1
Estimators are pushed out to the AF with no practical experience	5

Finally, Table 8 below contains the responses to question five, which asks experts to identify important questions that they believe this research should be addressing. The experts proffered several ideas. The first idea was establishing operation and support costs (O&S) benchmarks. The second idea was developing methods of improving cyber program cost estimating. Finally, EVM emerged once again from the data. Experts wished to determine if action is taken as a result of EVM findings.

Table 8: Response Subjects Question 1.5

What other important questions should this research address and why?	
Response	**# Experts**
Establishment of O&S cost benchmarks	1
How to better estimate cyber programs	2
What is the average that a system cost estimate is off from actuals? Does EVM he programs when cost overruns are identified, and do they take action to contain costs?	2
A study of manpower MER planning documents	1

Round Two Questionnaire

We used the responses from round one to generate questions for the second round questionnaire. Table 9 below displays the questions that we disseminated to experts for round two.

Table 9: Round 2 Investigative Questions

#	Questions
1	What can be done to improve O&S cost estimating?
2	What can be done to improve the 2366A/B requirements process?
3	What can be done to improve the trade-off analysis process?
4	What can be done to improve the Should Cost process?
5	Is the current state of communication between cost estimators and other acquisition professionals satisfactory? What can be done to encourage cross-disciplinary communication (if needed)?
6	What can be done to improve the schedule analysis expertise of cost estimators?
7	Suppose you are hiring a new cost estimator for a relatively senior position. What skills and experience would be most important/relevant in your hiring decision?

The first question addressed the responses from round one questions one and five. We asked this question to elaborate on specific ideas to improve this aspect of an estimate. Question two is a result of the feedback from round one, which identified the 2366A/B process. The 2366A/B certification "ties together certification requirements for cost, program execution schedules, and funding"(Bagby & Bagby, 2016). This process was included as a question since it is a direct result of WSARA, and allows the experts to cite any improvements or changes to the current requirement process that could further the positive effects identified in round one. Question three is linked to the expert responses from round one question one, which identified the trade-off analysis as an initiative that has not been effective. The purpose of this question is to seek out the expert's opinions detailing how to improve this process to generate a useful initiative that delivers more perceived value to experts in the field. Question four further developed the research concerning the Should Cost process. This question is a result of the responses found in round one question two. Participants identified Should Cost as a program in

need of improvement; this question is as an avenue for those participants to discuss

options for improving or changing the Should Cost process. Question five addresses

identified communication issues by prompting experts to provide specific methods of

improvement that could be used to improve communication skills within the field.

Round one questions three and four both reference schedule analysis as a skill that policy

changes directing further training and education within the cost community would

benefit. Question six addresses these concerns and asked what should be done to

improve schedule analysis expertise. Question seven is used to further assess, from the

experts point of view, what education and training is still falling short and could be

improved upon in the future for new cost estimators.

Eight participants responded to the round two questionnaires and the researcher

used these responses to establish what common topics of discussion were observed for

each second round investigative question through qualitative coding. The subjects

discussed by participants in response to the first question appear in Table 10 below.

Table 10: Response Subjects Question 2.1

What can be done to improve O&S cost estimating?	
Response	# Experts
Further development of historical data in databases	4
Greater research and trade studies to look into updating useful life factors (ie A-76 circular useful life table is dated 1999)	2
Estimators Job Coding Application of ADPD coding to O&S estimators at the depots	2
Development of better models predicated upon historical observations	3

The responses shown above are representative of the common ideas found in the

majority of the responses addressing the question concerning the improvement of O&S

cost estimating. The majority of experts agreed that the collection and use of historical data could greatly benefit O&S cost estimating. Specifically, development of databases such as The Air Force Total Ownership Cost System (AFTOC) was cited as vital to cost estimate improvement in the future. Similarly, updating useful life factors found in Office Management and Budget Circular Number A-76 Appendix 3 was cited as a viable means of improving cost estimates.

Table 11 below contains the responses addressing how to improve the 2366A/B requirements process. There were several common ideas among the responses from the experts. Several experts identified the subject of balancing program optimism and reality within the cost estimation process as an issue. This issue can lead to inaccurate estimates, and by bringing more objectivity into the process, the estimate could become more accurate. Additionally, we addressed the idea of applying the 2366A/B process to ACAT II and ACAT III programs. Currently the process is only required to be used on ACAT I programs, and some experts believed that applying the process to the other programs could lead to more beneficial outcomes for the Air Force. Finally, we identified the idea of building relationships between the O&S community and program office to develop cost key system attributes (KSA's) as a possible way to improve the cost estimation process. The KSA's resulting from such a relationship could allow for a sustainment focus in the design and manufacturing design of systems that could result in estimates that are more accurate.

Table 11: Response Subjects Question 2.2

What can be done to improve the 2366A/B requirements process?	
Response	# Experts
Need to force the necessary tension balancing program optimism and reality	2
We need the O&S community to work with the program offices in developing meaningful KSA's that will drive a sustainment focus in the upfront design and manufacturing layout	1
A lot of discussion currently on potential application to ACAT II/III programs	1

Table 12 below displays the main ideas found within the expert responses focusing on the improvement of the trade-off analysis process. First, experts agreed that the community must do a better job at establishing what a user actually wants before any trade-offs are even considered. The collection and centralization, through development and use of databases, of cost, schedule, and experts identified technical data as a priority to improve the trade-off process. Use of collected data allows for more robust and meaningful trade-offs within programs. We identified the idea of a meaningful trade-off itself as an aspect of this process to improve. Many of the participating experts believe that there is too much "lip service" in this process and trade-offs between requirements and schedule are not actually up for trade, and even if trades are made that they are merely variations on a central theme and not radical differences.

Table 12: Response Subjects Question 2.3

What can be done to improve the trade-off analysis process?	
Response	**# Experts**
The cost and engineering communities need to work closer together to develop databases that allow more robust cost of operational trade analysis	3
Trade-off options should be big differences	4
Additionally to facilitate true trade-offs we need to collect more data in a centralized way related to cost/schedule/technical attributes for more than just ACAT I programs	2
Improve objectivity of analysis	3

Table 13 below contains the responses focusing on the Should Cost process. Most of the responses centered on the ideas of working with the engineering, manufacturing, cost, and other communities to generate a more robust/standardized and automated process that would generate recurring savings across programs. The experts also stipulated that a means to plan to the Will Cost, while allowing a program manager to plan to the Should Cost, should be by legislation and practiced in the field. The issue of objectivity and realism is in the figure above. While not all risk or uncertainty can be foreseen, "we, as a profession, tend to go too far in the opposite direction" (Smart & Smart, 2016). It is possible that some of the large differences between should cost and will cost are attributable to the lack of objectivity. According to Smart, "as a result of risk blindness and project pressure to present an optimistic face to upper management, an all too common situation is that there is a severe disconnect between the cost risk analysis and the final cost" (Smart & Smart, 2016). Improving objectivity would allow a program to obtain a more realistic estimate while still striving to generate savings by performing at the Should Cost baseline.

Table 13: Response Subjects Question 2.4

What can be done to improve the Should Cost process?	
Response	**# Experts**
Make the process more automated	2
the engineering| manufacturing| and cost communities need to work closer together to build a robust should cost process	2
There needs to be a means (with congressional buy-in) to actually plan to the will-cost but allow the PM/PEO to plan to the should-cost	1
requirements trades that would result in longer term| recurring savings	1

Table 14 below details what experts identified in their responses addressing the current state of communication between cost estimators and other acquisition professionals. Experts agreed that there is room for better collaboration between the two communities, and that such collaboration would surely lead to more robust should cost and trade-off analysis. Additionally, we found that experts agree programs need to follow the congressional direction stating that a there should be a qualified cost estimator on every program at the same grade as the PM, and that such an estimator needs to have broad access and a deep interest in the program. Finally, experts suggested that both communities should work more closely to develop milestone estimates with independent technical and cost estimates.

Table 14: Response Subjects Question 2.5

Is the current state of communication between cost estimators and other acquisition professionals satisfactory? What can be done to encourage cross-disciplinary communication (if needed)?	
Response	**# Experts**
Would help if the congressional direction to have a qualified government cost estimator on every program at the same grade as the PM/Chief Engineer was actually followed	2
They should have broad access and deep interest	3
collaboration would lead to more robust should costs and trade-off studies	1

Table 15 below contains the expert responses addressing how to improve the schedule analysis expertise of cost estimators. Respondents agreed that better data collection of technical, cost, and schedule data will help garner improved estimates within the cost community. In addition, experts stipulated that there must be a clearly defined directive that designates which functional area owns schedule analysis and what its responsibilities are. This is because program managers typically believe this responsibility lies with acquisition personnel, engineers believe they own this process, and cost personnel believe they also own the process. A clear designation of responsibility would take any guesswork out of the process and would allow one community to focus on the process without outside interference.

Table 15: Response Subjects Question 2.6

What can be done to improve the schedule analysis expertise of cost estimators?	
Response	**# Experts**
Better define how to merge that knowledge with cost data	3
Better data collection in regards to cost/schedule/technical	3
Part of the problem boils down to who owns schedule analysis.	4
Cost Estimating represents ~14% of the unfunded positions required within AFMC while being less than 1% of the overall workforce.	2

Table 16 below details what the experts questioned expected when hiring a new cost estimator for a relatively senior position in terms of skills and experience that would be most important/relevant in their hiring decision. The experts agreed that written and verbal communication skills were paramount for the success of a new cost estimator. They also agreed that the estimators should have a broad understanding of the acquisition process, but should have strong technical abilities within their specific expertise. Finally, we identified an expectation of leadership experience within multi-functional teams as an important asset for a new cost estimator stepping into a senior position.

Table 16: Response Subjects Question 2.7

Suppose you are hiring a new cost estimator for a relatively senior position. What skills and experience would be most important/relevant in your hiring decision?	
Response	**# Experts**
Excellent communication skills and the ability to manage large teams	4
Multi-disciplinary experience	6
Broad understanding/articulation of program office interaction/integration.	3
expect solid leadership experience & attributes particularly for multi-functional teams| to include mentorship & training skills	4

Round Three Questionnaire

The responses from round two were used to generate questions for the third and final round of questionnaires. The tables found below display the questions the researchers disseminated to experts for round three. We asked our experts to select how important each question was and how easy to implement each idea would be using scaled scoring. This distinction between importance and implementation was very important. The scale provided the researcher with valuable information concerning what should or

should not be done, and what can and cannot be done based on these two distinctions.

Additionally, we invited the participants to expand on their ratings after each section if they desired to share any additional information with the researcher. It is important to note that our sample size is too small to draw definitive conclusions based on the averages found for each question. Since we cannot draw definitive conclusions, we will use the averages to draw attention to likely important issues.

Table 17 below displays the experts scaled scoring average of the importance and ease of implementation for each research thrust area question.

Table 17: Average Score Applicable Research Thrust Areas

Questions	Importance μ	Ease of Implementation μ
Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	4.140	3.000
Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	4.000	3.000
Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	4.000	2.860
Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	4.000	2.430

Based on the averages above, it seemed that the experts viewed every research thrust as very important with the improvement, expansion, and standardization of the AFTOC system rated insignificantly more important. We would draw attention to the ease of implementation of generating recommendations based on a full manpower study of cost

analysis positions. While we cannot conclude that the score is significantly lower than the other research areas, we can say that this research area has the lowest average implementation score.

Table 19 below displays the standard deviations associated with each applicable research thrust area. Using the range of standard deviation outcomes (0.48 to 1.51) we roughly defined any deviation between 0 and .8 as "small," between .8 and 1.2 as "moderate," and 1.2 and above as "large." These definitions are relative, not absolute.

Table 18: Research Thrust Areas Standard Deviations

	Importance	Standard Deviation	Ease of Implementation	Standard Deviation
Questions	μ	σ	μ	σ
1. AFTOC	4.140	1.069	3.000	1.414
2. Useful Life Factors	4.000	1.000	3.000	1.000
3. Databases	4.000	0.816	2.860	1.069
4. Manpower Study	4.000	0.577	2.430	1.512

Within our research thrust areas, there was a large deviation in the ease of implementation for the expansion of AFTOC (1.414) and conducting a manpower study (1.512). The smallest deviation was a .577 deviation in the importance of conducting the manpower study. Based on the deviations above we can assume that our questions were addressing useful life factors and databases were moderately representative of our participants.

Table 19 below displays the expert scaled scoring average of the importance and ease of implementation for each training emphasis/experience area question.

Table 19: Average Score Training Emphasis Areas

Questions	Importance μ	Ease of Implementation μ
Experience emphasis 1: Cost analysis personnel should obtain multi-disciplinary experience (program office, operations, staff, etc.) prior to appointment to senior positions.	3.857	2.714
Training emphasis 2: New cost analysis personnel should receive training in estimation methodologies (learning curves, regression, etc.) and software (Crystal Ball, ACEIT, etc.) before arriving at their first assignment.	2.571	3.000
Training emphasis 3: Cost analysis personnel should receive formal training in communication skills (e.g. persuasive presentations, inter-team coordination, visual display of quantitative information, etc.).	4.000	3.571

We would like to draw attention to the average importance score of the training area asking if new cost analysis personnel should receive training in estimation methodologies (learning curves, regression, etc.) and software (Crystal Ball, ACEIT, etc.) before arriving at their first assignment. Once again, we cannot claim the lower importance score is significant, but it may indicate that experts do view this training area as being less important since the other areas were all moderately important or very important. The research team would also draw attention to the average implementation score of the area asking if cost analysis personnel should obtain multi-disciplinary experience (program office, operations, staff, etc.) prior to appointment to senior positions. The average implementation score was lower than the other areas, being ranked as difficult instead of

neutral, but it may or not be significant. A larger sample size would be needed to determine if the difference lessened or grew with more responses.

The standard deviations associated with each training/experience areas are displayed in Table 20 below.

Table 20: Training/Experience Areas Standard Deviations

Questions	Importance	Standard Deviation	Ease of Implementation	Standard Deviation
	μ	σ	μ	σ
1. Multi-Disciplinary	3.857	0.690	2.714	0.755
2. Methodologies	2.571	1.397	3.000	1.290
3. Communication	4.000	1.291	3.571	0.786

Within our training/experience areas, there was a large deviation (1.397) in the importance of training new cost analysts in methodology techniques and skills and in providing formal communication training (1.291). There was also a large deviation (1.290) in the ease of implementation for providing new cost analysts training in methodology techniques and skills. The importance of providing multi-disciplinary experience to cost analysts had the smallest deviation (.690) in importance and ease of implementation (.755). Based on these findings, we believe that the responses to this question represented a small amount of variation and our finding was representative of our participants.

Table 21 below displays the response scaled scoring averages of the importance and ease of implementation for each policy change recommendation.

Table 21: Average Score Policy Change Recommendations

Questions	Importance μ	Ease of Implementation μ
Policy change 1: Policy that details who in the acquisition process owns schedule analysis, and what is required of the appointed party.	4.571	1.714
Policy Change 2: Policy to implement recommendations based on the results of research thrust 4 (manpower study).	4.286	2.143
Policy change 3: Policy that directs Program Managers to perform meaningful trade-offs, especially between requirements and schedule, which result in substantial changes to programs.	3.857	1.714

The research team would draw attention to the average importance rating of the policy that directs program managers to perform meaningful trade-offs, especially between requirements and schedule, which result in substantial changes to programs. This was rated as moderately important while the other areas were very important. This difference may not be significant; however, the lower score could be an indication that this is not as important as the other policy change areas. Additionally, we would draw the attention of the reader to the average implementation score of the three policy change areas. None of the areas rated higher than difficult. This could indicate that experts believe all the presented policy changes would be at least moderately important but difficult or very difficult.

The standard deviation associated with each policy change recommendation is displayed in Table 22 below.

Table 22: Policy Change Recommendation Standard Deviations

	Importance	Standard Deviation	Ease of Implementation	Standard Deviation
Questions	μ	σ	μ	σ
1. Schedule Analysis	4.571	0.535	1.714	1.112
2. Manpower Study	4.286	0.756	2.143	1.345
3. Trade-Offs	3.857	1.345	1.714	0.487

Within our policy change recommendations we found the largest deviation (1.345) in the importance of performing meaningful trade-offs and the ease of implementation in implementing the manpower study (1.345). The smallest deviation (.487) was found in the ease of implementation of implementing meaningful trade-offs. We concluded that the ease of implementing meaningful trade-offs policy is representative of our participants due to the small variation. We also believe that the importance found in the study of implementing policy concerning schedule analysis (.535) is representative of our participants due to the small variation.

Table 23 below displays the expert response to the cost analysis theories question that provided a list of cost analysis/decision support theories, models, and tools, and required experts to choose at most ten items form the list.

Table 23: Cost Analysis Theories Responses

Item	# Times Chosen*
Crystal Ball	5
Software Cost Estimation	5
Regression	4
Learning Curves	4
Parametric Cost Estimation	4
Cost and Schedule Risk	4
Data Mining	3
Business Case Analysis	3
Earned Value Management	3
Extrapolation form Actuals Estimating	3
CER Development	3
ACEIT	2
Economic Analysis	2
Inflation Indexing	2
Analogous Estimating	2
Cost As an Independent Variable(CAIV)	2
Value-Focused Thinking	1
Analysis of Alternatives	1
Note: Not all experts responded to this question.	

As seen above, seven experts chose Crystal ball and Software Cost Estimation five times as the most beneficial tools for cost analysts. The results for the remaining tools are in Table 23 above.

This research initially solicited forty-eight individuals for participation. Eight experts agreed to participate. These eight represented seventeen percent of our possible pool of applicants. Our response rate well below what is normal for most surveys. While no standard rate exists, other studies show that our response rate was quite low. In the paper titled, *The causes and consequences of Response Rates in Surveys by the News Media and Government Contractor Survey Research Firms,* the authors found an average response rate much higher than ours. Their study found that, "the response rates we

examined varied from 4 percent to 70 percent" (Holbrook, Krosnick, & Pfent, 2008).

This average is well above our rate so it is possible that further studies with more

participation would generate different results. The demographic information for these

participants is in Table 24 below along with the response rate for this study in Table 25.

Military participants accounted for thirteen percent of study participants, while the

civilian participants accounted for 87% of our participants. The difference between the

participation of military and civilian experts could demonstrate a skewed bias in our

findings.

Table 24: Participant Demographic Information

Type	% of Participants
Military	13%
Civilian	87%

Table 25: Research Response Rate

Response Rate		
# Possible Participants	# of Participants	Response Rate
48	8	17%

Summary

The results discussed above were the result of three rounds of questionnaires

using the Delphi Method, which we distributed to participants and later were analyzed by

the researcher. The results were coded qualitatively and the themes discussed above

emerged as the issues and areas most important to the studies participants. The

researchers used the results of the questionnaires to generate a ranked list of priorities

discussed in the conclusions and recommendations section below.

V. Conclusions and Recommendations

Chapter Overview

This chapter discusses the conclusions and recommendations the researcher generated during this study. The envisioned product of this research was a ranked priority list of actionable items separated into sections titled Applicable Research Thrust Areas, Training Emphasis/Experience Areas, Policy Change Recommendations, and Cost Analysis Theories.

Conclusions of Research

Based on the results of the questionnaires the below tables represent the ranked order of each section based on importance and ease of implementation. Since our sample size was too small to draw definitive conclusions, we will present the data we collected and explain what the researchers generally believed based on the data.

Table 26: Research Thrust Areas Ranked by Importance

Questions	Importance μ
Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	4.140
Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	4.000
Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	4.000
Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	4.000

Table 26 contains our research thrust areas ranked in descending order of importance. As noted before, we cannot draw conclusions based on the average score of each area due to our small sample size; however, we can use them to draw attention to what areas that scored differently. In this instance, all of the areas of research were rated as very important. Table 27 below contains the same research thrust areas ranked by ease of implementation.

Table 27: Research Thrust Areas Ranked by Ease of Implementation

Questions	Ease of Implementation
	μ
Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	3.000
Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	3.000
Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	2.860
Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	2.430

The scores in Table 27 ranged from difficult to neutral on our scale rating ease of implementation. We can say that the research team generally believes that research thrust areas one and two are easier to implement than research thrust areas four. However, we would emphasize that none of these areas were rated higher than no area rated higher

than neutral on our ease of implementation scale, which would make choosing an areas to pursue very difficult.

The tables below represent our training/emphasis training areas rankings based on importance and ease of implementation.

Table 28: Training/Experience Emphasis Areas Ranked by Importance

Questions	Importance μ
Training emphasis 3: Cost analysis personnel should receive formal training in communication skills (e.g. persuasive presentations, inter-team coordination, visual display of quantitative information, etc.).	4.000
Experience emphasis 1: Cost analysis personnel should obtain multi-disciplinary experience (program office, operations, staff, etc.) prior to appointment to senior positions.	3.857
Training emphasis 2: New cost analysis personnel should receive training in estimation methodologies (learning curves, regression, etc.) and software (Crystal Ball, ACEIT, etc.) before arriving at their first assignment.	2.571

As seen in Table 28, our ranking values in this instance ranged from somewhat important to very important. We can that we believe training emphasis three is more important than training emphasis two based on the ranked score. Again, we remind the reader that this belief is to highlight the difference in score and not a conclusive finding. Table 29 below contains our ranking of training/experience emphasis areas based on ease of implementation.

Table 29: Training/Experience Emphasis Areas Ranked by Ease of Implementation

Questions	Ease of Implementation μ
Training emphasis 3: Cost analysis personnel should receive formal training in communication skills (e.g. persuasive presentations, inter-team coordination, visual display of quantitative information, etc.).	3.571
Training emphasis 2: New cost analysis personnel should receive training in estimation methodologies (learning curves, regression, etc.) and software (Crystal Ball, ACEIT, etc.) before arriving at their first assignment.	3.000
Experience emphasis 1: Cost analysis personnel should obtain multi-disciplinary experience (program office, operations, staff, etc.) prior to appointment to senior positions.	2.714

The scores above range from difficult to neutral on our ease of implementation scoring scale. The researchers believe that generally training emphasis three is easier to implement than experience emphasis one. In this instance, it seems that experts agreed that providing formal training would be easier than obtaining experience for cost analysis personnel.

Next, the tables below display our policy change recommendation areas rankings based on importance and ease of implementation.

Table 30: Policy Change Recommendation Areas Ranked by Importance

Questions	Importance
	μ
Policy change 1: Policy that details who in the acquisition process owns schedule analysis, and what is required of the appointed party.	4.571
Policy Change 2: Policy to implement recommendations based on the results of research thrust 4 (manpower study).	4.286
Policy change 3: Policy that directs Program Managers to perform meaningful trade-offs, especially between requirements and schedule, which result in substantial changes to programs.	3.857

Our ranking values ranged from moderately to very important. We believe that policy change one which details who in the acquisition process owns schedule analysis, and what is required of the appointed party is generally viewed as more important than policy change three. Since our sample size is small this conclusion is not definitive, but policy change one received the highest importance rating within any section of these results. Table 31 below contains the same policy change areas ranked by ease of implementation.

Table 31: Policy Change Recommendation Areas Ranked by Ease of Implementation

	Ease of Implementation
Questions	μ
Policy Change 2: Policy to implement recommendations based on the results of research thrust 4 (manpower study).	2.143
Policy change 1: Policy that details who in the acquisition process owns schedule analysis, and what is required of the appointed party.	1.714
Policy change 3: Policy that directs Program Managers to perform meaningful trade-offs, especially between requirements and schedule, which result in substantial changes to programs.	1.714

The ranking values ranged from very difficult to difficult. We believe that policy change one is generally easier to implement than the other two policies. However, we would draw the reader's attention again to the difficulty rankings. Based on the scores seen in Table 31, we believe that our experts generally saw policy changes as very important but very difficult to implement. This negative relationship is possibly an area for more research that explores policy changes, and the mechanisms required to implement such changes.

Table 32 displays the ranked priority list of actionable items separated into sections. The rankings below do not represent a definitive scientific conclusion, but rather represent how each section should be ranked according to the researchers. Our purpose in this section was to discover the order in which our different findings should be acted upon. The findings that were most important and easily implemented are ranked highest for action. A visual example displaying the order of action can be seen below in

Figure 2. Figure 2 displays the rankings in a modified risk cube. The items reached first moving diagonally from green to red would be acted upon first.

Research Thrust Areas		1-Very Difficult	2-Difficult	3-Neutral	4-Easy	5-Very Easy		
R1,R2,R3,R4								
Training/Experience Emphasis Areas								Very High
E1,T2,T3								High
Policy Change Recommendation Areas								Neutral
P1,P2,P3,P4								Low
Importance								
1-Not Important								
2-Somewhat Important				T2				
3- Moderately Important		P3	E1					
4-Very Important		P1	R3,R4,P2	R1,R2,T3				
5-Extremely Important								
Ease of Implementation		1-Very Difficult	2-Difficult	3-Neutral	4-Easy	5-Very Easy		

Figure 2: Importance and Ease of Implementation Matrix

To determine the above rankings we first accounted for the importance score of each area within a section. We then ranked the items by ease of implementation in descending order. Next, we calculated the differences between the scores within each scale while assuming equal weighting. We ranked the items with the most important and easiest to implement first. We used the differences calculated to determine which item is ranked higher in the instances when two scores would match in the importance or ease of implementation section. For example, if research thrust one had a score that represented a higher importance rating, but also had a lower ease of implementation score than research area two, then the difference between the importance scale research thrust area one and two would be compared to the difference between research thrust one and research thrust two's ease of implementation score. Whichever difference was larger

determined which area was ranked higher. An example is below in Table 32 followed by

the ranked priorities displayed in Table 33.

Table 32: Research Thrust Difference Comparison

Questions	Importance μ	Ease of Implementation μ
Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	4.140	3.000
Difference (Between 1 and 2)	**0.140**	0.000
Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	4.000	3.000
Difference (Between 2 and 3)	0.000	**0.140**
Difference (Between 3 and 2)	0.000	-0.140
Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	4.000	2.860
Difference (Between 3 and 4)	0.000	**0.430**
Difference (Between 4 and 3)	0.000	-0.430
Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	4.000	2.430

Table 33: Ranked Priority List

New Research Thrust Areas
Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.
Update and improve useful life factors to provide an improved starting basis for O&S costs.
Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).
Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).

Training Emphasis/Experience Areas
Cost analysis personnel should receive formal training in communication skills (e.g. persuasive presentations, inter-team coordination, visual display of quantitative information, etc.).
Cost analysis personnel should obtain multi-disciplinary experience (program office, operations, staff, etc.) prior to appointment to senior positions.
New cost analysis personnel should receive training in estimation methodologies (learning curves, regression, etc.) and software (Crystal Ball, ACEIT, etc.) before arriving at their first assignment.

Policy Change Recommendations
Policy to implement recommendations based on the results of research thrust 4 (manpower study).
Policy that details who in the acquisition process owns schedule analysis, and what is required of the appointed party.
Policy that directs Program Managers to perform meaningful trade-offs, especially between requirements and schedule, which result in substantial changes to programs.

Cost Analysis Theories
Crystal Ball
Software Cost Estimation
Regression
Learning Curves
Parametric Cost Estimation
Cost and Schedule Risk
Data Mining
Business Case Analysis
Earned Value Management
Extrapolation form Actuals Estimating
CER Development

ACEIT
Economic Analysis
Inflation Indexing
Analogous Estimating
Cost As an Independent Variable(CAIV)
Value-Focused Thinking
Analysis of Alternatives

The order of each item within the section denotes priority from first to last. We suggest acting on the above priorities in sequential order if possible. The ranked list is a culmination of the responses of expert participants. We created this ranking with the intent of capturing the most important initiatives that are easiest to implement, and the harder and less important initiatives drifted to the lower section of each category. As described in Chapter IV, we cannot draw conclusions based on the averages found since our sample size was so small. However, we can draw attention to the items that emerged from expert responses, and we accomplished this by drawing the most attention to the items that trended toward being important and easily implemented.

Significance of Research

This research is significant in several ways. First, future researchers could use the research areas discussed above as a starting place for future studies. Second, senior leaders could use the above list to help guide their organizations current training, research, or use of tools could distribute the above list. Third, the above list represents a valuable tool to begin discussions within the cost field to discuss if individuals agree or disagree with this research's findings. Finally, the above list provides possible areas of policy to be changed.

Recommendations for Action

We provided the ranked priority list to senior leaders for evaluation and possible dissemination to the cost analysis field. The provided list could invest senior leaders with a means to focus organizational effort or provide a tool to begin discussions within their organizations concerning the areas researched in this study. In addition, we recommend that further research be conducted with the support of senior leaders. Findings that are more conclusive can be established with higher expert participation. Subsequently, if the sample size of participants were larger, the ranked priority list presented to leaders would more accurately represent the beliefs of experts in the field.

Recommendations for Future Research

The researchers divided the research into four sections containing many possibilities for future research. There were several research topics found when exploring applicable research thrust areas. We identified that research to improve, expand, and standardize AFTOC could be helpful to the cost analysis career field. Second, researchers identified updating and improving useful life factors as a likely future research project. Third, a researcher could begin to identify and evaluate databases in non-cost disciplines with the aim of providing useful data that could help improve estimates. Fourth, a researcher could undertake the generation of a full manpower study of the cost analysis positions with the aim of determining the health and strength of the cost community. Fifth, we would recommend researching if the inclusion of cost analysis training in the Basic Financial Management Course. We suggest that a researcher re-accomplish this study with a larger number or participants. Specifically, we

recommend easing the entrance criteria for this research to include program managers

and other acquisition personnel. The data obtained from a study mirroring this research,

but with a larger sample size, could draw stronger conclusions and collaborate or

challenge the conclusions drawn in this study.

Summary

This thesis described the use of the Delphi Method in an attempt to generate

applicable research thrust initiatives, training emphasis areas, policy change

recommendations, and cost analysis theories based on the feedback of expert participants.

The results of the research led to the creation of a ranked list of priorities presented in the

results section above. The significance of these results was discussed as well as

recommended actions. Finally, recommendations for continued research were discussed.

Ideally, this research will provide benefit to the cost field, and specifically cost analysis

students who may continue the research this study began.

Appendix A: Round 3 Questions

Table 34: Importance Rating Scale Example

Please rate the *importance* of the following research thrust areas:

		Not Important 1	Somewhat Important 2	Moderately Important 3	Very Important 4	Extremely Important 5
2.	Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	○	○	○	○	○

		Not Important 1	Somewhat Important 2	Moderately Important 3	Very Important 4	Extremely Important 5
3.	Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	○	○	○	○	○

		Not Important 1	Somewhat Important 2	Moderately Important 3	Very Important 4	Extremely Important 5
4.	Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	○	○	○	○	○

		Not Important 1	Somewhat Important 2	Moderately Important 3	Very Important 4	Extremely Important 5
5.	Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	○	○	○	○	○

Table 35: Ease of Implementation Rating Scale Example

Please rate the *ease of implementation* of the following research thrust areas:

		Very Difficult 1	Difficult 2	Neutral 3	Easy 4	Very Easy 5
6.	Research thrust 1: Improvement, expansion, and standardization of the Air Force Total Ownership Cost (AFTOC) system.	○	○	○	○	○

		Very Difficult 1	Difficult 2	Neutral 3	Easy 4	Very Easy 5
7.	Research thrust 2: Update and improve useful life factors to provide an improved starting basis for O&S costs.	○	○	○	○	○

		Very Difficult 1	Difficult 2	Neutral 3	Easy 4	Very Easy 5
8.	Research thrust 3: Identify and evaluate databases in non-cost disciplines for potential use in schedule and cost analysis (e.g. engineering & technical databases).	○	○	○	○	○

		Very Difficult 1	Difficult 2	Neutral 3	Easy 4	Very Easy 5
9.	Research Thrust 4: Generate recommendations based on full manpower study of cost analysis positions (health / strength of the cost community).	○	○	○	○	○

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14. ABSTRACT

     The Department of Defense (DOD) has faced many fiscal challenges in recent years, and these challenges have driven cost saving initiatives across all services and career fields. Many improvement initiatives or new policies aimed at better estimating, controlling, and reducing costs have been initiated to meet fiscal challenges. The senior leaders within the cost analysis workforce are faced with the challenge of managing change within their organizations to improve cost analysis processes and practices, while continuing to provide key decision support in the form of ongoing quality cost estimates.

     This purpose of this research is to generate applicable research thrust initiatives, training emphasis areas, policy change recommendations, and cost analysis theories. The Delphi Method was used in conjunction with Grounded Theory to produce a qualitative study that built a consensus among expert participants. The consensus that emerged from the data was then developed into a ranked priority list that can be used by senior leaders within the cost analysis field, and by AFIT students for future research.

15. SUBJECT TERMS				
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