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A Total Ownership With Life-Cycle Cost Model Under Uncertainty For Surface Ship Electro-Optic And Infrared Systems

December 2019

LT Katelyn M. George, USN
LT Eliah J. Ledbetter, USN

Thesis Advisors: Dr. Johnathan C. Mun, Professor
Dr. Robert F. Mortlock, Professor

Graduate School of Defense Management

Naval Postgraduate School

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF DEFENSE MANAGEMENT
NAVAL POSTGRADUATE SCHOOL

ABSTRACT

This thesis examines the basics of total ownership cost (TOC) modeling over the life cycle of electro-optic/infrared sensors, including the inception phase of Acquisition Costs, followed by annual Operations and Maintenance (O&M) expenses, and a final set of Disposition Costs at the end of life of the sensor. This model allows cost analysts to have better decision analytics of the costs for use in cost comparisons across sensor platforms, return on investment analysis, portfolio allocation of resources, and analysis of alternatives. The findings show that the developed model is functional and could be used in the Department of Defense total ownership cost estimation process to facilitate decisions among sensor platforms.

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ABOUT THE AUTHORS

LT Katelyn George is a recent graduate of Naval Postgraduate School with a Masters of Business Administration in Financial Management. She is a Surface Warfare Officer in the United States Navy. Afloat, LT George has completed tours aboard the USS Lake Erie (CG 70) as the Electrical Officer and Navigator, and flag lieutenant for Commander, Carrier Strike Group 11.

LT Eliah Ledbetter is a recent graduate of Naval Postgraduate School with a Masters of Business Administration in Financial Management. He is a Surface Warfare Officer in the United States Navy. Afloat, LT Ledbetter has completed tours aboard the USS Benfold (DDG 65) as the Auxiliaries Officer and served on the Staff of Destroyer Squadron 15 as the Assistant Operations Officer forward deployed to Seventh Fleet.

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Our time at the Naval Postgraduate School has been a fantastic ride. Taking the time to step away from day-to-day struggles of the fleet has given us the ability to think much bigger. The school has allowed us to share, challenge, and explore ideas with not only peers but also with subject matter experts. We look forward to taking the knowledge that we have gained here back to the fleet, as more rounded naval officers, and plan to pay the experience forward through the remainder of our military service and life.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF ACRONYMS AND ABBREVIATIONS

CAPE	Cost Assessment and Program Evaluation
CBA	Capabilities-Based Assessment
CER	cost estimation relationship
DAS	Defense Acquisition System
DAU	Defense Acquisition University
DoD	Department of Defense
DoN	Department of the Navy
DOTmLPF	doctrine, organization, training, materiel, leadership, personnel, and facilities
DT&E	Developmental Test and Evaluation
EMD	Engineering and Manufacturing Development
EO	electro-optics
EO/IR	electro-optic infrared
IOT&E	Initial Operational Test and Evaluation
IR	infrared
IWS	Integrated Warfare Systems
JCIDS	Joint Capabilities Integration and Development System
JPG	Joint Programming Guidance
LCC	life-cycle cost
LCCE	life-cycle cost estimation
LRIP	low rate initial production
LWIR	long-wave infrared
MAIS	Major Automated Information System
MDAP	Major Defense Acquisition Program
MILCON	Military Construction
MILPERS	Military Personnel
MSA	Materiel Solution Analysis
MWIR	midwave infrared
NAVSEA	Naval Sea Systems Command
NIR	near-infrared
O&M	Operations and Maintenance
O&S	Operating and Support

OMB	Office of Management and Budget
OSD	Office of the Secretary of Defense
OT&E	Operational Test and Evaluation
P&D	Production and Development
PEO	Program Executive Office
PEO IWS	Program Executive Office Integrated Warfare System
POM	Program Objective Memorandum
PPBE	Planning, Programing, Budgeting, and Execution
PV	present value
R&D	Research and Development
ROI	return on investment
ROM	rough order of magnitude
RTD&E	Research, Testing, Development, and Evaluation
SME	subject matter expert
SWIR	short-wave infrared
TMRR	Technology Maturation and Risk Reduction
TOC	Total Ownership Cost
VBA	Visual Basic for Applications
WBS	Work Breakdown Structure

I.   INTRODUCTION

Despite the colossal Department of Defense (DoD) budget, the DoD does not have the luxury of unlimited resources. The DoD has a plethora of competing priorities that it is required to fund to support the U.S. National Defense Strategy. Therefore, as leaders, it is imperative to make financial decisions that maximize the overall DoD portfolio. Portfolio optimization encompasses several tenets including, properly building and refining budgets, allocating every taxpayers' dollar as efficiently as possible, and avoiding cost overruns. An essential tool in portfolio optimization is cost estimation. Reliable cost estimation allow decision makers and leaders to make more informed financial decisions and decrease the strain on the DoD's budget. Cost estimation is both a hard science and an art. Analysts have the benefit of using historical estimates and actual cost data from previous programs and projects. Historical data gives costs analysts a starting point for new cost estimates; however, the uncertainty involved in real life and future events is always present. This uncertainty makes it impossible to provide the exact cost of a future program, which is where the skill in cost estimation comes into play. To produce credible and defendable cost estimates, cost analysts must utilize multiple tools and techniques. This thesis provides a model designed to help cost analysts understand system life-cycle costs while incorporating uncertainty. The model allows those analysts to have better decision analytics when making financial decisions.

A.   RESEARCH PURPOSE

The purpose of this thesis is to develop a model to estimate total ownership with life-cycle costs under uncertainty associated with surface electro-optic infrared (EO/IR) sensors. It examines the basics of total ownership cost (TOC) modeling over the life cycle of the EO/IR sensors, including the inception phase of Acquisition Costs, followed by annual Operations and Maintenance (O&M) expenses, along with a final set of Disposition Costs at the end of life of the sensor. This model allows managers to have better decision analytics of the costs of said sensors for use in subsequent cost comparisons across sensor platforms, return on investment analysis, portfolio allocation of resources, and analysis of alternatives.

B.   RESEARCH FOCUS

In this research, we answer the following primary question: Would an advanced analytical model be a more effective metric to estimate total ownership with life-cycle cost under uncertainty than the current method of life-cycle cost estimates for surface EO/IR sensors? To accomplish this, we will develop and analyze a total ownership with life-cycle cost model under uncertainty for surface electro-optical infrared sensors. In the development of the model, we determine what data are required to implement our proposed model for surface ship EO/IR sensors. We also examine the current Department of Defense (DoD) method for determining system life-cycle costs for defense systems and will consider whether the proposed model is a useful alternative to the current method of determining the life-cycle costs for EO/IR sensors on surface ships. Last, we consider whether the developed model can be applied to cost estimating in other sectors of DoD cost projections.

C.   RESEARCH SUMMARY

While executing a standard life-cycle–based total ownership cost analysis, we assume that before the system is operational, there are substantial acquisition costs. Acquisition costs typically are broken down into Research, Testing, Development, and Evaluation (RTD&E) costs and procurement costs. These costs are usually referred to as Year 0, followed by the operational years where operation and maintenance costs will apply. The final price analyzed is the salvage cost, or the cost to properly dispose of, sell, or render the system inoperable. The sum of these three expenses is called the life-cycle cost.

Unfortunately, the accurate calculation of these costs is not as straightforward as their descriptions. To accurately incorporate these three factors, it is essential to consider economic theory. The elements of time valuation of money are critical in the analysis of alternatives. The economic growth, annual discount rate, inflation, and opportunity cost of investing in a specific system are essential to our study. Other factors include budgetary cutbacks and changes in technology. Our model allows the cost analyst to input these changes to manually adjust for each of these. Utilizing this model serves as a proof of concept to understand how this approach could be used to reduce cost overflow and prevent

budget overruns. The model provides greater insight into the true nature of the cost of cash outflow and the life cycle of the product and its associated costs. The results the model produces give leaders a more effective metric to analyze total ownership cost under uncertainty, therefore allowing leadership to make more informed decisions in the DoD acquisition process.

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II. BACKGROUND AND LITERATURE REVIEW

A. INTRODUCTION

This background and literature review provide a comprehensive overview of the topics pertinent to our project. We examine the concepts and best practices in the field of cost and cost estimation and their application inside the DoD. We then look into the DoD's acquisition process as a whole to analyze how the DoD can utilize cost estimation to influence decision-making. Once we cover basic cost estimation and the acquisition system, we then move to discussing total ownership cost and life-cycle cost estimation (LCCE) and how these factors play a role in calculating the overall cost of a system.

The review covers the topics of risk and uncertainty to explain the relationship and differences between the two, as well as to highlight the importance of properly accounting for both factors. We conclude with an overview of our model's subject, the electro-optical infrared sensor (EO/IR). We give a brief overview of the capabilities as well as the applications that these sensors have on Navy surface vessels, along with the sensors', rapidly changing technology, and state why it is imperative that the Navy continues to buy these sensors while ensuring the cost stays at a rational price point.

B. COST ESTIMATION

1. Cost Estimation Overview

The DoD receives a limited amount of funds every fiscal year and must decide how those funds are used in support of national strategies and goals. Specifically, those decisions fall into one of three categories: long-term planning, budgeting, and choosing among alternatives (Mislick & Nussbaum, 2015). The government is tasked with spending taxpayers' dollars effectively and efficiently. This means that DoD decision-makers must ensure they make strategic investments, including the acquisition of new programs and systems. Before a program is implemented or system purchased, decision-makers must understand the full cost that will be incurred and its effect on the DoD's limited budget.

The projected costs of major acquisitions are produced through a process known as cost estimation. Cost estimation is defined as "the process of collecting and analyzing

historical data and applying quantitative models, techniques, tools, and databases in order to predict an estimate of the future cost of an item, product, or task" (Mislick & Nussbaum, 2015, p. 11). In basic terms, cost estimation is performed by running relevant data from the past through a model or database to predict what an item will cost in the future. It is important to note that reliable historical data is fundamental to this process.

In order to produce cost estimates, analysts must first gather available historical data. In Mislick and Nussbaum's book, *Cost Estimation Methods and Tools*, they describe data collection as often the most time-consuming and costly step of the entire cost estimation process (2015). Mislick and Nussbaum assert that only after the historical data has been obtained can the cost analyst start the "organization, normalization, and management of that historical data" (p. 11). They go on to clarify that normalization refers to taking the historical data and "applying adjustments to that data to gain consistent, comparable data to be used in your estimates" (p. 78). Normalizing the data set allows the analyst to compare data across different periods of time by adjusting for different factors. Mislick and Nussbaum explain that a data set must be normalized three different ways: for content, for quantity, and for inflation. Normalizing for content ensures you are comparing the same category or type of data (Mislick & Nussbaum, 2015). Normalizing for quantity ensures that the analyst is comparing data at the same point on the learning curve of production and comparing equal quantities (Mislick & Nussbaum, 2015). Lastly, the data is adjusted to account for inflation when comparing data from different years (Mislick & Nussbaum, 2015).

The second component of cost estimation is the quantitative model that is used to turn normalized historical data into a future cost estimate. Mislick and Nussbaum (2015) explain that the "profession of cost estimating is scientifically grounded by using transparent, rationally defensible and reviewable quantitative methods" (p. 12). The development of a high-quality quantitative model is key in cost estimation. If a poor quantitative model is used, then the quality and reliability of the cost estimate will also be poor. This axiom highlights the importance of the development of quality cost models for EO/IR sensors.

The third part of Mislick and Nussbaum's (2015) definition of cost estimation is the prediction. The ultimate goal of cost estimation is to predict a future cost. The prediction is based on the information available at the time. We can only "estimate the conditions that will pertain later when the project is executed" (Mislick & Nussbaum, 2015, p. 12) and must rely on the information available in the present. While no one can forecast the future with 100% accuracy, through historical data and quantitative models we are able to provide a more accurate prediction that, while not perfect, is still a useful tool for decision-makers in the acquisition process.

Mislick and Nussbaum (2015) explain that the overall objective of the cost estimation is to provide a complete, reasonable, credible, and analytically defensible estimation of future costs—a quality estimate—that can be used by decision-makers. They have provided a breakdown of characteristics essential to a quality cost estimate, and we explore some of these characteristics in the following paragraphs.

One of most important characteristics of a quality cost estimate is that it must be understandable to the cost analyst or decision-maker in order to be an efficient decision-making tool (Mislick & Nussbaum, 2015). To this end, a complex approach to cost estimation should be avoided, and a simpler approach should be used (Mislick & Nussbaum, 2015). An understandable estimate also clearly lays out the assumptions and ground rules that were used in the process (Mislick & Nussbaum, 2015). With the diversity among people's backgrounds and experiences, there can be differing underlying assumptions in the cost-estimation process. Therefore, the assumptions used must be clearly stated, and a sensitivity analysis should be performed to accommodate additional variations of assumptions (Mislick & Nussbaum, 2015).

Another characteristic of a quality cost estimate is that it is "anchored in historical program performance" (Mislick & Nussbaum, 2015, p. 13). We previously stated that cost estimation uses historical data to predict future cost. Therefore, an important aspect of the historical data is its relation to the future costs we are trying to predict. The cost estimation must be based on data from a similar system or program (Mislick & Nussbaum, 2015). For example, if we are trying to estimate the cost of a new class of surface ship, we should not be using historical data from a submarine program as such data would not produce a quality

estimate. Instead, we should use the historical data from a past class of surface ship that has features similar to the new class. Although we are using historical data as a base, we must also account for "current and potential future process and design improvements" (Mislick & Nussbaum, 2015, p. 13). We are trying to predict the cost of a new future system, which may have updated designs and processes with no historical data. These updates and improvements still need to be accounted for in our estimation and are often accomplished by subject matter experts (SMEs) and their professional judgment (Mislick & Nussbaum, 2015). Lastly, cost estimates are about predicting the future, and with the future comes uncertainty. In order to produce quality estimates, cost analysts must address the uncertainties and risk associated with the program (Mislick & Nussbaum, 2015). We go into more detail about how risk and uncertainties are addressed in cost estimation later.

2.   Cost Overview

Before comprehending cost estimation methods, it is important to become familiar with the terms associated with cost estimation. To begin with, an understanding of cost provides a solid foundation in the cost estimation process. If analysts and decision-makers do not understand what we are trying to predict, then we will not produce a quality or credible estimation. The term cost is often used interchangeably with the term price; however, they do not have the same meaning. There is an important distinction between the two terms. Mislick and Nussbaum (2015) define *cost* as the total amount of money needed to produce a certain item, or a quantitative measurement that accounts for all resources needed to produce an item. However, they refer to *price* as the amount of money that a person must pay for an item. When people go into a store, they normally ask the salesperson "What does this item cost?" Answering the literal question of what an item costs would encompass every resource that went into the development and production of that item. Instead, the accurate question is "What's the item's price?" or "How much money must I exchange to receive that item?" In cost estimation, we are focused on the question of what a program or project costs.

Because the term cost can refer to a number of different types or categories, the type of cost is important to understand during the cost estimation process. One of the first distinctions is between recurring and nonrecurring costs. A recurring cost is "repetitive and

occurs each time a company produces a unit" (Mislick & Nussbaum, 2015, p. 26). When a bottling company produces a bottled beverage, each bottle cap has an associated cost. The cost of each bottle cap is recurring. In contrast, a nonrecurring cost is "not repetitive and cannot be tied to the quantity of the items being produced" (Mislick & Nussbaum, 2015, p. 26). The cost associated with the purchase of the bottling machine would be considered nonrecurring. Closely related to recurring and nonrecurring costs are *fixed* and *variable* costs. According to Mislick & Nussbaum (2015), variable costs are associated and vary with the level of production. The more units produced the more the total variable cost. However, they describe fixed costs as unaffected by the level of production and are "generally associated with nonrecurring costs" (p. 27). No matter how many units are produced, the fixed cost will remain unchanged.

Another distinction between types of cost is *direct* and *indirect* costs. A direct cost can be "reasonably measured and allocated to a specific output, product, or work activity" (Mislick & Nussbaum, 2015, p. 26). The material used to produce an item is a direct cost. An indirect cost "cannot be attributed or allocated to a specific output, product, or work activity" (Mislick & Nussbaum, 2015, p. 27). The maintenance required for the upkeep of a machine used in production is indirect. Operating costs that are not direct labor or material, such as electricity and property taxes, are classified as *overhead* costs (Mislick & Nussbaum, 2015).

Other cost classifications are *sunk costs* and *opportunity costs*. A sunk cost is a cost that has already been incurred, as it occurred in the past. These costs are considered irrelevant to decision-makers, as the money spent cannot be retrieved (Mislick & Nussbaum, 2015). If a person walks into a car dealership and purchases a car, the cost of that car is not used in considering future upkeep or upgrades. The person cannot get back the money spent and reallocate it; therefore, it is sunk. Opportunity cost arises when there is more than one option to be considered. Mislick and Nussbaum (2015) define opportunity cost as the "measure of the lost value when you do not choose what turns out to be the optimal solution or alternative" (p. 29). In the car dealership scenario, you have the option of buying several different cars. Each of those cars has different features and a different value. In order to buy one car, you have to decide not to buy the others. This means you are giving up some features or value. Opportunity costs are important for decision-makers

when determining the best available option among multiple alternatives. Decision-makers must also consider the classification of life-cycle costs.

3. Life-Cycle Cost

In developing a cost estimate, cost analysts first must understand a program's or project's life cycle. A life cycle follows the project or program from its inception to its disposal, or "cradle to grave." It includes "the various stages of activity or phases through which the project progresses on its way from beginning to completion" (Rendon & Snider, 2008, p. 3). The life cycle starts at a program's development, flows through its production, operation, and maintenance, and finally concludes after proper disposal. The costs associated with this process are classified as the program's life-cycle cost (LCC).

The Defense Acquisition University (DAU) defines life-cycle cost as the direct cost of the acquisition program, as well as the indirect cost that can be logically attributed to the program over the entire life cycle ("Life cycle cost," n.d.). It includes the cost to the government to "acquire, operate, support (to include manpower), and where applicable, dispose" ("Life cycle cost," n.d., para. 2) of a system or program. There are multiple stakeholders in the DoD, such as Congress, the program manager and office, and contractors, who view a program's life-cycle cost from different perspectives. These multiple perspectives have led to three different methods of breaking down and displaying LCC.

The first method is breaking down program life-cycle costs into five different appropriation categories ("Life cycle cost," n.d.): Research, Development, Test, and Evaluation (RDT&E); Procurement; Operations and Maintenance (O&M); Military Construction (MILCON); and Military Personnel (MILPERS). This method is used to develop and submit budget requests to Congress ("Life cycle cost," n.d.).

However, program managers and program offices would not find the first method as useful as Congress does. Instead, they utilize program life-cycle costs that are broken down by Work Breakdown Structure (WBS; "Life cycle cost," n.d.). The DAU describes a WBS as a framework that displays "the total system as a product-oriented family tree composed of hardware, software, services, data, and facilities" ("Life cycle cost," n.d.,

para. 5). The WBS relates all of the work elements to each other and eventually to the final product ("Life cycle cost," n.d.). A WBS encompasses all of the work necessary to produce a product (Huynh & Snider, 2008). This breakdown shows the relationship between costs and different elements of a system, which is a useful tool for program managers and contractors.

The Office of the Secretary of Defense (OSD) for Cost Assessment and Program Evaluation (CAPE) outlines the third display method in its *Operating and Support Cost-Estimating Guide* (OSD CAPE, 2014). OSD CAPE defines a program's life-cycle cost as the summation of four different cost categories or phases: Research and Development (R&D), Investment, Operating and Support, and Disposal (OSD CAPE, 2014). Figure 1 provides a graphical representation of the four cost categories over a program's life cycle.
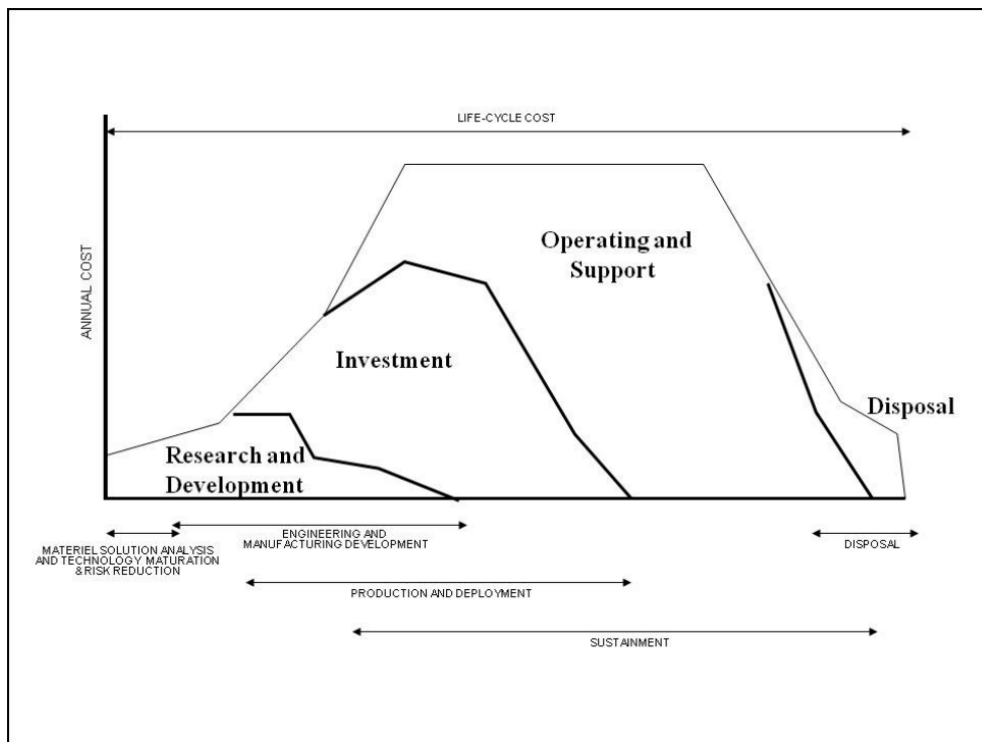
Figure 1.   Notional Profile of Annual Program Expenditures by Major Cost Category over the System Life Cycle. Source: OSD CAPE (2014).

R&D is the initial cost category or phase in a program's life cycle. These costs are the first incurred in the research, design, and development of a new system or program. They can also include the "system design and integration; development, fabrication, assembly, and test of hardware and software for prototypes and/or engineering development models" (OSD CAPE, 2014, p. 2-3).

Following R&D is the Investment cost category. These costs are incurred from "procurement and related activities from the beginning of low rate initial production (LRIP) through completion of deployment" (OSD CAPE, 2014, p. 2-3). LRIP refers to the production of the minimal number of a product or system that is required for Initial Operational Test and Evaluation (IOT&E; "Low Rate Initial Production [LRIP] of Production and Deployment Phase," n.d.). Investment costs can include program management, initial spares, technical publications, and equipment training (OSD CAPE, 2014).

The Operating and Support (O&S) phase is the third phase in the OSD CAPE definition of LCC. The O&S phase normally accounts for a majority of a project's life-cycle costs (OSD CAPE, 2014). O&S consists of all of a system's operation and sustainment costs from initial deployment to the end of its operational life. This includes all costs associated with "operating, maintaining, and supporting a fielded system" (OSD CAPE, 2014, p. 2-3). Specifically, costs can include "personnel, equipment, supplies, software, and services associated with operating, modifying, maintain, supplying, and otherwise supporting a system" (OSD CAPE, 2014, p. 2-3).

The fourth and final OSD CAPE cost category is Disposal. Disposal costs are those associated with the proper disposal or demilitarization at the end of a system's operational life (OSD CAPE, 2014). These costs can include "disassembly, materials processing, decontamination, collection/storage/disposal of hazardous materials and/or waste, safety precautions, and transportation of the system to and from the disposal site" (OSD CAPE, 2014, p. 2-5). However, disposal costs can also be incurred during the sustainment phase due to unplanned system losses (OSD CAPE, 2014). We will revisit this method of life-cycle costing in our discussion of total ownership costing.

C. DEPARTMENT OF DEFENSE ACQUISITION PROCESS

1. Defense Acquisition Overview

To comprehend how life-cycle costs and cost estimation are used in the DoD, cost analysts first must have a basic understanding of the DoD acquisition process. DoD Directive 5000.01 defines the purpose of the acquisition process as the ability to "acquire quality products that satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price" (Office of the Under Secretary of Defense for Acquisition, Technology, & Logistics [OUSD(AT&L)], 2007, p. 3). In acquiring a new system or program, the DoD uses the Defense Acquisition System (DAS), which is defined in Directive 5000.01 as a "management process by which the Department of Defense provides effective, affordable, and timely systems to the users" (OUSD[AT&L], 2007, p. 2). However, the DAS is not the only part of the acquisition process. It is used in conjunction with two other DoD Decision Support Systems (Ambrose, 2017a): the Joint Capabilities Integration and Development System (JCIDS) and the Planning, Programing, Budgeting, and Execution process (PPBE). These support systems identify and document the operational requirements or needs and guide the program's financing process. We are providing a brief overview of both support systems because they are fundamental to the overall DoD acquisition process.

Dealing with identifying, assessing, and prioritizing military operational requirements, JCIDS represents the foundation of the defense acquisition program process. It uses a top-down approach stemming from the National Military Strategy and flows into joint concepts and joint capabilities. The DAU ("Joint Capabilities Integration and development System [JCIDS]," n.d.) describes the JCIDS process as a "collaborative effort that uses joint concepts and integrated architectures to identify prioritized capability gaps and integrated doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTmLPF) solutions (materiel and non-materiel) to resolve those gaps" (para. 2). The JCIDS process starts with the identification of an operational capability gap and the requirements needed to fill the associated gap. This can be achieved through a Capabilities-Based Assessment (CBA) and two different potential solutions:

materiel or non-materiel (JCIDS, n.d.). If a materiel solution is decided on, then the DoD acquisition process proceeds.

As an example, if a commander discovers his or her sailors are unable to combat a new threat with the ship's current systems, a capability gap has been identified. The DoD will address this gap and the need for a solution through the JCIDS process. If the solution is a new or updated system, then a new program will be developed through the defense acquisition process. Once the need for a new system or program has been identified, decision-makers can transition to the financing side of the acquisition process.

The Planning, Programing, Budgeting, and Execution process (PPBE) is the second acquisition support system. The DAU defines the process as the DoD's "internal methodology used to allocate resources to provide capabilities deemed necessary to accomplish the Department's missions" ("Planning, programming, budgeting & execution process [PPBE], n.d., para. 3). The process focuses on how resources are allocated in the DoD to support both current and future acquisition programs, and more specifically, on how the DoD finances those programs. The PPBE process is broken down into four phases.

In the first phase, planning, the required capabilities to support and complete the missions outlined in the national policy are developed. This phase produces the Joint Programming Guidance (JPG), which provides guidance and establishes priorities for the Program Objective Memorandum (POM; Candreva, 2008). However, the JPG does not account for any fiscal constraints. The next phase in the PPBE process is programming. This phase entails applying fiscal constraints to the objects produced in the planning phase and results in the production of the POM, which outlines the plan for the allocation of funding to programs (Candreva, 2008). The third part of the PPBE process is the budgeting phase. The goal of this phase is converting the information contained in the POM into the budget format required by Congress and the Office of Management and Budget (OMB; Candreva, 2008). The budget outlines what the money is for, why is it needed (justification), and the monetary amount; it represents a request for spending authority. The appropriations from Congress grant that authority and give the power to obligate funds from the U.S. Treasury to an objective (Candreva, 2008). After the authorization and appropriations bill has been signed, decision-makers can enter the execution phase, the

fourth phase of the PPBE process (Candreva, 2008). *Execution* refers to the act of exercising the authority granted by the appropriation or the spending of the money (Candreva, 2008). The PPBE is an important part of the acquisition process. Without the funding piece, the DoD would not be able to acquire the new programs and systems that have been identified as a need through the JCIDS process.

Now that the two support systems, JCIDS and PPBE, have identified capability need and established program funding, decision-makers can turn to the DAS. The DAS is governed by the DoD's Instruction 5000 series, which provides policy and principles, as well as a foundation of management for the DAS. The DAS has established a five-phase framework for defense acquisition programs. It takes the capability need identified through the JCIDS process and develops it into a working system. The process follows the system from the program's conception through its operational phase and ends with its disposal. Figure 2 from DoDI 5000.02 (OUSD[AT&L], 2017) shows the DAS process for a hardware-intensive product.
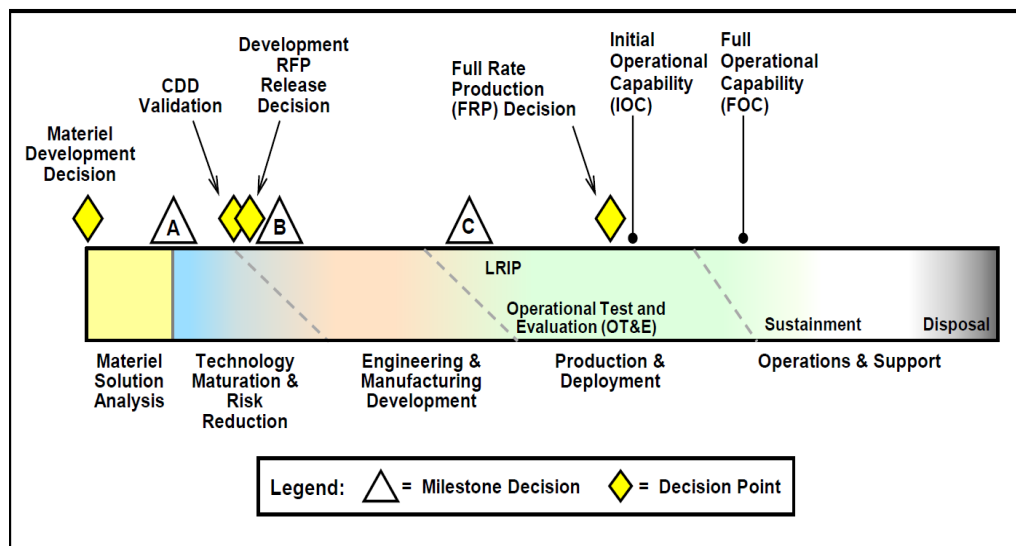
Figure 2. Hardware-Intensive DAS Process. Source: OUSD(AT&L; 2017).

Materiel Solution Analysis (MSA) is the first phase of the DAS. DoDI 5000.02 describes the MSA purpose as "conduct [ing] the analysis and other activities needed to choose the concept for the product that will be acquired, to begin translating validated capability gaps in system-specific requirements" (OUSD[AT&L], 2017, p. 18). This phase

takes the identified capability gaps and needs from the JCIDS process and translates them into the requirements for the desired acquisition. Numerous technologies are then analyzed and evaluated to determine which one best fulfills those needs and requirements (Ambrose, 2017b).

The second phase of the DAS is Technology Maturation and Risk Reduction (TMMR). The purpose of this phase, as defined by the DAU, is "to reduce technology, engineering, integration, and life-cycle cost risk to the point that the decision to contract for Engineering and Manufacturing Development (EMD) can be made with confidence for the successful program execution of development, production, and sustainment" ("Technology maturation and risk reduction," n.d.). The goal of this phase is to reduce the risks associated with the product that will be developed (OUSD[AT&L], 2017).

Following the TMMR phase, the process enters the EMD phase of the DAS. The goal of the TMMR phase is to ensure that a system meets all the operational requirements through development and testing (OUSD[AT&L], 2017). The hardware and software designed are being completed and prototypes are built during this phase. These prototypes will undergo a Developmental Test and Evaluation (DT&E) to verify the capability requirements have been met (OUSD[AT&L], 2017). These results will support the decision to enter into the next phase.

Production and Development (P&D) is the fourth phase of the DAS. The purpose of this phase is "to produce and deliver requirements-compliant products to receiving military organizations" (OUSD[AT&L], 2017, p. 30). In this phase, the product undergoes testing, including Operational Test and Evaluation (OT&E), to verify that the product meets the operational requirements before full production and deployment (OUSD[AT&L], 2017). After successful testing, the product can be produced and then fielded for use by operational forces. The phase also encompasses Low Rate Initial Production, Limited Deployment, Full-Rate Production Decision, and eventually Full-Rate Production and Deployment (OUSD[AT&L], 2017).

The last phase of the DAS is Operating and Support (O&S). Its purpose is to "execute the product support strategy, satisfy materiel readiness and operational support performance requirements, and sustain the system over its life cycle (to include disposal)"

(OUSD[AT&L], 2017, p. 31). The phase consists of two main stages, sustainment and disposal. Sustainment continues the full rate production, deployment, and operational support of the product throughout its life (OUSD[AT&L], 2017). This phase also includes proper disposal at the end of the product's life. At the end of a product's operational life, it will be "demilitarized and disposed of in accordance with all legal and regulatory requirements" (OUSD[AT&L], 2017, p. 32). After a product's disposal, the DAS is complete.

2. Cost Estimation in the Department of Defense

Cost estimation is an important and required tool used by decision-makers in defense acquisitions. The requirement for a cost estimation is outlined in the DoD Instruction 5000.02, *Operation of the Defense Acquisition System.* Specifically, the instruction mandates that the "DoD Component will develop a DoD Component Cost Estimate that covers the entire life cycle of the program for all Major Defense Acquisition Programs (MDAPs) prior to Milestone A, B, and C reviews and the Full-Rate Production Decision; and for all Major Automated Information System (MAIS) programs at any time an Economic Analysis is due" (OUSD[AT&L], 2017, p. 135). This means that before the acquisition process can move beyond the MSA, TMRR, and EMD phases and ultimately continue on to full production, a cost estimate encompassing the entire program life cycle must be produced. In addition to the DoD's Component Cost Estimate, a separate, independent cost estimate is also required. DoDI 5000.02 requires the Milestone Decision Authority to consider an "independent estimate of the full life-cycle cost of a program, prepared or approved by the Director of Cost Analysis and Program Evaluation (DCAPE)" (OUSD[AT&L], 2017, p. 135). The DoD Component and DCAPE estimates are classified by the DoD as Life-Cycle Cost Estimations (LCCEs). Mislick and Nussbaum (2015) describe an LCCE as "a cost estimate for the totality of the resources that will be necessary throughout the product's life cycle" (p. 18).

There are four main cost-estimating techniques used in the DoD to develop an LCCE, and they can be used in different phases of a program's life cycle (Ambrose, 2017a). The first method is parametric cost estimating and involves the use of statistical inferences to generate an estimate based on system performance and design (Ambrose, 2017a). Using

historical data from similar systems, cost estimation relationships (CERs) and patterns are identified. Those patterns are assumed to hold true in the future and are used to predict cost (Mislick & Nussbaum, 2015). The second method is analogy cost estimating, whereby a new system is compared to a similar existing system. The analogy method is a relatively quick and inexpensive method; however, it may not be as precise as other methods (Ambrose, 2017a). The parametric and analogy methods are normally used early in the acquisition process during the MSA, TMMR, and EMD phases (Ambrose, 2017a). The third and most time-consuming method is engineering cost estimation. In this method, the system is broken down into its WBS elements in which individual detail estimates are conducted. These estimates are then summed together to create the overall estimate (Mislick & Nussbaum, 2015). The engineering method is used during the TMRR phase and through the remaining acquisition process (Ambrose, 2017a). The last main method used by the DoD is actual costing. This method uses the actual costs from a system that were incurred in the past to predict the cost of producing that system in the future (Ambrose, 2017a). This method can be used after a program has entered the P&D phase.

D.   TOTAL OWNERSHIP COST

While LCCEs are useful tools for decision-makers, they present a narrower scope when a broader perspective may be more beneficial (Kobren, 2014). Thus, we introduce the concept of total ownership cost (TOC). The DAU defines *total ownership cost* as including the "elements of life-cycle cost as well as other infrastructure or business process costs not normally attributed to the program" (Kobren, 2014, para. 2). Infrastructures refers to "all military department and defense agency activities that sustain the military forces assigned to the combatant and component commanders" (Kobren, 2014, para. 3). The major infrastructure categories are support to equipment, support to military personnel, and support to military bases (Kobren, 2014). Not normally included in a traditional LCCE, other support activities to consider in a cost estimate are recruiting, environmental and safety compliance, management headquarters functions, and logistics infrastructure activities (Kobren, 2014).

DoD Directive 5000.01 states that "DoD Components shall plan programs based on realistic projections of the dollars and manpower likely to be available in future years.

To the greatest extent possible, the MDAs shall identify the total costs of ownership, and at a minimum, the major drivers of total ownership costs" (OUSD[AT&L], 2007, p. 5). This requires the DoD to expand beyond the basic life-cycle cost estimation and include the support activities and infrastructure costs. To support the DoD directive, the Department of the Navy (DoN; 2014) issued its *Total Ownership Cost (TOC) Guidebook* in which it describes "new departmental and naval processes" (p. 6) that support the DoD policy of the identification of total costs of ownership. Specifically, the guidebook assists the DoN and its organizations in developing, understanding, and applying the TOC requirements of the DoD.

The DoN (2014) outlines the importance of TOC: "As the DoD (and Navy) funding remains constant or declines, and as Navy's purchasing power declines as a result, increasing the decision weight priority for alternatives that can mitigate and reduce TOC becomes our clearest path to a capable and optimally affordable Fleet" (DoN, 2014, p. 8). For this reason, we focus our model on TOC instead of a standard life-cycle cost.

E.   RISK AND UNCERTAINTY

A key point that we need to understand in cost estimating is that the future is uncertain. Therefore, an essential pillar in developing a defendable and credible cost estimate is ensuring that risk and uncertainty are incorporated. A cost estimate can be severely affected by factors such as technological maturity, schedule slips, software requirements, or any other unforeseen event (Mislick & Nussbaum, 2015). Unknown factors make any point estimate or any exact answer extraordinarily unlikely (Mislick & Nussbaum, 2015). A more accurate estimate uses a central tendency centered on the original point estimate and a range both higher and lower to define the bounds of the estimate.

Though similar and related, risk and uncertainty are not synonymous. In the simplest terms, risk is the probability of the occurrence of a negative or unfavorable event, while uncertainty is the lack of certainty, or the realization that definitively knowing the outcome of any future event is completely impossible (Mislick & Nussbaum, 2015). In Johnathan Mun's (2015) book, *Readings in Certified Quantitate Risk Management (CQRM),* he states that

The concepts of risk and uncertainty are related but different. Uncertainty involves variables that are unknown and changing, but uncertainty will become known and resolved through the passage of time, events and action. Risk is something one bears and is the outcome of uncertainty. Sometimes risk may remain constant while uncertainty increases over time. (p. 28)

A good way to think about risk and uncertainty is to imagine going on a skydiving trip with a friend. As the plane takes off, you and your friend realize that there is only one parachute and that parachute is looking like it is somewhat past its service life. Your friend, being slightly more adventurous than you, decides to grab the parachute and take the jump. Both you and your friend share the same level of uncertainty about whether the parachute will open and whether your friend will live to tell the story. However, only your friend will assume the risk of jumping out of the plane and falling to his or her death.

Though better than ignoring risk altogether, incorrect treatment of risk can significantly affect the estimate. Cost estimating risk, schedule or technical risk, requirements risk, and threat risk are the four types of risk that play a factor in the cost estimation for a life-cycle cost. Cost estimating risk is the risk attributed to cost estimating error and uncertainty due to the numerical methodology used (Mislick & Nussbaum, 2015). Next, schedule or technical risk is the risk associated with the inability to accomplish schedule or technical objectives of the design or current specification, which stretches the timeline of the program completion (Mislick & Nussbaum, 2015). Requirements risk is the risk of the original requirements being shifted due to shortfalls in the original requirements documentation or due to the current design failing to complete the requirement. The final category is threat risk, the risk of a new unforeseen threat due to a complete change in the original problem (Mislick & Nussbaum, 2015).

Even after a cost estimator does due diligence in looking at historical data and normalizing data to build an analogy, parametric, engineering, or actual estimate, the multiple sources of uncertainty can still play a large factor in the estimate. Because cost estimators do not have a crystal ball that they can use to tell the exact future, they must use assumptions such as inflation rates and changes in technology.

F. ELECTRO-OPTICAL INFRARED SENSORS

1. Background

As cited in Driggers, Friedman, and Nichols (2012) book, *Introduction to Infrared and Electro-Optical Systems*, electro-optics (EO) refers to the field of systems that convert photons into electrons. Driggers et al. note that these systems are designed to respond to wavelengths within the 0.4–3 micrometer region. They deliver images that are analogous to human vision, and the authors point out that some EO systems are even capable of processing the near or short infrared (IR) spectral region (Driggers et al., 2012).

The term *target* is used to describe the desired image sought with an EO sensor. The signal from a target usually has a large reflective component, typically in the EO wavelength band. The target is provided this reflection component by moonlight, starlight, sunlight, or any artificial light source (Driggers et al., 2012). The light sources reflecting off of the background and the target are known as external radiation. Radiation reflected by targets and background does not go directly to the EO sensor. The reflected radiation must first transition through the atmosphere, where it experiences scattering, before being processed by the EO sensor (Driggers et al., 2012). Scattering is a phenomenon where particles in the atmosphere such as smoke, smog, or mist interfere with the reflection. Once the reflected radiation meets the EO sensor, it is passed through the sensing element, which could be detectors, tubes, or image intensifiers (low light situations) (Driggers et al., 2012). Next, the output of the sensor element is digested by the electronics and sent to a human interface for the operator (human) to gather some information from the process. This information could take myriad shapes such as detection, recognition, or identification of targets such as a warship. In short, EO sensors detect the light reflected off the subject from the scene (Driggers et al., 2012). Figure 3 represents a typical EO sensor scenario.
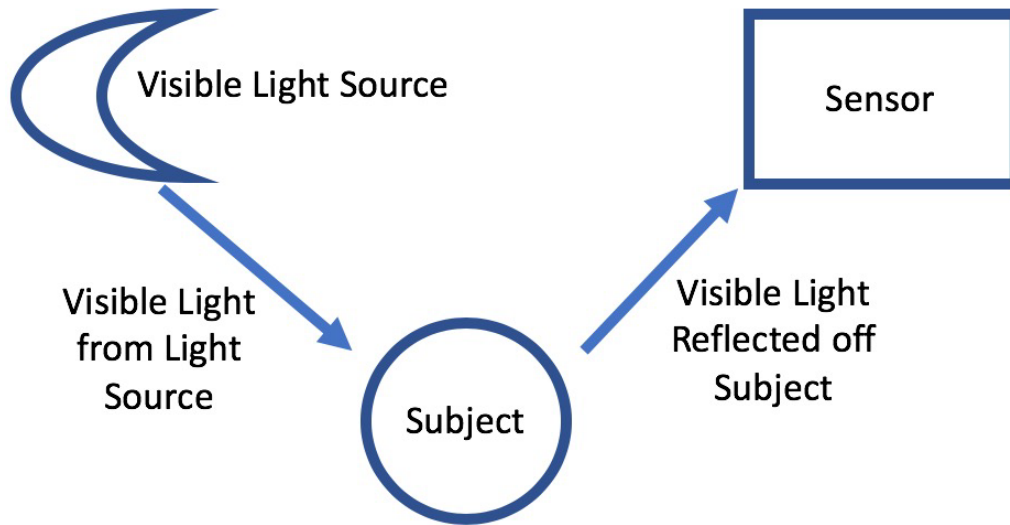
Figure 3.   Typical EO Sensor Scenario. Adapted from Driggers et al. (2012).

Infrared is able to recognize the spectral region from 0.7 to 14 micrometer wavelengths. It is divided into four subregions: the near-infrared (NIR) region is from 0.7 to 1.1 mm, the short-wave infrared (SWIR) region is from 1.1 to 3 mm, the mid-wave infrared (MWIR) region is from 3 to 5 mm, and the long-wave infrared (LWIR) region is from 8 to 14 mm (Driggers et al., 2012). Infrared is primarily used in night operations (Driggers et al., 2012). The science of infrared is based on the science supporting Planck's law, which states that all bodies above the temperature of absolute zero emit electromagnetic radiation. The electromagnetic radiation is exploited to uncover the electromagnetic signatures given off that do not correlate to the wavelengths visible by the human eye or EO sensors.

> As the temperature of the object gets hotter, the peak wavelength moves to shorter wavelengths so that at very hot temperatures the radiation is perceived by the eye as light. The emissive surface characteristics of the hot object determine the spectral emission weighting of the radiation. The radiation emitted travels through the atmosphere, where it will then meet the aperture of the sensor. (Driggers et al., 2012, p. 7)

Most IR sensors provide situational awareness for very low light situations such as night vision, surveillance of low-lit areas, and navigating through smoke-filled compartments (Driggers et al., 2012). Figure 4 shows the basics of an infrared sensor scenario.
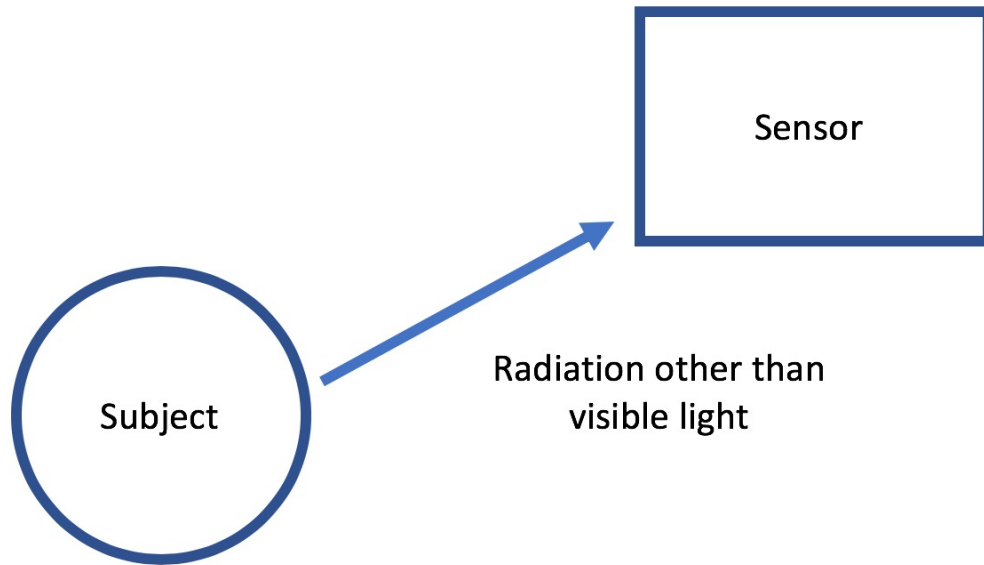
Figure 4. Typical IR Sensor Scenario. Adapted from Driggers et al. (2012).

The design of EO or IR imaging is very dependent on the purpose of the sensor, and the performance of the system is predicated on the functions of the wavelength (Driggers et al., 2012). Factors such as the characteristics of the scene and the atmosphere will determine the quality of the image obtained by the sensor. For EO sensors, the largest factor is reflectivity, or how much of the external radiation from the scene is going to make it back to the sensor (Driggers et al., 2012). For IR sensors, the question is far more focused on the emissivity of the target, or how much electromagnetic radiation the target is creating that will get back to the sensor (Driggers et al., 2012).

2. EO/IR Sensors on Surface Ships

Before the advent of electro-optics, direct optics were a commander's main resource in support of tactical decision-making. Binoculars, stadimeters, and periscopes were the key in situational awareness and obtaining fire control solutions for torpedoes and gun engagements (Davidson, 2015). With the invention of EO, warfighters are no longer restricted to the limitations of the human eye. The application of using television cameras and the discovery of light-sensitive semiconductor materials allow images to be converted into electrical signals that are fed into displays for humans to process information. EO sensors paired with the ability of infrared sensors allow warfighters to discern a target in the most vast and unlit environments (Davidson, 2015).

In Nitschke's (2007) article, "New Generation Naval Electro-Optics," he states that

Electro Optical/Infrared technology is an invaluable aid for the 21st century digitised battlespace arena. It provides surface warships, submarines, and maritime aviation operating in the varying naval environment with extensive image gathering, navigational, and targeting capabilities. (p. 87)

The constant advances in EO/IR systems have developed sensors with integral lasers that are used to measure distances with extreme accuracy and are a fraction of the size of the range finders of legacy ships (Davidson, 2015). In an Institute for Defense Analyses report entitled *A Tutorial on Electro-Optical/Infrared (EO/IR) Theory and Systems*, it is stated that "the performance of an EO/IR sensor depends on the optics, detector, display, target-background contrast and the intensity of the illumination source" (Koretsky, Nicoll, & Taylor, 2013, p. 5). Using the background on EO/IR sensors detailed previously, it can be seen that there are a multitude of applications for these sensors on surface ships.

Technological advances have emphasized the importance of the opportunity and the necessity to reinvest in the newest technologies and systems. These advances in technology will drive future EO/IR system purchases by the DoD. These system acquisitions will require a credible and reliable cost estimation to ensure the DoD manages its budget effectively. With the complexity and uniqueness of EO/IR systems, an efficient cost estimation model is needed to account for all life-cycle costs. The additional aspect of uncertainty should also be considered in the estimation. The cost estimation model we are proposing takes into account total ownership costs for and uncertainty of the acquisition of EO/IR systems for U.S. Navy surface ships. This model serves as a proof of concept to help future DoD decision-makers understand the costs associated with EO/IR systems so they can make strategic investments.

3. Program Executive Office Integrated Warfare Systems

The mission of Naval Sea Systems Command (NAVSEA) is to "design, build, deliver, and maintain ships and systems on time and on cost for the United States Navy" (NAVSEA, n.d.). NAVSEA is overall responsible for systems on Navy surface ships including EO/IR sensors. To help manage all of these programs, NAVSEA contains five

affiliated Program Executive Offices (PEOs). Each PEO is responsible for managing all aspects of its assigned programs' life cycles (NAVSEA, n.d.). EO/IR sensors fall under the purview of the PEO Integrated Warfare Systems (IWS). The Program Executive Office Integrated Warfare Systems (PEO IWS) is tasked to "develop, deliver, and sustain operationally dominant combat systems for Sailors" (Assistant Secretary of the Navy for Research, Development & Acquisition, n.d.). In August 2018, PEO IWS had 196 active contracts with a total value of $33.2 billion and was responsible for 129 programs and projects (Deputy Major Program Manager, 2018).

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III. MODEL INTRODUCTION

A. MODEL GUIDANCE

This chapter gives a comprehensive description of our model entitled "TOC Model Worksheet (Final).xlsx" and the directions for operating it. This model was developed by Johnathan Mun (jcmun@nps.edu), Eliah Ledbetter (eliah.ledbetter@nps.edu), and Katelyn George (katelyn.george@nps.edu) at the Naval Postgraduate School in Monterey, CA, to model the life-cycle and total ownership costs of surface electro-optic infrared (EO/IR) sensors for NAVSEA. This chapter is intended to prepare the model's cost to apply the fundamentals of TOC over the entire life cycle of an EO/IR sensor from the acquisition cost through disposal.

B. TOTAL OWNERSHIP COST WITH LIFE-CYCLE MODEL

This chapter is not a guidance on design specification; it is, instead, a guide to decision-analytic modeling of a sensor for use in a follow-on comparison between alternatives. In a life-cycle–based analysis of TOC, an essential set of assumptions includes that there is a multitude of costs incurred prior to the system being operational, such as R&D and Production. In this example, these costs are identified as Year 0 (as shown in Figure 5). The follow-on cost represents the operational years of the system; in this example, these years are designated as Year 1 through Year 10 (see Figure 5) where the Operation and Maintenance (O&M) costs apply. In the final year of operations (Year 10 in Figure 5), the additional cost incurred must be considered to either dispose of, salvage, or otherwise render the system inoperable. Figure 5 shows the typical life-cycle cost over time, which is calculated by taking the summation of the aforementioned costs incurred over the life cycle of the system. It is imperative to remember the importance of economic theory while dealing with multiyear projects. These costs must be annually discounted at a predetermined discount rate to reflect the time value of money (the purchasing power of a dollar today is not equivalent to the purchasing power of a dollar tomorrow due to economic factors such as economic growth rate, inflation, and changes in interest rates). Finally, the O&M cost may also change over the system's life due to inflation, budget restrictions, and changes in technology; this model allows for these factors to be adjusted manually.
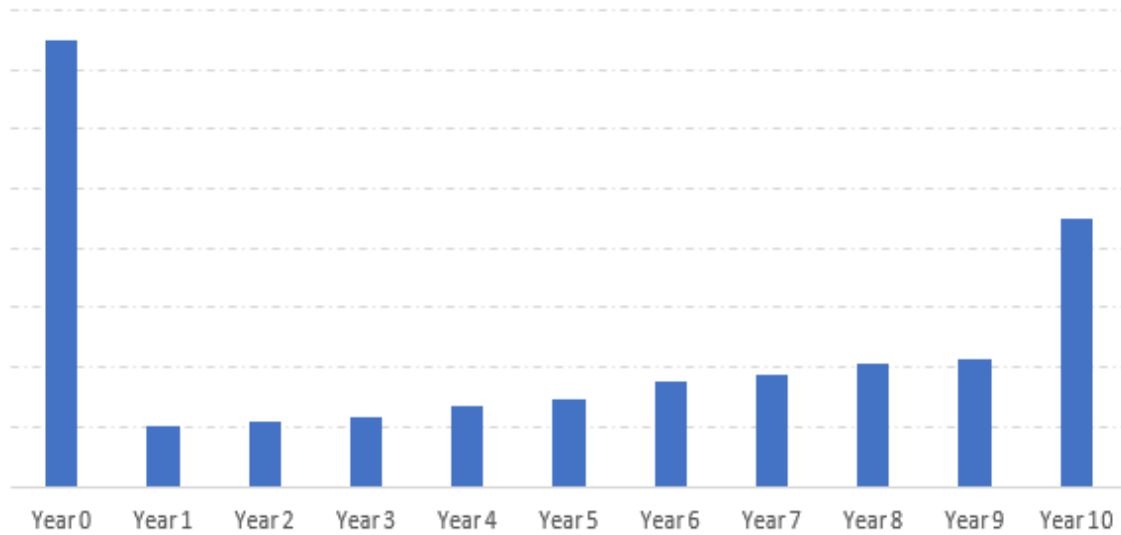
Figure 5.   Typical Life-Cycle Cost over Time

To understand this chapter, it is imperative that the reader be familiar with the primary function of Microsoft Excel and comprehend the fundamentals of Risk Simulator. These two prerequisites are essential for running Monte Carlo simulation to attempt to quantify the uncertainties in the cost over a system's life. Risk simulation only needs to be applied to the model when a risk or uncertainty analysis is required for the modeled sensor or system. The Excel model is divided into multiple worksheets. The first five worksheets are labeled System A to System E. These are five identical worksheets prepopulated with standard EO/IR generic cost structures (see Figure 6). Unlocking the worksheets allows the cost analyst to make modifications to the equations and model, alter the model structure, and audit the model's calculations. However, for regular use, it is recommended that the worksheets remain locked to prevent insertions of any accidental and erroneous changes to the model. Figure 6 shows the first two dozen rows of the model, while Figures 7 and 8 show the last two sections of the model. The following list provides additional clarity and guidance to this worksheet.

Figure 6. Model Input Worksheet

- The Excel file has five worksheets (Systems A–E), where each worksheet is meant for a different system. Alternatively, one of these can be set as the current or baseline system. If additional systems need to be included for analysis, we recommend creating a new file (simply perform a File | Save As to create a duplicate file).

- The figures in this document show a sample dataset where all unit and dollar inputs are set to 1 or $1, respectively. This was done intentionally to illustrate the location of data entry cells, as well as to have some sample results to show how the model works. Analysts can access the same results either by manually entering these unitary values or by opening the associated "TOC Model - Example Only (Repeated Data and Locked Sheets).xlsx" file to follow along.

- Row 1 is where you enter the name of the System in cell *D1*. Then enter any discount rate value ≥ 0%. The discount rate is used to calculate the present value of all future cash flows. Use 0% if no present valuation is needed, or enter the annualized cost of money (e.g., from 3% for inflationary adjustments only to 15% to account for risks and reinvestment opportunity costs of the cash flows). Also, here you can select the economic or operational life of this current system. These inputs can be unique for each of the five systems under analysis.

- Row 2 allows you to select the uncertainty range on which to perform risk-based Monte Carlo simulations. You can select to not run any simulations, a small ±5% range, standard ±10% to ±20% range, wide ±25% to ±40% range, or a highly uncertain ±45% to ±50% range. These ranges will be automatically computed and applied as probability distributions on the inputted costs (see the following bullet points) in order to run simulations. There is also a section where you can enter notes about the system under analysis (cells *D2:O2*).

- Row 3 allows you to enter an annual positive growth rate or an annual negative decline rate to be applied to the O&M over time, starting in the second year. This allows the cost analyst to increment the O&M over time or perform a similar reduction in costs over the lifetime of the system.

- The data input grid starts from row 6 to row 187, around columns B to P. All white-colored cells with borders are cost analyst input cells. You can also make modifications to subsection headers (e.g., rows 6, 24, etc.) and line item titles (e.g., cells *B7:B23*). The subsections and line item titles are generic inputs and can be changed as required. There is also an "Other:" line item that can be used as required.

- Because the model has been structured to run simulations and other advanced analytics, it is highly recommended that the analyst does not make any structural adjustments or modifications by deleting worksheets or inserting rows and columns unnecessarily. Also, the model has been optimized for printing, and any major modifications will muddle the printing capabilities.

- The number of units per system and number of platforms (columns C and D) have to be ≥ 0 and are self-explanatory. The acquisition cost, operational cost, maintenance per year, and replacement per year are on a per-unit basis. If you wish to enter the total replacement cost for the year, first take that value and divide it by the product of units with the number of platforms to obtain a per-unit cost. Enter only per-unit costs. Continue data entry until row 145.

- All grayed-out cells are computed values and should be left alone. If you wish to audit the calculations, first unlock/unprotect the worksheet and then select a cell to view its calculations.

- Area *B147: D177* looks at nonrecurring costs to the acquisition process of this current system. All acquisition costs are summed and set as today's (Year 0) cost.

- Area *B179:D187* looks at the nonrecurring end-of-life or disposition costs. These costs will be incurred at the end of the selected economic life (droplist circa cell *K2*) and will be discounted appropriately based on the discount rate and term of life selected.

- Replicate the data entry just described for up to five systems as required. If fewer than five systems are needed, simply ignore the unused worksheets, but remember not to delete them unnecessarily. If more than five systems are required, create a copy of the file and apply these remaining systems as a separate file. Changing the structure of the file may invalidate some of the preset simulation models and assumptions.

Figure 9 illustrates the Monte Carlo simulations section. This table summarizes the sections of the costs and created simulation variables (cells in green). Figure 10 shows how

these simulated results will be used to generate the life cycle of the cost structure of the system, where the economic life of the system is accounted for, as well as any required discounting to generate the present value of the costs. If the cost analyst wishes to run a simulation using Risk Simulator, we recommend first coming to this section and then hitting Run. This way, the analyst can see the actual simulation executing and how the cells in green change (Figure 9), as well as how the subsequent calculations will simulate and change (Figure 10). Note that by default, 10,000 simulation trials have been set because triangular probability distributions were applied to each of the subtotaled cost items, and the process is modeled to run without any predetermined seed values.

	A	B	C	D	E	F	G	H	I	J	K	L	M
147		**Nonrecurring Acquisition and End of Lifecycle Costs**	**Total**	**%**									
148		**Acquisition and Procurement**	**$29.00**										
149		Bid Specifications Development	$1.00	3.4%			**Analysis Notes**						
150		Proposal Evaluation	$1.00	3.4%									
151		Data Collection	$1.00	3.4%									
152		Data Analysis	$1.00	3.4%									
153		Contracts Development	$1.00	3.4%									
154		Program Planning	$1.00	3.4%			**Analysis Assumptions**						
155		Hardware Purchases	$1.00	3.4%									
156		*Personal Computers*	$1.00	3.4%									
157		*Peripherals*	$1.00	3.4%									
158		*Storage*	$1.00	3.4%									
159		*Networking*	$1.00	3.4%									
160		*Related Equipment*	$1.00	3.4%									
161		Other costs	$1.00	3.4%									
162		Administrative Cost	$1.00	3.4%									
163		Asset Management	$1.00	3.4%									
164		Overseeing Contractor Services	$1.00	3.4%									
165		In-House Training for Staff	$1.00	3.4%									
166		Product Maintenance	$1.00	3.4%									
167		Help Desk Support	$1.00	3.4%									
168		IT Support for Database Management	$1.00	3.4%									
169		Network Management Support	$1.00	3.4%									
170		Software Upgrades	$1.00	3.4%									

Figure 7.   Input Worksheet (Nonrecurring Acquisition Cost)

	A	B	C	D
179		**Nonrecurring End of Lifecycle Costs**	**Total**	**%**
180		**End of Lifecycle**	**$7.00**	
181		Administrative Cost	$1.00	14.3%
182		Asset Management	$1.00	14.3%
183		Vendor Contract Procurement	$1.00	14.3%
184		Staging, Sanitizing, Testing	$1.00	14.3%
185		Follow-Up Support	$1.00	14.3%
186		Recycling and Disposal Fees	$1.00	14.3%
187		Value of Sold Products and Materials	$1.00	14.3%

Figure 8.   Input Worksheet (Nonrecurring End-of-Life-Cycle Cost)

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$16.15	$17.00	$17.85	$17.00	$48.45	$51.00	$53.55	$51.00
Wide Field of View (WFOV) Sensors	$6.65	$7.00	$7.35	$7.00	$19.95	$21.00	$22.05	$21.00
EO/IR Sensor Manager (ESM)	$5.70	$6.00	$6.30	$6.00	$17.10	$18.00	$18.90	$18.00
Human Machine Interface (HMI)	$4.75	$5.00	$5.25	$5.00	$14.25	$15.00	$15.75	$15.00
Product Support Management	$8.55	$9.00	$9.45	$9.00	$25.65	$27.00	$28.35	$27.00
Design Interface	$10.45	$11.00	$11.55	$11.00	$31.35	$33.00	$34.65	$33.00
Supply Support	$11.40	$12.00	$12.60	$12.00	$34.20	$36.00	$37.80	$36.00
Support Equipment	$7.60	$8.00	$8.40	$8.00	$22.80	$24.00	$25.20	$24.00
Packaging, Handling, Storage and Transportation	$3.80	$4.00	$4.20	$4.00	$11.40	$12.00	$12.60	$12.00
Computer Resources	$5.70	$6.00	$6.30	$6.00	$17.10	$18.00	$18.90	$18.00
Manpower and Personnel	$5.70	$6.00	$6.30	$6.00	$17.10	$18.00	$18.90	$18.00
Maintenance Planning and Management	$14.25	$15.00	$15.75	$15.00	$42.75	$45.00	$47.25	$45.00
Training and Training Support	$7.60	$8.00	$8.40	$8.00	$22.80	$24.00	$25.20	$24.00
Facilities and Infrastructure	$3.80	$4.00	$4.20	$4.00	$11.40	$12.00	$12.60	$12.00
Technical Data Management	$6.65	$7.00	$7.35	$7.00	$19.95	$21.00	$22.05	$21.00
Acquisition Costs	$27.55	$29.00	$30.45	$29.00				
End of Life Disposition Costs	$6.65	$7.00	$7.35	$7.00				

Figure 9.   Monte Carlo Uncertainty Simulation

	Q	R	S	T	U	V	W	X	Y	Z	AA
25		Year	Acquisition	1	2	3	4	5	6	7	
26		Cash Flow	$154.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	
27		Present Value of Cash Flow	$154.00	$364.08	$358.78	$353.55	$348.40	$343.33	$338.33	$333.40	
28		Year	8	9	10	11	12	13	14	15	
29		Cash Flow	$416.19	$422.43	$428.77	$435.20	$441.73	$448.36	$455.08	$461.91	
30			$328.55	$323.76	$319.05	$314.40	$309.82	$305.31	$300.86	$296.48	
31		Year	16	17	18	19	20	21	22	23	
32		Cash Flow	$468.84	$475.87	$483.01	$490.25	$497.61	$505.07	$512.65	$520.34	
33			$292.16	$287.91	$283.72	$279.58	$275.51	$271.50	$267.55	$263.65	
34		Year	24	25	26	27	28	29	30	Disposition	
35		Cash Flow	$528.14	$536.06	$544.10	$552.27	$560.55	$568.96	$577.49	$7.00	
36			$259.81	$256.03	$252.30	$248.62	$245.00	$241.44	$237.92	$7.00	
37		Total Acquisition Cost for System A	$154.00								
38			5 Years	10 Years	15 Years	20 Years	25 Years	30 Years			
39		List of Total Lifetime Cost for System A	$2,093.10	$4,174.52	$6,416.80	$8,832.38	$11,434.63	$14,238.01			
40		List of Present Value Lifetime Cost for System A	$1,928.17	$3,570.42	$5,096.58	$6,514.85	$7,832.85	$9,057.68			
41											
42		Total Lifetime Cost for System A (20 Years)	$8,832.38	20 Years							
43		Total PV Lifetime Cost for System A (20 Years)	$6,514.85								

Figure 10. Life-Cycle Cost Cash Flow Calculations

In the summary worksheet (Figure 11), the total costs, as well as present values of total costs for various economic and useful lives, are tabulated. Analysts can view the results as tables and charts. Here, a comparative cross-sectional analysis of alternatives assessment can be seen, and a growth of the costs can be seen in the charts. Note that these results and charts are single-point estimates and are calculated prior to any simulations.

Analysis Period/Type	System A	System B	System C	System D	System E
5 Year Cash Total Net Cost	$2,093.10	$2,093.10	$2,093.10	$2,093.10	$2,093.10
10 Year Cash Total Net Cost	$4,174.52	$4,174.52	$4,174.52	$4,174.52	$4,174.52
15 Year Cash Total Net Cost	$6,416.80	$6,416.80	$6,416.80	$6,416.80	$6,416.80
20 Year Cash Total Net Cost	$8,832.38	$8,832.38	$8,832.38	$8,832.38	$8,832.38
25 Year Cash Total Net Cost	$11,434.63	$11,434.63	$11,434.63	$11,434.63	$11,434.63
30 Year Cash Total Net Cost	$14,238.01	$14,238.01	$14,238.01	$14,238.01	$14,238.01

Analysis Period/Type	System A	System B	System C	System D	System E
5 Year Cash Cost in Present Values	$1,928.17	$1,928.17	$1,928.17	$1,928.17	$1,928.17
10 Year Cash Cost in Present Values	$3,570.42	$3,570.42	$3,570.42	$3,570.42	$3,570.42
15 Year Cash Cost in Present Values	$5,096.58	$5,096.58	$5,096.58	$5,096.58	$5,096.58
20 Year Cash Cost in Present Values	$6,514.85	$6,514.85	$6,514.85	$6,514.85	$6,514.85
25 Year Cash Cost in Present Values	$7,832.85	$7,832.85	$7,832.85	$7,832.85	$7,832.85
30 Year Cash Cost in Present Values	$9,057.68	$9,057.68	$9,057.68	$9,057.68	$9,057.68
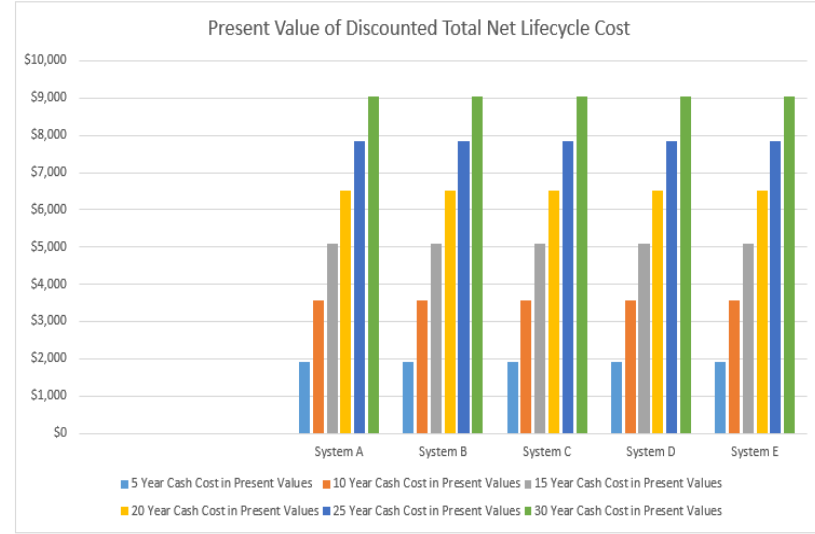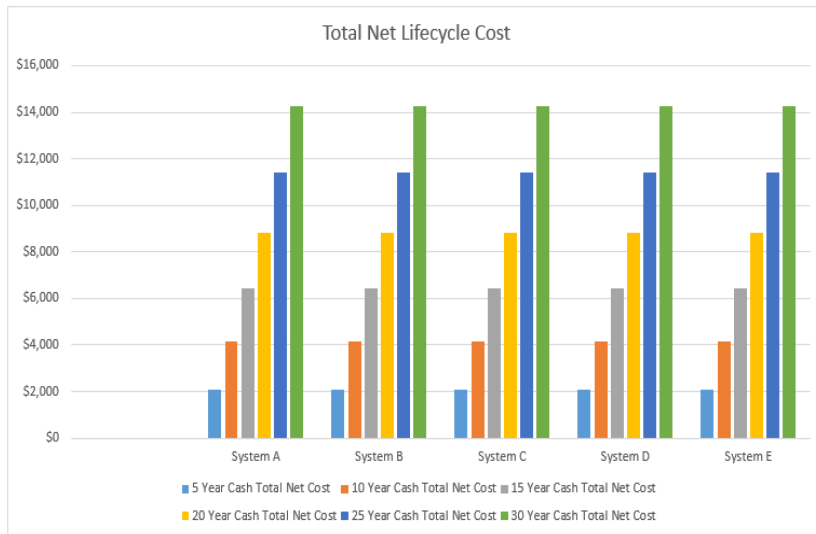
Figure 11.   Life-Cycle Cost Cash Flow Summary Results and Dashboard

If a simulation is run, the resulting charts in Figure 12 will be automatically generated. For more information, see Chapter IV for instructions on setting up and running simulations and interpreting the basic results as well as using some basic decision-analytics tools. Note that this current chapter provides only the most basic information needed. If detailed understanding is required, please see Mun's more than two dozen books (*Modeling Risk,* 3rd ed., 2016, is particularly recommended).

The model has predetermined simulation settings created, and, as such, the cost analyst can simply click on the Run Simulation icon in Risk Simulator to execute the run. Running the simulation will make changes to the cells in Figures 9 and 10, as previously discussed. If the other worksheets have populated inputs, these worksheets will also be run, and the results will be presented as probability distributions (shown in Figure 12). Each system's calculated Total Cost and Present Value of Total Costs will be shown (for the selected economic and useful life) as probability distributions and simulation statistics. Analysts can also perform a comparative analysis by using Overlay Charts (see the bottom of Figure 12), generate reports of the statistical results (see Figure 13), and run detailed reports of the analysis (see Figure 14), as well as other complete analytics such as scenario analysis and sensitivity analysis (see Chapter IV).

Finally, in the Summary Worksheet, analysts have the option to make adjustments to the cost cash flow series by making ± $ adjustments in the empty cells with borders (see Figure 15). This capability allows for any known factors such as technology insertion, foreseen major structural modifications, or any other such adjustments to be applied every few years. The cash flows will be adjusted accordingly in this worksheet. Note that as of the current version of Risk Simulator, simulations will be applied not to any such modifications, but only to single-point results.
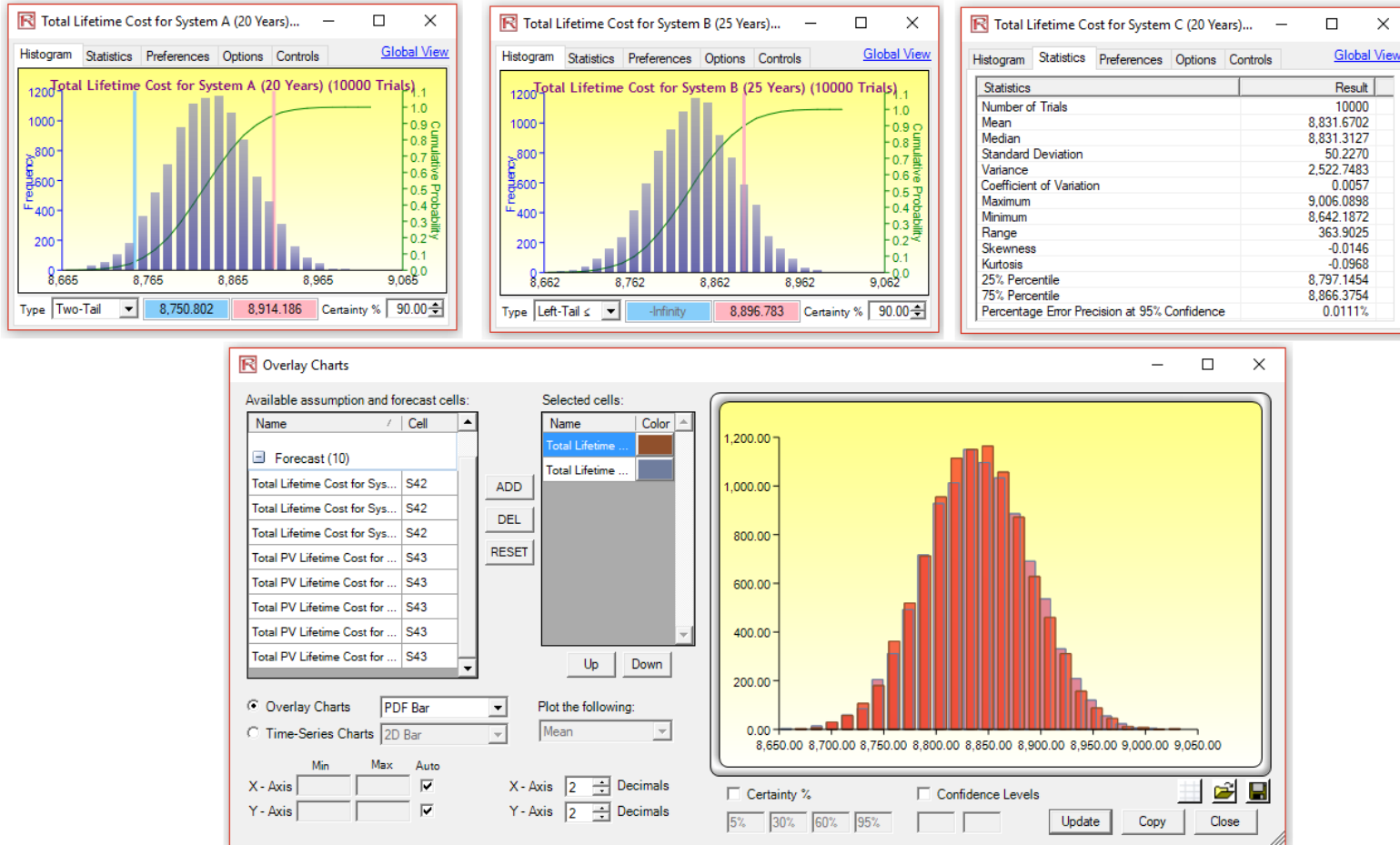
Figure 12.   Example Simulation Results

Forecast Statistics Table - TOC Model

Cell	Total Lifetime Cost for System A (20 Years)	Total Lifetime Cost for System B (25 Years)	Total Lifetime Cost for System C (20 Years)	Total Lifetime Cost for System D (10 Years)	Total Lifetime Cost for System E (15 Years)	Total PV Lifetime Cost for System A (20 Years)	Total PV Lifetime Cost for System B (25 Years)	Total PV Lifetime Cost for System C (20 Years)	Total PV Lifetime Cost for System D (10 Years)	Total PV Lifetime Cost for System E (15 Years)
Name	S42	S42	S42	S42	S42	S43	S43	S43	S43	S43
Number of Datapoints	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Mean	$8,831.96	$8,832.11	$8,831.67	$8,832.22	$8,833.20	$6,514.55	$6,514.66	$6,514.34	$6,514.74	$6,515.45
Median	$8,832.09	$8,832.36	$8,831.31	$8,832.68	$8,833.84	$6,514.71	$6,514.79	$6,514.06	$6,515.10	$6,515.92
Standard Deviation	$49.60	$49.78	$50.23	$49.66	$50.31	$36.37	$36.49	$36.83	$36.41	$36.89
Variance	2460.2390	2477.5659	2522.7483	2465.9911	2531.3819	1322.4143	1331.8844	1356.4244	1325.8729	1360.8216
Coefficient of Variation	0.56%	0.56%	0.57%	0.56%	0.57%	0.56%	0.56%	0.57%	0.56%	0.57%
Maximum	$9,027.86	$9,011.75	$9,006.09	$9,009.43	$9,003.96	$6,658.10	$6,646.07	$6,642.13	$6,644.26	$6,640.59
Minimum	$8,655.82	$8,652.68	$8,642.19	$8,660.92	$8,665.34	$6,385.77	$6,382.97	$6,375.27	$6,389.07	$6,392.70
Range	$372.04	$359.07	$363.90	$348.51	$338.63	$272.33	$263.11	$266.86	$255.19	$247.90
Skewness	0.0074	-0.0160	-0.0146	-0.0251	-0.0198	0.0077	-0.0158	-0.0150	-0.0256	-0.0202
Kurtosis	-0.0662	-0.0987	-0.0968	-0.0796	-0.0914	-0.0653	-0.0993	-0.0963	-0.0786	-0.0916
25% Percentile	$8,798.40	$8,798.34	$8,797.15	$8,799.02	$8,798.81	$6,489.99	$6,489.93	$6,488.95	$6,490.41	$6,490.24
75% Percentile	$8,865.49	$8,865.74	$8,866.38	$8,865.77	$8,866.89	$6,539.05	$6,539.33	$6,539.87	$6,539.27	$6,540.17
Error Precision at 95%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%	0.01%
5% Percentile	$8,750.80	$8,749.88	$8,748.87	$8,750.02	$8,750.08	$6,455.09	$6,454.33	$6,453.63	$6,454.58	$6,454.45
10% Percentile	$8,768.11	$8,768.33	$8,767.45	$8,767.78	$8,767.83	$6,467.70	$6,467.94	$6,467.36	$6,467.41	$6,467.44
20% Percentile	$8,790.18	$8,789.76	$8,788.77	$8,790.54	$8,790.56	$6,483.91	$6,483.59	$6,482.92	$6,484.17	$6,484.13
30% Percentile	$8,805.71	$8,805.99	$8,804.53	$8,806.06	$8,806.62	$6,495.32	$6,495.49	$6,494.57	$6,495.54	$6,496.10
40% Percentile	$8,818.82	$8,819.88	$8,818.79	$8,819.62	$8,820.54	$6,504.97	$6,505.68	$6,504.87	$6,505.48	$6,506.12
50% Percentile	$8,832.09	$8,832.36	$8,831.31	$8,832.68	$8,833.84	$6,514.71	$6,514.79	$6,514.06	$6,515.10	$6,515.92
60% Percentile	$8,844.69	$8,844.76	$8,844.26	$8,845.26	$8,846.54	$6,523.91	$6,523.96	$6,523.52	$6,524.33	$6,525.27
70% Percentile	$8,858.16	$8,857.91	$8,858.11	$8,858.30	$8,859.69	$6,533.76	$6,533.60	$6,533.74	$6,533.85	$6,534.87
80% Percentile	$8,873.26	$8,874.27	$8,874.71	$8,874.33	$8,875.39	$6,544.78	$6,545.59	$6,545.98	$6,545.52	$6,546.35
90% Percentile	$8,896.26	$8,896.78	$8,896.86	$8,895.78	$8,897.90	$6,561.77	$6,562.09	$6,562.10	$6,561.33	$6,562.91
95% Percentile	$8,914.19	$8,914.12	$8,913.73	$8,914.62	$8,916.08	$6,574.83	$6,574.91	$6,574.50	$6,575.13	$6,576.09
99% Percentile	$8,946.27	$8,945.13	$8,946.00	$8,946.14	$8,950.41	$6,598.43	$6,597.55	$6,598.03	$6,598.03	$6,601.18

Figure 13.   Example Simulation Statistics Table (Only Sample Basic Results Shown)

General

Number of Trials	10000
Stop Simulation on Error	No
Random Seed	Random
Enable Correlations	Yes

Assumptions

Name	**Field of View (NFOV) Sensors**	**Name**	**Wide Field of View (WFOV) Sensors**	**Name**	**O/IR Sensor Manager (ESM)**
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V6	Cell	V7	Cell	V8
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	16.15	Minimum	6.65	Minimum	5.7
Most Likely	17	Most Likely	7	Most Likely	6
Maximum	17.85	Maximum	7.35	Maximum	6.3

Figure 14.   Example Simulation Report

	C	D	E	F	G	H	I	J	K	L	M	N	O	P
37		Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10	11
38	Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
39	Manual Adjustment													
40	Net Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
41	PV Cash Flows	$154.00		$364.08	$358.78	$353.55	$348.40	$343.33	$338.33	$333.40	$328.55	$323.76	$319.05	$314.40
42														
43														
44	System B	Discount Rate	3.00%											
45		Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10	11
46	Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
47	Manual Adjustment													
48	Net Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
49	PV Cash Flows	$154.00		$364.08	$358.78	$353.55	$348.40	$343.33	$338.33	$333.40	$328.55	$323.76	$319.05	$314.40
50														
51														
52	System C	Discount Rate	3.00%											
53		Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10	11
54	Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
55	Manual Adjustment													
56	Net Cash Flow	$154.00	$7.00	$375.00	$380.63	$386.33	$392.13	$398.01	$403.98	$410.04	$416.19	$422.43	$428.77	$435.20
57	PV Cash Flows	$154.00		$364.08	$358.78	$353.55	$348.40	$343.33	$338.33	$333.40	$328.55	$323.76	$319.05	$314.40

Figure 15.   Manual Adjustments to Life-Cycle Cost Cash Flow

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IV.   MONTE CARLO RISK SIMULATION

A.   WHAT IS MONTE CARLO SIMULATION?

Monte Carlo risk simulation is the process of running multiple probability simulations (Mun, 2015). Monte Carlo risk simulation provides analysts and decision-makers a method to more easily solve complex real-world problems (Mun, 2015). Monte Carlo simulation produces synthetic future outcomes by computing thousands and even millions of different sample paths of outcomes to observe the prevalent characteristics (Mun, 2015). To obtain proficiency in the skills required to solve these complex problems, analysts would need to use high-level math; However, this not a sensible solution (Mun, 2015). In an effort to make this more practical, analysts will use any available tools and techniques to simplify the process (Mun, 2015). Monte Carlo risk simulation provides an analyst with answers that are comparable to the more sophisticated and time-consuming mathematical methods (Mun, 2015).

In his book, *Readings in Certified Quantitative Risk Management,* Mun (2015) describes Monte Carlo simulation as a random number generator that is a very effective tool for estimation and risk analysis. A simulation generates a multitude of scenarios for a model by repeatedly choosing random values from a spectrum of potential outcomes chosen by the cost analysis (Mun, 2015). The outcomes calculated by the model will produce a probability distribution for the uncertain variables (Mun, 2015). All of the outcomes will result in a model. From this model, an analyst will be able to derive a forecast that defines an important piece of information such as estimated total cost, net profit, or total expenses (Mun, 2015). This chapter provides a step-by-step walk-through of the Simulation Module in Risk Simulator used in forecasting cost estimates.

B.   RISK SIMULATOR SOFTWARE INSTALLATION REQUIREMENTS AND PROCEDURES

Mun (2015) explains the following six modules (see Figure 16) contained in the Risk Simulator software:

1. The Monte Carlo Simulation module gives an analyst the ability to run a variety of different simulations. These products can include distribution fitting and correlation reports.

2. Analysts can use the Forecasting module to produce a number of different forecast reports, including automatic time-series and econometric forecast.

3. The Optimization Under Uncertainty module provides analysts with a tool that can minimize or maximize the objective through the optimization of the model's constrained variables.

4. The Modeling and Analytical Tools module gives analysts the ability to run statistical testing on the input data, as well as a variety of types of sensitivity analyses on the simulation.

5. The ROV BizStats module allows analysts to run over 130 types of business analyses on the simulated model.

6. The ROV Decision Tree module allows analysts to incorporate advanced analytics into the common method of decision tree modeling (Mun, 2015).
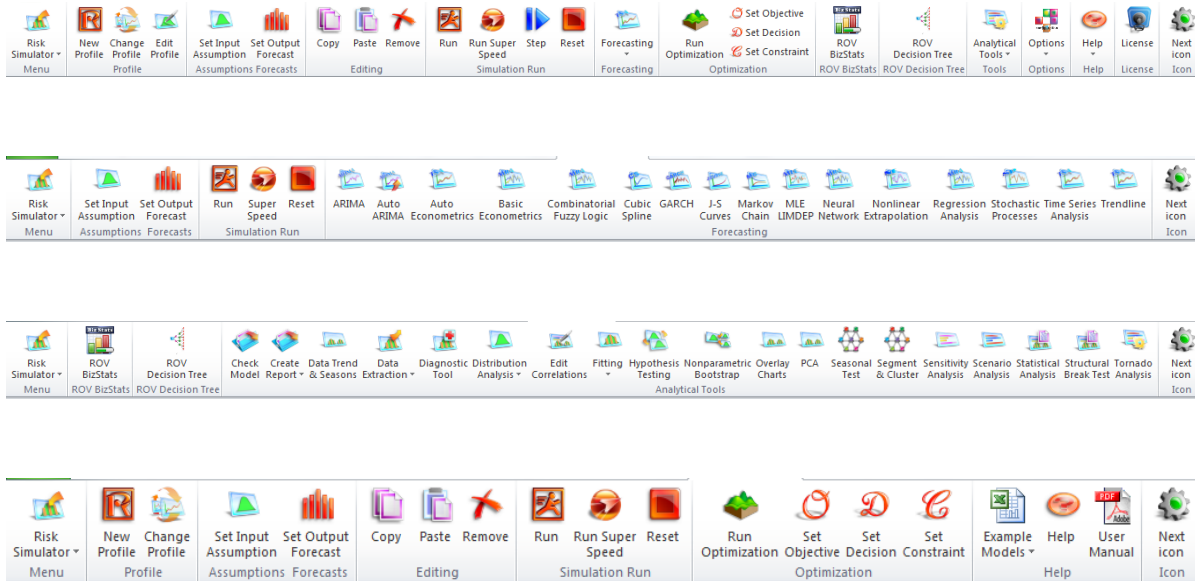
Figure 16. Risk Simulator Icon Toolbars in Excel

C. GETTING STARTED WITH RISK SIMULATOR

1. A High-Level Software Overview

The Risk Simulator software is equipped with several applications such as Monte Carlo simulation, forecasting, optimization, and risk analytics (Mun, 2015).

Mun (2015) explains that the Simulation Module allows cost analysts to run the following simulations:

- Simulation Forecasts can be generated using the Simulation Model. These forecasts provide a tool for analysts to examine various distributions.

- Distribution Fitting can also be preform using the Simulation Module. This application automatically finds the statistical distribution that is the best fit for the model data.

- The Simulation Module also examines the relationship between the variables in the simulation and determines the extent of correlations between those variables.

- The Simulation Module also can generate sensitivity analysis charts, such as tornado and spider charts. These sensitivities charts provide analysts a tool to identify sensitivity factors for the simulation.

- To determine the differences between forecasts, the simulation model allows analysts to test statistical hypotheses.

- To assess the strength of the result statistic an analyst should run the bootstrap simulation.

- Instead of selecting parameters, an analyst can use historical data analysts to run custom simulations (Mun, 2015).

In his book, Mun (2015) describes the forecasting:

used to generate automatic time-series forecasts (with and without seasonality and trend), multivariate regressions (modeling relationships among variables), nonlinear extrapolations (curve fitting), stochastic process (random walk, mean-reversion, jump-diffusion, and mixed processes), Box-Jenkins [autoregressive integrated moving average] ARIMA (economic forecasts), Auto ARIMA, basic econometrics and auto-econometrics (modeling relationships and generating forecasts), exponential J-curves, logistic S- curves, [generalized autoregressive conditional heteroskedasticity] GARCH models and its multiple variations (modeling and forecasting volatility). (p. 76)

The Optimization Module allows the cost analyst to optimize multiple variables to maximize or minimize the objective with the range that the analyst inputs, the optimization can be run as either a static, dynamic, or stochastic optimization under uncertainty together in the Monte Carlo risk simulator (Mun, 2015).

Analysts have access to multiple business and analytical models in the ROV BizStats module (Mun, 2015). The ROV Decisions Tree module provides analysts the ability to create traditional decision tree models and the option to run those models through Monte Carlo risk simulations (Mun, 2015). Analysts can also use this module for sensitivity and scenario analyses (Mun, 2015).

2. Running a Monte Carlo Simulation

To run a simulation in an existing Excel model, Mun (2015) lays out the following steps:

1. An analyst should open an existing simulation profile or create a new one.

2. In the open simulation profile, the analyst should define and then use appropriate cells to enter the input assumptions.

3. The analyst should define and then use appropriate cells to enter any output forecasts.

4. The analyst will then run the simulation.

5. The analyst should interpret the simulation results (Mun, 2015).

An analyst can practice these steps using the example, Basic Simulation Model, provided by the Risk Simulator software (Mun, 2015). This file allows the analyst to run example simulations on a basic model. The example file can be accessed through the installation folder (i.e., c:\Program Files (x86)\Real Options Valuation\Risk Simulator\Risk Simulator) or accessing directly through clicking the Risk Simulator icon, followed by the Example Models button (Mun, 2015).

a. Starting a New Simulation Profile

The first step for an analyst when running a new simulation is creating a new simulation profile (Mun, 2015). A simulation profile is tailored to each simulation based on the analysis preference and contains setup instructions for specific uses (Mun, 2015). The profile will include all of the assumptions, run profile, and forecasts. Multiple scenarios for a single profile allow an analyst to run the simulation using different input assumptions (Mun, 2015). Conversely, a team of analysts could independently run a simulation in the same model profile using their own assumptions (Mun, 2015).

Mun (2015) outlines the steps for creating a new simulation profile:

1. An analyst should open an existing model or create a new one. If the analyst does not have an existing model or does not want to create a new one, then the sample Basic Simulation Model can be used.

2. Once the model is open, the analyst will select the Risk Simulator button and then click on the New Simulation Profile Icon.

3.   The analyst will then choose a name for the simulation and enter any additional relevant information (see Figure 17; Mun, 2015).
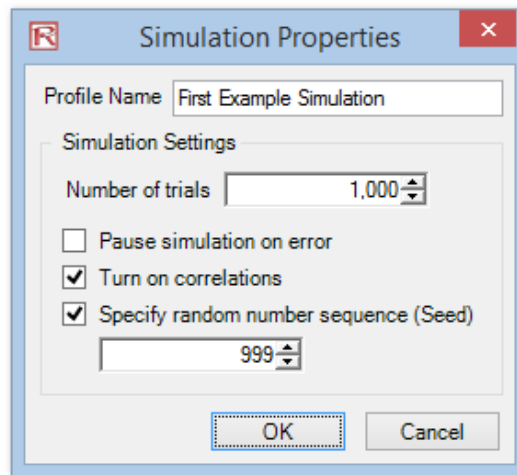
Figure 17.   New Simulation Profile Example

Mun (2015) outlines the following input requirement for a simulation profile:

- **Title:** Providing a title for the simulation allows an analyst to create and save multiple profiles for a single model. Once a title is inputted, the profiled can be saved without overwriting assumptions that were previously entered. This technique prevents the analyst from having to re-enter or change the assumptions when rerunning scenarios. To change a profile name, the analyst can select the Risk Simulator button then click Edit profile. The analyst will then enter the new profile name.

- **Number of trials:** An analyst can select the amount of simulation trials necessary in this section. When an analyst is unsure of how many trials are required to be run for the model, the analyst can use error and precision controls. These controls will assist an analyst in determining the requisite number of trials that should be run based on the model. The Risk Simulator software default number is set at 1,000 trials. An analyst can enter any positive integer into this block. The number entered will directly correlate to the number of trials the simulator will run.

- **Pause simulation on error:** Once this selection is checked, the simulation will stop each time an error is faced in the model. For example, if the model encounters an error in its calculation, the simulation will stop. If an analyst wants to audit a model to ensure there are no computational errors in it, this function is essential.

- **Turn on correlations:** This function directs the software to calculate correlations between the input assumptions. An analyst should check this box to ensure these calculations are performed. If correlations are left

unchecked, they will automatically be set to zero, and the simulation is done under the assumption that there are no cross-correlations among input assumptions.

- **Specify random number sequence:** Mun (2015) explains that each simulation will produce marginally different results every time that simulation is run. He clarifies that the variation in the results stems from the random number generator ingrained in the Monte Carlo risk simulation. However, when making a presentation or a demonstration, an analyst may require the same results; this is especially true when trying to use the simulation to drive a live presentation using one specific set of data and wants to know the outcome of the simulation before it is run. This setting is set by the analyst by entering any positive integer as an initial seed number. The analyst will use the same initial seed value, number of trials, and input assumptions for the simulation. This specification will consistently generate the exact same random number sequence, which will ensure the same end results each time the simulation is run (Mun, 2015).

If needed, an analyst can adjust the above selections after the simulation profile has been created (Mun, 2015). To adjust the simulation settings, the analyst must ensure that the currently active profile is the one that the analyst wants to change; if it is not, the analyst needs to switch profiles (Mun, 2015). To do so, the analyst will click on the Risk Simulator icon, followed by the Change Simulation Profile button, and select the desired profile (Mun, 2015). Figure 18 shows the Risk Simulator box, where the analyst can view and select various profiles (Mun, 2015). Once the correct profile is active, the analyst will click on the Risk Simulator icon then select the Edit Simulation button (Mun, 2015). This will allow the analyst to make the desired changes to the profile's settings (Mun, 2015). This function also gives an analyst the ability to replicate or rename a preexisting profile (Mun, 2015). The analyst should ensure that each simulation profile has a distinct name to differentiate between the various profiles (Mun, 2015). Simulation profiles are hidden within segments of the existing Excel file; this means the analyst will not have to save multiple files for each profile (Mun, 2015). Each simulation profile is automatically saved when the analyst saves the Excel file (Mun, 2015). When the analyst re-opens the Excel file, the last active simulation profile will automatically open as the current profile (Mun, 2015).
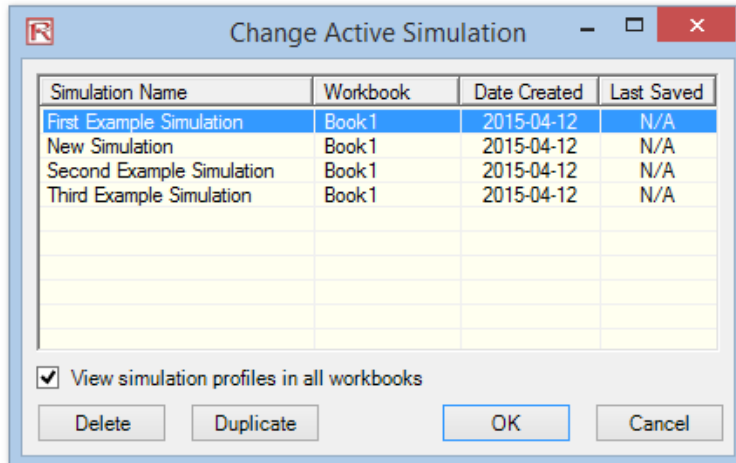
Figure 18. Change Active Simulation Example

b. *Defining Input Assumptions*

After the simulation profile has been created, the analyst will then set input assumptions (Mun, 2015). These assumptions are only assigned to cells that do not contain functions or equations (Mun, 2015). Input assumptions are numbers that are entered by the analysts (Mun, 2015). Conversely, cells that contain functions or equations are designated for output forecasts or model outputs (Mun, 2015). It is important to remember that these assumptions can only be set after a simulation profile is opened (Mun, 2015).

Mun (2015) outlines the following steps to set up new input assumptions for a model:

1. The analyst should create a new profile or open an existing one. To start a new profile, the analysist will click the Risk Simulator icon, followed by the New Simulation Profile button.

2. Then the analyst will select the desired input assumption cell. If following along using the sample model, analyst will select cell *G8*.

3. To set an assumption in the selected cell, the analyst will select the Risk Simulator icon, followed by the Set Input Assumption button. If the Risk. Simulator toolbar is displayed, instead the analyst can click on the Set Assumption icon.

4. The analyst will then select the desired distribution for the model. The analyst will then have opportunity to adjust the distribution parameters. Once all the relevant information has been imputed in the Assumption Properties window (see Figure 19), the analyst will hit OK (Mun, 2015).
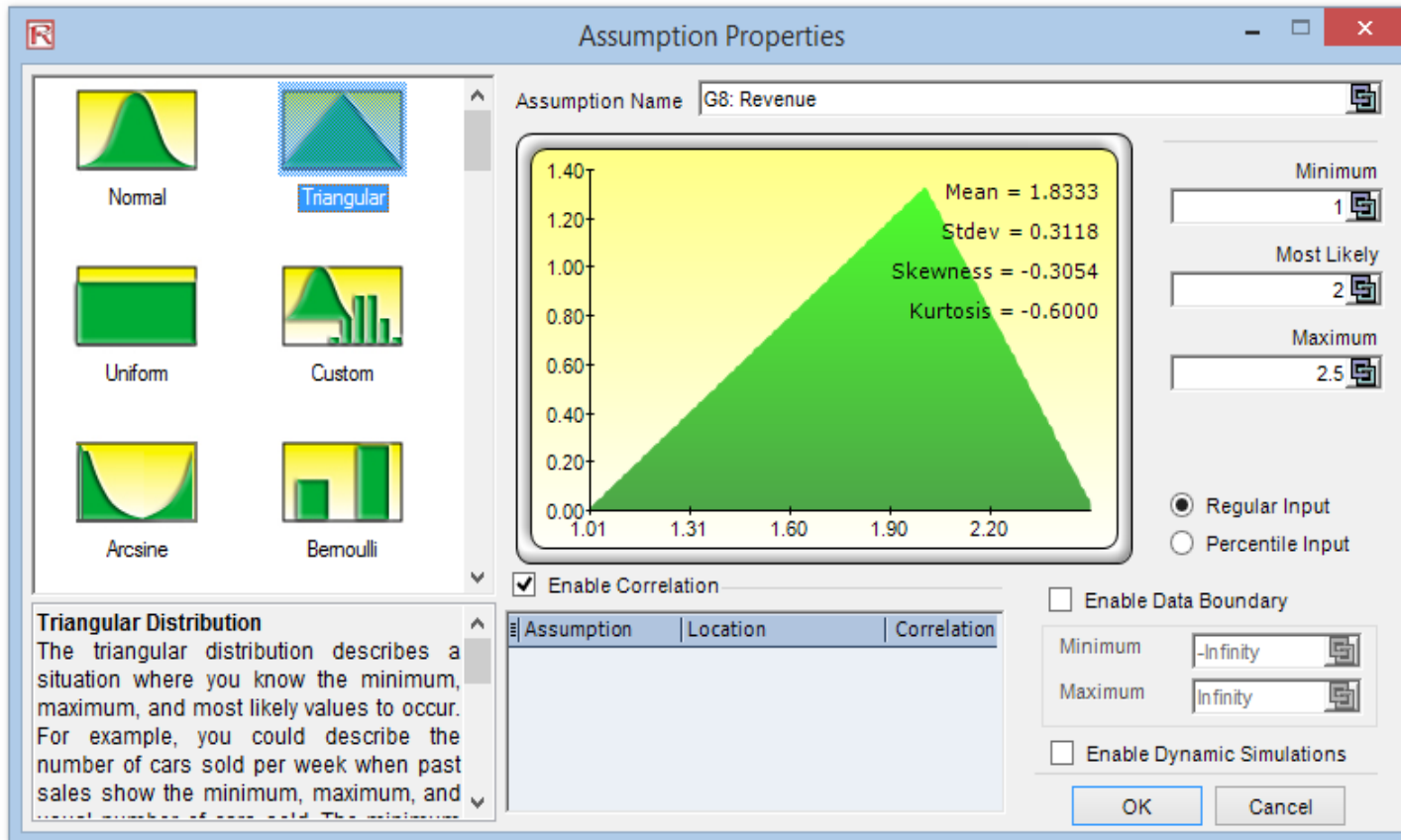
Figure 19.   Setting an Input Assumption Example

The cost analyst can also set assumptions by accessing the shortcut to the Risk Simulator menu. To accomplish this, the analyst selects the desired cell in which to place the assumption in and right-clicks to open the Risk Simulator menu (Mun, 2015). Figure 20 shows the multiple key areas in the Assumption Properties.

In his book, Mun (2015) describes the noteworthy assumption properties:

- **Assumption Name:** Most simulation profiles will have multiple input assumptions, and it is imperative for an analyst to keep track of each assumption. In order to organize the assumptions present, an analyst can name the assumptions using this feature.

- **Distribution Gallery:** The left side of Figure 20 is the Distribution Gallery. It shows the different distributions available in the simulation software. This software is capable of running over 20 distributions, and each can be selected by simply right-clicking on the desired distribution.

- **Input Parameters:** Once the analyst selects the desired distribution, the required parameters will be displayed. Parameters can be manually entered by the analyst, or they can be linked from the desired cell. If a parameter is not expected to change, it is easier to manually type it into the cell. However, if the parameter is allowed to change, then linking the cells is more efficient.

- **Correlations:** If correlations are required, then the analysts should verify the correlation status. To accomplish this, the analyst will click on the Risk Simulator icon, followed by the Edit Simulation Profile button. The analyst can then decide to either shorten or correlate the distribution to another assumption; however, these two actions cannot be used at the same time.

- **Short Descriptions:** To understand why a certain distribution was used, an analyst can review the explanation using the short description feature. Short descriptions are available for all distributions available in the software's gallery.

- **Regular Input and Percentile Input:** To test an input assumption, an analyst can use either the regular input or the percentile input function. If an analyst is working with a model that has a normal distribution with given inputs for the standard deviation and mean, the analyst could see what the corresponding 90th and 10th percentiles would be by clicking on the percentile input function (Mun, 2015).

If an analyst decides to use the example model provided by the Risk Simulator software, then cell *G9* will need an input assumption (Mun, 2015). The analyst should select the uniform distribution with a maximum value of 1.1 and a minimum value of 0.9 (Mun, 2015). Then, the analyst can proceed to the next step, defining the output forecasts (Mun, 2015).
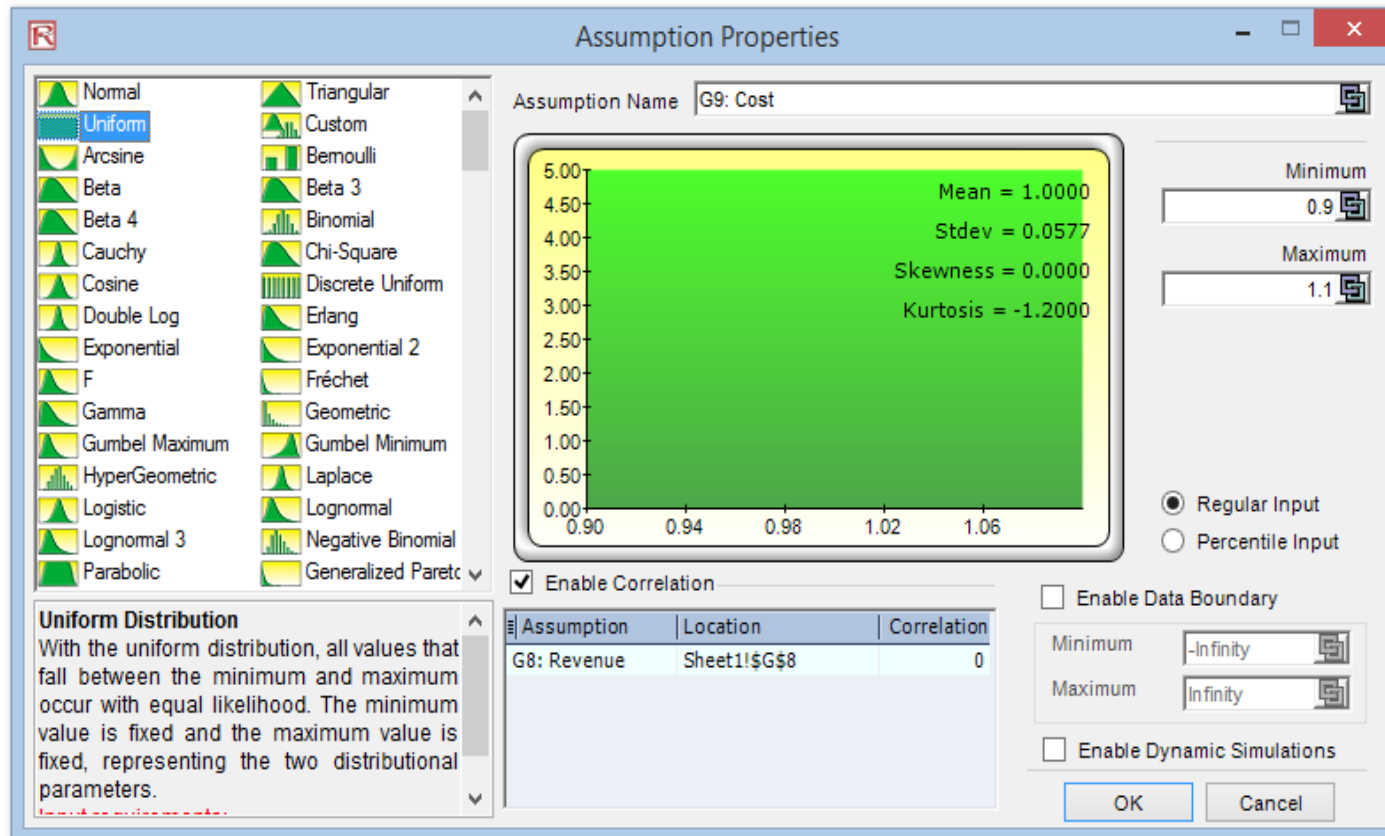
Figure 20.   Assumption Properties Example

c. Defining Output Forecast

Defining output forecasts is the next step in running a simulation (Mun, 2015). Analysts should remember that outputs cells that contain functions or equations are the only place that forecasts can be inputted (Mun, 2015).

Johnathan Mun (2015) describes the steps to set output forecasts:

1. First, the analyst will select the desired forecast output cell. If using the example model provided, the analyst will select cell *G10*.

2. Once the appropriate cell has been selected, the analyst will click on the Risk Simulator icon, followed by the Set Output Forecast button. If the Risk Simulator toolbar (Figure 16) is displayed, the analyst can click in the Set Output Forecast icon.

3. Lastly, the analyst will enter the required information in the Set Output Forecast popup window (Mun, 2015).

To set an output forecast, an analyst can choose the desired cell in which they want the forecast to be displayed (Mun, 2015). Then the analyst can access the Risk Simulator shortcut by right-clicking the cell (Mun, 2015). Figure 21 shows the set forecast properties.

- **Forecast Name:** This is where the cost analyst would insert the name of the forecast cell. Not only is this simple step good practice for modeling, but it also gives the analyst the ability to access the desired results quickly (Mun, 2015).

- **Forecast Precision:** Instead of a cost analyst guessing the number of trials needed to run in a simulation, the cost analyst can input precision and error controls. This function will pause the simulation and alert the analyst when the error-precision combination has been met, allowing the simulation process to be automatic rather than a guessing game for the analyst (Mun, 2015).

- **Show Forecast Window:** Forecast windows are displayed as the software's default setting. However, an analyst can choose to hide the window using the Show Forecast Window feature (Mun, 2015).
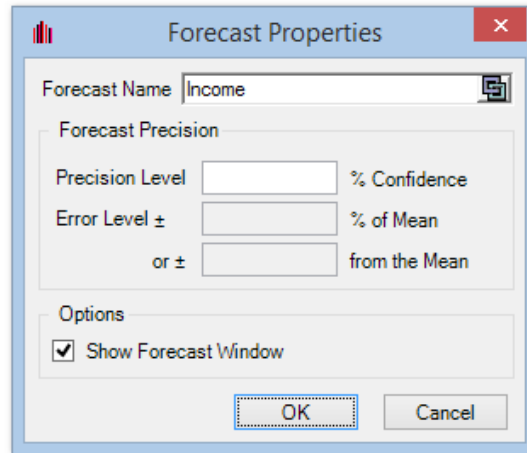
Figure 21.   Set Output Forecast

d.   *Running the Simulation*

After the setup is complete, the analysts can now run the simulation. To start the simulation, the analysts will click on the Risk Simulation icon followed by the Run Simulation button (Mun, 2015). If the Risk Simulator toolbar is displayed, the analyst can click the Run icon to start the simulation (Mun, 2015). To rerun the simulation, the analyst will need to reset it (Mun, 2015). This can be accomplished by clicking the Risk Simulator icon and selecting the Reset Simulation button (Mun, 2015). The simulation can also be reset by clicking the Reset Simulation icon on the Risk Simulator toolbar (Mun, 2015). If desired, the analyst can run one simulation at a time using the step function (Mun, 2015). To do this, the analyst will select the Step Simulation icon on the Risk Simulation toolbar or click on the Risk Simulation icon, followed by the Step Simulation button (Mun, 2015). The Step Simulation function can be used when teaching others how the program works (Mun, 2015). It allows the analyst to show that the entire model is recalculated every time a simulation is run (Mun, 2015).

The Risk Simulator program also contains a function called Super Speed (Mun, 2015). This allows analysts to run simulations at very fast speeds (Mun, 2015). An analyst can access this function by clicking the Super Speed icon on the Risk Simulator toolbar or clicking the Risk Simulator icon and selecting the Run Super Speed Simulation button. An analyst can practice this function using the example model. First, the analyst will need to reset the model, and then edit the simulation profile (Mun, 2015). Next, the analyst should

change the Number of Trials box to 100,000 (Mun, 2015). After hitting the Run Super Speed icon, the model with run 100,000 trials in only a few seconds (Mun, 2015). Super Speed simulation will not run if the model contains errors, external data links, or Visual Basic for Applications (VBA) (Mun, 2015). The analyst will be notified if the model contains any of these aforementioned conditions, and the simulation will proceed at normal speed (Mun, 2015). It is important to note that simulations can run at normal speeds, even if they contain errors (Mun, 2015).

e. *Interpreting the Forecast Charts*

The final step for an analyst in running a Monte Carlo risk simulation is interpreting results (Mun, 2015). After the simulation is complete, the analyst can generate a variety of statistical reports and forecast charts. Examples of these reports and charts are shown in Figures 22 through 31. The forecast chart and forecast statistics are extremely helpful to analysts when analyzing the results (Mun, 2015).

Mun (2015) explains that the forecast chart (Figure 22) is the "probability histogram that shows the frequency counts of values occurring in the total number of trials simulated" (p. 83). He further explains that the x-axis is describing the number of times that a particular value results from the simulation (Mun, 2015). The y-axis represents the possible values that can occur from the simulation (Mun, 2015). The curved line going through the histogram describes the cumulative frequency or the overall probability that the x will fall within the required parameters set at the bottom of the histogram display panel (Mun, 2015).

The forecast statistics that summarize the distribution of the forecast values in terms of four instances in the distribution are displayed in Figure 23 (Mun, 2015). A cost analyst can switch between the statistics and the histogram tabs by pressing the space bar (Mun, 2015).
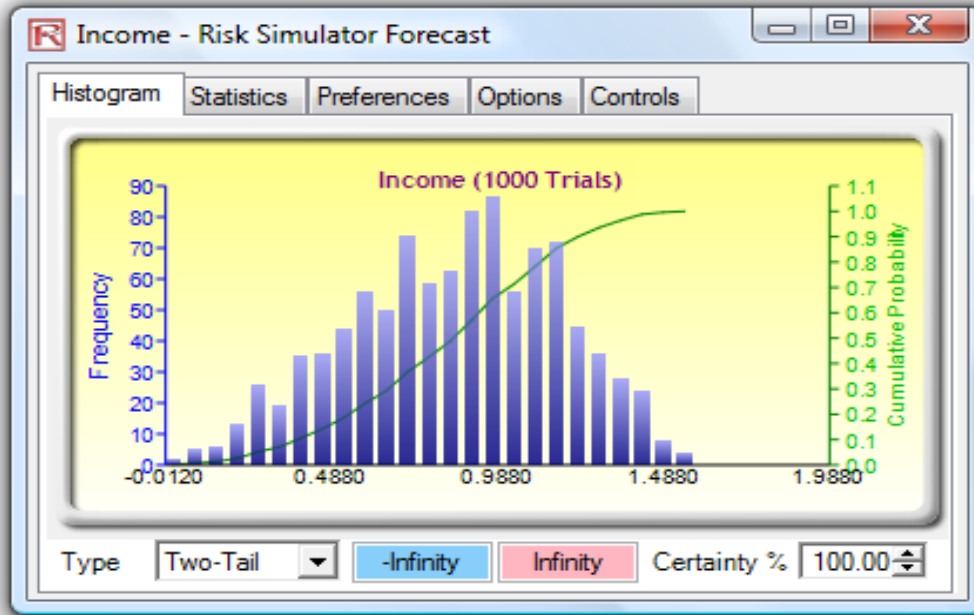
Figure 22.   Example Forecast Chart

Figure 23.   Example Forecast Statistics

3.   Forecast Chart Tabs

a.   *Preferences*

As shown in Figure 24, the middle tab in the Risk Simulator Forecast sheet is designed to let the analyst adjust the preferences in the forecast simulation (Mun, 2015). Changing the preferences changes the style of the charts and allows the analyst to extract the data more efficiently (Mun, 2015). The analyst can choose to show where data is shown by selecting one of the two boxes, or the analyst can change the speed at which the simulation is run (Mun, 2015). The analyst can also adjust the number of bins within the histogram between 5 and 100 (Mun, 2015). Finally, the preferences tab allows the analyst to adjust the Data Update Interval (Mun, 2015). Adjusting this feature gives the analyst control over the run speed of the simulation compared to the update rate of the forecast chart (Mun, 2015). It is important to remember that the more frequently the analyst views the simulation, the slower the simulation will run, and the more memory it will use in the process (Mun, 2015). The update rate is based solely on the preference of the analyst (Mun, 2015). It will not change the overall outcome of the results, only the speed at which the simulation is run (Mun, 2015). To significantly reduce the amount of memory used while running the simulation, the analyst can minimize the excel program (Mun, 2015). Minimizing the window will allow the computer more memory to complete the simulation (Mun, 2015).

b.   *Options*

An analyst will use the Options tab on the forecast chart, as shown in Figure 25, to tailor the results of the forecast (Mun, 2015). The analyst can use this options tab to filter in specific data in or out, by entering left and right boundaries or looking at data within a particular standard deviation (Mun, 2015). The analyst can specify the required precision level of the forecast by entering an allowed error percentage from 0 to 100%. The Options tab allows the analyst to display the mean, median, and 1st or 3rd quartile statistics (Mun, 2015). Finally, the analyst can use the Options tab to decide how many significant figures are needed by choosing the number of decimals to include in the forecast result data (Mun, 2015).

c.   Controls

Figure 26 shows the control tab, which allows the cost analyst to manipulate all of the functionalities including the type, color, zoom, size, 3D, and tilt in the forecast chart (Mun, 2015). The control tab also gives the analyst the ability to generate overlay charts (PDF, CDF) and run distributional fitting on the analyst's forecast data (Mun, 2015).

d.   Global View versus Normal View

Figures 24, 25, and 26 show how an analyst can display the forecast view in Normal mode (Mun, 2015). In Normal mode, the forecast options are broken up into tabs, as described in the paragraphs above (Mun, 2015). Global mode, as depicted in Figure 27, has the same functionality as the Normal mode; however, all of the options are displayed under one interface (Mun, 2015). An analyst cans witch between both Global and Normal modes by clicking the icon in the top right corner (Mun, 2015).
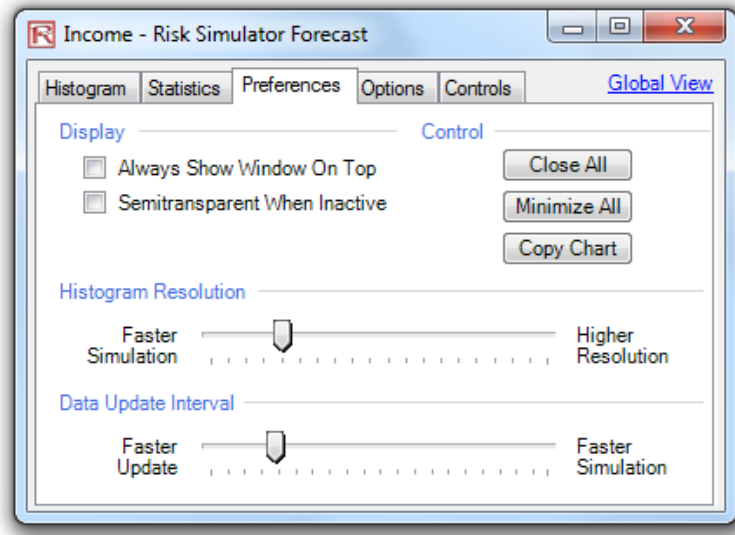
Figure 24.   Forecast Chart Preferences
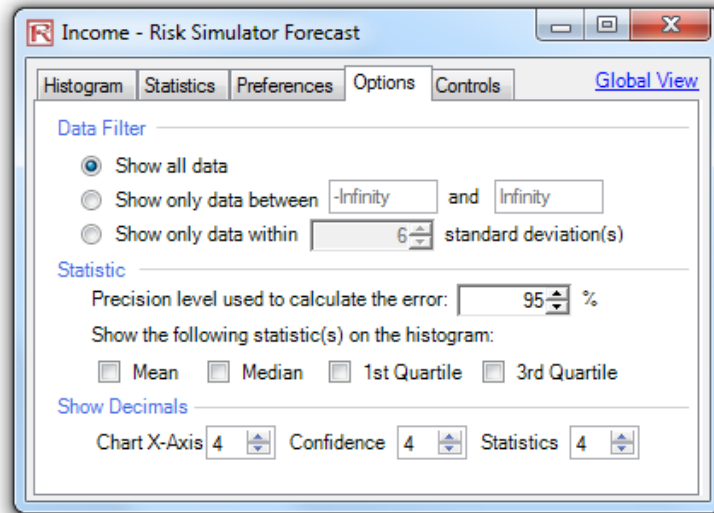
Figure 25.   Forecast Chart Options
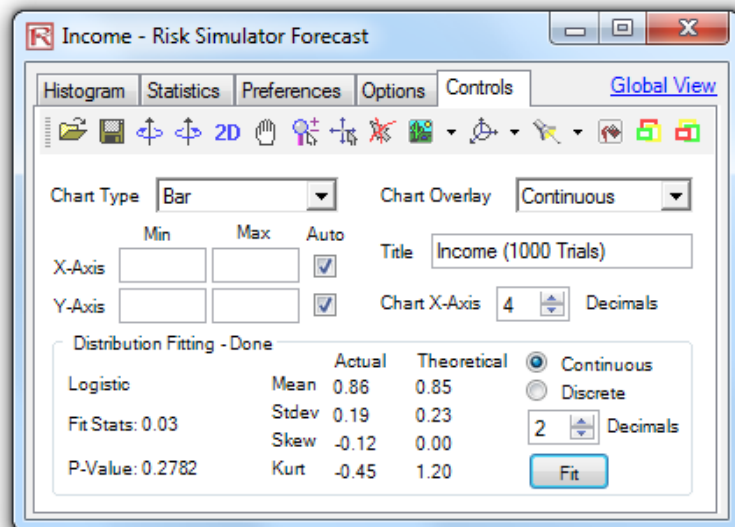
Figure 26.   Forecast Chart Controls
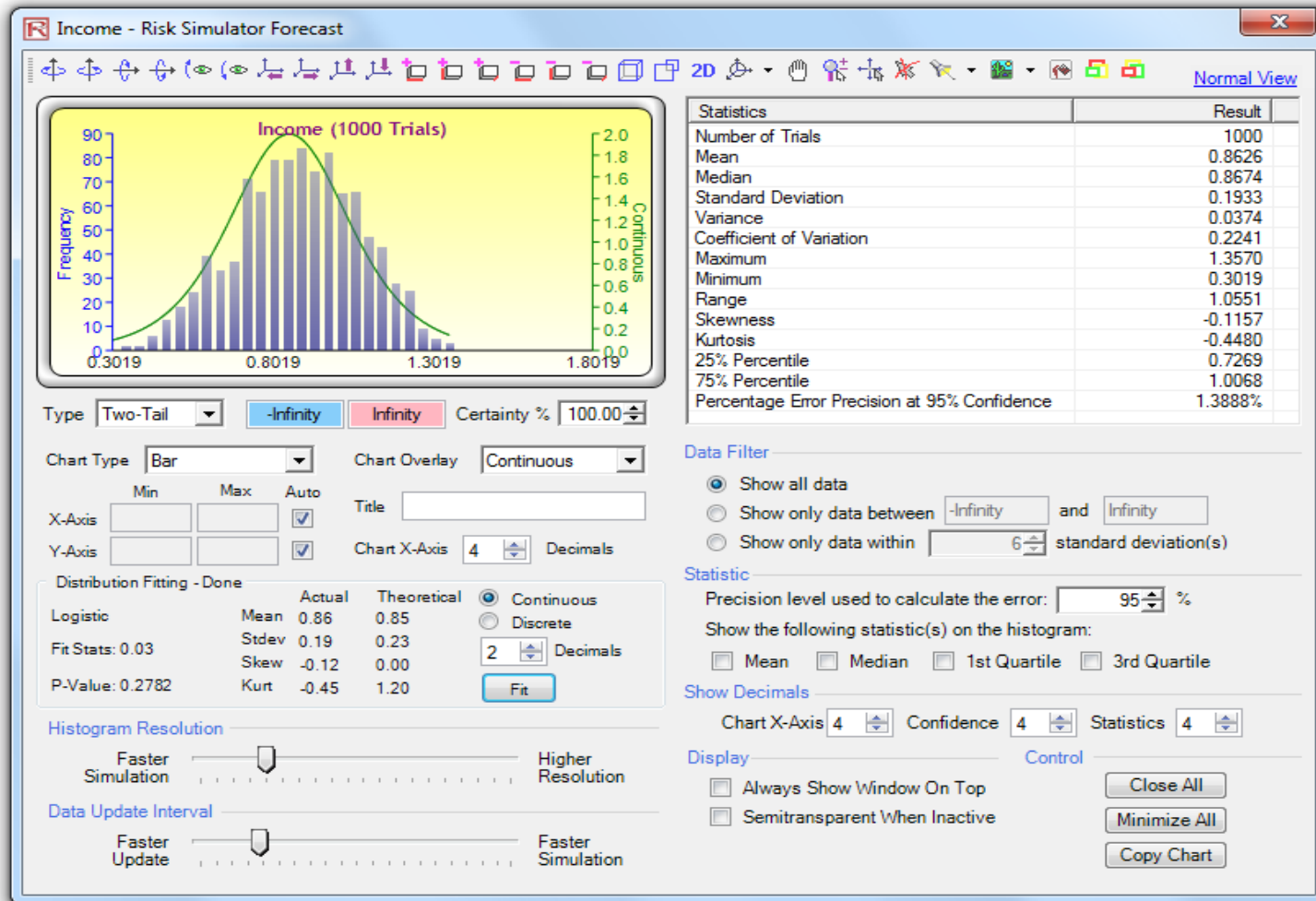
Figure 27.   Example Forecast Chart Global View

4.   Using Forecast Charts and Confidence Intervals

The forecast charts allow the cost analyst to identify the probability of occurrence, also known as confidence intervals (Mun, 2015). Using the example simulation, Figure 28 shows a 90% probability that the outcome will fall between $0.2653 and $1.3230 (Mun, 2015). If a two-tail confidence interval is desired, the analyst selects two-tail in the type drop-down window (Mun, 2015). The analyst could then change the certainty value (e.g., 90) and then hit the TAB key (Mun, 2015). The two computed values are displayed in the pink and blue boxes (Mun, 2015). In the example, there is a 5% chance that the result will be above $1.3430, and there will be another 5% chance that result will be below $0.2653 (Mun, 2015). This shows that the two-tailed confidence interval is centered on the 50th percentile, or the median value (Mun, 2015). Therefore, both tails have the same probability.

Alternatively, a one-tail probability can be computed by setting up the Forecast simulation as shown in Figure 29 (Mun, 2015). This figure shows that a cost analyst choosing a left-tail selection with a 95% confidence by selecting Left-Tail ≤ in the type box, then entering 95 as the certainty level and hitting the TAB key (Mun, 2015). This means there is a 5% chance that income will be above $1.3230 or a 95% chance that income will be below $1.3230, which perfectly replicates the results displayed in Figure 28 (Mun, 2015).
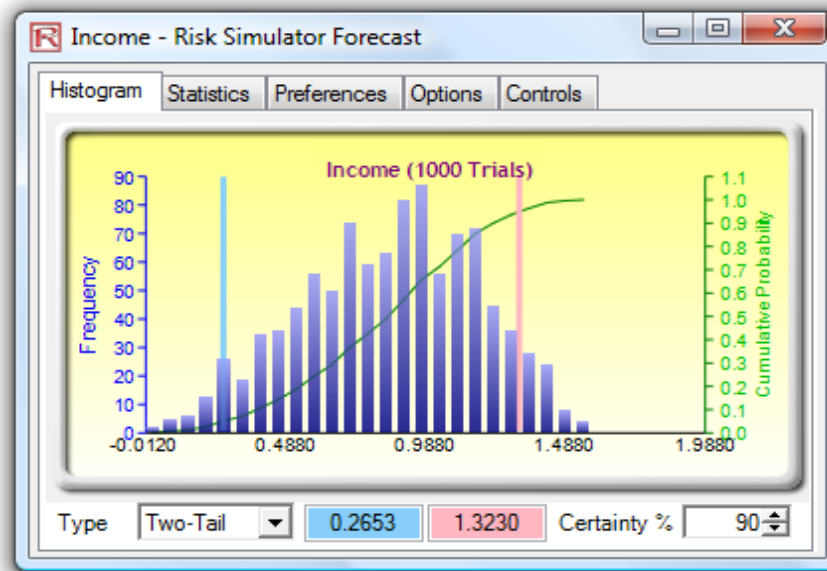
Figure 28.   Forecast Chart Two-Tail Confidence Interval
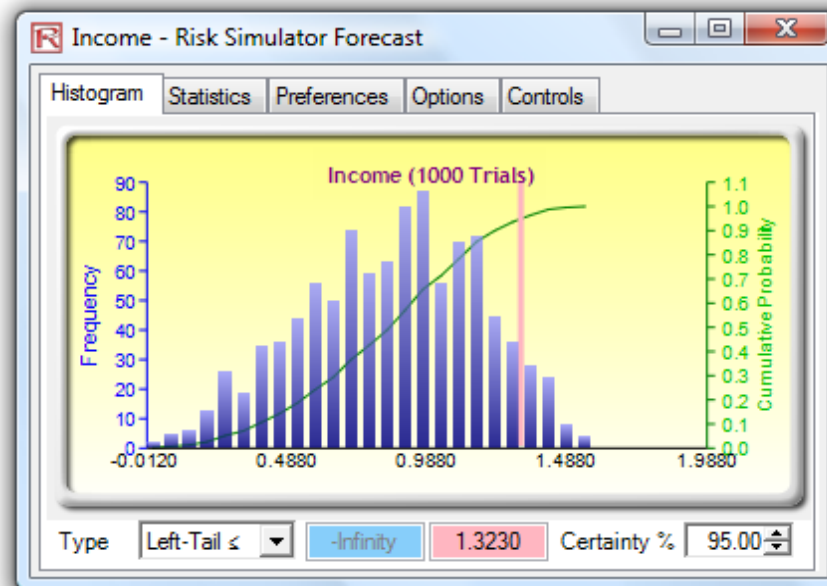
Figure 29.   Forecast Chart One-Tail Confidence Interval

Additionally, the cost analyst can determine the probability of an income's value (Mun, 2015). For example, what are the chances of the output being less than or equal to $1? To display the answer, the analyst should click the Left-Tail ≤ probability type, then input 1 for the value and hit the TAB key; then the corresponding certainty will be

calculated (Mun, 2015). Figure 30 that shows there is a 67.70% chance that the income will be equal to or less than $1 (Mun, 2015).

To ensure completeness, the cost analyst can select the Right-Tail > probability type, input 1 for the value 1, and hit the TAB key (Mun, 2015). This calculated probability shows the right-tail probability passes the value 1, or the probability of income being above $1 (Mun, 2015). Figure 31 shows that there is a 32.30% chance of income exceeding $1 (Mun, 2015). The probabilities of 67.70% and 32.30% sum to 100%, accounting for the full probability under the curve (Mun, 2015).
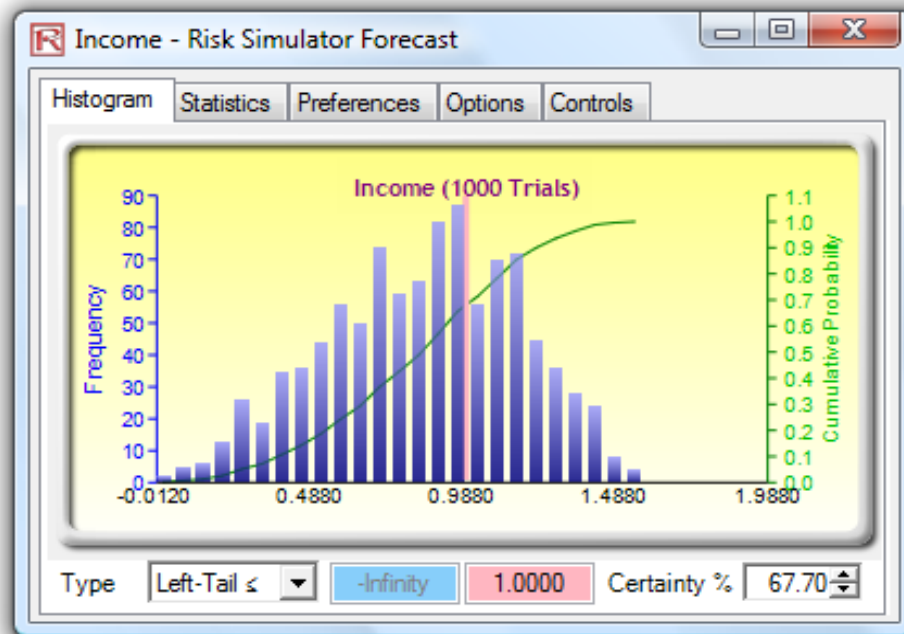
Figure 30.   Forecast Chart Probability Evaluation (Less than $1)
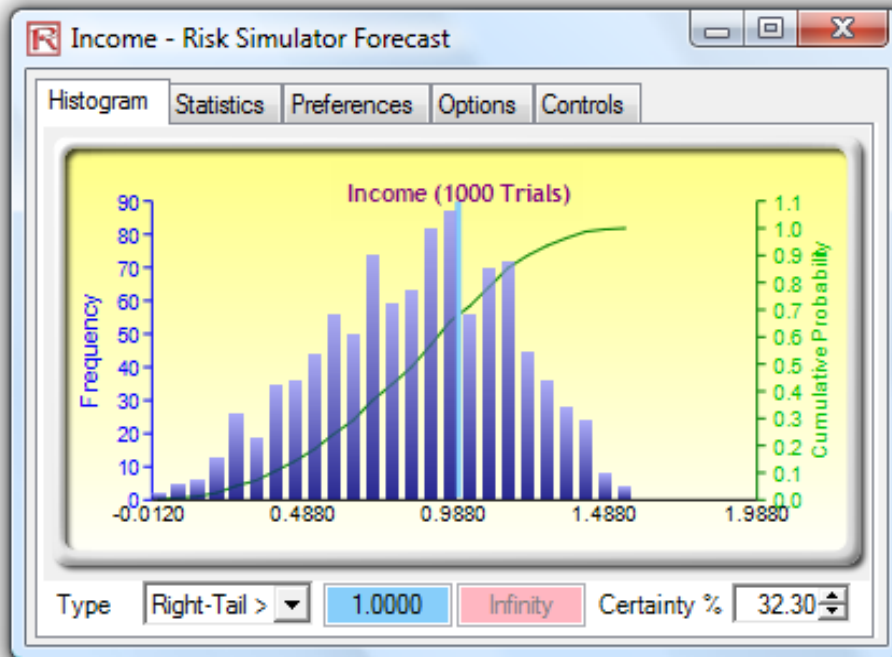
Figure 31.   Forecast Chart Probability Evaluation (Greater than $1)

D.   TORNADO AND SENSITIVITY TOOLS IN SIMULATION

To completely capture the static impacts on each individual variable effect on the outcome of the model, a cost analyst would consult a Tornado Analysis Chart (Mun, 2015). The tornado chart can break down the amount of fluctuation each variable has on the model and is able to rank each variable from most to least significant (Mun, 2015). Figures 32 through 37 pertain to the use of the Tornado Analysis tool. Figure 32 shows a sample discount cash flow model that displays the analyst's input assumptions. If an analyst is trying to decipher the greatest impact factor that will drive the outcome of the model, the Tornado Analysis chart is a valuable tool (Mun, 2015). In this case, the question becomes, what are the main drivers that make the Net Present Value $96.63, or which input variable most impacts this value?

The analyst can access the Tornado Chart Analysis tool by clicking the Risk Simulator icon, followed by the Analytical Tools button (Mun, 2015). Next, the analyst will select Tornado Analysis from the list of options (Mun, 2015). If the analyst decides to use the example model as practice, the analyst will open the Tornado Analysis tool (Mun, 2015). This can be accessed by clicking on the Risk Simulator Icon, followed by the

Example Models button (Mun, 2015). The analyst will then select option 22 Tornado ad Sensitivity Charts (Linear) to load the example (Mun, 2015). In the sample model (Figure 33), the Net Present Value will be selected as the output variable and be shown in cell *G6* (Mun, 2015). To build the tornado chart, the software will use the input variables that have the ability to affect the output variable (Mun, 2015). The testing range of the input variables is also displayed in Figure 33 (Mun, 2015). Mun (2015), explains that the testing range of simple input variables will be a simple perturbation. The default setting for the model is ± 10%, however the analyst has the ability to adjust the percentage if required (Mun, 2015). Jonathan Mun (2015) informs that a "wider range is important as it is better able to test extreme values rather than smaller perturbations around the expected values" (Mun, 2015, p. 169). Wider ranges do a better job of capturing nonlinear impacts (Mun, 2015).

1. Procedure

The following are Mun's (2015) steps for running a Tornado Analysis on the example model:

1.   To open the example model, the analyst will click on the Risk Simulator icon, followed by the Example Models button. Then the analyst will select option 22 Tornado and Sensitivity Charts (Linear) and proceed to the DCF model Worksheet.

2.   Next, the single output cell should be selected. In the example model, the analyst should select cell *G6*.

3.   To generate the Tornado Analysis, the analysis will then click on the Risk Simulator icon, followed by the Analytical Tools button. From the options provided, the analyst will select the Tornado Analysis button.

4.   The analyst should review the input variables' names before hitting OK. If required, the analyst can rename any of the variables to make the tornado and spider charts easier to analyze (Mun, 2015).

Discounted Cash Flow Model

Base Year	2005	Sum PV Net Benefits	$1,896.63	
Market Risk-Adjusted Discount Rate	15.00%	Sum PV Investments	$1,800.00	
Private-Risk Discount Rate	5.00%	Net Present Value	$96.63	
Annualized Sales Growth Rate	2.00%	Internal Rate of Return	18.80%	
Price Erosion Rate	5.00%	Return on Investment	5.37%	
Effective Tax Rate	40.00%			

	2005	2006	2007	2008	2009
Product A Avg Price/Unit	$10.00	$9.50	$9.03	$8.57	$8.15
Product B Avg Price/Unit	$12.25	$11.64	$11.06	$10.50	$9.98
Product C Avg Price/Unit	$15.15	$14.39	$13.67	$12.99	$12.34
Product A Sale Quantity ('000s)	50.00	51.00	52.02	53.06	54.12
Product B Sale Quantity ('000s)	35.00	35.70	36.41	37.14	37.89
Product C Sale Quantity ('000s)	20.00	20.40	20.81	21.22	21.65
Total Revenues	**$1,231.75**	**$1,193.57**	**$1,156.57**	**$1,120.71**	**$1,085.97**
Direct Cost of Goods Sold	$184.76	$179.03	$173.48	$168.11	$162.90
Gross Profit	**$1,046.99**	**$1,014.53**	**$983.08**	**$952.60**	**$923.07**
Operating Expenses	$157.50	$160.65	$163.86	$167.14	$170.48
Sales, General and Admin. Costs	$15.75	$16.07	$16.39	$16.71	$17.05
Operating Income (EBITDA)	**$873.74**	**$837.82**	**$802.83**	**$768.75**	**$735.54**
Depreciation	$10.00	$10.00	$10.00	$10.00	$10.00
Amortization	$3.00	$3.00	$3.00	$3.00	$3.00
EBIT	**$860.74**	**$824.82**	**$789.83**	**$755.75**	**$722.54**
Interest Payments	$2.00	$2.00	$2.00	$2.00	$2.00
EBT	**$858.74**	**$822.82**	**$787.83**	**$753.75**	**$720.54**
Taxes	$343.50	$329.13	$315.13	$301.50	$288.22
Net Income	**$515.24**	**$493.69**	**$472.70**	**$452.25**	**$432.33**
Noncash: Depreciation Amortization	$13.00	$13.00	$13.00	$13.00	$13.00
Noncash: Change in Net Working Capital	$0.00	$0.00	$0.00	$0.00	$0.00
Noncash: Capital Expenditures	$0.00	$0.00	$0.00	$0.00	$0.00
Free Cash Flow	**$528.24**	**$506.69**	**$485.70**	**$465.25**	**$445.33**
Investment Outlay	**$1,800.00**				

Financial Analysis

	2005	2006	2007	2008	2009
Present Value of Free Cash Flow	$528.24	$440.60	$367.26	$305.91	$254.62
Present Value of Investment Outlay	$1,800.00	$0.00	$0.00	$0.00	$0.00
Net Cash Flows	($1,271.76)	$506.69	$485.70	$465.25	$445.33

Figure 32.   Sample Discounted Cash Flow Model

	A	B	C	D	E	F	G
2		**Discounted Cash Flow Model**					
4		Base Year	2005		Sum PV Net Benefits	**$1,896.63**	
5		Market Risk-Adjusted Discount Rate	15.00%		Sum PV Investments	**$1,800.00**	
6		Private-Risk Discount Rate	5.00%		Net Present Value	**$96.63**	
7		Annualized Sales Growth Rate	2.00%		Internal Rate of Return	18.80%	
8		Price Erosion Rate	5.00%		Return on Investment	5.37%	
9		Effective Tax Rate	40.00%				
11			2005	2006			
12		Prod A Avg Price	$10.00	$9.50			
13		Prod B Avg Price	$12.25	$11.64			
14		Prod C Avg Price	$15.15	$14.39			
15		Prod A Quantity	50.00	51.00			
16		Prod B Quantity	35.00	35.70			
17		Prod C Quantity	20.00	20.40			
18		**Total Revenues**	**$1,231.75**	**$1,193.57**			
19		Cost of Goods Sold	$184.76	$179.03			
20		**Gross Profit**	**$1,046.99**	**$1,014.53**			
21		Operating Expenses	$157.50	$160.65			
22		SG&A Costs	$15.75	$16.07			
23		**Operating Income (EBITDA)**	**$873.74**	**$837.82**			
24		Depreciation	$10.00	$10.00			
25		Amortization	$3.00	$3.00			
26		**EBIT**	**$860.74**	**$824.82**			
27		Interest Payments	$2.00	$2.00			
28		**EBT**	**$858.74**	**$822.82**			
29		Taxes	$343.50	$329.13			
30		**Net Income**	**$515.24**	**$493.69**			
31		Depreciation	$13.00	$13.00			
32		Change in Net Working Capital	$0.00	$0.00			
33		Capital Expenditures	$0.00	$0.00			
34		**Free Cash Flow**	**$528.24**	**$506.69**			
36		**Investments**	**$1,800.00**				
39		*Financial Analysis*					
40		**Present Value of Free Cash Flow**	$528.24	$440.60	$367.26	$305.91	$254.62
41		**Present Value of Investment Outlay**	$1,800.00	$0.00	$0.00	$0.00	$0.00
42		**Net Cash Flows**	($1,271.76)	$506.69	$485.70	$465.25	$445.33

Tornado Analysis ● SHARING

Tornado analysis creates static perturbations (i.e., each precedent is perturbed one at a time) to identify the impact to the results. It is used to identify critical success factors of a model before running simulations.

Review the precedents below and make any necessary changes:

Selection	Name	Worksheet	Cell	Base Value	% Upside	% Downside	Test Points
☑	Market	DCF Mode	C5	0.15	10.00%	10.00%	10
☑	Investm	DCF Mode	C36	1800	10.00%	10.00%	10
☐	Capital	DCF Mode	C33	0	10.00%	10.00%	10
☐	Change i	DCF Mode	C32	0	10.00%	10.00%	10
☑	Depreci	DCF Mode	C24	10	10.00%	10.00%	10
☑	Amortiza	DCF Mode	C25	3	10.00%	10.00%	10
☑	Interest	DCF Mode	C27	2	10.00%	10.00%	10
☑	Prod A	DCF Mode	C15	50	10.00%	10.00%	10
☑	Prod B	DCF Mode	C16	35	10.00%	10.00%	10
☑	Prod C	DCF Mode	C17	20	10.00%	10.00%	10
☑	Prod C	DCF Mode	C14	15.15	10.00%	10.00%	10

Options

○ Show All Variables   ☐ Use Cell Address
○ Show Top [1] Variables   ☐ Ignore all possible integer values
☑ Ignore zero or empty values   ☐ Highlight possible integer values
☐ Use Global Setting

● Analyze This Worksheet Only   ○ Analyze All Worksheets

[OK] [Cancel] [Copy]

Figure 33.   Running Tornado Analysis

The tornado analysis report (Figure 34) was generated using the example model provided with the Risk Simulator program. It depicts which input variables are the most impactful and least impactful on the out variable, Net Present Value (Mun, 2015). In Figure 34, Capital investment is the most impactful input variable (Mun, 2015).

Jonathan Mun (2015) explains the four sections that a tornado analysis report contains:

- The first section outlines the procedure that was performed.

- The second section (Figure 35) is a sensitivity table. This table displays the model variables from those that have the greatest influence on the model down to the variables with the lowest influence. It also shows how each variable independently impacts the Net Present Value. Using the example sensitivity table, an analyst can determine that capital investment has the greatest impact on the results.

- Information contained in a sensitivity table can be displayed graphically using a spider chart. Figure 36 shows an example spider chart based on the data contained in Figure 35. In this case, the y-axis depicts the Net Present Value. The percentage change away from the base value is represented on the x-axis. If a variable's effects produce a line that is positively sloped, then the relationship is positivity. Conversely, a negative relationship is depicted by a negatively sloped line. To determine the magnitude of a variable's effect, an analyst would take the absolute value of the slope of the variable's line.

- The last section of a tornado analysis report is the tornado chart (Figure 37). Similar to a spider chart, tornado charts also graphically display the data contained in the sensitivity table. However, a tornado chart ranks the variables from the most impactful to the least impactful variable and displays them on the y-axis. In a tornado chart, the x-axis represents the output variable, or in this case, the Net Present Value. Positive effects from a variable are depicted as a green bar, and negative effects are displayed as a red bar. Meaning, for tax rate, a positive effect of the tax rate on a lower Net Present Value is signified by the green bar on the left side. In this example, Net Present Value and tax rate are negatively correlated (Mun, 2015).

Statistical Summary

One of the powerful simulation tools is the tornado chart—it captures the static impacts of each variable on the outcome of the model. That is, the tool automatically perturbs each precedent variable in the model a user-specified preset amount, captures the fluctuation on the model's forecast or final result, and lists the resulting perturbations ranked from the most significant to the least. Precedents are all the input and intermediate variables that affect the outcome of the model. For instance, if the model consists of A = B + C, where C = D + E, then B, D, and E are the precedents for A (C is not a precedent as it is only an intermediate calculated value). The range and number of values perturbed is user-specified and can be set to test extreme values rather than smaller perturbations around the expected values. In certain circumstances, extreme values may have a larger, smaller, or unbalanced impact (e.g., nonlinearities may occur where increasing or decreasing economies of scale and scope creep occurs for larger or smaller values of a variable) and only a wider range will capture this nonlinear impact.

A tornado chart lists all the inputs that drive the model, starting from the input variable that has the most effect on the results. The chart is obtained by perturbing each precedent input at some consistent range (e.g., ±10% from the base case) one at a time, and comparing their results to the base case. A spider chart looks like a spider with a central body and its many legs protruding. The positively sloped lines indicate a positive relationship, while a negatively sloped line indicates a negative relationship. Further, spider charts can be used to visualize linear and nonlinear relationships. The tornado and spider charts help identify the critical success factors of an output cell in order to identify the inputs to simulate. The identified critical variables that are uncertain are the ones that should be simulated. Do not waste time simulating variables that are neither uncertain nor have little impact on the results.

Result

Precedent Cell	Base Value: 96.6261638553219			Input Changes		
	Output Downside	Output Upside	Effective Range	Input Downside	Input Upside	Base Case Value
Investment	$276.63	($83.37)	360.00	$1,620.00	$1,980.00	$1,800.00
Tax Rate	$219.73	($26.47)	246.20	36.00%	44.00%	40.00%
A Price	$3.43	$189.83	186.40	$9.00	$11.00	$10.00
B Price	$16.71	$176.55	159.84	$11.03	$13.48	$12.25
A Quantity	$23.18	$170.07	146.90	45.00	55.00	50.00
B Quantity	$30.53	$162.72	132.19	31.50	38.50	35.00
C Price	$40.15	$153.11	112.96	$13.64	$16.67	$15.15
C Quantity	$48.05	$145.20	97.16	18.00	22.00	20.00
Discount Rate	$138.24	$57.03	81.21	13.50%	16.50%	15.00%
Price Erosion	$116.80	$76.64	40.16	4.50%	5.50%	5.00%
Sales Growth	$90.59	$102.69	12.10	1.80%	2.20%	2.00%
Depreciation	$95.08	$98.17	3.08	$9.00	$11.00	$10.00
Interest	$97.09	$96.16	0.93	$1.80	$2.20	$2.00
Amortization	$96.16	$97.09	0.93	$2.70	$3.30	$3.00
Capex	$96.63	$96.63	0.00	$0.00	$0.00	$0.00
Net Capital	$96.63	$96.63	0.00	$0.00	$0.00	$0.00

Figure 34. Tornado Analysis Report

2. Notes

Mun (2015) encourages analysts to "remember that tornado analysis is a static sensitivity analysis applied on each input variable in the model" (p. 173). This means that variables are separated, and their effects are then delineated and displayed (Mun, 2015). One could argue that tornado analysis is an important, if not the most important, analysis to perform prior to executing a simulation (Mun, 2015). When performed, this analysis allows the cost analyst to capture and identify risk and to identify the major cost drivers of the model. Once the analyst teases out the most important factors, the next step is to identify which of the factors are uncertain. It is essential for an analyst to examine the model's uncertain impact drivers because, as critical success drivers, they will have a significant influence on the model's results (Mun, 2015). Analysts should ensure the uncertain impact drivers are simulated (Mun, 2015). The cost analyst should not focus on using the Tornado Analysis tool on the factors that are certain and those that have little impact on the model (Mun, 2015). In using this model, the most important factors for an analyst to simulate will be price and quantity, assuming that the required investment and effective tax rate are both known and are fixed (Mun, 2015).

Precedent Cell	Base Value: 96.6261638553219			Input Changes		
	Output Downside	Output Upside	Effective Range	Input Downside	Input Upside	Base Case Value
Investment	$276.63	($83.37)	360.00	$1,620.00	$1,980.00	$1,800.00
Tax Rate	$219.73	($26.47)	246.20	36.00%	44.00%	40.00%
A Price	$3.43	$189.83	186.40	$9.00	$11.00	$10.00
B Price	$16.71	$176.55	159.84	$11.03	$13.48	$12.25
A Quantity	$23.18	$170.07	146.90	45.00	55.00	50.00
B Quantity	$30.53	$162.72	132.19	31.50	38.50	35.00
C Price	$40.15	$153.11	112.96	$13.64	$16.67	$15.15
C Quantity	$48.05	$145.20	97.16	18.00	22.00	20.00
Discount Rate	$138.24	$57.03	81.21	13.50%	16.50%	15.00%
Price Erosion	$116.80	$76.64	40.16	4.50%	5.50%	5.00%
Sales Growth	$90.59	$102.69	12.10	1.80%	2.20%	2.00%
Depreciation	$95.08	$98.17	3.08	$9.00	$11.00	$10.00
Interest	$97.09	$96.16	0.93	$1.80	$2.20	$2.00
Amortization	$96.16	$97.09	0.93	$2.70	$3.30	$3.00
Capex	$96.63	$96.63	0.00	$0.00	$0.00	$0.00
Net Capital	$96.63	$96.63	0.00	$0.00	$0.00	$0.00

Figure 35.   Sensitivity Table
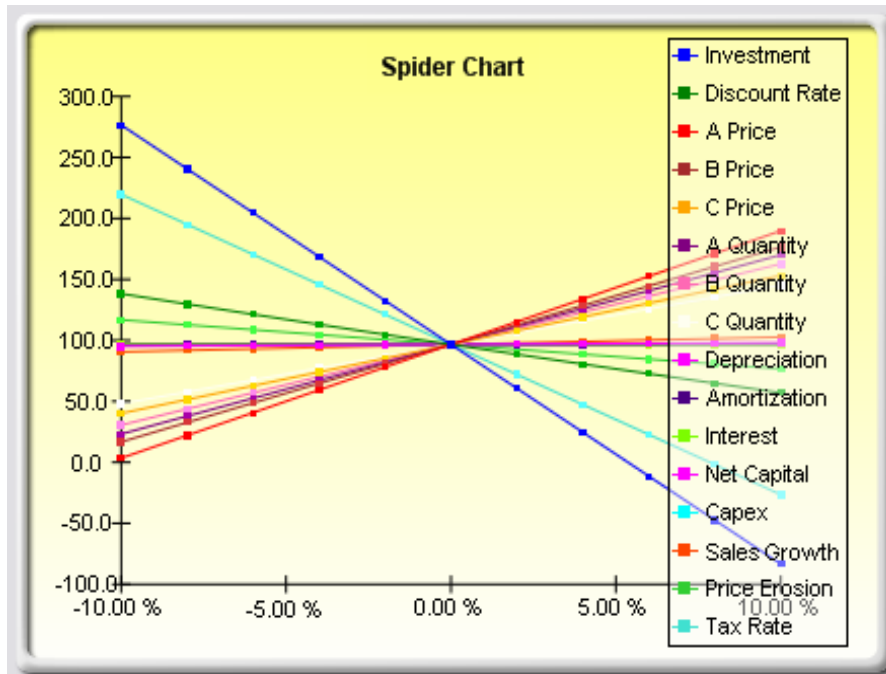
Figure 36.　Spider Chart
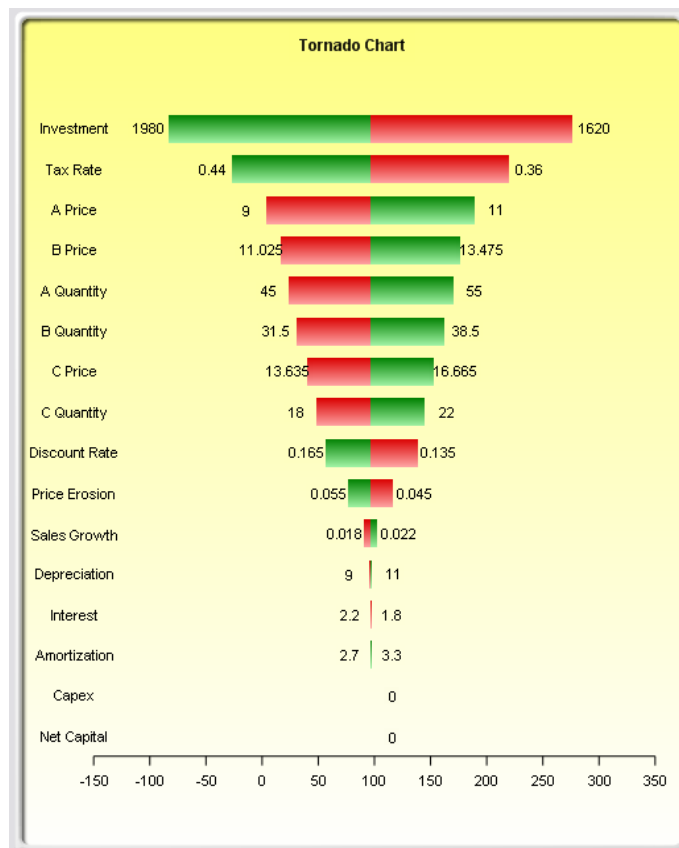
Figure 37.　Tornado Chart

Although spider charts can be for an analyst to interpret, they are an important tool for determining if nonlinearities exist (Mun, 2015). For example, the spider chart shown in Figure 38 depicts a situation where nonlinearities are present in the model (Mun, 2015). The analyst can identify nonlinearities as curved lines instead of straight ones (Mun, 2015). An analyst can generate an example spider chart by using the example model that is embedded in the Risk Simulator software (Mun, 2015). To access the example model, the analyst will click on the Risk Simulator icon, followed by the Example Models button (Mun, 2015). Next, the analyst will select option 23 Tornado and Sensitivity Charts (Nonlinear) to generate the example spider chart (Mun, 2015). The built-in example model uses the Black-Scholes option pricing model (Mun, 2015). Tornado charts do not have the ability to identify the nonlinearities that are present in a model (Mun, 2015). However, these nonlinearities can be essential information, as they can provide analysts vital insight into the dynamics of the model (Mun, 2015).

Figure 33 shows the Tornado Analysis tool's cost analyst interface. In the following bullet points, Mun provides tips on running tornado analysis and details on new enhancements:

- Tornado analysis should always be run more than once. This tool was designed to be a diagnostic tool for the model and therefore should be run multiple times on each model. The first time the tornado analysis is run, the cost analyst should select the default setting and show all of the analysis on all of the variables. The resulting report will be large but will give the analyst a starting point in being able to derive how many of the precedents are critical factors. When running the tool with all the variables, the chart may show that only 5 variables significantly impacted the output, while the remaining 100 variables have minimal to no impact on the model. The cost analyst could then run the analysis with the top 10 most impactful variables to create an effective tornado report that highlights the differences between the critical and less important variables (Mun, 2015).
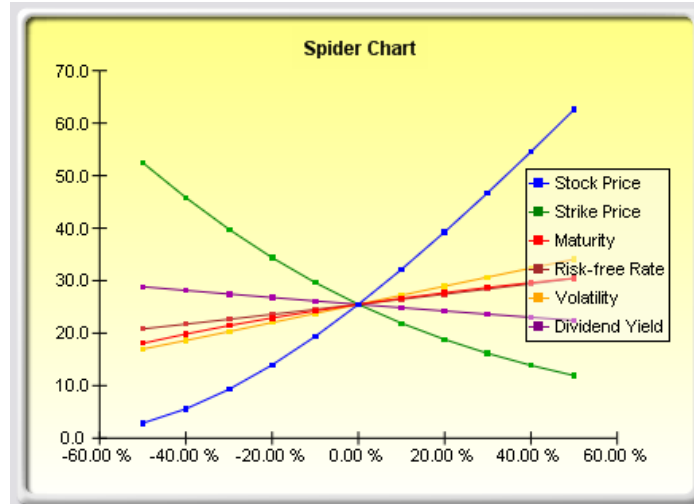
Figure 38.   Example Nonlinear Spider Chart

E.   SENSITIVITY ANALYSIS

Spider and tornado charts apply static perturbations prior to running the simulation. Mun (2015), explains that sensitivity analysis differs because it "applies dynamic perturbations created after the simulation run" (p. 176). He goes on to explain that static perturbations imply "that each precedent or assumption variable is perturbed a preset amount one at a time, and the fluctuations in the results are tabulated" (p. 176). Conversely, sensitivity charts are created by dynamic perturbations, or when multiple assumptions are changed simultaneously (Mun, 2015). The effects of the dynamic perturbations and variable correlations are reflected in the fluctuation of the results (Mun, 2015). Tornado charts are used to identify and rank the variables that drive the factors the most, while the sensitivity model shows the impact when multiple factors are interaction together in the model (Mun, 2015). The relationship between static and dynamic perturbations is shown in Figure 39. Similar tornado charts, the sensitivity analysis ranks critical success drivers in order of most impactful down to the less impactful (Mun, 2015). However, an analyst will get different results if the correlations between the input assumptions are compiled (Mun, 2015). In Figure 39, an analyst can determine that the Net Present Value is marginally impacted by the price erosion (Mun, 2015). However, when reviewing Figure 40, where correlation between input assumptions is present, an analyst can conclude that price erosion has a much greater impact on the Net Present Value (Mun, 2015).
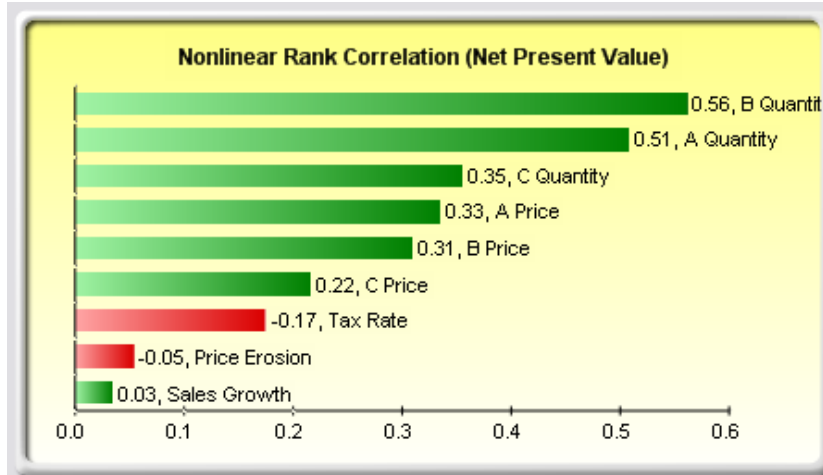
Figure 39.   Example Sensitivity Chart without Correlations
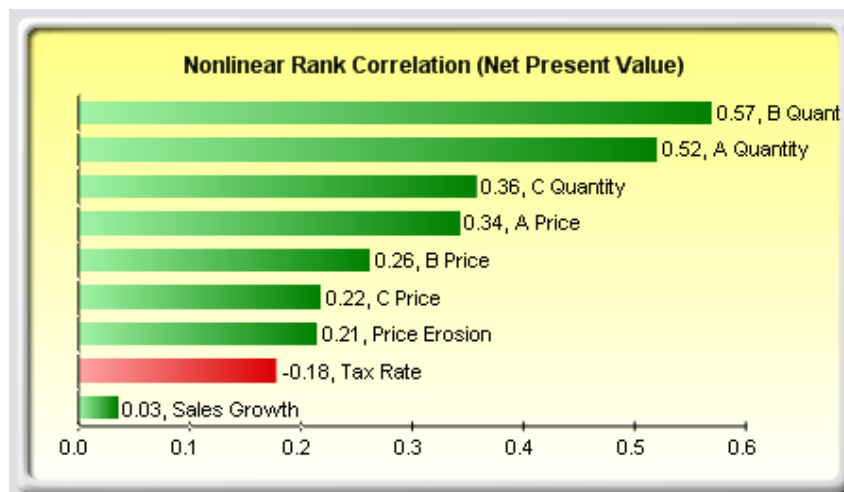
Figure 40.   Example Sensitivity Chart with Correlations

1.   Procedure

The steps for running a Sensitivity Analysis are outlined by Mun (2015):

1.   The analyst will open an existing excel model. If there is no preexisting model, the analyst must create a new one. After a model has been created, the analyst will create a simulation profile by defining the input assumptions and then the output forecasts. These assumptions and forecasts should be entered into the appropriate cells. If the analyst does not want to use an existing model or create a new one, the sample model can be used. To access this model, the analyst will select the Risk Simulator icon and click on the Example Models button. Next, the analyst

will choose the 22 Tornado and Sensitivity Charts (Linear) option and proceed to the DCF Model Worksheet.

2. After there is an active model open, the analysts will select the Risk Simulator icon and click on the Run Simulation button.

3. Once the simulation run has finished, the analyst will need to open the Sensitivity Analysis function. To accomplish this, the analyst will select the Risk Simulator icon followed by the Analytical Tools button. From the Analytical Tools menu, the analyst will then select the Sensitivity Analysis option.

4. In the Sensitivity Analysis window (Figure 41), the analyst will select the appropriate forecast that will be used to analyze their model (Mun, 2015).

Figure 41.   Running a Sensitivity Analysis

The sensitivity analysis report results consist of two key charts and one report. The first is a nonlinear rank correlation chart shown in Figure 42. This ranks assumption-forecast correlation pairs from highest to lowest. Because these correlations are non-parametric and nonlinear, they are free from any distributional requirements. The results should be similar to the tornado analysis charts previously described with the exception of Tax Rate (Mun, 2015). Using the sensitivity analysis chart shown in Figure 39, it can be seen that Tax Rate has far less impact on the model. When analyzing the impact of tax rate alone on the model, it can be seen that it has a significant impact, but when tax rate is interacting with other variables in the model, it has a far less powerful impact (Mun, 2015). This example is used to demonstrate the importance of running sensitivity analysis after a model has undergone simulation to truly gauge the interaction between multiple variables (Mun, 2015). Figure 43 shows the fluctuation in the forecast, or how much of the variation is explained by the model.
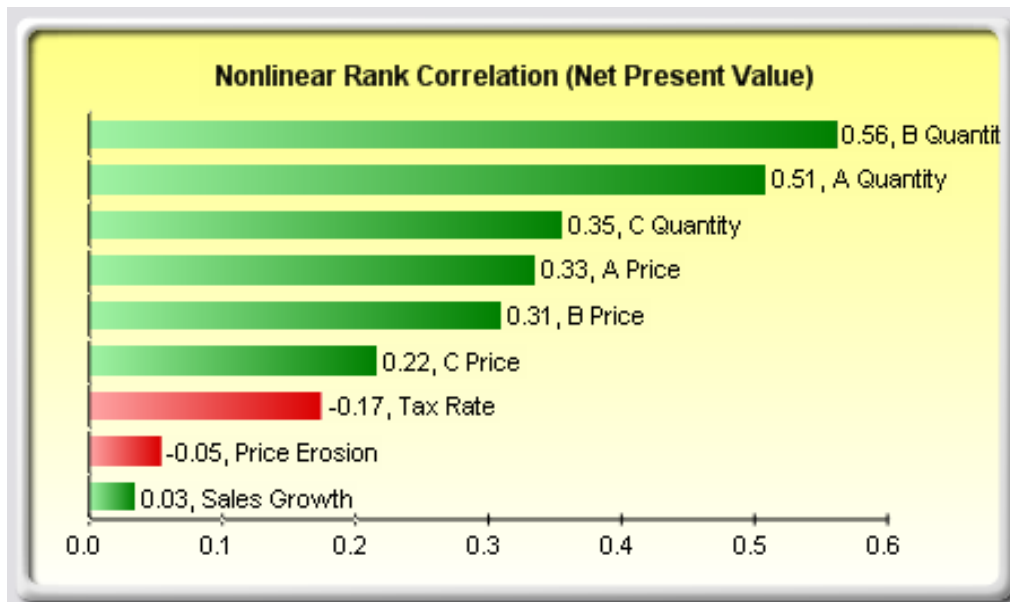
Figure 42.   Example Rank Correlation Chart
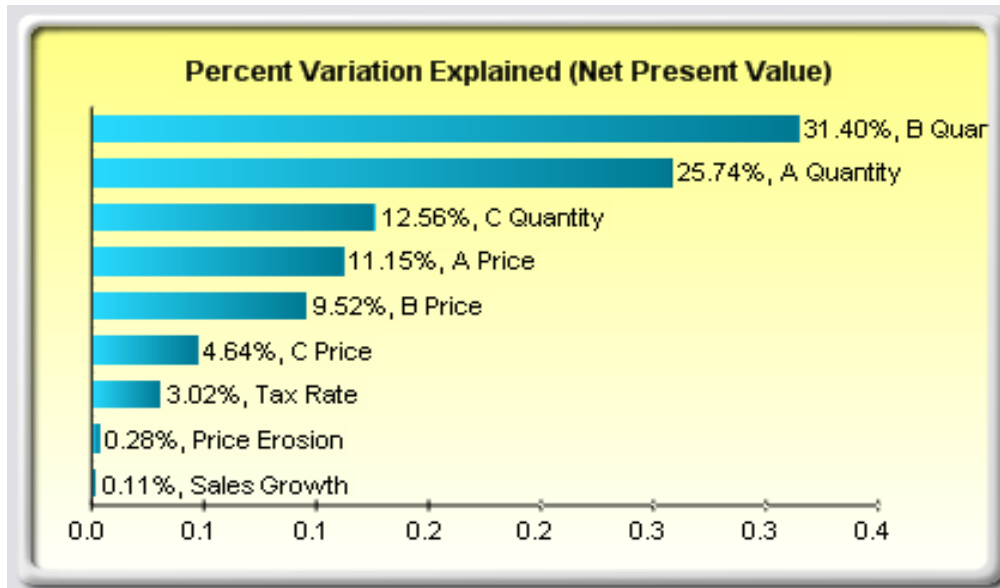
Figure 43.   Example Contribution to Variance Chart

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V.   MODEL APPLICATION AND RESULTS

A.   INTRODUCTION

The inputs for this model were sourced from the program components lists provided by the research sponsor, NAVSEA, for the (generic or specific) EO/IR sensor. The cost estimates for this model were sourced using rough of order magnitude (ROM) values. The values fluctuate slightly between the five different systems to illustrate the differing systems' costs between contract estimates. These values were explicitly created to further the proof of concept of the model and therefore do not necessarily reflect the accurate value for component, part, or salary of support team members. However, these values do show how the simulation can provide an estimate of an entire system and demonstrate how much impact each variable will have on the overall life-cycle cost estimate. In this example, we simulate a cost estimate of an EO/IR system being implemented on 55 platforms with a service life of 20 years.

B.   MODEL INPUTS AND DATA

The Total Ownership Cost is calculated by summing the initial Acquisition Cost, Operation Cost, Maintenance Cost, and Disposal Cost. The model accounts for these four phases, beginning with the Acquisition Cost. In a real-world scenario, a cost analyst would utilize the technical specifications given by the program office to enter the required values. From the technical specifications, the analyst would insert two crucial metrics. The first is the number of platforms that will receive the system, and the second is the number of components required in each system. Since real-world data is not available for this notional model, this thesis uses ROM system to fill in the blanks.

In systems A-E, the model uses 55 as the number of platforms. Though the number of platforms remains the same in the simulation, the technical specifications for the number of components required for each sensor are different. Figure 44 shows the input column for Number of Platforms and Number of Units per System.

Categories	Number of Units per System	Number of Platforms
Grand Total		
Narrow-Medium Field of View (NFOV) Sensors	**43**	**935**
NF-DIR (NFOV Director)	2	55
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55
NF-EOS (Electro-Optic Sensor) - EOS #1	3	55
NF-EOS (Electro-Optic Sensor) - EOS #2	3	55
NF-EOS (Electro-Optic Sensor) - EOS #3	3	55
NF-LRF (Laser Rangefinder)	2	55
NF-LDR (Laser Designator/Rangefinder)	2	55
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	2	55
NF-LP (Laser Pointer)	5	55
NF-LOI (Laser Optical/Ocular Interrupter)	1	55
NF-LI (Laser Illuminator)	3	55
NF-IRU (Inertial Reference Unit)	2	55
NF-BSM (Boresight Module)	1	55
NF-EU (Electronics Unit)	2	55
Ancillary Material (cabling, mounting hardware, etc.)	3	55
Other: _____	4	55

Figure 44.   Number of Platforms and Units per System

The Acquisition Unit Cost accounts for all of the planning, design, and construction costs to make each component possible. The model also considers the estimated cost for a replacement component. The estimated cost for replacement parts should be considerably lower than the initial Acquisition Cost because developed technology will only need to be reproduced instead of being redeveloped. The Operational Cost per year is an estimate of the amount required to run the component for a year. The Operation Cost includes equipment depreciation, costs of the energy source used to power the component, cost of damage due to use, and so on. Similarly, the Maintenance cost is an estimate based on the amount required to maintain the equipment every year. Figure 45 shows the categories for Acquisition and Operation and Maintenance Costs.

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			#############		$217.00		$1,164.00		$42,391.00		$45,863,500.00		$15,308,443.00	
Narrow-Medium Field of View (NFOV) Sensors	**43**	**935**	**$7,110.00**	**0.2%**	**$73.00**	**33.6%**	**$594.00**	**51.0%**	**$4,880.00**	**11.5%**	**$960,850.00**	**2.1%**	**$753,720.00**	**4.9%**
NF-DIR (NFOV Director)	2	55	$400.00	0.0%	$5.00	2.3%	$30.00	2.6%	$300.00	0.7%	$44,000.00	0.1%	$36,850.00	0.2%
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55	$350.00	0.0%	$6.00	2.8%	$23.00	2.0%	$150.00	0.4%	$57,750.00	0.1%	$29,535.00	0.2%
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55	$460.00	0.0%	$7.00	3.2%	$25.00	2.1%	$300.00	0.7%	$50,600.00	0.1%	$36,520.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #1	3	55	$230.00	0.0%	$5.00	2.3%	$34.00	2.9%	$200.00	0.5%	$37,950.00	0.1%	$39,435.00	0.3%
NF-EOS (Electro-Optic Sensor) - EOS #2	3	55	$340.00	0.0%	$3.00	1.4%	$45.00	3.9%	$220.00	0.5%	$56,100.00	0.1%	$44,220.00	0.3%
NF-EOS (Electro-Optic Sensor) - EOS #3	3	55	$450.00	0.0%	$2.00	0.9%	$56.00	4.8%	$250.00	0.6%	$74,250.00	0.2%	$50,820.00	0.3%
NF-LRF (Laser Rangefinder)	2	55	$560.00	0.0%	$3.00	1.4%	$45.00	3.9%	$560.00	1.3%	$61,600.00	0.1%	$66,880.00	0.4%
NF-LDR (Laser Designator/Rangefinder)	2	55	$430.00	0.0%	$4.00	1.8%	$34.00	2.9%	$220.00	0.5%	$47,300.00	0.1%	$28,380.00	0.2%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	2	55	$460.00	0.0%	$5.00	2.3%	$23.00	2.0%	$140.00	0.3%	$50,600.00	0.1%	$18,480.00	0.1%
NF-LP (Laser Pointer)	5	55	$450.00	0.0%	$6.00	2.8%	$45.00	3.9%	$270.00	0.6%	$123,750.00	0.3%	$88,275.00	0.6%
NF-LOI (Laser Optical/Ocular Interrupter)	1	55	$560.00	0.0%	$6.00	2.8%	$65.00	5.6%	$320.00	0.8%	$30,800.00	0.1%	$21,505.00	0.1%
NF-LI (Laser Illuminator)	3	55	$430.00	0.0%	$3.00	1.4%	$43.00	3.7%	$540.00	1.3%	$70,950.00	0.2%	$96,690.00	0.6%
NF-IRU (Inertial Reference Unit)	2	55	$430.00	0.0%	$3.00	1.4%	$34.00	2.9%	$450.00	1.1%	$47,300.00	0.1%	$53,570.00	0.3%
NF-BSM (Boresight Module)	1	55	$230.00	0.0%	$3.00	1.4%	$23.00	2.0%	$220.00	0.5%	$12,650.00	0.0%	$13,530.00	0.1%
NF-EU (Electronics Unit)	2	55	$670.00	0.0%	$3.00	1.4%	$23.00	2.0%	$330.00	0.8%	$73,700.00	0.2%	$39,160.00	0.3%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$430.00	0.0%	$3.00	1.4%	$23.00	2.0%	$200.00	0.5%	$70,950.00	0.2%	$37,290.00	0.2%
Other: _____	4	55	$230.00	0.0%	$6.00	2.8%	$23.00	2.0%	$210.00	0.5%	$50,600.00	0.1%	$52,580.00	0.3%
Wide Field of View (WFOV) Sensors	**23**	**385**	**$25,600.00**	**0.6%**	**$24.00**	**11.1%**	**$245.00**	**21.0%**	**$14,200.00**	**33.5%**	**$4,240,500.00**	**9.2%**	**$2,487,100.00**	**16.2%**
WF-DIR (Director)	2	55	$4,500.00	0.1%	$4.00	1.8%	$35.00	3.0%	$2,000.00	4.7%	$495,000.00	1.1%	$224,290.00	1.5%
WF-TIS (Thermal Imaging Sensor)	3	55	$3,500.00	0.1%	$3.00	1.4%	$43.00	3.7%	$1,200.00	2.8%	$577,500.00	1.3%	$205,590.00	1.3%
WF-EOS (Electro-Optic Sensor)	1	55	$4,500.00	0.1%	$2.00	0.9%	$23.00	2.0%	$3,200.00	7.5%	$247,500.00	0.5%	$177,375.00	1.2%
WF-IRU (Inertial Reference Unit)	2	55	$5,300.00	0.1%	$6.00	2.8%	$22.00	1.9%	$2,300.00	5.4%	$583,000.00	1.3%	$256,080.00	1.7%
WF-EU (Electronics Unit)	4	55	$1,000.00	0.0%	$3.00	1.4%	$55.00	4.7%	$1,000.00	2.4%	$220,000.00	0.5%	$232,760.00	1.5%
Ancillary Material (cabling, mounting hardware, etc.)	5	55	$2,300.00	0.1%	$2.00	0.9%	$45.00	3.9%	$2,100.00	5.0%	$632,500.00	1.4%	$590,425.00	3.9%
Other: _____	6	55	$4,500.00	0.1%	$4.00	1.8%	$22.00	1.9%	$2,400.00	5.7%	$1,485,000.00	3.2%	$800,580.00	5.2%
EO/IR Sensor Manager (ESM)	**17**	**330**	**$1,910.00**	**0.0%**	**$45.00**	**20.7%**	**$124.00**	**10.7%**	**$1,400.00**	**3.3%**	**$282,150.00**	**0.6%**	**$275,990.00**	**1.8%**
Processing Equipment	3	55	$340.00	0.0%	$4.00	1.8%	$15.00	1.3%	$150.00	0.4%	$56,100.00	0.1%	$27,885.00	0.2%
Processing Software	4	55	$230.00	0.0%	$6.00	2.8%	$23.00	2.0%	$230.00	0.5%	$50,600.00	0.1%	$56,980.00	0.4%
Recording Equipment	5	55	$240.00	0.0%	$5.00	2.3%	$40.00	3.4%	$430.00	1.0%	$66,000.00	0.1%	$130,625.00	0.9%
Docking Station Equipment	2	55	$350.00	0.0%	$5.00	2.3%	$21.00	1.8%	$230.00	0.5%	$38,500.00	0.1%	$28,160.00	0.2%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	1	55	$210.00	0.0%	$12.00	5.5%	$10.00	0.9%	$210.00	0.5%	$11,550.00	0.0%	$12,760.00	0.1%
Other: _____	2	55	$540.00	0.0%	$13.00	6.0%	$15.00	1.3%	$150.00	0.4%	$59,400.00	0.1%	$19,580.00	0.1%

Figure 45.   Categories for Acquisition and Operation and Maintenance Costs

Once the cost analyst has entered the Acquisition Cost for the hardware and software required for the system, the analyst must remember to account for the human element. The analyst will need to ensure that the cost required to pay for those responsible for the design, logistics, management, and technology are represented in the model. This model uses the Acquisition Cost column to record the initial salary of each job. The Number of Platforms column describes the number of teams required for each system. The Number of Units per System column describes the number of people required on each team. The Operation Cost column is used to annotate the continuing salary for the human element for the remainder of the program's life. Essentially, this is how an analyst would annotate a recurring salary payment. Throughout the five systems, the number of people per team and the amount requested per salary will vary. Figure 46 shows an example of where salaries are input into the model.

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%
Grand Total			$4,202,920.00		$1,907,716.00	
Manpower and Personnel	30	6	$321,000.00	7.6%	$240,000.00	12.6%
Program Management Office Team	8	1	$80,000.00	1.9%	$80,000.00	4.2%
Manning and military occupational series training	6	1	$40,000.00	1.0%	$40,000.00	2.1%
Depot Activation	5	1	$60,000.00	1.4%	$55,000.00	2.9%
Software Sustainment	4	1	$40,000.00	1.0%	$35,000.00	1.8%
Initial Fielding Support	4	1	$56,000.00	1.3%	$30,000.00	1.6%
Other: _____	3	1	$45,000.00	1.1%	$0.00	0.0%

Figure 46.   Manpower and Personnel Salary Input Section

All of the costs mentioned previously are recurring costs, costs that will be multiplied by the number of years of the program and summed to get the total cost. Analysts must be sure not to forget to account for all of the one-time costs associated with the origins of any project. Figure 47 shows the list of nonrecurring costs accounted for in the model.

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Figure 47.   Nonrecurring Acquisition and Procurement Costs

Finally, we account for all of the disposal and end-of-life-cycle costs that will also be one-time costs. Figure 48 shows the nonrecurring end-of-life-cycle costs.

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 48.   Nonrecurring End-of-Life-Cycle Costs

C.   RESULTS AND ANALYSIS

Once the data have been manually inputted into the model, the cost analyst can utilize the multitude of charts, graphs, and tools to analyze the total ownership cost of the systems. These graphs, charts, and tools will allow the analyst to compare multiple cost estimates over the entire life of the system at the same time. This thesis analyzed the following tables and charts to highlight the functionality of the model: Total Net Life-Cycle Cost, Present Value of Discounted Total Net Life-Cycle Cost, Cash Total Net Cost at Five-Year increments, Total Ownership Cost Forecast Statistic Table, Simulation Probability Charts, and the Tornado Analysis.

1.   Total Net Life-Cycle Costs and Cash Total Net Cost at Five-Year Increments

Figure 49 shows the Total Net Life-Cycle Cost for all five systems over a span of 30 years. The table and graph show the cost for the systems broken down into five-year estimates. The model projects the life span of the system past the 20-year expected service life. This extension allows the cost analyst to consider cost out to the 30-year point, as many DoD systems tend to exceed their expected service lives. However, the five-year increments also allow a decision-maker to understand the total net cost of disposing of a system before its 20-year service life. The side-by-side comparison enables a decision-maker to graphically perceive the potential differences between the cost estimates of the multiple systems. When choosing between alternatives, Figure 49 can be a beneficial decision aid.

In the analysis table in Figure 49, the 20-Year Cash Total Net Cost ranges from $554 million (System C) to $771 million (System D). If cost was the determining factor, a decision-maker could quickly determine that System C should be selected. To make the comparison even easier to analyze, Figure 50 provides a side-by-side comparison of all five systems at each of the five-year increments. Looking at the 20-Year Total Net Cost Graph, it can be clearly seen that System C has the lowest Total Net Cost.

Cost analysis should only be one part of the picture when it comes to making then correct strategic decision. For example, each system's specifications and capabilities—its military benefits or returns—should also be computed, such that each system will have its

own return on investment (ROI). Nonetheless, the major component of any ROI analysis is its cost. The focus of this research is to determine this cost computation. Another aspect of TOC analysis is its use in cost mitigation, cost savings, and cost deferred, which constitute another point of view of cost-based decision analytics.

Analysis Period/Type	System A	System B	System C	System D	System E
5 Year Cash Total Net Cost	$192,078,759.39	$199,950,888.59	$158,074,801.16	$206,656,401.49	$161,982,378.15
10 Year Cash Total Net Cost	$348,972,742.05	$366,909,094.54	$280,489,136.93	$381,039,284.24	$291,014,854.14
15 Year Cash Total Net Cost	$517,992,119.86	$546,770,499.13	$412,364,142.71	$568,899,174.37	$430,019,476.51
20 Year Cash Total Net Cost	$700,073,991.93	$740,532,313.22	$554,430,976.94	$771,277,628.99	$579,766,932.65
25 Year Cash Total Net Cost	$896,227,880.11	$949,268,816.09	$707,477,304.94	$989,296,700.88	$741,087,471.77
30 Year Cash Total Net Cost	$1,107,541,326.15	$1,174,137,311.67	$872,351,665.95	$1,224,165,159.57	$914,875,508.07
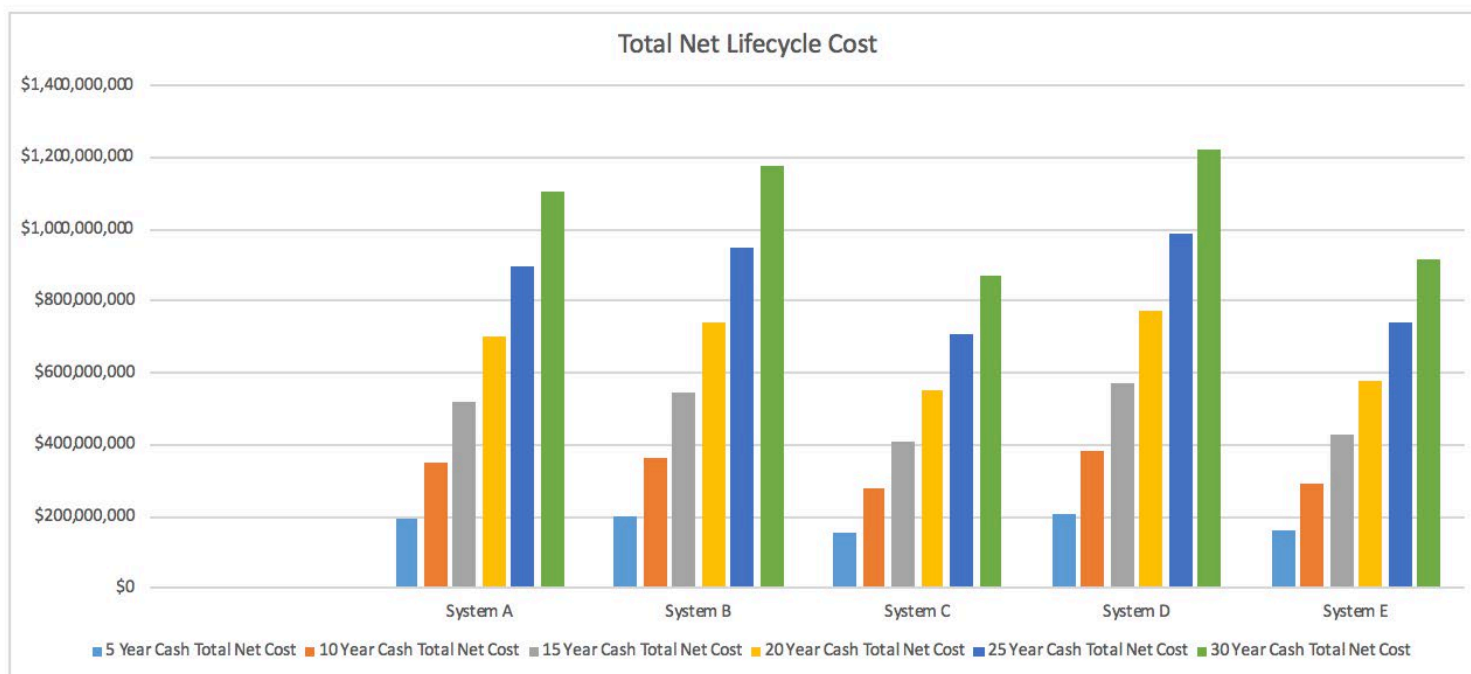
Figure 49.   Total Net Life-Cycle Cost
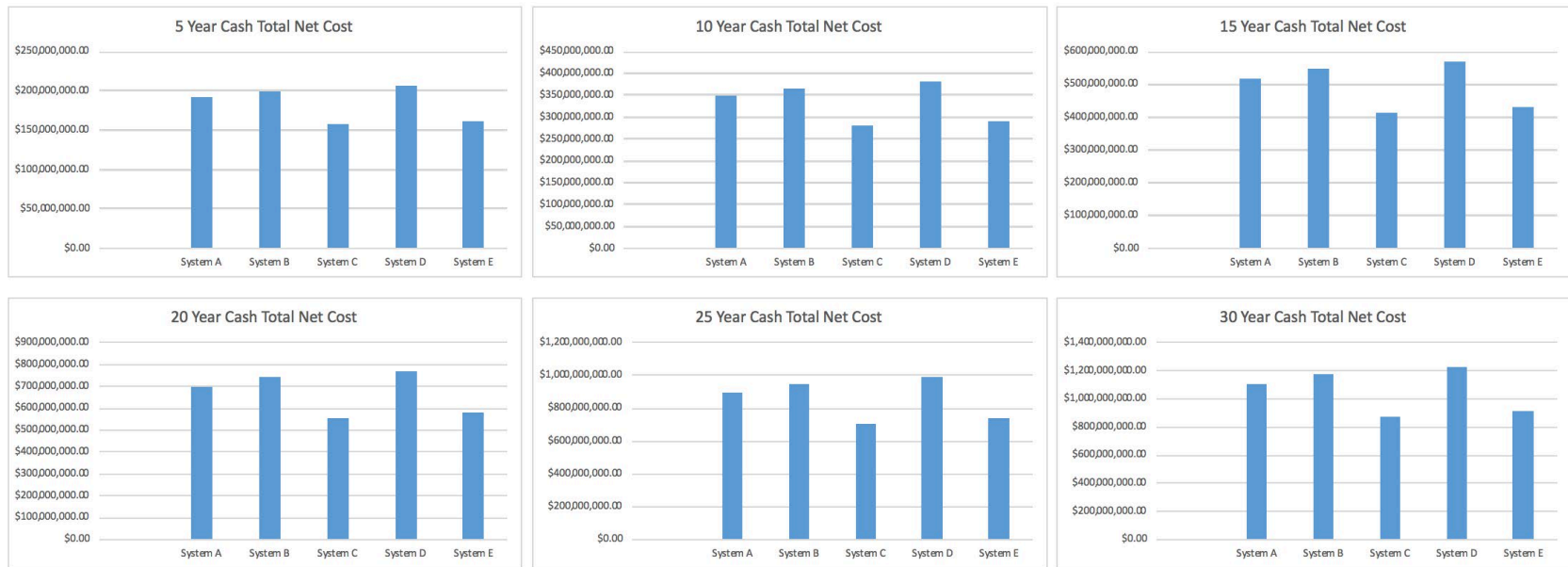
Figure 50.   Five-Year Increment of Net Total Cost

2. Present Value of Discounted Total Net Life-Cycle Cost

While Figure 49 shows the Total Net Life-Cycle Cost, it does not include consideration of economic factors such as the time value of money and uncertainty risk. To mitigate these factors in the model, Figure 51 incorporates a Net Present Value Life-Cycle Cost estimate using a discount rate of 3% (i.e., the government's cost of money, where we can use 20-year and 30-year Treasury bond yields as proxies). In the analysis table in Figure 49, the 20 Year Total Net Cost ranges from $554 million (System C) to $771 million (System D), but when looking at the more realistic Present Value Discounted Net Life-Cycle Cost, the range between Systems C and D decreases to $418 million and $577 million. Not only do the estimates for the minimum and maximum values decrease when the discount factor is applied, but the delta of the range between the values also shrinks by $57.8 million. Incorporating the discount rate into the model gives the decision-maker a complete analysis of the costs. Specifically, it shows the value of the lifetime cost of a system in today's money, thereby putting all systems with different life cycles and life spans on an equal footing with each other, for a better cost comparison.

Analysis Period/Type	System A	System B	System C	System D	System E
5 Year Cash Cost in Present Values	$179,704,285.34	$186,783,594.12	$148,416,499.73	$192,904,219.83	$151,802,725.35
10 Year Cash Cost in Present Values	$303,544,126.37	$318,568,174.68	$245,037,964.84	$330,549,870.97	$253,648,577.73
15 Year Cash Cost in Present Values	$418,626,211.89	$441,033,105.19	$334,826,703.72	$458,461,345.77	$348,292,207.24
20 Year Cash Cost in Present Values	$525,569,818.93	$554,837,402.90	$418,265,845.06	$577,326,978.99	$436,242,875.34
25 Year Cash Cost in Present Values	$624,950,442.22	$660,593,492.07	$495,804,364.31	$687,786,438.92	$517,973,842.03
30 Year Cash Cost in Present Values	$717,302,888.41	$758,870,497.06	$567,859,497.04	$790,434,167.10	$593,924,909.86
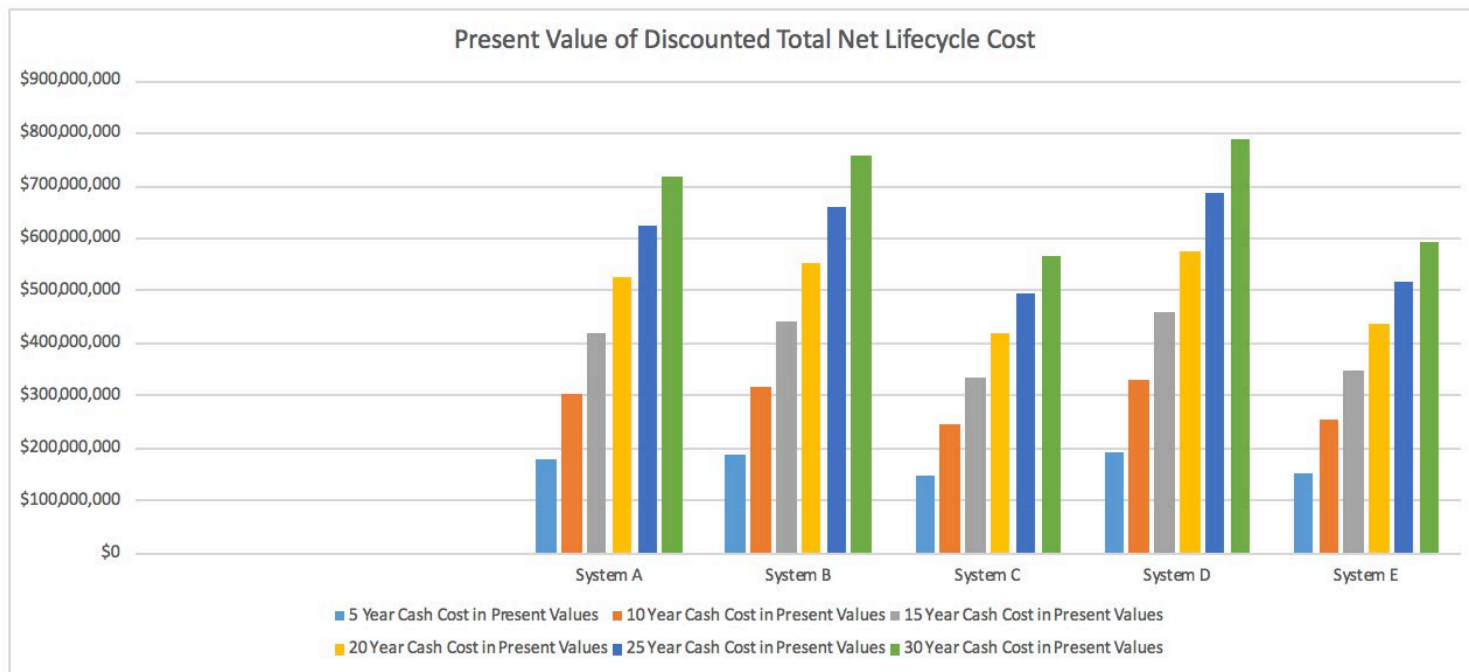
Figure 51.   Present Value of Discounted Net Life-Cycle Cost

3. Total Ownership Cost Forecast Statistics Table

The Forecast Statistics Table, shown in Figure 52, summarizes the distribution of the Total Life-Cycle Cost and the Total Present Value (PV) Life-Cycle Cost for the five systems at different points in the life cycle of the system. Figure 52 highlights the outcomes of running 10,000 trials using the Monte Carlo Risk Simulator. The takeaways from this figure are the mean, standard deviation, maximum, minimum, and range data points. These metrics provide a decision-maker with a better understanding of how uncertainty can affect the Total Life-Cycle Cost and Total PV Life-Cycle Cost of a system.

System C looks at the cost over a 20-year life span. Using the Monte Carlo Risk Simulator, the maximum Total Life-Cycle Cost of the system is $568 million, while the minimum is $540 million. These values represent the worst- and best-case scenarios, respectively. The simulations produced a Total Life-Cycle Cost range of $28 million and a mean value of $554 million. The standard deviation of Total Life-Cycle Cost simulations for System C is $4.5 million, meaning 68.2% of the estimates will fall within ±$4.5 million of the mean if the distribution is somewhat normally distributed. Figure 52 also shows the same metrics for the PV of the Total Life-Cycle Cost for all systems.

Forecast Statistics Table - TOC Model

Cell	Total Lifetime Cost for System A (20 Years)	Total Lifetime Cost for System B (25 Years)	Total Lifetime Cost for System C (20 Years)	Total Lifetime Cost for System D (10 Years)	Total Lifetime Cost for System E (15 Years)	Total PV Lifetime Cost for System A (20 Years)	Total PV Lifetime Cost for System B (25 Years)	Total PV Lifetime Cost for System C (20 Years)	Total PV Lifetime Cost for System D (10 Years)	Total PV Lifetime Cost for System E (15 Years)
Name	S42	S42	S42	S42	S42	S43	S43	S43	S43	S43
Number of Datapoints	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Mean	$700,128,499.57	$740,532,963.43	$554,392,425.60	$771,338,025.77	$579,775,293.62	$525,611,374.46	$554,838,179.48	$418,238,633.17	$577,371,510.62	$436,248,097.08
Median	$700,141,006.85	$740,535,580.46	$554,384,371.67	$771,364,875.28	$579,759,448.54	$525,610,342.27	$554,835,058.62	$418,245,556.21	$577,382,472.47	$436,233,772.78
Standard Deviation	$6,257,100.80	$5,845,829.50	$4,467,888.27	$7,611,267.45	$4,630,641.37	$4,594,559.43	$4,292,302.35	$3,283,147.51	$5,583,858.78	$3,400,790.39
Coefficient of Variation	0.89%	0.79%	0.81%	0.99%	0.80%	0.87%	0.77%	0.78%	0.97%	0.78%
Maximum	$721,408,465.72	$760,794,257.46	$568,380,140.14	$792,265,719.52	$595,514,481.66	$541,361,082.89	$569,528,468.16	$428,545,963.69	$592,883,001.86	$447,659,644.97
Minimum	$679,850,811.09	$719,523,385.66	$540,339,232.67	$748,640,296.95	$564,025,304.82	$510,709,204.65	$539,393,598.53	$407,787,597.45	$560,676,945.01	$424,678,356.35
Range	$41,557,654.63	$41,270,871.80	$28,040,907.47	$43,625,422.57	$31,489,176.84	$30,651,878.24	$30,134,869.63	$20,758,366.24	$32,206,056.85	$22,981,288.62
Skewness	-0.0032	-0.0042	-0.0148	-0.0026	0.0087	-0.0023	-0.0028	-0.0144	-0.0026	0.0091
Kurtosis	-0.4009	-0.2633	-0.3281	-0.5003	-0.3088	-0.3995	-0.2616	-0.3249	-0.4998	-0.3093
25% Percentile	$695,719,253.67	$736,446,455.02	$551,284,478.55	$765,796,106.33	$576,509,002.84	$522,378,543.35	$551,839,791.47	$415,958,053.49	$573,311,007.82	$433,851,693.64
75% Percentile	$704,532,335.37	$744,600,466.38	$557,526,620.08	$776,618,455.92	$582,946,797.53	$528,851,703.11	$557,822,109.37	$420,545,180.57	$581,253,957.83	$438,577,466.99
Error Precision at 95%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%
5% Percentile	$689,682,929.25	$730,959,587.63	$546,946,259.66	$758,769,396.90	$572,144,154.21	$517,951,178.33	$547,793,197.77	$412,759,859.00	$568,154,901.40	$430,640,138.12
10% Percentile	$691,747,640.51	$732,794,898.81	$548,533,001.64	$761,225,549.84	$573,689,454.88	$519,468,239.36	$549,181,125.39	$413,946,175.50	$569,990,913.70	$431,776,478.59
20% Percentile	$694,602,871.32	$735,367,935.12	$550,510,692.26	$764,515,420.38	$575,778,821.69	$521,563,700.07	$551,045,883.57	$415,386,396.82	$572,378,313.33	$433,315,521.79
30% Percentile	$696,704,619.48	$737,452,394.84	$551,979,547.59	$767,095,731.78	$577,226,617.51	$523,096,629.77	$552,578,355.90	$416,460,293.34	$574,253,331.14	$434,382,267.57
40% Percentile	$698,493,546.06	$739,011,582.52	$553,233,344.80	$769,309,931.15	$578,543,844.11	$524,394,394.43	$553,713,041.68	$417,379,609.28	$575,880,312.72	$435,341,189.38
50% Percentile	$700,141,006.85	$740,535,580.46	$554,384,371.67	$771,364,875.28	$579,759,448.54	$525,610,342.27	$554,835,058.62	$418,245,556.21	$577,382,472.47	$436,233,772.78
60% Percentile	$701,843,734.05	$742,099,383.62	$555,579,609.61	$773,403,235.14	$580,989,590.40	$526,887,691.99	$555,979,070.58	$419,103,492.37	$578,891,015.17	$437,139,948.28
70% Percentile	$703,601,587.76	$743,714,003.76	$556,847,632.09	$775,491,755.81	$582,222,603.44	$528,161,141.23	$557,172,586.27	$420,044,672.96	$580,410,041.35	$438,057,186.64
80% Percentile	$705,593,527.64	$745,597,406.41	$558,265,766.20	$778,104,442.05	$583,805,528.28	$529,626,241.70	$558,543,630.43	$421,090,371.98	$582,332,648.63	$439,205,172.05
90% Percentile	$708,345,917.64	$748,088,346.78	$560,256,120.90	$781,498,101.24	$585,875,474.23	$531,647,003.55	$560,385,422.61	$422,546,755.03	$584,823,963.64	$440,711,757.31
95% Percentile	$710,307,855.95	$750,205,085.99	$561,774,937.44	$784,001,472.92	$587,517,826.61	$533,116,251.14	$561,929,004.53	$423,658,279.36	$586,692,336.33	$441,943,293.84
99% Percentile	$713,991,274.06	$753,529,283.26	$564,370,570.06	$787,642,529.91	$589,971,521.84	$535,763,348.04	$564,406,101.50	$425,570,623.73	$589,320,737.18	$443,747,515.40

Figure 52.   Total Ownership Cost Forecast Statistics Table

4.   Simulation Probability Charts

A simulation probability chart is a histogram or frequency distribution of all of the total life-cycle costs of a system based on 10,000 simulation runs or trials. The probability chart produces a graphic representation of the information contained in the forecast statistics table. Figure 53 shows the frequency distribution of the total life-cycle cost for System A over a 20-year life. In the figure, it can be seen that System A's frequency distribution is shaped as a roughly symmetrical bell curve centered on a mean of $700 million. Using this chart, an analyst could confidently conclude the total life-cycle cost for this system will fall between $679 million and $721 million. The figure also shows the 90% confidence interval of the TOC to be between $690 million and $710 million. This means that there is a 90% chance that given all uncertainties that exist in each of the input assumptions, the 20-year total lifetime cost for System A will be between these two values. In addition, there is only a 5% chance that the cost can be below $690 million and 5% chance it can exceed $710 million.

Figure 54 uses the same frequency distribution over the same 20-year system life as in Figure 53; however, Figure 54/ takes into account the discount rate to better illustrate the economic factor of inflation over time. Similarly, the 90% confidence interval in present values is between $518 million and $533 million.
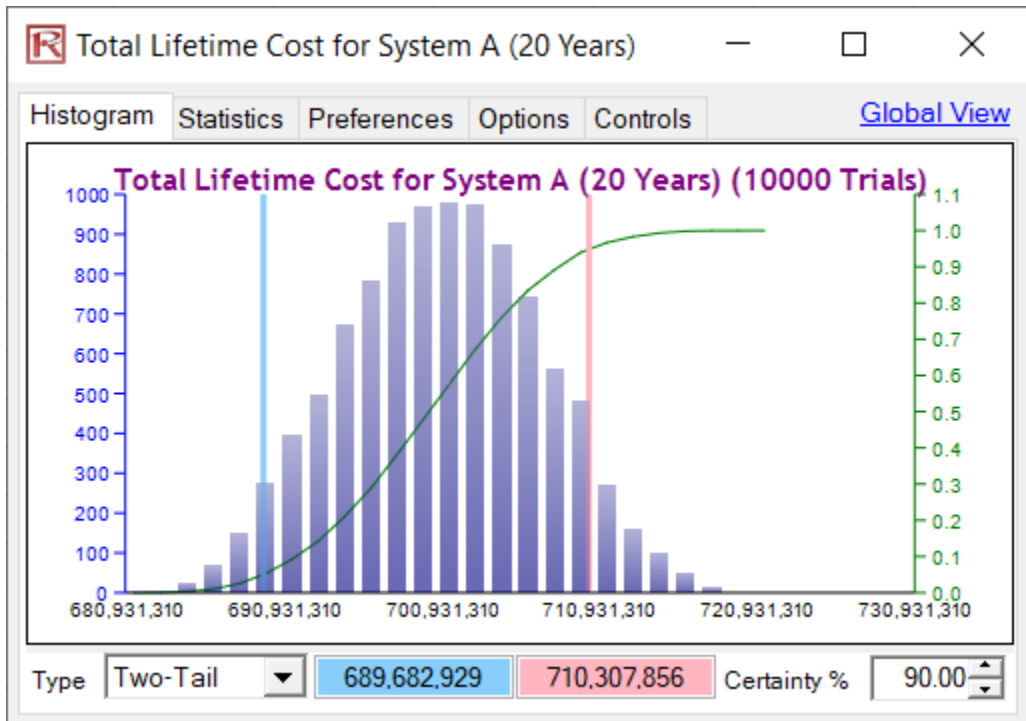
Figure 53.   Total Life Cycle-Cost for System A (20 Years)
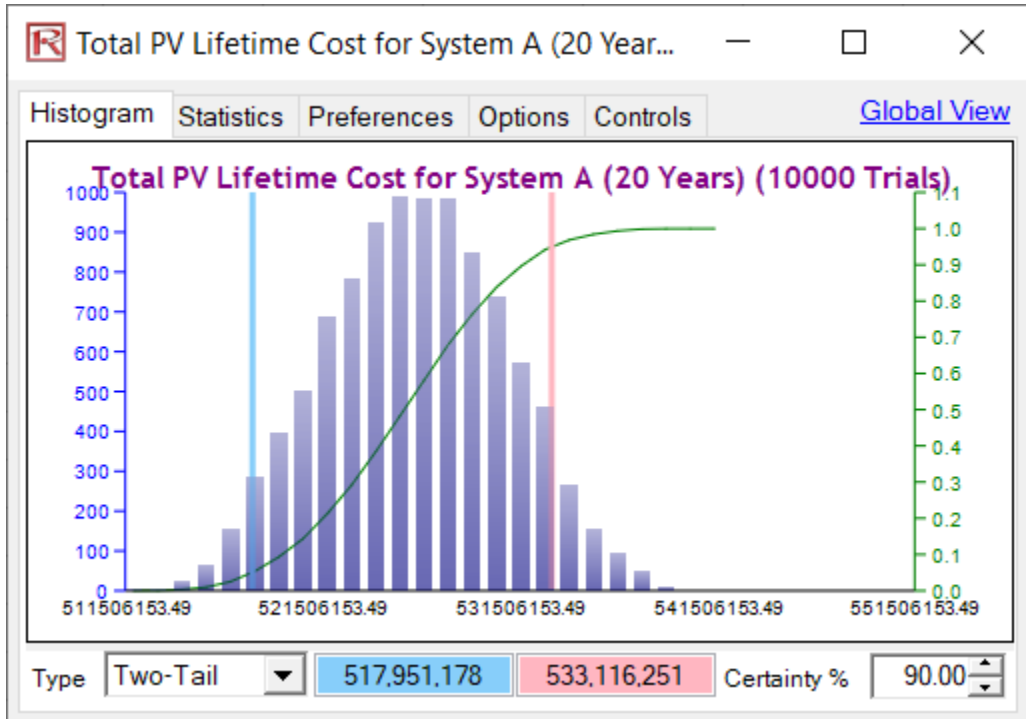
Figure 54.   Total Present Value Life-Cycle Cost for System A (20 Years)

Figure 55 shows the total life-cycle cost for System B; however, the system's life span has been extended to 25 years versus 20 years. The probability charts allow cost analysts to graphically compare the frequency distributions of two different systems with varying life spans. In a comparison between Figure 53 and Figure 55, System A has a shorter life span and lower total cost range. Through this analysis, a decision-maker can determine if the extended life span of System B is worth the higher total life-cycle cost. Figure 56 displays the total PV life-cycle cost for System B, which has been adjusted using a discount factor for inflation.
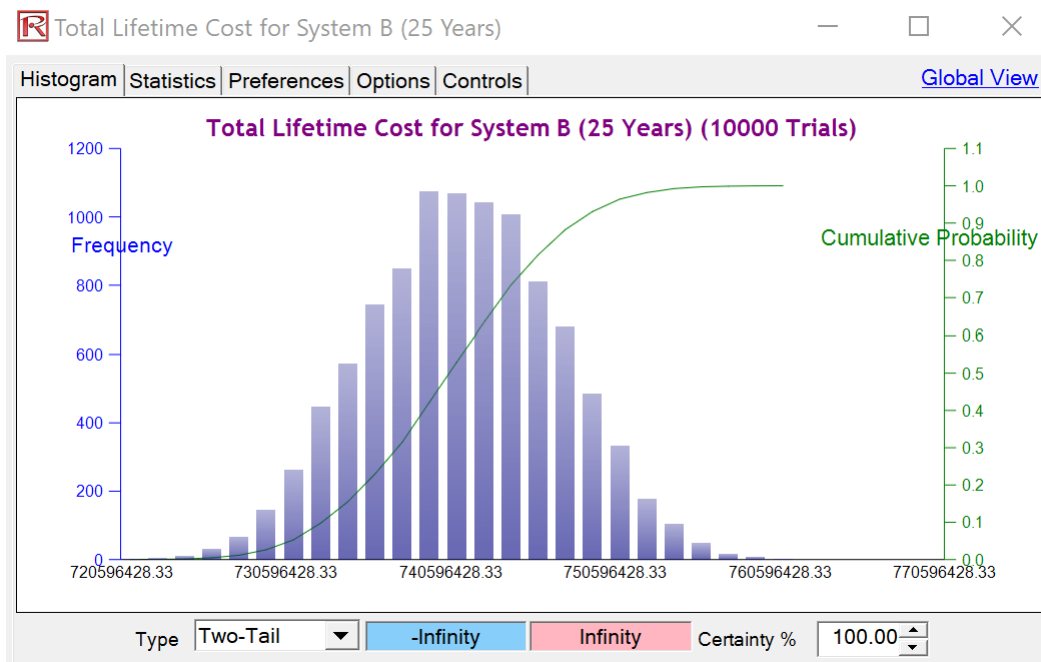
Figure 55.   Total Life-Cycle Cost for System B (25 Years)
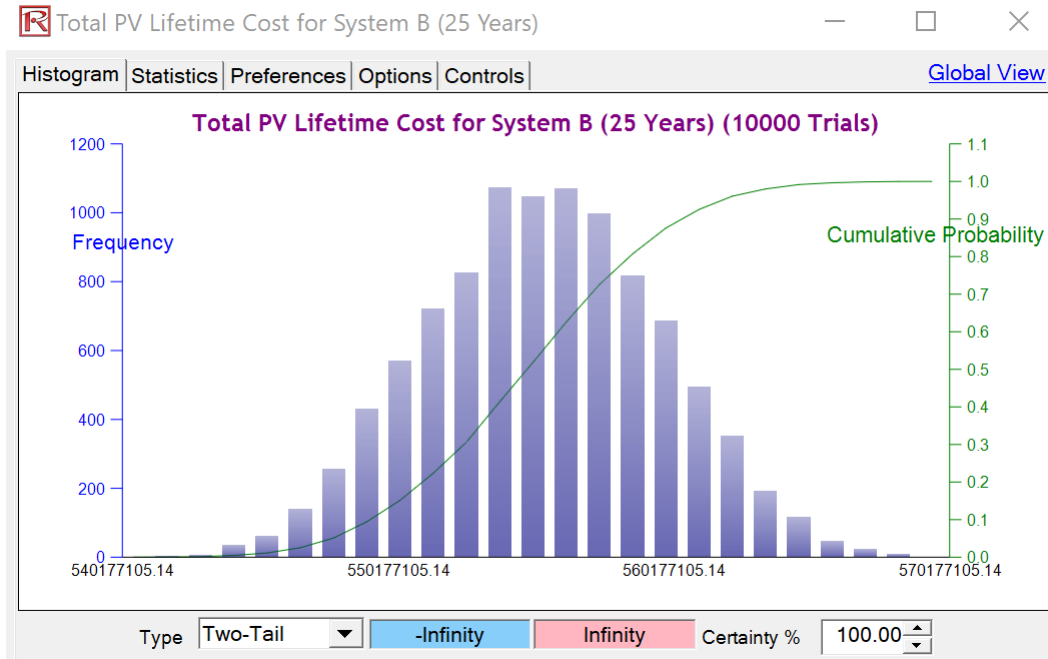
Figure 56.　Total Present Value Life-Cycle Cost for System B (25 Years)

Figure 57 shows the total life-cycle cost for System D; however, the system's life span has been shortened to 10 years versus the original 20 years. The probability chart allows an analyst to compare the total life-cycle cost of a system with a shorter life span to systems with longer life spans. In a comparison between Figure 53 and Figure 57, System A has a longer life span and a lower total cost range than System D. This comparison illustrates that despite System D's shorter life span, the total life-cycle cost is higher than that of System A. This could be a vital metric for decision-makers to consider when determining which system has the best value. Figure 58 shows System D's total PV life-cycle cost to account for economic factors. These probability distributions can also be overlaid and compared against one another for a better view of the potential cost spreads, as shown in Figure 59.
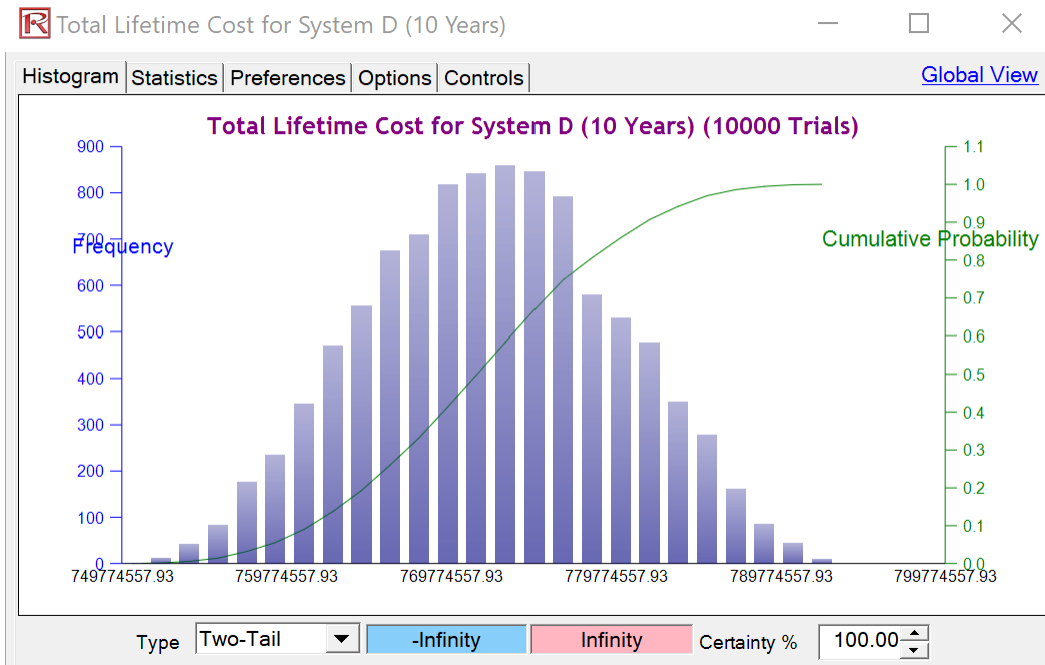
Figure 57. Total Life-Cycle Cost for System D (10 Years)
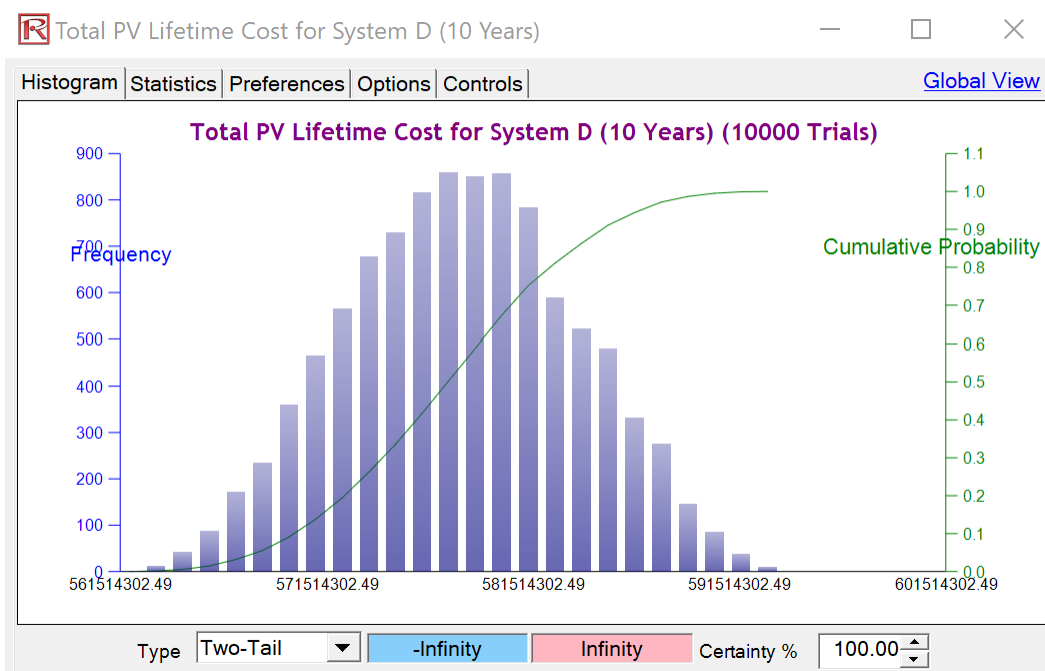
Figure 58. Total Present Value Life-Cycle Cost for System D (10 Years)
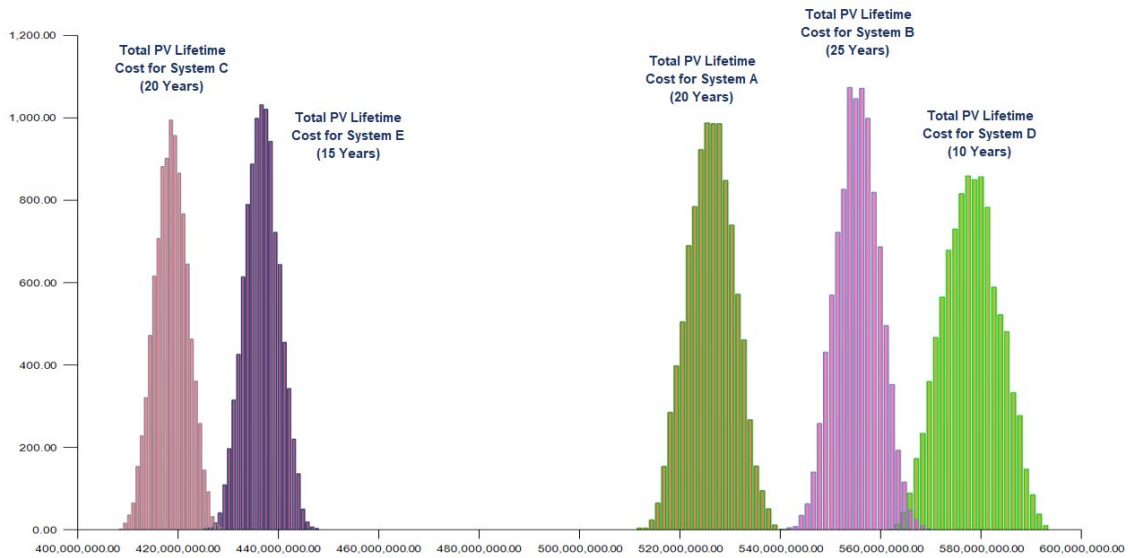
Figure 59. Probability Distribution Cost Overlay of the Five Systems

5. Tornado Analysis

The tornado analysis chart gives decision-makers the ability to break down which variables have the most significant impact on the overall outcome of the simulation. By focusing on the top critical factors, decision-makers can focus on cost reduction techniques in places that will have the most effect. The tornado analysis allows the decision-makers to adjust how many critical variables to display. Figure 60 shows the tornado analysis chart detailing the 20 most impactful variables on the TOC model. Based on the notional cost values inputted into the model, the number of platforms containing that ancillary material is the most critical factor.
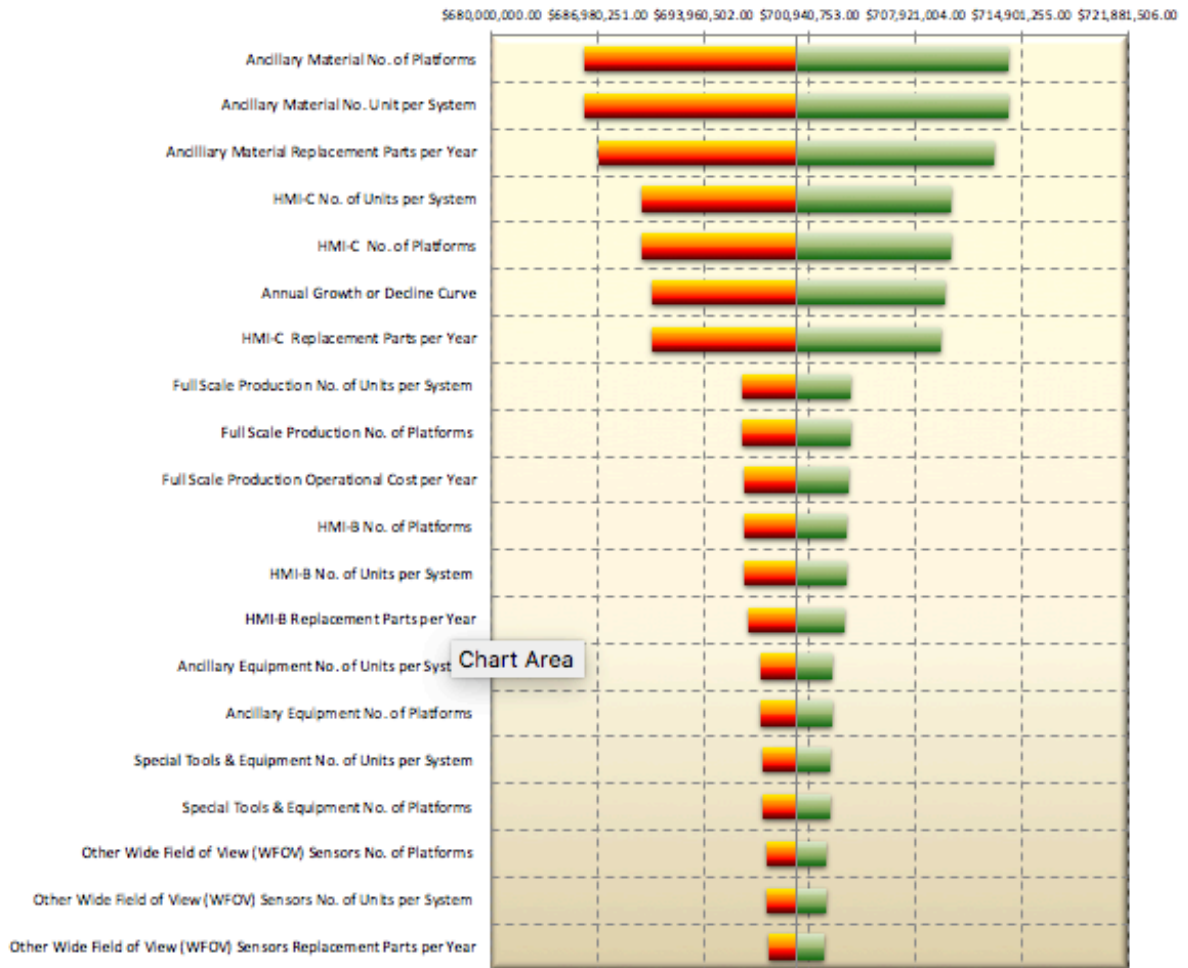
Figure 60.   Tornado Analysis

VI. CONCLUSION

A. KEY CONCLUSIONS

The purpose of this thesis was to develop a total ownership with life-cycle cost model while considering uncertainty for EO/IR sensors on U.S. Navy surface ships. Through the examination of total ownership cost (TOC) modeling over the life cycle of EO/IR sensors, including the inception phase of Acquisition Costs, followed by annual Operations and Maintenance expenses, along with a final set of Disposition Costs, we were able to develop a useful model for TOC estimations. Using Monte Carlo risk simulation, our model accounts for risk and uncertainty when producing cost estimates. The model also provides analysts with a more realistic estimate by factoring in economic theory, such as economic growth, annual discount rate, and inflation.

As discussed, the cost analysis models presented should only be one part of a larger picture when it comes to making the correct strategic investment decisions. For example, each system's specifications, capabilities, military benefits, or financial and non-economic returns, should also be computed, such that each system will have its own return of investment (ROI). Nonetheless, the major component of any ROI analysis is its cost. The focus of this research was to determine these critical cost computations. Another use of TOC modeling is in determining cost mitigation, cost savings, and cost deferred, that is, what the cost differential might be or an Analysis of Alternatives, which constitute another point of view of cost-based decision analytics.

The model allows decision-makers to have better decision analytics of the costs of EO/IR surface sensors. These analytics can be used in subsequent cost comparisons between different sensor platforms, Analysis of Alternatives, and portfolio allocation of resources. Specifically, PEO IWS and NAVSEA can utilize this model in future program cost estimation development. Since the model is tailorable to different sensor configurations, it can provide clarity in analyzing different and complex alternative sensor systems to develop and outfit the fleet. The results of this model give decision-makers a more effective metric to analyze TOC under uncertainty; this can reduce cost overflow and

prevent budget overruns. Ultimately, the model allows leadership to make more informed decisions in the DoD acquisition process and maximize the use of its limited resources.

B.   CURRENT RESEARCH LIMITATIONS AND FOLLOW-ON RESEARCH

The main limitation of the current study is that notional cost data was used to provide a proof of concept that the model functions as designed. However, this presents an opportunity for future research whereby additional follow-on research with empirical data should be conducted. This model can analyze cost data in past, present, and future EO/IR models.

Beginning with historical data, a cost analyst could compile a list of program components associated with a system that is retired or currently in use. Once the list of components is obtained, the analyst can then associate the estimated historical cost assigned to each component during the program's initial cost estimate (e.g., a program cost estimate developed in 1992). Using the original cost data and component list, the analyst could then run the new total ownership with life-cycle cost model under uncertainty. This would produce a new cost estimate for the program, which could then be compared to the original estimate and the actual life-cycle cost of the program. Executing this study would determine whether the TOC model developed in this thesis is a superior method of cost estimation for the DoD.

Another follow-on study could be done using the data from a program that is currently undergoing its initial cost estimation. The cost estimate could be done in conjunction with the DoD's current methods of cost estimation. Another researcher could partner with PEO IWS and the new system's program office to complete a cost estimate using the TOC model developed in this thesis. This process would allow for real time cost comparisons at different stages in the acquisition process. The comparison between the two estimates would provide decision-makers with another method of verifying assumptions and validating that their cost estimates are reasonable and credible. Concurrently conducting the cost estimates allows researchers and cost estimators to compare their estimates to actual cost data at the different increments throughout the program's life cycle. This comparison would determine which method of cost estimation was more accurate at different points in the system's life cycle.

These follow-on studies require real-world cost data from historical or current EO/IR programs. While data collection may prove difficult and time-consuming, this research would be beneficial to the DoD and well worth the investment. Working with PEO IWS and the program office's cost estimation teams could result in model improvements and provide an even more robust total ownership with life-cycle cost model under uncertainty.

C.   OTHER APPLICATIONS AND CONCLUSIONS

This thesis focuses specifically on the application of this TOC model with regard to EO/IR sensors on surface ships; it barely scratches the surface of the model's potential. This model could be applied to any one of the thousands of acquisition projects in the DoD. The model's use is not confined to EO/IR sensors on surface ships but can be adjusted and developed for various programs. The process and the strength of the results that the model would provide would be the same; the only necessary change a cost analyst would need to make is to alter the list of components to reflect whichever system or program is being analyzed. In the same fashion, this model could also provide contractors and non-DoD organizations with an additional method of cost estimation.

Cost estimation is not an exact science; however, this model provides a coherent method of estimating the total ownership with life-cycle costs under uncertainty for EO/IR sensors on surface ships. It gives a decision-maker another tool when evaluating alternative programs and courses of action. The ultimate goal of this model is to provide a more effective tool in determining how the DoD spends its limited resources on competing priorities. While follow-on research needs to be conducted to validate the efficacy of the model, this thesis offers a proof of concept and takes a step towards DoD portfolio optimization.

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APPENDIX A. SYSTEM A EXCEL SPREADSHEET DATA

Appendix A contains the model's Excel spreadsheet for System A, shown in Figures 60-67. This spreadsheet includes the recurring cost inputs, the nonrecurring cost inputs, the end-of-life-cycle cost inputs, and the risk-based Monte Carlo simulation uncertainty ranges.

	Name:	**System A**		Discount Rate:	3.00%		Economic Life:	20 Years	
	Notes:								
	Annual Growth or Decline Curve:			1.50%					

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			**$4,202,920.00**		**$1,907,716.00**		**$106,663.00**		**$99,880.00**		**$45,863,500.00**		**$28,266,870.00**	
Narrow-Medium Field of View (NFOV) Sensors	**43**	**935**	**$7,110.00**	**0.2%**	**$73.00**	**0.0%**	**$594.00**	**0.6%**	**$4,880.00**	**4.9%**	**$960,850.00**	**2.1%**	**$753,720.00**	**2.7%**
NF-DIR (NFOV Director)	2	55	$400.00	0.0%	$5.00	0.0%	$30.00	0.0%	$300.00	0.3%	$44,000.00	0.1%	$36,850.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55	$350.00	0.0%	$6.00	0.0%	$23.00	0.0%	$150.00	0.2%	$57,750.00	0.1%	$29,535.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55	$460.00	0.0%	$7.00	0.0%	$25.00	0.0%	$300.00	0.3%	$50,600.00	0.1%	$36,520.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #1	3	55	$230.00	0.0%	$5.00	0.0%	$34.00	0.0%	$200.00	0.2%	$37,950.00	0.1%	$39,435.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #2	3	55	$340.00	0.0%	$3.00	0.0%	$45.00	0.0%	$220.00	0.2%	$56,100.00	0.1%	$44,220.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #3	3	55	$450.00	0.0%	$2.00	0.0%	$56.00	0.1%	$250.00	0.3%	$74,250.00	0.2%	$50,820.00	0.2%
NF-LRF (Laser Rangefinder)	2	55	$560.00	0.0%	$3.00	0.0%	$45.00	0.0%	$560.00	0.6%	$61,600.00	0.1%	$66,880.00	0.2%
NF-LDR (Laser Designator/Rangefinder)	2	55	$430.00	0.0%	$4.00	0.0%	$34.00	0.0%	$220.00	0.2%	$47,300.00	0.1%	$28,380.00	0.1%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	2	55	$460.00	0.0%	$5.00	0.0%	$23.00	0.0%	$140.00	0.1%	$50,600.00	0.1%	$18,480.00	0.1%
NF-LP (Laser Pointer)	5	55	$450.00	0.0%	$6.00	0.0%	$45.00	0.0%	$270.00	0.3%	$123,750.00	0.3%	$88,275.00	0.3%
NF-LOI (Laser Optical/Ocular Interrupter)	1	55	$560.00	0.0%	$6.00	0.0%	$65.00	0.1%	$320.00	0.3%	$30,800.00	0.1%	$21,505.00	0.1%
NF-LI (Laser Illuminator)	3	55	$430.00	0.0%	$3.00	0.0%	$43.00	0.0%	$540.00	0.5%	$70,950.00	0.2%	$96,690.00	0.3%
NF-IRU (Inertial Reference Unit)	2	55	$430.00	0.0%	$3.00	0.0%	$34.00	0.0%	$450.00	0.5%	$47,300.00	0.1%	$53,570.00	0.2%
NF-BSM (Boresight Module)	1	55	$230.00	0.0%	$3.00	0.0%	$23.00	0.0%	$220.00	0.2%	$12,650.00	0.0%	$13,530.00	0.0%
NF-EU (Electronics Unit)	2	55	$670.00	0.0%	$3.00	0.0%	$23.00	0.0%	$330.00	0.3%	$73,700.00	0.2%	$39,160.00	0.1%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$430.00	0.0%	$3.00	0.0%	$23.00	0.0%	$200.00	0.2%	$70,950.00	0.2%	$37,290.00	0.1%
Other: _____	4	55	$230.00	0.0%	$6.00	0.0%	$23.00	0.0%	$210.00	0.2%	$50,600.00	0.1%	$52,580.00	0.2%
Wide Field of View (WFOV) Sensors	**23**	**385**	**$25,600.00**	**0.6%**	**$24.00**	**0.0%**	**$245.00**	**0.2%**	**$14,200.00**	**14.2%**	**$4,240,500.00**	**9.2%**	**$2,487,100.00**	**8.8%**
WF-DIR (Director)	2	55	$4,500.00	0.1%	$4.00	0.0%	$35.00	0.0%	$2,000.00	2.0%	$495,000.00	1.1%	$224,290.00	0.8%
WF-TIS (Thermal Imaging Sensor)	3	55	$3,500.00	0.1%	$3.00	0.0%	$43.00	0.0%	$1,200.00	1.2%	$577,500.00	1.3%	$205,590.00	0.7%
WF-EOS (Electro-Optic Sensor)	1	55	$4,500.00	0.1%	$2.00	0.0%	$23.00	0.0%	$3,200.00	3.2%	$247,500.00	0.5%	$177,375.00	0.6%
WF-IRU (Inertial Reference Unit)	2	55	$5,300.00	0.1%	$6.00	0.0%	$22.00	0.0%	$2,300.00	2.3%	$583,000.00	1.3%	$256,080.00	0.9%
WF-EU (Electronics Unit)	4	55	$1,000.00	0.1%	$3.00	0.0%	$55.00	0.1%	$1,000.00	1.0%	$220,000.00	0.5%	$232,760.00	0.8%
Ancillary Material (cabling, mounting hardware, etc.)	5	55	$2,300.00	0.1%	$2.00	0.0%	$45.00	0.0%	$2,100.00	2.1%	$632,500.00	1.4%	$590,425.00	2.1%
Other: _____	6	55	$4,500.00	0.1%	$4.00	0.0%	$22.00	0.0%	$2,400.00	2.4%	$1,485,000.00	3.2%	$800,580.00	2.8%
EO/IR Sensor Manager (ESM)	**17**	**330**	**$1,910.00**	**0.0%**	**$45.00**	**0.0%**	**$124.00**	**0.1%**	**$1,400.00**	**1.4%**	**$282,150.00**	**0.6%**	**$275,990.00**	**1.0%**
Processing Equipment	3	55	$340.00	0.0%	$4.00	0.0%	$15.00	0.0%	$150.00	0.2%	$56,100.00	0.1%	$27,885.00	0.1%
Processing Software	4	55	$230.00	0.0%	$6.00	0.0%	$23.00	0.0%	$230.00	0.2%	$50,600.00	0.1%	$56,980.00	0.2%
Recording Equipment	5	55	$240.00	0.0%	$5.00	0.0%	$40.00	0.0%	$430.00	0.4%	$66,000.00	0.1%	$130,625.00	0.5%
Docking Station Equipment	2	55	$350.00	0.0%	$5.00	0.0%	$21.00	0.0%	$230.00	0.2%	$38,500.00	0.1%	$28,160.00	0.1%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	1	55	$210.00	0.0%	$12.00	0.0%	$10.00	0.0%	$210.00	0.2%	$11,550.00	0.0%	$12,760.00	0.0%
Other: _____	2	55	$540.00	0.0%	$13.00	0.0%	$15.00	0.0%	$150.00	0.2%	$59,400.00	0.1%	$19,580.00	0.1%

Figure 61.   System A: Recurring Cost Inputs, Section 1

Human Machine Interface (HMI)	52	275	$30,000.00	0.7%	$74.00	0.0%	$200.00	0.2%	$21,900.00	21.9%	$14,740,000.00	32.1%	$11,791,560.00	41.7%
HMI-B (HMI Bridge/Cockpit)	5	55	$6,000.00	0.1%	$7.00	0.0%	$43.00	0.0%	$5,000.00	5.0%	$1,650,000.00	3.6%	$1,388,750.00	4.9%
HMI-C (HMI Combat Information Center/Cabin)	15	55	$7,000.00	0.2%	$10.00	0.0%	$56.00	0.1%	$5,000.00	5.0%	$5,775,000.00	12.6%	$4,179,450.00	14.8%
HMI-I (HMI Intel)	1	55	$5,000.00	0.1%	$15.00	0.0%	$25.00	0.0%	$4,500.00	4.5%	$275,000.00	0.6%	$249,700.00	0.9%
Ancillary Material (additional displays, control panel switches, cabling, mounts, etc.	30	55	$4,000.00	0.1%	$32.00	0.0%	$54.00	0.1%	$3,400.00	3.4%	$6,600,000.00	14.4%	$5,751,900.00	20.3%
Other: _____	1	55	$8,000.00	0.2%	$10.00	0.0%	$22.00	0.0%	$4,000.00	4.0%	$440,000.00	1.0%	$221,760.00	0.8%
Product Support Management	76	9	$355,000.00	8.4%	$323,000.00	16.9%	$0.00	0.0%	$0.00	0.0%	$2,850,000.00	6.2%	$3,179,000.00	11.2%
Program Management Office Team	5	1	$80,000.00	1.9%	$80,000.00	4.2%	$0.00	0.0%	$0.00	0.0%	$400,000.00	0.9%	$400,000.00	1.4%
Sustainment Planning and Data Procurement	10	1	$50,000.00	1.2%	$45,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$500,000.00	1.1%	$450,000.00	1.6%
Depot Activation	2	1	$20,000.00	0.5%	$21,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$40,000.00	0.1%	$42,000.00	0.1%
Software Sustainment	7	1	$40,000.00	1.0%	$35,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.6%	$245,000.00	0.9%
Integrated Product Support Team	6	1	$35,000.00	0.8%	$40,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$240,000.00	0.8%
Provisioning and Initial Spares Lay-in	4	1	$40,000.00	1.0%	$5,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.3%	$20,000.00	0.1%
Contracting Strategy	6	1	$20,000.00	0.5%	$12,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$72,000.00	0.3%
Full Scale Production	30	1	$30,000.00	0.7%	$50,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$900,000.00	2.0%	$1,500,000.00	5.3%
Other: _____	6	1	$40,000.00	1.0%	$35,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$210,000.00	0.7%
Design Interface	63	11	$320,000.00	7.6%	$24,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$1,839,000.00	4.0%	$115,000.00	0.4%
Technology development (TRL2 to TRL4)	3	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$0.00	0.0%
Materiel development and LRIP (TRL5 to TRL7)	3	1	$12,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$36,000.00	0.1%	$0.00	0.0%
Operational Test (TRL8)	7	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.5%	$0.00	0.0%
Combat system integration (software changes)	8	1	$19,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$152,000.00	0.3%	$0.00	0.0%
Reliability Growth Program	4	1	$32,000.00	0.8%	$5,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$128,000.00	0.3%	$20,000.00	0.1%
Technology Refresh (P3I, emerging threats, obsolescence...)	5	1	$24,000.00	0.6%	$19,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$95,000.00	0.3%
Technology Roadmap	6	1	$18,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$108,000.00	0.2%	$0.00	0.0%
Design for Maintainability	7	1	$45,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.7%	$0.00	0.0%
Modularity	8	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$256,000.00	0.6%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	3	1	$35,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.2%	$0.00	0.0%
Other: _____	9	1	$29,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$261,000.00	0.6%	$0.00	0.0%
Supply Support	77	12	$284,300.00	6.8%	$361,000.00	18.9%	$0.00	0.0%	$0.00	0.0%	$2,096,000.00	4.6%	$2,425,000.00	8.6%
Wholesale and Retail Supply Chain Management	20	1	$40,000.00	1.0%	$30,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$800,000.00	1.7%	$600,000.00	2.1%
Spares Worldwide Transportation	8	1	$20,000.00	0.5%	$45,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.3%	$360,000.00	1.3%
Spares Warehousing	6	1	$30,000.00	0.7%	$100,000.00	5.2%	$0.00	0.0%	$0.00	0.0%	$180,000.00	0.4%	$600,000.00	2.1%
Consumable Spares Replenishment	5	1	$23,000.00	0.5%	$26,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$115,000.00	0.3%	$130,000.00	0.5%
Provisioning and Initial Spares Lay-in	1	1	$10,000.00	0.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$10,000.00	0.0%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	1	1	$23,000.00	0.5%	$33,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$23,000.00	0.1%	$33,000.00	0.1%
Contracting Strategy	6	1	$15,000.00	0.4%	$15,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$90,000.00	0.2%	$90,000.00	0.3%
Decreasing Economies of Scale	5	1	$30,000.00	0.7%	$25,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$150,000.00	0.3%	$125,000.00	0.4%
Battle Damage	20	1	$23,300.00	0.6%	$20,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$466,000.00	1.0%	$400,000.00	1.4%
Initial Fielding Support	2	1	$12,000.00	0.3%	$9,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$24,000.00	0.1%	$18,000.00	0.1%
Prepositioned Stock	3	1	$26,000.00	0.6%	$23,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$78,000.00	0.2%	$69,000.00	0.2%
Other: _____	0	1	$32,000.00	0.8%	$35,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%

Figure 62.   System A: Recurring Cost Inputs, Section 2

Support Equipment	52	8	$310,000.00	7.4%	$269,000.00	14.1%	$65,000.00	60.9%	$57,500.00	57.6%	$2,028,000.00	4.4%	$3,010,000.00	10.6%
Depot Activation	8	1	$45,000.00	1.1%	$50,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$400,000.00	1.4%
Software Sustainment	6	1	$43,000.00	1.0%	$30,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$180,000.00	0.6%
Special Tools & Equipment	8	1	$56,000.00	1.3%	$75,000.00	3.9%	$30,000.00	28.1%	$10,500.00	10.5%	$448,000.00	1.0%	$924,000.00	3.3%
Ancillary Equipment	9	1	$23,000.00	0.5%	$43,000.00	2.3%	$25,000.00	23.4%	$47,000.00	47.1%	$207,000.00	0.5%	$1,035,000.00	3.7%
Support Equipment Sustainment	6	1	$34,000.00	0.8%	$23,000.00	1.2%	$10,000.00	9.4%	$0.00	0.0%	$204,000.00	0.4%	$198,000.00	0.7%
Initial Fielding Support	5	1	$53,000.00	1.3%	$15,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$265,000.00	0.6%	$75,000.00	0.3%
Obsolescence Mitigation (Cost should be escalated)	6	1	$31,000.00	0.7%	$33,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$186,000.00	0.4%	$198,000.00	0.7%
Other: _____	4	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$100,000.00	0.2%	$0.00	0.0%
Packaging, Handling, Storage and Transportation	5	4	$133,000.00	3.2%	$46,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$846,000.00	1.8%	$287,000.00	1.0%
Transportability Requirements	6	1	$54,000.00	1.3%	$20,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$324,000.00	0.7%	$120,000.00	0.4%
Transportation Limitations	6	1	$31,000.00	0.7%	$15,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$186,000.00	0.4%	$90,000.00	0.3%
Initial Fielding Support	7	1	$25,000.00	0.6%	$5,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$175,000.00	0.4%	$35,000.00	0.1%
Other: _____	7	1	$23,000.00	0.5%	$6,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$161,000.00	0.4%	$42,000.00	0.1%
Computer Resources	35	6	$237,000.00	5.6%	$209,000.00	11.0%	$0.00	0.0%	$0.00	0.0%	$1,328,000.00	2.9%	$1,241,000.00	4.4%
Manning and military occupational series training	4	1	$60,000.00	1.4%	$40,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$160,000.00	0.6%
Depot Activation	5	1	$45,000.00	1.1%	$25,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$225,000.00	0.5%	$125,000.00	0.4%
Software Sustainment	6	1	$32,000.00	0.8%	$37,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.4%	$222,000.00	0.8%
O-level publications and new equipment training	7	1	$37,000.00	0.9%	$75,000.00	3.9%	$0.00	0.0%	$0.00	0.0%	$259,000.00	0.6%	$525,000.00	1.9%
Initial Fielding Support	6	1	$29,000.00	0.7%	$15,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$174,000.00	0.4%	$90,000.00	0.3%
Other: _____	7	1	$34,000.00	0.8%	$17,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.5%	$119,000.00	0.4%
Manpower and Personnel	30	6	$321,000.00	7.6%	$240,000.00	12.6%	$0.00	0.0%	$0.00	0.0%	$1,699,000.00	3.7%	$1,415,000.00	5.0%
Program Management Office Team	8	1	$80,000.00	1.9%	$80,000.00	4.2%	$0.00	0.0%	$0.00	0.0%	$640,000.00	1.4%	$640,000.00	2.3%
Manning and military occupational series training	6	1	$40,000.00	1.0%	$40,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$240,000.00	0.8%
Depot Activation	5	1	$60,000.00	1.4%	$55,000.00	2.9%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$275,000.00	1.0%
Software Sustainment	4	1	$40,000.00	1.0%	$35,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.3%	$140,000.00	0.5%
Initial Fielding Support	4	1	$56,000.00	1.3%	$30,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$224,000.00	0.5%	$120,000.00	0.4%
Other: _____	3	1	$45,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$135,000.00	0.3%	$0.00	0.0%
Maintenance Planning and Management	268	15	$430,000.00	10.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$8,330,000.00	18.2%	$0.00	0.0%
System Support Strategy	30	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$1,200,000.00	2.6%	$0.00	0.0%
Title 10 Core 50/50	10	1	$30,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$0.00	0.0%
Depot Activation	16	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$400,000.00	0.9%	$0.00	0.0%
Software Sustainment	34	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$1,360,000.00	3.0%	$0.00	0.0%
Depot Repair and Overhaul	67	1	$30,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$2,010,000.00	4.4%	$0.00	0.0%
Manning and military occupational series training	20	1	$35,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$700,000.00	1.5%	$0.00	0.0%
O-level publications and new equipment training	21	1	$23,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$483,000.00	1.1%	$0.00	0.0%
Sustainment Planning and Data Procurement	10	1	$12,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$0.00	0.0%
Provisioning and Initial Spares Lay-in	15	1	$43,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$645,000.00	1.4%	$0.00	0.0%
Demilitarization and Disposal	13	1	$23,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$299,000.00	0.7%	$0.00	0.0%
Full Scale Production	5	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.4%	$0.00	0.0%
Decreasing Economies of Scale	7	1	$16,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$112,000.00	0.2%	$0.00	0.0%
Initial Fielding Support	7	1	$20,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$140,000.00	0.3%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	5	1	$21,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.2%	$0.00	0.0%
Other: _____	8	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$256,000.00	0.6%	$0.00	0.0%

Figure 63. System A: Recurring Cost Inputs, Section 3

Training and Training Support	29	8	$298,000.00	7.1%	$138,500.00	7.3%	$0.00	0.0%	$0.00	0.0%	$1,064,000.00	2.3%	$521,500.00	1.8%
Depot Activation	1	1	$42,000.00	1.0%	$18,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$42,000.00	0.1%	$18,000.00	0.1%
Software Sustainment	3	1	$32,000.00	0.8%	$7,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$21,000.00	0.1%
Manning and military occupational series training	4	1	$34,000.00	0.8%	$32,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$136,000.00	0.3%	$128,000.00	0.5%
O-level publications and new equipment training	5	1	$25,000.00	0.6%	$38,000.00	2.0%	$0.00	0.0%	$0.00	0.0%	$125,000.00	0.3%	$190,000.00	0.7%
Sustainment Planning and Data Procurement	3	1	$35,000.00	0.8%	$9,500.00	0.5%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.2%	$28,500.00	0.1%
Transportability Requirements	4	1	$60,000.00	1.4%	$17,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$68,000.00	0.2%
Initial Fielding Support	5	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.4%	$0.00	0.0%
Other: _____	4	1	$30,000.00	0.7%	$17,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$68,000.00	0.2%
Facilities and Infrastructure	6	4	$1,070,000.00	25.5%	$184,000.00	9.6%	$40,500.00	38.0%	$0.00	0.0%	$1,720,000.00	3.8%	$274,000.00	1.0%
Ship alteration for initial fielding	1	1	$120,000.00	2.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$0.00	0.0%
Depot Activation	2	1	$250,000.00	5.9%	$25,000.00	1.3%	$7,000.00	6.6%	$0.00	0.0%	$500,000.00	1.1%	$64,000.00	0.2%
Software Sustainment	2	1	$400,000.00	9.5%	$9,000.00	0.5%	$8,500.00	8.0%	$0.00	0.0%	$800,000.00	1.7%	$35,000.00	0.1%
Other: _____	1	1	$300,000.00	7.1%	$150,000.00	7.9%	$25,000.00	23.4%	$0.00	0.0%	$300,000.00	0.7%	$175,000.00	0.6%
Technical Data Management	37	7	$380,000.00	9.0%	$113,000.00	5.9%	$0.00	0.0%	$0.00	0.0%	$1,840,000.00	4.0%	$491,000.00	1.7%
Depot Activation	4	1	$160,000.00	3.8%	$75,000.00	3.9%	$0.00	0.0%	$0.00	0.0%	$640,000.00	1.4%	$300,000.00	1.1%
Software Sustainment	5	1	$60,000.00	1.4%	$9,500.00	0.5%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$47,500.00	0.2%
Manning and military occupational series training	6	1	$20,000.00	0.5%	$6,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$36,000.00	0.1%
O-level publications and new equipment training	7	1	$40,000.00	1.0%	$7,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.6%	$52,500.00	0.2%
Sustainment Planning and Data Procurement	3	1	$30,000.00	0.7%	$10,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$90,000.00	0.2%	$30,000.00	0.1%
Contracting Strategy	5	1	$40,000.00	1.0%	$5,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.4%	$25,000.00	0.1%
Other: _____	7	1	$30,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$0.00	0.0%

Figure 64.   System A: Recurring Cost Inputs, Section 4

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 65.   System A: Nonrecurring and End-of-Life-Cycle Cost Inputs Section

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$912,807.50	$960,850.00	$1,008,892.50	$960,850.00	$716,034.00	$753,720.00	$791,406.00	$753,720.00
Wide Field of View (WFOV) Sensors	$4,028,475.00	$4,240,500.00	$4,452,525.00	$4,240,500.00	$2,362,745.00	$2,487,100.00	$2,611,455.00	$2,487,100.00
EO/IR Sensor Manager (ESM)	$268,042.50	$282,150.00	$296,257.50	$282,150.00	$262,190.50	$275,990.00	$289,789.50	$275,990.00
Human Machine Interface (HMI)	$14,003,000.00	$14,740,000.00	$15,477,000.00	$14,740,000.00	$11,201,982.00	$11,791,560.00	$12,381,138.00	$11,791,560.00
Product Support Management	$2,707,500.00	$2,850,000.00	$2,992,500.00	$2,850,000.00	$3,020,050.00	$3,179,000.00	$3,337,950.00	$3,179,000.00
Design Interface	$1,747,050.00	$1,839,000.00	$1,930,950.00	$1,839,000.00	$109,250.00	$115,000.00	$120,750.00	$115,000.00
Supply Support	$1,991,200.00	$2,096,000.00	$2,200,800.00	$2,096,000.00	$2,303,750.00	$2,425,000.00	$2,546,250.00	$2,425,000.00
Support Equipment	$1,926,600.00	$2,028,000.00	$2,129,400.00	$2,028,000.00	$2,859,500.00	$3,010,000.00	$3,160,500.00	$3,010,000.00
Packaging, Handling, Storage and Transportation	$803,700.00	$846,000.00	$888,300.00	$846,000.00	$272,650.00	$287,000.00	$301,350.00	$287,000.00
Computer Resources	$1,261,600.00	$1,328,000.00	$1,394,400.00	$1,328,000.00	$1,178,950.00	$1,241,000.00	$1,303,050.00	$1,241,000.00
Manpower and Personnel	$1,614,050.00	$1,699,000.00	$1,783,950.00	$1,699,000.00	$1,344,250.00	$1,415,000.00	$1,485,750.00	$1,415,000.00
Maintenance Planning and Management	$7,913,500.00	$8,330,000.00	$8,746,500.00	$8,330,000.00	$0.00	$0.00	$0.00	$0.00
Training and Training Support	$1,010,800.00	$1,064,000.00	$1,117,200.00	$1,064,000.00	$495,425.00	$521,500.00	$547,575.00	$521,500.00
Facilities and Infrastructure	$1,634,000.00	$1,720,000.00	$1,806,000.00	$1,720,000.00	$260,300.00	$274,000.00	$287,700.00	$274,000.00
Technical Data Management	$1,748,000.00	$1,840,000.00	$1,932,000.00	$1,840,000.00	$466,450.00	$491,000.00	$515,550.00	$491,000.00
Acquisition Costs	$444,410.00	$467,800.00	$491,190.00	$467,800.00				
End of Life Disposition Costs	$103,550.00	$109,000.00	$114,450.00	$109,000.00				

Year	Acquisition	1	2	3	4	5	6	7
Cash Flow	$46,331,300.00	$28,266,870.00	$28,690,873.05	$29,121,236.15	$29,558,054.69	$30,001,425.51	$30,451,446.89	$30,908,218.59
Present Value of Cash Flow	$46,331,300.00	$27,443,563.11	$27,043,899.57	$26,650,056.37	$26,261,948.75	$25,879,493.19	$25,502,607.36	$25,131,210.17
Year	8	9	10	11	12	13	14	15
Cash Flow	$31,371,841.87	$31,842,419.50	$32,320,055.79	$32,804,856.63	$33,296,929.48	$33,796,383.42	$34,303,329.17	$34,817,879.11
	$24,765,221.67	$24,404,563.10	$24,049,156.85	$23,698,926.41	$23,353,796.41	$23,013,692.58	$22,678,541.72	$22,348,271.69
Year	16	17	18	19	20	21	22	23
Cash Flow	$35,340,147.30	$35,870,249.51	$36,408,303.25	$36,954,427.80	$37,508,744.22	$38,071,375.38	$38,642,446.01	$39,222,082.70
	$22,022,811.42	$21,702,090.87	$21,386,041.00	$21,074,593.80	$20,767,682.24	$20,465,240.27	$20,167,202.79	$19,873,505.66
Year	24	25	26	27	28	29	30	Disposition
Cash Flow	$39,810,413.94	$40,407,570.15	$41,013,683.70	$41,628,888.96	$42,253,322.29	$42,887,122.13	$43,530,428.96	$109,000.00
	$19,584,085.67	$19,298,880.54	$19,017,828.89	$18,740,870.21	$18,467,944.92	$18,198,994.26	$17,933,960.37	$109,000.00

Figure 66.   System A: Monte Carlo Simulation Uncertainty Ranges, Section 1

		5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
Total Acquisition Cost for System A	$46,331,300.00						
List of Total Lifetime Cost for System A		$192,078,759.39	$348,972,742.05	$517,992,119.86	$700,073,991.93	$896,227,880.11	$1,107,541,326.15
List of Present Value Lifetime Cost for System A		$179,704,285.34	$303,544,126.37	$418,626,211.89	$525,569,818.93	$624,950,442.22	$717,302,888.41
Total Lifetime Cost for System A (20 Years)	$700,073,991.93	20 Years					
Total PV Lifetime Cost for System A (20 Years)	$525,569,818.93						

Figure 67.   System A: Monte Carlo Simulation Uncertainty Ranges, Section 2

APPENDIX B. SYSTEM B EXCEL SPREADSHEET DATA

Appendix B contains the model's Excel spreadsheet for System B, shown in Figures 68-74. This spreadsheet includes the recurring cost inputs, the nonrecurring cost inputs, the end-of-life-cycle cost inputs, and the risk-based Monte Carlo simulation uncertainty ranges.

	Name:	**System B**		Discount Rate:	3.00%		Economic Life:	20 Years
	Notes:							
	Annual Growth or Decline Curve:		1.50%					

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			**$4,041,157.00**		**$2,412,814.00**		**$91,372.00**		**$102,209.00**		**$44,393,410.00**		**$30,080,095.00**	
Narrow-Medium Field of View (NFOV) Sensors	43	935	$7,229.00	0.2%	$135.00	0.0%	$578.00	0.6%	$5,663.00	5.5%	$1,004,795.00	2.3%	$925,760.00	3.1%
NF-DIR (NFOV Director)	2	55	$500.00	0.0%	$7.00	0.0%	$20.00	0.0%	$400.00	0.4%	$55,000.00	0.1%	$46,970.00	0.2%
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55	$430.00	0.0%	$6.00	0.0%	$23.00	0.0%	$200.00	0.2%	$70,950.00	0.2%	$37,785.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #2	4	55	$324.00	0.0%	$5.00	0.0%	$43.00	0.0%	$300.00	0.3%	$71,280.00	0.2%	$76,560.00	0.3%
NF-EOS (Electro-Optic Sensor) - EOS #1	1	55	$450.00	0.0%	$6.00	0.0%	$56.00	0.1%	$230.00	0.2%	$24,750.00	0.1%	$16,060.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #2	3	55	$543.00	0.0%	$4.00	0.0%	$54.00	0.1%	$400.00	0.4%	$89,595.00	0.2%	$75,570.00	0.3%
NF-EOS (Electro-Optic Sensor) - EOS #3	4	55	$520.00	0.0%	$3.00	0.0%	$43.00	0.0%	$320.00	0.3%	$114,400.00	0.3%	$80,520.00	0.3%
NF-LRF (Laser Rangefinder)	3	55	$200.00	0.0%	$4.00	0.0%	$23.00	0.0%	$420.00	0.4%	$33,000.00	0.1%	$73,755.00	0.2%
NF-LDR (Laser Designator/Rangefinder)	2	55	$592.00	0.0%	$5.00	0.0%	$21.00	0.0%	$432.00	0.4%	$65,120.00	0.1%	$50,380.00	0.2%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	1	55	$300.00	0.0%	$6.00	0.0%	$2.00	0.0%	$320.00	0.3%	$16,500.00	0.0%	$18,040.00	0.1%
NF-LP (Laser Pointer)	1	55	$600.00	0.0%	$1.00	0.0%	$33.00	0.0%	$200.00	0.2%	$33,000.00	0.1%	$12,870.00	0.0%
NF-LOI (Laser Optical/Ocular Interrupter)	2	55	$400.00	0.0%	$4.00	0.0%	$44.00	0.0%	$430.00	0.4%	$44,000.00	0.1%	$52,580.00	0.2%
NF-LI (Laser Illuminator)	1	55	$200.00	0.0%	$3.00	0.0%	$55.00	0.1%	$321.00	0.3%	$11,000.00	0.0%	$20,845.00	0.1%
NF-IRU (Inertial Reference Unit)	4	55	$340.00	0.0%	$2.00	0.0%	$43.00	0.0%	$430.00	0.4%	$74,800.00	0.2%	$104,500.00	0.3%
NF-BSM (Boresight Module)	3	55	$450.00	0.0%	$3.00	0.0%	$42.00	0.0%	$320.00	0.3%	$74,250.00	0.2%	$60,225.00	0.2%
NF-EU (Electronics Unit)	2	55	$540.00	0.0%	$4.00	0.0%	$32.00	0.0%	$210.00	0.2%	$59,400.00	0.1%	$27,060.00	0.1%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$310.00	0.0%	$5.00	0.0%	$21.00	0.0%	$230.00	0.2%	$51,150.00	0.1%	$42,240.00	0.1%
Other: _____	4	55	$530.00	0.0%	$67.00	0.0%	$23.00	0.0%	$500.00	0.5%	$116,600.00	0.3%	$129,800.00	0.4%
Wide Field of View (WFOV) Sensors	20	385	$28,400.00	0.7%	$41.00	0.0%	$34.00	0.0%	$24,100.00	23.6%	$4,532,000.00	10.2%	$3,591,830.00	11.9%
WF-DIR (Director)	3	55	$6,000.00	0.1%	$5.00	0.0%	$4.00	0.0%	$3,000.00	2.9%	$990,000.00	2.2%	$496,485.00	1.7%
WF-TIS (Thermal Imaging Sensor)	2	55	$2,300.00	0.1%	$6.00	0.0%	$5.00	0.0%	$5,000.00	4.9%	$253,000.00	0.6%	$551,210.00	1.8%
WF-EOS (Electro-Optic Sensor)	1	55	$4,300.00	0.1%	$7.00	0.0%	$3.00	0.0%	$3,200.00	3.1%	$236,500.00	0.5%	$176,550.00	0.6%
WF-IRU (Inertial Reference Unit)	2	55	$4,500.00	0.1%	$8.00	0.0%	$6.00	0.0%	$3,200.00	3.1%	$495,000.00	1.1%	$353,540.00	1.2%
WF-EU (Electronics Unit)	3	55	$2,300.00	0.1%	$6.00	0.0%	$7.00	0.0%	$4,300.00	4.2%	$379,500.00	0.9%	$711,645.00	2.4%
Ancillary Material (cabling, mounting hardware, etc.)	4	55	$5,400.00	0.1%	$5.00	0.0%	$5.00	0.0%	$3,400.00	3.3%	$1,188,000.00	2.7%	$750,200.00	2.5%
Other: _____	5	55	$3,600.00	0.1%	$4.00	0.0%	$4.00	0.0%	$2,000.00	2.0%	$990,000.00	2.2%	$552,200.00	1.8%
EO/IR Sensor Manager (ESM)	20	330	$2,328.00	0.1%	$26.00	0.0%	$135.00	0.1%	$2,066.00	2.0%	$419,815.00	0.9%	$407,110.00	1.4%
Processing Equipment	3	55	$540.00	0.0%	$5.00	0.0%	$12.00	0.0%	$500.00	0.5%	$89,100.00	0.2%	$85,305.00	0.3%
Processing Software	4	55	$324.00	0.0%	$4.00	0.0%	$21.00	0.0%	$340.00	0.3%	$71,280.00	0.2%	$80,300.00	0.3%
Recording Equipment	3	55	$563.00	0.0%	$6.00	0.0%	$43.00	0.0%	$230.00	0.2%	$92,895.00	0.2%	$46,035.00	0.2%
Docking Station Equipment	3	55	$264.00	0.0%	$6.00	0.0%	$12.00	0.0%	$345.00	0.3%	$43,560.00	0.1%	$59,895.00	0.2%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	4	55	$325.00	0.0%	$4.00	0.0%	$22.00	0.0%	$330.00	0.3%	$71,500.00	0.2%	$78,320.00	0.3%
Other: _____	3	55	$312.00	0.0%	$1.00	0.0%	$25.00	0.0%	$321.00	0.3%	$51,480.00	0.1%	$57,255.00	0.2%

Figure 68.   System B: Recurring Cost Inputs, Section 1

Human Machine Interface (HMI)	64	275	$23,000.00	0.6%	$112.00	0.0%	$125.00	0.1%	$15,380.00	15.0%	$16,280,000.00	36.7%	$9,860,895.00	32.8%
HMI-B (HMI Bridge/Cockpit)	7	55	$6,000.00	0.1%	$20.00	0.0%	$1.00	0.0%	$4,000.00	3.9%	$2,310,000.00	5.2%	$1,548,085.00	5.1%
HMI-C (HMI Combat Information Center/Cabin)	16	55	$5,000.00	0.1%	$23.00	0.0%	$43.00	0.0%	$3,200.00	3.1%	$4,400,000.00	9.9%	$2,874,080.00	9.6%
HMI-I (HMI Intel)	1	55	$4,000.00	0.1%	$32.00	0.0%	$34.00	0.0%	$3,500.00	3.4%	$220,000.00	0.5%	$196,130.00	0.7%
Ancillary Material (additional displays, control panel switches, cabling, mounts, etc.	25	55	$5,000.00	0.1%	$21.00	0.0%	$25.00	0.0%	$2,340.00	2.3%	$6,875,000.00	15.5%	$3,280,750.00	10.9%
Other: _____	15	55	$3,000.00	0.1%	$16.00	0.0%	$22.00	0.0%	$2,340.00	2.3%	$2,475,000.00	5.6%	$1,961,850.00	6.5%
Product Support Management	56	9	$531,000.00	13.1%	$327,500.00	13.6%	$0.00	0.0%	$0.00	0.0%	$3,292,000.00	7.4%	$2,085,500.00	6.9%
Program Management Office Team	6	1	$90,000.00	2.2%	$90,000.00	3.7%	$0.00	0.0%	$0.00	0.0%	$540,000.00	1.2%	$540,000.00	1.8%
Sustainment Planning and Data Procurement	6	1	$50,000.00	1.2%	$51,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$306,000.00	1.0%
Depot Activation	7	1	$60,000.00	1.5%	$57,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$420,000.00	0.9%	$399,000.00	1.3%
Software Sustainment	8	1	$45,000.00	1.1%	$45,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$360,000.00	1.2%
Integrated Product Support Team	5	1	$56,000.00	1.4%	$23,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.6%	$115,000.00	0.4%
Provisioning and Initial Spares Lay-in	6	1	$45,000.00	1.1%	$7,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$42,000.00	0.1%
Contracting Strategy	7	1	$65,000.00	1.6%	$9,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$455,000.00	1.0%	$66,500.00	0.2%
Full Scale Production	5	1	$53,000.00	1.3%	$13,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$265,000.00	0.6%	$65,000.00	0.2%
Other: _____	6	1	$67,000.00	1.7%	$32,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$402,000.00	0.9%	$192,000.00	0.6%
Design Interface	62	11	$447,000.00	11.1%	$22,500.00	0.9%	$0.00	0.0%	$0.00	0.0%	$2,516,000.00	5.7%	$142,500.00	0.5%
Technology development (TRL2 to TRL4)	6	1	$50,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$0.00	0.0%
Materiel development and LRIP (TRL5 to TRL7)	5	1	$60,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$0.00	0.0%
Operational Test (TRL8)	4	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.4%	$0.00	0.0%
Combat system integration (software changes)	7	1	$54,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$0.00	0.0%
Reliability Growth Program	3	1	$53,000.00	1.3%	$7,500.00	0.3%	$0.00	0.0%	$0.00	0.0%	$159,000.00	0.4%	$22,500.00	0.1%
Technology Refresh (P3I, emerging threats, obsolescence...)	8	1	$34,000.00	0.8%	$15,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$272,000.00	0.6%	$120,000.00	0.4%
Technology Roadmap	8	1	$42,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$336,000.00	0.8%	$0.00	0.0%
Design for Maintainability	6	1	$21,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$126,000.00	0.3%	$0.00	0.0%
Modularity	5	1	$27,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$135,000.00	0.3%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$0.00	0.0%
Other: _____	4	1	$23,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$92,000.00	0.2%	$0.00	0.0%
Supply Support	64	12	$469,000.00	11.6%	$247,000.00	10.2%	$0.00	0.0%	$0.00	0.0%	$2,364,000.00	5.3%	$1,344,000.00	4.5%
Wholesale and Retail Supply Chain Management	7	1	$43,000.00	1.1%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$301,000.00	0.7%	$140,000.00	0.5%
Spares Worldwide Transportation	5	1	$36,000.00	0.9%	$41,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$180,000.00	0.4%	$205,000.00	0.7%
Spares Warehousing	6	1	$45,000.00	1.1%	$33,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$198,000.00	0.7%
Consumable Spares Replenishment	4	1	$53,000.00	1.3%	$25,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$212,000.00	0.5%	$100,000.00	0.3%
Provisioning and Initial Spares Lay-in	3	1	$65,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$195,000.00	0.4%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$34,000.00	0.8%	$23,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$138,000.00	0.5%
Contracting Strategy	8	1	$23,000.00	0.6%	$15,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$184,000.00	0.4%	$120,000.00	0.4%
Decreasing Economies of Scale	7	1	$35,000.00	0.9%	$21,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$245,000.00	0.6%	$147,000.00	0.5%
Battle Damage	6	1	$12,000.00	0.3%	$17,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$72,000.00	0.2%	$102,000.00	0.3%
Initial Fielding Support	5	1	$43,000.00	1.1%	$9,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$215,000.00	0.5%	$45,000.00	0.1%
Prepositioned Stock	4	1	$46,000.00	1.1%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$184,000.00	0.4%	$80,000.00	0.3%

Figure 69.   System B: Recurring Cost Inputs, Section 2

Supply Support	64	12	$469,000.00	11.6%	$247,000.00	10.2%	$0.00	0.0%	$0.00	0.0%	$2,364,000.00	5.3%	$1,344,000.00	4.5%
Wholesale and Retail Supply Chain Management	7	1	$43,000.00	1.1%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$301,000.00	0.7%	$140,000.00	0.5%
Spares Worldwide Transportation	5	1	$36,000.00	0.9%	$41,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$180,000.00	0.4%	$205,000.00	0.7%
Spares Warehousing	6	1	$45,000.00	1.1%	$33,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$198,000.00	0.7%
Consumable Spares Replenishment	4	1	$53,000.00	1.3%	$25,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$212,000.00	0.5%	$100,000.00	0.3%
Provisioning and Initial Spares Lay-in	3	1	$65,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$195,000.00	0.4%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$34,000.00	0.8%	$23,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$138,000.00	0.5%
Contracting Strategy	8	1	$23,000.00	0.6%	$15,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$184,000.00	0.4%	$120,000.00	0.4%
Decreasing Economies of Scale	7	1	$35,000.00	0.9%	$21,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$245,000.00	0.6%	$147,000.00	0.5%
Battle Damage	6	1	$12,000.00	0.3%	$17,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$72,000.00	0.2%	$102,000.00	0.3%
Initial Fielding Support	5	1	$43,000.00	1.1%	$9,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$215,000.00	0.5%	$45,000.00	0.1%
Prepositioned Stock	4	1	$46,000.00	1.1%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$184,000.00	0.4%	$80,000.00	0.3%
Other:_____	3	1	$34,000.00	0.8%	$23,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$102,000.00	0.2%	$69,000.00	0.2%
Support Equipment	40	8	$270,000.00	6.7%	$214,500.00	8.9%	$60,000.00	65.7%	$55,000.00	53.8%	$1,408,000.00	3.2%	$1,477,000.00	4.9%
Depot Activation	5	1	$20,000.00	0.5%	$30,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$100,000.00	0.2%	$150,000.00	0.5%
Software Sustainment	3	1	$23,000.00	0.6%	$25,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$69,000.00	0.2%	$75,000.00	0.2%
Special Tools & Equipment	5	1	$43,000.00	1.1%	$55,000.00	2.3%	$30,000.00	32.8%	$15,000.00	14.7%	$215,000.00	0.5%	$500,000.00	1.7%
Ancillary Equipment	2	1	$34,000.00	0.8%	$30,000.00	1.2%	$17,000.00	18.6%	$40,000.00	39.1%	$68,000.00	0.2%	$174,000.00	0.6%
Support Equipment Sustainment	7	1	$54,000.00	1.3%	$27,000.00	1.1%	$13,000.00	14.2%	$0.00	0.0%	$378,000.00	0.9%	$280,000.00	0.9%
Initial Fielding Support	8	1	$32,000.00	0.8%	$17,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$256,000.00	0.6%	$136,000.00	0.5%
Obsolescence Mitigation (Cost should be escalated)	6	1	$33,000.00	0.8%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$198,000.00	0.4%	$120,000.00	0.4%
Other:_____	4	1	$31,000.00	0.8%	$10,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$124,000.00	0.3%	$42,000.00	0.1%
Packaging, Handling, Storage and Transportation	18	4	$175,000.00	4.3%	$79,000.00	3.3%	$0.00	0.0%	$0.00	0.0%	$807,000.00	1.8%	$354,000.00	1.2%
Transportability Requirements	6	1	$62,000.00	1.5%	$25,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$372,000.00	0.8%	$150,000.00	0.5%
Transportation Limitations	3	1	$40,000.00	1.0%	$23,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$69,000.00	0.2%
Initial Fielding Support	4	1	$50,000.00	1.2%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.5%	$80,000.00	0.3%
Other:_____	5	1	$23,000.00	0.6%	$11,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$115,000.00	0.3%	$55,000.00	0.2%
Computer Resources	40	6	$225,200.00	5.6%	$515,000.00	21.3%	$0.00	0.0%	$0.00	0.0%	$1,504,800.00	3.4%	$3,560,000.00	11.8%
Manning and military occupational series training	7	1	$34,000.00	0.8%	$35,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.5%	$245,000.00	0.8%
Depot Activation	8	1	$54,000.00	1.3%	$45,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$432,000.00	1.0%	$360,000.00	1.2%
Software Sustainment	8	1	$21,000.00	0.5%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$168,000.00	0.4%	$160,000.00	0.5%
O-level publications and new equipment training	7	1	$34,000.00	0.8%	$345,000.00	14.3%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.5%	$2,415,000.00	8.0%
Initial Fielding Support	6	1	$50,000.00	1.2%	$50,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$300,000.00	1.0%
Other:_____	4	1	$32,200.00	0.8%	$20,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$128,800.00	0.3%	$80,000.00	0.3%
Manpower and Personnel	35	6	$270,000.00	6.7%	$696,000.00	28.8%	$0.00	0.0%	$0.00	0.0%	$1,650,000.00	3.7%	$4,584,000.00	15.2%
Program Management Office Team	3	1	$40,000.00	1.0%	$40,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$120,000.00	0.4%
Manning and military occupational series training	7	1	$54,000.00	1.3%	$540,000.00	22.4%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$3,780,000.00	12.6%
Depot Activation	6	1	$43,000.00	1.1%	$40,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$240,000.00	0.8%
Software Sustainment	5	1	$34,000.00	0.8%	$34,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$170,000.00	0.4%	$170,000.00	0.6%
Initial Fielding Support	8	1	$65,000.00	1.6%	$11,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$520,000.00	1.2%	$88,000.00	0.3%
Other:_____	6	1	$34,000.00	0.8%	$31,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$186,000.00	0.6%

Figure 70.   System B: Recurring Cost Inputs, Section 3

Maintenance Planning and Management	79	15	$607,000.00	15.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$3,119,000.00	7.0%	$0.00	0.0%
System Support Strategy	4	1	$55,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$220,000.00	0.5%	$0.00	0.0%
Title 10 Core 50/50	5	1	$57,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$285,000.00	0.6%	$0.00	0.0%
Depot Activation	3	1	$63,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$189,000.00	0.4%	$0.00	0.0%
Software Sustainment	4	1	$42,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$168,000.00	0.4%	$0.00	0.0%
Depot Repair and Overhaul	5	1	$31,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$155,000.00	0.3%	$0.00	0.0%
Manning and military occupational series training	6	1	$24,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$144,000.00	0.3%	$0.00	0.0%
O-level publications and new equipment training	4	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$172,000.00	0.4%	$0.00	0.0%
Sustainment Planning and Data Procurement	3	1	$26,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$78,000.00	0.2%	$0.00	0.0%
Provisioning and Initial Spares Lay-in	7	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$301,000.00	0.7%	$0.00	0.0%
Demilitarization and Disposal	6	1	$42,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$252,000.00	0.6%	$0.00	0.0%
Full Scale Production	8	1	$31,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$248,000.00	0.6%	$0.00	0.0%
Decreasing Economies of Scale	7	1	$50,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$350,000.00	0.8%	$0.00	0.0%
Initial Fielding Support	5	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$215,000.00	0.5%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$150,000.00	0.3%	$0.00	0.0%
Other: _____	6	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.4%	$0.00	0.0%
Training and Training Support	43	8	$380,000.00	9.4%	$120,500.00	5.0%	$0.00	0.0%	$0.00	0.0%	$2,102,000.00	4.7%	$690,000.00	2.3%
Depot Activation	5	1	$35,000.00	0.9%	$13,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$175,000.00	0.4%	$65,000.00	0.2%
Software Sustainment	4	1	$24,000.00	0.6%	$5,500.00	0.2%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$22,000.00	0.1%
Manning and military occupational series training	7	1	$43,000.00	1.1%	$27,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$301,000.00	0.7%	$189,000.00	0.6%
O-level publications and new equipment training	6	1	$86,000.00	2.1%	$39,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$516,000.00	1.2%	$234,000.00	0.8%
Sustainment Planning and Data Procurement	5	1	$27,000.00	0.7%	$7,500.00	0.3%	$0.00	0.0%	$0.00	0.0%	$135,000.00	0.3%	$37,500.00	0.1%
Transportability Requirements	5	1	$46,000.00	1.1%	$14,500.00	0.6%	$0.00	0.0%	$0.00	0.0%	$230,000.00	0.5%	$72,500.00	0.2%
Initial Fielding Support	6	1	$54,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$324,000.00	0.7%	$0.00	0.0%
Other: _____	5	1	$65,000.00	1.6%	$14,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$325,000.00	0.7%	$70,000.00	0.2%
Facilities and Infrastructure	25	4	$250,000.00	6.2%	$78,000.00	3.2%	$30,500.00	33.4%	$0.00	0.0%	$1,560,000.00	3.5%	$614,500.00	2.0%
Ship alteration for initial fielding	7	1	$70,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$490,000.00	1.1%	$0.00	0.0%
Depot Activation	6	1	$50,000.00	1.2%	$27,000.00	1.1%	$8,000.00	8.8%	$0.00	0.0%	$300,000.00	0.7%	$210,000.00	0.7%
Software Sustainment	7	1	$60,000.00	1.5%	$11,000.00	0.5%	$7,500.00	8.2%	$0.00	0.0%	$420,000.00	0.9%	$129,500.00	0.4%
Other: _____	5	1	$70,000.00	1.7%	$40,000.00	1.7%	$15,000.00	16.4%	$0.00	0.0%	$350,000.00	0.8%	$275,000.00	0.9%
Technical Data Management	37	7	$356,000.00	8.8%	$112,500.00	4.7%	$0.00	0.0%	$0.00	0.0%	$1,834,000.00	4.1%	$443,000.00	1.5%
Depot Activation	3	1	$100,000.00	2.5%	$74,000.00	3.1%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$222,000.00	0.7%
Software Sustainment	6	1	$30,000.00	0.7%	$11,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$180,000.00	0.4%	$66,000.00	0.2%
Manning and military occupational series training	6	1	$50,000.00	1.2%	$9,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$57,000.00	0.2%
O-level publications and new equipment training	7	1	$54,000.00	1.3%	$5,000.00	0.2%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$35,000.00	0.1%
Sustainment Planning and Data Procurement	5	1	$36,000.00	0.9%	$7,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$180,000.00	0.4%	$35,000.00	0.1%
Contracting Strategy	6	1	$76,000.00	1.9%	$2,000.00	0.1%	$0.00	0.0%	$0.00	0.0%	$456,000.00	1.0%	$12,000.00	0.0%
Other: _____	4	1	$10,000.00	0.2%	$4,000.00	0.2%	$0.00	0.0%	$0.00	0.0%	$40,000.00	0.1%	$16,000.00	0.1%

Figure 71.　System B: Recurring Cost Inputs, Section 4

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 72.   System B: Nonrecurring and End-of-Life-Cycle Cost Inputs Section

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$954,555.25	$1,004,795.00	$1,055,034.75	$1,004,795.00	$879,472.00	$925,760.00	$972,048.00	$925,760.00
Wide Field of View (WFOV) Sensors	$4,305,400.00	$4,532,000.00	$4,758,600.00	$4,532,000.00	$3,412,238.50	$3,591,830.00	$3,771,421.50	$3,591,830.00
EO/IR Sensor Manager (ESM)	$398,824.25	$419,815.00	$440,805.75	$419,815.00	$386,754.50	$407,110.00	$427,465.50	$407,110.00
Human Machine Interface (HMI)	$15,466,000.00	$16,280,000.00	$17,094,000.00	$16,280,000.00	$9,367,850.25	$9,860,895.00	$10,353,939.75	$9,860,895.00
Product Support Management	$3,127,400.00	$3,292,000.00	$3,456,600.00	$3,292,000.00	$1,981,225.00	$2,085,500.00	$2,189,775.00	$2,085,500.00
Design Interface	$2,390,200.00	$2,516,000.00	$2,641,800.00	$2,516,000.00	$135,375.00	$142,500.00	$149,625.00	$142,500.00
Supply Support	$2,245,800.00	$2,364,000.00	$2,482,200.00	$2,364,000.00	$1,276,800.00	$1,344,000.00	$1,411,200.00	$1,344,000.00
Support Equipment	$1,337,600.00	$1,408,000.00	$1,478,400.00	$1,408,000.00	$1,403,150.00	$1,477,000.00	$1,550,850.00	$1,477,000.00
Packaging, Handling, Storage and Transportation	$766,650.00	$807,000.00	$847,350.00	$807,000.00	$336,300.00	$354,000.00	$371,700.00	$354,000.00
Computer Resources	$1,429,560.00	$1,504,800.00	$1,580,040.00	$1,504,800.00	$3,382,000.00	$3,560,000.00	$3,738,000.00	$3,560,000.00
Manpower and Personnel	$1,567,500.00	$1,650,000.00	$1,732,500.00	$1,650,000.00	$4,354,800.00	$4,584,000.00	$4,813,200.00	$4,584,000.00
Maintenance Planning and Management	$2,963,050.00	$3,119,000.00	$3,274,950.00	$3,119,000.00	$0.00	$0.00	$0.00	$0.00
Training and Training Support	$1,996,900.00	$2,102,000.00	$2,207,100.00	$2,102,000.00	$655,500.00	$690,000.00	$724,500.00	$690,000.00
Facilities and Infrastructure	$1,482,000.00	$1,560,000.00	$1,638,000.00	$1,560,000.00	$583,775.00	$614,500.00	$645,225.00	$614,500.00
Technical Data Management	$1,742,300.00	$1,834,000.00	$1,925,700.00	$1,834,000.00	$420,850.00	$443,000.00	$465,150.00	$443,000.00
Acquisition Costs	$444,410.00	$467,800.00	$491,190.00	$467,800.00				
End of Life Disposition Costs	$103,550.00	$109,000.00	$114,450.00	$109,000.00				

Year	Acquisition	1	2	3	4	5	6	7
Cash Flow	$44,861,210.00	$30,080,095.00	$30,531,296.43	$30,989,265.87	$31,454,104.86	$31,925,916.43	$32,404,805.18	$32,890,877.26
Present Value of Cash Flow	$44,861,210.00	$29,203,975.73	$28,778,675.11	$28,359,568.19	$27,946,564.77	$27,539,575.96	$27,138,514.18	$26,743,293.10
Year	8	9	10	11	12	13	14	15
Cash Flow	$33,384,240.42	$33,885,004.02	$34,393,279.08	$34,909,178.27	$35,432,815.94	$35,964,308.18	$36,503,772.80	$37,051,329.40
	$26,353,827.66	$25,970,034.06	$25,591,829.68	$25,219,133.13	$24,851,864.20	$24,489,943.85	$24,133,294.18	$23,781,838.44
Year	16	17	18	19	20	21	22	23
Cash Flow	$37,607,099.34	$38,171,205.83	$38,743,773.91	$39,324,930.52	$39,914,804.48	$40,513,526.55	$41,121,229.45	$41,738,047.89
	$23,435,500.99	$23,094,207.28	$22,757,883.88	$22,426,458.38	$22,099,859.47	$21,778,016.86	$21,460,861.28	$21,148,324.46
Year	24	25	26	27	28	29	30	Disposition
Cash Flow	$42,364,118.61	$42,999,580.39	$43,644,574.09	$44,299,242.70	$44,963,731.34	$45,638,187.31	$46,322,760.12	$109,000.00
	$20,840,339.15	$20,536,839.07	$20,237,758.89	$19,943,034.24	$19,652,601.71	$19,366,398.77	$19,084,363.83	$109,000.00

Total Acquisition Cost for System B	$44,861,210.00

Figure 73.   System B: Monte Carlo Simulation Uncertainty Ranges, Section 1

	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
List of Total Lifetime Cost for System B	$199,950,888.59	$366,909,094.54	$546,770,499.13	$740,532,313.22	$949,268,816.09	$1,174,137,311.67
List of Present Value Lifetime Cost for System B	$186,783,594.12	$318,568,174.68	$441,033,105.19	$554,837,402.90	$660,593,492.07	$758,870,497.06
Total Lifetime Cost for System B (20 Years)	$740,532,313.22	20 Years				
Total PV Lifetime Cost for System B (20 Years)	$554,837,402.90					

Figure 74.   System B: Monte Carlo Simulation Uncertainty Ranges, Section 2

APPENDIX C. SYSTEM C EXCEL SPREADSHEET DATA

Appendix C contains the model's Excel spreadsheet for System C, shown in Figures 75-81. This spreadsheet includes the recurring cost inputs, the nonrecurring cost inputs, the end-of-life-cycle cost inputs, and the risk-based Monte Carlo simulation uncertainty ranges.

Select Uncertainty Range:	Use Small +/− 5% Range			Name:	System C			Discount Rate:	3.00%		Economic Life:	20 Years		
				Notes:										
				Annual Growth or Decline Curve:			1.50%							

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			**$4,467,618.00**		**$1,706,454.00**		**$92,775.00**		**$95,820.00**		**$43,865,630.00**		**$22,054,830.00**	
Narrow-Medium Field of View (NFOV) Sensors	**41**	**935**	**$7,578.00**	**0.2%**	**$105.00**	**0.0%**	**$112.00**	**0.1%**	**$5,580.00**	**5.8%**	**$1,023,880.00**	**2.3%**	**$783,255.00**	**3.6%**
NF-DIR (NFOV Director)	2	55	$400.00	0.0%	$5.00	0.0%	$9.00	0.0%	$300.00	0.3%	$44,000.00	0.1%	$34,540.00	0.2%
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55	$550.00	0.0%	$1.00	0.0%	$8.00	0.0%	$250.00	0.3%	$90,750.00	0.2%	$42,735.00	0.2%
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55	$340.00	0.0%	$7.00	0.0%	$6.00	0.0%	$340.00	0.4%	$37,400.00	0.1%	$38,830.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #1	4	55	$540.00	0.0%	$8.00	0.0%	$5.00	0.0%	$400.00	0.4%	$118,800.00	0.3%	$90,860.00	0.4%
NF-EOS (Electro-Optic Sensor) - EOS #2	2	55	$600.00	0.0%	$7.00	0.0%	$6.00	0.0%	$500.00	0.5%	$66,000.00	0.2%	$56,430.00	0.3%
NF-EOS (Electro-Optic Sensor) - EOS #3	3	55	$320.00	0.0%	$5.00	0.0%	$8.00	0.0%	$230.00	0.2%	$52,800.00	0.1%	$40,095.00	0.2%
NF-LRF (Laser Rangefinder)	2	55	$120.00	0.0%	$4.00	0.0%	$7.00	0.0%	$430.00	0.4%	$13,200.00	0.0%	$48,510.00	0.2%
NF-LDR (Laser Designator/Rangefinder)	2	55	$430.00	0.0%	$8.00	0.0%	$6.00	0.0%	$120.00	0.1%	$47,300.00	0.1%	$14,740.00	0.1%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	3	55	$450.00	0.0%	$7.00	0.0%	$5.00	0.0%	$520.00	0.5%	$74,250.00	0.2%	$87,780.00	0.4%
NF-LP (Laser Pointer)	2	55	$650.00	0.0%	$6.00	0.0%	$8.00	0.0%	$240.00	0.3%	$71,500.00	0.2%	$27,940.00	0.1%
NF-LOI (Laser Optical/Ocular Interrupter)	2	55	$430.00	0.0%	$5.00	0.0%	$7.00	0.0%	$340.00	0.4%	$47,300.00	0.1%	$38,720.00	0.2%
NF-LI (Laser Illuminator)	3	55	$720.00	0.0%	$8.00	0.0%	$6.00	0.0%	$420.00	0.4%	$118,800.00	0.3%	$71,610.00	0.3%
NF-IRU (Inertial Reference Unit)	2	55	$467.00	0.0%	$8.00	0.0%	$5.00	0.0%	$300.00	0.3%	$51,370.00	0.1%	$34,430.00	0.2%
NF-BSM (Boresight Module)	2	55	$620.00	0.0%	$5.00	0.0%	$8.00	0.0%	$190.00	0.2%	$68,200.00	0.2%	$22,330.00	0.1%
NF-EU (Electronics Unit)	3	55	$340.00	0.0%	$6.00	0.0%	$7.00	0.0%	$340.00	0.4%	$56,100.00	0.1%	$58,245.00	0.3%
Ancillary Material (cabling, mounting hardware, etc.)	2	55	$245.00	0.0%	$7.00	0.0%	$6.00	0.0%	$240.00	0.3%	$26,950.00	0.1%	$27,830.00	0.1%
Other:	2	55	$356.00	0.0%	$8.00	0.0%	$5.00	0.0%	$420.00	0.4%	$39,160.00	0.1%	$47,630.00	0.2%
Wide Field of View (WFOV) Sensors	**20**	**385**	**$24,400.00**	**0.5%**	**$44.00**	**0.0%**	**$44.00**	**0.0%**	**$18,500.00**	**19.3%**	**$3,839,000.00**	**8.8%**	**$3,087,535.00**	**14.0%**
WF-DIR (Director)	2	55	$4,300.00	0.1%	$4.00	0.0%	$7.00	0.0%	$3,000.00	3.1%	$473,000.00	1.1%	$331,210.00	1.5%
WF-TIS (Thermal Imaging Sensor)	3	55	$3,500.00	0.1%	$6.00	0.0%	$6.00	0.0%	$3,500.00	3.7%	$577,500.00	1.3%	$579,480.00	2.6%
WF-EOS (Electro-Optic Sensor)	4	55	$5,400.00	0.1%	$8.00	0.0%	$5.00	0.0%	$2,400.00	2.5%	$1,188,000.00	2.7%	$530,860.00	2.4%
WF-IRU (Inertial Reference Unit)	4	55	$1,200.00	0.0%	$6.00	0.0%	$2.00	0.0%	$4,300.00	4.5%	$264,000.00	0.6%	$947,760.00	4.3%
WF-EU (Electronics Unit)	2	55	$3,400.00	0.1%	$7.00	0.0%	$10.00	0.0%	$1,000.00	1.0%	$374,000.00	0.9%	$111,870.00	0.5%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$4,300.00	0.1%	$5.00	0.0%	$2.00	0.0%	$2,000.00	2.1%	$709,500.00	1.6%	$331,155.00	1.5%
Other: _____	2	55	$2,300.00	0.0%	$8.00	0.0%	$12.00	0.0%	$2,300.00	2.4%	$253,000.00	0.6%	$255,200.00	1.2%
EO/IR Sensor Manager (ESM)	**18**	**330**	**$2,340.00**	**0.1%**	**$45.00**	**0.0%**	**$50.00**	**0.1%**	**$1,840.00**	**1.9%**	**$393,250.00**	**0.9%**	**$330,220.00**	**1.5%**
Processing Equipment	2	55	$430.00	0.0%	$8.00	0.0%	$9.00	0.0%	$300.00	0.3%	$47,300.00	0.1%	$34,870.00	0.2%
Processing Software	3	55	$350.00	0.0%	$7.00	0.0%	$8.00	0.0%	$200.00	0.2%	$57,750.00	0.1%	$35,475.00	0.2%
Recording Equipment	4	55	$560.00	0.0%	$9.00	0.0%	$7.00	0.0%	$500.00	0.5%	$123,200.00	0.3%	$113,520.00	0.5%
Docking Station Equipment	3	55	$240.00	0.0%	$7.00	0.0%	$9.00	0.0%	$200.00	0.2%	$39,600.00	0.1%	$35,640.00	0.2%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	3	55	$320.00	0.0%	$7.00	0.0%	$9.00	0.0%	$340.00	0.4%	$52,800.00	0.1%	$58,740.00	0.3%
Other: _____	3	55	$440.00	0.0%	$7.00	0.0%	$8.00	0.0%	$300.00	0.3%	$72,600.00	0.2%	$51,975.00	0.2%

Figure 75.   System C: Recurring Cost Inputs, Section 1

Human Machine Interface (HMI)	52	275	$30,300.00	0.7%	$60.00	0.0%	$69.00	0.1%	$17,400.00	18.2%	$15,295,500.00	34.9%	$8,131,420.00	36.9%
HMI-B (HMI Bridge/Cockpit)	6	55	$7,000.00	0.2%	$10.00	0.0%	$12.00	0.0%	$5,000.00	5.2%	$2,310,000.00	5.3%	$1,657,260.00	7.5%
HMI-C (HMI Combat Information Center/Cabin)	18	55	$6,000.00	0.1%	$12.00	0.0%	$15.00	0.0%	$3,000.00	3.1%	$5,940,000.00	13.5%	$2,996,730.00	13.6%
HMI-I (HMI Intel)	2	55	$7,600.00	0.2%	$13.00	0.0%	$13.00	0.0%	$5,000.00	5.2%	$836,000.00	1.9%	$552,860.00	2.5%
Ancillary Material (additional displays, control panel switches, cabling, mounts, etc.	25	55	$4,300.00	0.1%	$15.00	0.0%	$15.00	0.0%	$2,000.00	2.1%	$5,912,500.00	13.5%	$2,791,250.00	12.7%
Other: _____	1	55	$5,400.00	0.1%	$10.00	0.0%	$14.00	0.0%	$2,400.00	2.5%	$297,000.00	0.7%	$133,320.00	0.6%
Product Support Management	48	9	$447,000.00	10.0%	$350,000.00	20.5%	$0.00	0.0%	$0.00	0.0%	$2,263,000.00	5.2%	$1,796,000.00	8.1%
Program Management Office Team	4	1	$75,000.00	1.7%	$75,000.00	4.4%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$300,000.00	1.4%
Sustainment Planning and Data Procurement	5	1	$45,000.00	1.0%	$43,000.00	2.5%	$0.00	0.0%	$0.00	0.0%	$225,000.00	0.5%	$215,000.00	1.0%
Depot Activation	6	1	$56,000.00	1.3%	$55,000.00	3.2%	$0.00	0.0%	$0.00	0.0%	$336,000.00	0.8%	$330,000.00	1.5%
Software Sustainment	5	1	$65,000.00	1.5%	$65,000.00	3.8%	$0.00	0.0%	$0.00	0.0%	$325,000.00	0.7%	$325,000.00	1.5%
Integrated Product Support Team	6	1	$43,000.00	1.0%	$40,000.00	2.3%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$240,000.00	1.1%
Provisioning and Initial Spares Lay-in	6	1	$23,000.00	0.5%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$138,000.00	0.3%	$90,000.00	0.4%
Contracting Strategy	7	1	$47,000.00	1.1%	$13,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$329,000.00	0.8%	$91,000.00	0.4%
Full Scale Production	8	1	$37,000.00	0.8%	$23,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$296,000.00	0.7%	$184,000.00	0.8%
Other: _____	1	1	$56,000.00	1.3%	$21,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$56,000.00	0.1%	$21,000.00	0.1%
Design Interface	55	11	$509,000.00	11.4%	$27,500.00	1.6%	$0.00	0.0%	$0.00	0.0%	$2,506,000.00	5.7%	$150,500.00	0.7%
Technology development (TRL2 to TRL4)	2	1	$54,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$108,000.00	0.2%	$0.00	0.0%
Materiel development and LRIP (TRL5 to TRL7)	4	1	$65,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$260,000.00	0.6%	$0.00	0.0%
Operational Test (TRL8)	5	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$170,000.00	0.4%	$0.00	0.0%
Combat system integration (software changes)	6	1	$54,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$324,000.00	0.7%	$0.00	0.0%
Reliability Growth Program	7	1	$32,000.00	0.7%	$6,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$224,000.00	0.5%	$45,500.00	0.2%
Technology Refresh (P3I, emerging threats, obsolescence...)	5	1	$35,000.00	0.8%	$21,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$175,000.00	0.4%	$105,000.00	0.5%
Technology Roadmap	4	1	$38,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$152,000.00	0.3%	$0.00	0.0%
Design for Maintainability	5	1	$42,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$0.00	0.0%
Modularity	7	1	$54,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	5	1	$53,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$265,000.00	0.6%	$0.00	0.0%
Other: _____	5	1	$48,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$0.00	0.0%

Figure 76.   System C: Recurring Cost Inputs, Section 2

Supply Support	68	12	$523,000.00	11.7%	$272,700.00	16.0%	$0.00	0.0%	$0.00	0.0%	$2,974,000.00	6.8%	$1,551,900.00	7.0%
Wholesale and Retail Supply Chain Management	4	1	$32,000.00	0.7%	$21,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$128,000.00	0.3%	$84,000.00	0.4%
Spares Worldwide Transportation	5	1	$22,000.00	0.5%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$110,000.00	0.3%	$175,000.00	0.8%
Spares Warehousing	5	1	$26,000.00	0.6%	$40,000.00	2.3%	$0.00	0.0%	$0.00	0.0%	$130,000.00	0.3%	$200,000.00	0.9%
Consumable Spares Replenishment	6	1	$50,000.00	1.1%	$26,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$156,000.00	0.7%
Provisioning and Initial Spares Lay-in	6	1	$89,000.00	2.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$534,000.00	1.2%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	5	1	$54,000.00	1.2%	$33,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$165,000.00	0.7%
Contracting Strategy	7	1	$42,000.00	0.9%	$15,700.00	0.9%	$0.00	0.0%	$0.00	0.0%	$294,000.00	0.7%	$109,900.00	0.5%
Decreasing Economies of Scale	7	1	$34,000.00	0.8%	$21,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.5%	$147,000.00	0.7%
Battle Damage	4	1	$25,000.00	0.6%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$100,000.00	0.2%	$60,000.00	0.3%
Initial Fielding Support	5	1	$98,000.00	2.2%	$11,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$490,000.00	1.1%	$55,000.00	0.2%
Prepositioned Stock	6	1	$14,000.00	0.3%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$84,000.00	0.2%	$120,000.00	0.5%
Other: _____	8	1	$37,000.00	0.8%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$296,000.00	0.7%	$280,000.00	1.3%
Support Equipment	36	8	$350,000.00	7.8%	$204,000.00	12.0%	$70,000.00	75.5%	$52,500.00	54.8%	$1,725,000.00	3.9%	$1,450,000.00	6.6%
Depot Activation	6	1	$76,000.00	1.7%	$50,000.00	2.9%	$0.00	0.0%	$0.00	0.0%	$456,000.00	1.0%	$300,000.00	1.4%
Software Sustainment	7	1	$45,000.00	1.0%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.7%	$140,000.00	0.6%
Special Tools & Equipment	4	1	$39,000.00	0.9%	$45,000.00	2.6%	$30,000.00	32.3%	$12,500.00	13.0%	$156,000.00	0.4%	$350,000.00	1.6%
Ancillary Equipment	3	1	$52,000.00	1.2%	$27,000.00	1.6%	$25,000.00	26.9%	$40,000.00	41.7%	$156,000.00	0.4%	$276,000.00	1.3%
Support Equipment Sustainment	6	1	$74,000.00	1.7%	$33,000.00	1.9%	$15,000.00	16.2%	$0.00	0.0%	$444,000.00	1.0%	$288,000.00	1.3%
Initial Fielding Support	2	1	$29,000.00	0.6%	$10,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$58,000.00	0.1%	$20,000.00	0.1%
Obsolescence Mitigation (Cost should be escalated)	4	1	$12,000.00	0.3%	$7,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$48,000.00	0.1%	$28,000.00	0.1%
Other: _____	4	1	$23,000.00	0.5%	$12,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$92,000.00	0.2%	$48,000.00	0.2%
Packaging, Handling, Storage and Transportation	18	4	$120,000.00	2.7%	$72,000.00	4.2%	$0.00	0.0%	$0.00	0.0%	$553,000.00	1.3%	$339,000.00	1.5%
Transportability Requirements	6	1	$51,000.00	1.1%	$25,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$306,000.00	0.7%	$150,000.00	0.7%
Transportation Limitations	7	1	$15,000.00	0.3%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.2%	$105,000.00	0.5%
Initial Fielding Support	3	1	$34,000.00	0.8%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$102,000.00	0.2%	$60,000.00	0.3%
Other: _____	2	1	$20,000.00	0.4%	$12,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$40,000.00	0.1%	$24,000.00	0.1%
Computer Resources	26	6	$268,000.00	6.0%	$200,000.00	11.7%	$0.00	0.0%	$0.00	0.0%	$1,294,000.00	2.9%	$989,000.00	4.5%
Manning and military occupational series training	6	1	$46,000.00	1.0%	$40,000.00	2.3%	$0.00	0.0%	$0.00	0.0%	$276,000.00	0.6%	$240,000.00	1.1%
Depot Activation	7	1	$58,000.00	1.3%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$406,000.00	0.9%	$245,000.00	1.1%
Software Sustainment	4	1	$43,000.00	1.0%	$37,000.00	2.2%	$0.00	0.0%	$0.00	0.0%	$172,000.00	0.4%	$148,000.00	0.7%
O-level publications and new equipment training	5	1	$66,000.00	1.5%	$60,000.00	3.5%	$0.00	0.0%	$0.00	0.0%	$330,000.00	0.8%	$300,000.00	1.4%
Initial Fielding Support	2	1	$16,000.00	0.4%	$11,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$32,000.00	0.1%	$22,000.00	0.1%
Other: _____	2	1	$39,000.00	0.9%	$17,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$78,000.00	0.2%	$34,000.00	0.2%
Manpower and Personnel	33	6	$296,000.00	6.6%	$250,000.00	14.7%	$0.00	0.0%	$0.00	0.0%	$1,680,000.00	3.8%	$1,364,000.00	6.2%
Program Management Office Team	3	1	$23,000.00	0.5%	$23,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$69,000.00	0.2%	$69,000.00	0.3%
Manning and military occupational series training	4	1	$54,000.00	1.2%	$54,000.00	3.2%	$0.00	0.0%	$0.00	0.0%	$216,000.00	0.5%	$216,000.00	1.0%
Depot Activation	6	1	$59,000.00	1.3%	$57,000.00	3.3%	$0.00	0.0%	$0.00	0.0%	$354,000.00	0.8%	$342,000.00	1.6%
Software Sustainment	5	1	$62,000.00	1.4%	$58,000.00	3.4%	$0.00	0.0%	$0.00	0.0%	$310,000.00	0.7%	$290,000.00	1.3%
Initial Fielding Support	7	1	$53,000.00	1.2%	$17,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$371,000.00	0.8%	$119,000.00	0.5%
Other: _____	8	1	$45,000.00	1.0%	$41,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$328,000.00	1.5%

Figure 77.   System C: Recurring Cost Inputs, Section 3

Maintenance Planning and Management	78	15	$717,000.00	16.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$3,728,000.00	8.5%	$0.00	0.0%
System Support Strategy	3	1	$78,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$234,000.00	0.5%	$0.00	0.0%
Title 10 Core 50/50	4	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$100,000.00	0.2%	$0.00	0.0%
Depot Activation	6	1	$70,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$420,000.00	1.0%	$0.00	0.0%
Software Sustainment	7	1	$76,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$532,000.00	1.2%	$0.00	0.0%
Depot Repair and Overhaul	8	1	$43,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$344,000.00	0.8%	$0.00	0.0%
Manning and military occupational series training	2	1	$65,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$130,000.00	0.3%	$0.00	0.0%
O-level publications and new equipment training	5	1	$16,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$80,000.00	0.2%	$0.00	0.0%
Sustainment Planning and Data Procurement	6	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$150,000.00	0.3%	$0.00	0.0%
Provisioning and Initial Spares Lay-in	8	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$272,000.00	0.6%	$0.00	0.0%
Demilitarization and Disposal	7	1	$54,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$0.00	0.0%
Full Scale Production	4	1	$15,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$60,000.00	0.1%	$0.00	0.0%
Decreasing Economies of Scale	2	1	$39,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$78,000.00	0.2%	$0.00	0.0%
Initial Fielding Support	5	1	$43,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$215,000.00	0.5%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$65,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$390,000.00	0.9%	$0.00	0.0%
Other: _____	5	1	$69,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$345,000.00	0.8%	$0.00	0.0%
Training and Training Support	40	8	$490,000.00	11.0%	$143,500.00	8.4%	$0.00	0.0%	$0.00	0.0%	$2,453,000.00	5.6%	$717,000.00	3.3%
Depot Activation	8	1	$79,000.00	1.8%	$19,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$632,000.00	1.4%	$152,000.00	0.7%
Software Sustainment	6	1	$65,000.00	1.5%	$7,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$390,000.00	0.9%	$45,000.00	0.2%
Manning and military occupational series training	7	1	$42,000.00	0.9%	$30,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$294,000.00	0.7%	$210,000.00	1.0%
O-level publications and new equipment training	3	1	$87,000.00	1.9%	$36,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$261,000.00	0.6%	$108,000.00	0.5%
Sustainment Planning and Data Procurement	4	1	$62,000.00	1.4%	$11,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$248,000.00	0.6%	$44,000.00	0.2%
Transportability Requirements	5	1	$72,000.00	1.6%	$19,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$95,000.00	0.4%
Initial Fielding Support	4	1	$19,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$76,000.00	0.2%	$0.00	0.0%
Other: _____	3	1	$64,000.00	1.4%	$21,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.4%	$63,000.00	0.3%
Facilities and Infrastructure	26	4	$202,000.00	4.5%	$53,500.00	3.1%	$22,500.00	24.3%	$0.00	0.0%	$1,338,000.00	3.1%	$519,500.00	2.4%
Ship alteration for initial fielding	6	1	$73,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$438,000.00	1.0%	$0.00	0.0%
Depot Activation	7	1	$48,000.00	1.1%	$21,000.00	1.2%	$9,000.00	9.7%	$0.00	0.0%	$336,000.00	0.8%	$210,000.00	1.0%
Software Sustainment	8	1	$53,000.00	1.2%	$19,500.00	1.1%	$7,000.00	7.5%	$0.00	0.0%	$424,000.00	1.0%	$212,000.00	1.0%
Other: _____	5	1	$28,000.00	0.6%	$13,000.00	0.8%	$6,500.00	7.0%	$0.00	0.0%	$140,000.00	0.3%	$97,500.00	0.4%
Technical Data Management	39	7	$481,000.00	10.8%	$133,000.00	7.8%	$0.00	0.0%	$0.00	0.0%	$2,800,000.00	6.4%	$845,500.00	3.8%
Depot Activation	7	1	$67,000.00	1.5%	$60,000.00	3.5%	$0.00	0.0%	$0.00	0.0%	$469,000.00	1.1%	$420,000.00	1.9%
Software Sustainment	5	1	$63,000.00	1.4%	$23,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.7%	$115,000.00	0.5%
Manning and military occupational series training	8	1	$120,000.00	2.7%	$19,500.00	1.1%	$0.00	0.0%	$0.00	0.0%	$960,000.00	2.2%	$156,000.00	0.7%
O-level publications and new equipment training	6	1	$35,000.00	0.8%	$10,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$60,000.00	0.3%
Sustainment Planning and Data Procurement	5	1	$57,000.00	1.3%	$7,500.00	0.4%	$0.00	0.0%	$0.00	0.0%	$285,000.00	0.6%	$37,500.00	0.2%
Contracting Strategy	5	1	$72,000.00	1.6%	$9,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$45,000.00	0.2%
Other: _____	3	1	$67,000.00	1.5%	$4,000.00	0.2%	$0.00	0.0%	$0.00	0.0%	$201,000.00	0.5%	$12,000.00	0.1%

Figure 78.   System C: Recurring Cost Inputs, Section 4

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 79.   System C: Nonrecurring and End-of-Life-Cycle Cost Inputs Section

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$972,686.00	$1,023,880.00	$1,075,074.00	$1,023,880.00	$744,092.25	$783,255.00	$822,417.75	$783,255.00
Wide Field of View (WFOV) Sensors	$3,647,050.00	$3,839,000.00	$4,030,950.00	$3,839,000.00	$2,933,158.25	$3,087,535.00	$3,241,911.75	$3,087,535.00
EO/IR Sensor Manager (ESM)	$373,587.50	$393,250.00	$412,912.50	$393,250.00	$313,709.00	$330,220.00	$346,731.00	$330,220.00
Human Machine Interface (HMI)	$14,530,725.00	$15,295,500.00	$16,060,275.00	$15,295,500.00	$7,724,849.00	$8,131,420.00	$8,537,991.00	$8,131,420.00
Product Support Management	$2,149,850.00	$2,263,000.00	$2,376,150.00	$2,263,000.00	$1,706,200.00	$1,796,000.00	$1,885,800.00	$1,796,000.00
Design Interface	$2,380,700.00	$2,506,000.00	$2,631,300.00	$2,506,000.00	$142,975.00	$150,500.00	$158,025.00	$150,500.00
Supply Support	$2,825,300.00	$2,974,000.00	$3,122,700.00	$2,974,000.00	$1,474,305.00	$1,551,900.00	$1,629,495.00	$1,551,900.00
Support Equipment	$1,638,750.00	$1,725,000.00	$1,811,250.00	$1,725,000.00	$1,377,500.00	$1,450,000.00	$1,522,500.00	$1,450,000.00
Packaging, Handling, Storage and Transportation	$525,350.00	$553,000.00	$580,650.00	$553,000.00	$322,050.00	$339,000.00	$355,950.00	$339,000.00
Computer Resources	$1,229,300.00	$1,294,000.00	$1,358,700.00	$1,294,000.00	$939,550.00	$989,000.00	$1,038,450.00	$989,000.00
Manpower and Personnel	$1,596,000.00	$1,680,000.00	$1,764,000.00	$1,680,000.00	$1,295,800.00	$1,364,000.00	$1,432,200.00	$1,364,000.00
Maintenance Planning and Management	$3,541,600.00	$3,728,000.00	$3,914,400.00	$3,728,000.00	$0.00	$0.00	$0.00	$0.00
Training and Training Support	$2,330,350.00	$2,453,000.00	$2,575,650.00	$2,453,000.00	$681,150.00	$717,000.00	$752,850.00	$717,000.00
Facilities and Infrastructure	$1,271,100.00	$1,338,000.00	$1,404,900.00	$1,338,000.00	$493,525.00	$519,500.00	$545,475.00	$519,500.00
Technical Data Management	$2,660,000.00	$2,800,000.00	$2,940,000.00	$2,800,000.00	$803,225.00	$845,500.00	$887,775.00	$845,500.00
Acquisition Costs	$444,410.00	$467,800.00	$491,190.00	$467,800.00				
End of Life Disposition Costs	$103,550.00	$109,000.00	$114,450.00	$109,000.00				

Year	Acquisition	1	2	3	4	5	6	7
Cash Flow	$44,333,430.00	$22,054,830.00	$22,385,652.45	$22,721,437.24	$23,062,258.80	$23,408,192.68	$23,759,315.57	$24,115,705.30
Present Value of Cash Flow	$44,333,430.00	$21,412,456.31	$21,100,624.42	$20,793,333.78	$20,490,518.24	$20,192,112.63	$19,898,052.74	$19,608,275.27
Year	8	9	10	11	12	13	14	15
Cash Flow	$24,477,440.88	$24,844,602.49	$25,217,271.53	$25,595,530.60	$25,979,463.56	$26,369,155.52	$26,764,692.85	$27,166,163.24
	$19,322,717.86	$19,041,319.06	$18,764,018.30	$18,490,755.89	$18,221,473.04	$17,956,111.78	$17,694,615.01	$17,436,926.44
Year	16	17	18	19	20	21	22	23
Cash Flow	$27,573,655.69	$27,987,260.53	$28,407,069.43	$28,833,175.48	$29,265,673.11	$29,704,658.20	$30,150,228.08	$30,602,481.50
	$17,182,990.62	$16,932,752.89	$16,686,159.40	$16,443,157.08	$16,203,693.63	$15,967,717.51	$15,735,177.93	$15,506,024.86
Year	24	25	26	27	28	29	30	Disposition
Cash Flow	$31,061,518.72	$31,527,441.50	$32,000,353.12	$32,480,358.42	$32,967,563.80	$33,462,077.25	$33,964,008.41	$109,000.00
	$15,280,208.96	$15,057,681.65	$14,838,395.02	$14,622,301.89	$14,409,355.74	$14,199,510.76	$13,992,721.77	$109,000.00

Total Acquisition Cost for System C	$44,333,430.00

Figure 80. System C: Monte Carlo Simulation Uncertainty Ranges, Section 1

	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
List of Total Lifetime Cost for System C	$158,074,801.16	$280,489,136.93	$412,364,142.71	$554,430,976.94	$707,477,304.94	$872,351,665.95
List of Present Value Lifetime Cost for System C	$148,416,499.73	$245,037,964.84	$334,826,703.72	$418,265,845.06	$495,804,364.31	$567,859,497.04

Total Lifetime Cost for System C (20 Years)	$554,430,976.94	20 Years
Total PV Lifetime Cost for System C (20 Years)	$418,265,845.06	

Figure 81.   System C: Monte Carlo Simulation Uncertainty Ranges, Section 2

APPENDIX D. SYSTEM D EXCEL SPREADSHEET DATA

Appendix D contains the model's Excel spreadsheet for System D, shown in Figures 82-88. This spreadsheet includes the recurring cost inputs, the nonrecurring cost inputs, the end-of-life-cycle cost inputs, and the risk-based Monte Carlo simulation uncertainty ranges.

Select Uncertainty Range:	Use Small +/− 5% Range		Name:	System D		Discount Rate:	3.00%		Economic Life:	20 Years		
			Notes:									
			Annual Growth or Decline Curve:		1.50%							

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			**$3,836,317.00**		**$1,645,990.00**		**$98,468.00**		**$118,917.00**		**$44,206,890.00**		**$31,417,765.00**	
Narrow-Medium Field of View (NFOV) Sensors	37	935	$6,617.00	0.2%	$115.00	0.0%	$210.00	0.2%	$6,617.00	5.6%	$769,890.00	1.7%	$810,975.00	2.6%
NF-DIR (NFOV Director)	3	55	$560.00	0.0%	$4.00	0.0%	$12.00	0.0%	$560.00	0.5%	$92,400.00	0.2%	$95,040.00	0.3%
NF-TIS (Thermal Imaging Sensor) - TIS #1	1	55	$320.00	0.0%	$5.00	0.0%	$10.00	0.0%	$320.00	0.3%	$17,600.00	0.0%	$18,425.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55	$490.00	0.0%	$6.00	0.0%	$14.00	0.0%	$490.00	0.4%	$53,900.00	0.1%	$56,100.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #1	1	55	$350.00	0.0%	$7.00	0.0%	$12.00	0.0%	$350.00	0.3%	$19,250.00	0.0%	$20,295.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #2	4	55	$220.00	0.0%	$5.00	0.0%	$3.00	0.0%	$220.00	0.2%	$48,400.00	0.1%	$50,160.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #3	1	55	$380.00	0.0%	$7.00	0.0%	$5.00	0.0%	$380.00	0.3%	$20,900.00	0.0%	$21,560.00	0.1%
NF-LRF (Laser Rangefinder)	4	55	$267.00	0.0%	$8.00	0.0%	$7.00	0.0%	$267.00	0.2%	$58,740.00	0.1%	$62,040.00	0.2%
NF-LDR (Laser Designator/Rangefinder)	2	55	$450.00	0.0%	$11.00	0.0%	$8.00	0.0%	$450.00	0.4%	$49,500.00	0.1%	$51,590.00	0.2%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	1	55	$190.00	0.0%	$2.00	0.0%	$4.00	0.0%	$190.00	0.2%	$10,450.00	0.0%	$10,780.00	0.0%
NF-LP (Laser Pointer)	2	55	$270.00	0.0%	$4.00	0.0%	$6.00	0.0%	$270.00	0.2%	$29,700.00	0.1%	$30,800.00	0.1%
NF-LOI (Laser Optical/Ocular Interrupter)	1	55	$540.00	0.0%	$6.00	0.0%	$6.00	0.0%	$540.00	0.5%	$29,700.00	0.1%	$30,360.00	0.1%
NF-LI (Laser Illuminator)	2	55	$620.00	0.0%	$10.00	0.0%	$25.00	0.0%	$620.00	0.5%	$68,200.00	0.2%	$72,050.00	0.2%
NF-IRU (Inertial Reference Unit)	2	55	$590.00	0.0%	$7.00	0.0%	$15.00	0.0%	$590.00	0.5%	$64,900.00	0.1%	$67,320.00	0.2%
NF-BSM (Boresight Module)	3	55	$310.00	0.0%	$8.00	0.0%	$34.00	0.0%	$310.00	0.3%	$51,150.00	0.1%	$58,080.00	0.2%
NF-EU (Electronics Unit)	3	55	$280.00	0.0%	$9.00	0.0%	$23.00	0.0%	$280.00	0.2%	$46,200.00	0.1%	$51,480.00	0.2%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$420.00	0.0%	$10.00	0.0%	$15.00	0.0%	$420.00	0.4%	$69,300.00	0.2%	$73,425.00	0.2%
Other: _____	2	55	$360.00	0.0%	$6.00	0.0%	$11.00	0.0%	$360.00	0.3%	$39,600.00	0.1%	$41,470.00	0.1%
Wide Field of View (WFOV) Sensors	21	385	$23,500.00	0.6%	$55.00	0.0%	$48.00	0.0%	$15,600.00	13.1%	$3,861,000.00	8.7%	$2,563,550.00	8.2%
WF-DIR (Director)	3	55	$3,400.00	0.1%	$4.00	0.0%	$12.00	0.0%	$1,200.00	1.0%	$561,000.00	1.3%	$200,640.00	0.6%
WF-TIS (Thermal Imaging Sensor)	3	55	$4,200.00	0.1%	$6.00	0.0%	$9.00	0.0%	$3,400.00	2.9%	$693,000.00	1.6%	$563,475.00	1.8%
WF-EOS (Electro-Optic Sensor)	3	55	$5,400.00	0.1%	$7.00	0.0%	$8.00	0.0%	$2,100.00	1.8%	$891,000.00	2.0%	$348,975.00	1.1%
WF-IRU (Inertial Reference Unit)	4	55	$2,100.00	0.1%	$8.00	0.0%	$7.00	0.0%	$1,900.00	1.6%	$462,000.00	1.0%	$421,300.00	1.3%
WF-EU (Electronics Unit)	3	55	$4,200.00	0.1%	$9.00	0.0%	$6.00	0.0%	$3,200.00	2.7%	$693,000.00	1.6%	$530,475.00	1.7%
Ancillary Material (cabling, mounting hardware, etc.)	2	55	$2,400.00	0.1%	$10.00	0.0%	$4.00	0.0%	$2,400.00	2.0%	$264,000.00	0.6%	$265,540.00	0.8%
Other: _____	3	55	$1,800.00	0.1%	$11.00	0.0%	$2.00	0.0%	$1,400.00	1.2%	$297,000.00	0.7%	$233,145.00	0.7%
EO/IR Sensor Manager (ESM)	24	330	$14,200.00	0.4%	$52.00	0.0%	$63.00	0.1%	$14,200.00	11.9%	$3,003,000.00	6.8%	$3,027,530.00	9.6%
Processing Equipment	6	55	$1,200.00	0.0%	$12.00	0.0%	$12.00	0.0%	$1,200.00	1.0%	$396,000.00	0.9%	$403,920.00	1.3%
Processing Software	5	55	$3,400.00	0.1%	$6.00	0.0%	$9.00	0.0%	$3,400.00	2.9%	$935,000.00	2.1%	$939,125.00	3.0%
Recording Equipment	4	55	$2,100.00	0.1%	$7.00	0.0%	$8.00	0.0%	$2,100.00	1.8%	$462,000.00	1.0%	$465,300.00	1.5%
Docking Station Equipment	4	55	$1,900.00	0.0%	$8.00	0.0%	$7.00	0.0%	$1,900.00	1.6%	$418,000.00	0.9%	$421,300.00	1.3%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	3	55	$3,200.00	0.1%	$9.00	0.0%	$6.00	0.0%	$3,200.00	2.7%	$528,000.00	1.2%	$530,475.00	1.7%
Other: _____	2	55	$2,400.00	0.1%	$10.00	0.0%	$21.00	0.0%	$2,400.00	2.0%	$264,000.00	0.6%	$267,410.00	0.9%

Figure 82.   System D: Recurring Cost Inputs, Section 1

EO/IR Sensor Manager (ESM)	24	330	$14,200.00	0.4%	$52.00	0.0%	$63.00	0.1%	$14,200.00	11.9%	$3,003,000.00	6.8%	$3,027,530.00	9.6%
Processing Equipment	6	55	$1,200.00	0.0%	$12.00	0.0%	$12.00	0.0%	$1,200.00	1.0%	$396,000.00	0.9%	$403,920.00	1.3%
Processing Software	5	55	$3,400.00	0.1%	$6.00	0.0%	$9.00	0.0%	$3,400.00	2.9%	$935,000.00	2.1%	$939,125.00	3.0%
Recording Equipment	4	55	$2,100.00	0.1%	$7.00	0.0%	$8.00	0.0%	$2,100.00	1.8%	$462,000.00	1.0%	$465,300.00	1.5%
Docking Station Equipment	4	55	$1,900.00	0.0%	$8.00	0.0%	$7.00	0.0%	$1,900.00	1.6%	$418,000.00	0.9%	$421,300.00	1.3%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	3	55	$3,200.00	0.1%	$9.00	0.0%	$6.00	0.0%	$3,200.00	2.7%	$528,000.00	1.2%	$530,475.00	1.7%
Other: _____	2	55	$2,400.00	0.1%	$10.00	0.0%	$21.00	0.0%	$2,400.00	2.0%	$264,000.00	0.6%	$267,410.00	0.9%
Human Machine Interface (HMI)	55	275	$23,000.00	0.6%	$68.00	0.0%	$147.00	0.1%	$23,000.00	19.3%	$14,960,000.00	33.8%	$15,071,210.00	48.0%
HMI-B (HMI Bridge/Cockpit)	6	55	$6,000.00	0.2%	$34.00	0.0%	$10.00	0.0%	$6,000.00	5.0%	$1,980,000.00	4.5%	$1,994,520.00	6.3%
HMI-C (HMI Combat Information Center/Cabin)	19	55	$5,000.00	0.1%	$10.00	0.0%	$12.00	0.0%	$5,000.00	4.2%	$5,225,000.00	11.8%	$5,247,990.00	16.7%
HMI-I (HMI Intel)	1	55	$4,000.00	0.1%	$9.00	0.0%	$65.00	0.1%	$4,000.00	3.4%	$220,000.00	0.5%	$224,070.00	0.7%
Ancillary Material (additional displays, control panel switches, cabling, mounts, etc.	25	55	$5,000.00	0.1%	$10.00	0.0%	$36.00	0.0%	$5,000.00	4.2%	$6,875,000.00	15.6%	$6,938,250.00	22.1%
Other: _____	4	55	$3,000.00	0.1%	$5.00	0.0%	$24.00	0.0%	$3,000.00	2.5%	$660,000.00	1.5%	$666,380.00	2.1%
Product Support Management	40	9	$355,000.00	9.3%	$289,500.00	17.6%	$0.00	0.0%	$0.00	0.0%	$1,665,000.00	3.8%	$1,510,500.00	4.8%
Program Management Office Team	6	1	$80,000.00	2.1%	$80,000.00	4.9%	$0.00	0.0%	$0.00	0.0%	$480,000.00	1.1%	$480,000.00	1.5%
Sustainment Planning and Data Procurement	5	1	$50,000.00	1.3%	$50,000.00	3.0%	$0.00	0.0%	$0.00	0.0%	$250,000.00	0.6%	$250,000.00	0.8%
Depot Activation	4	1	$20,000.00	0.5%	$21,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$80,000.00	0.2%	$84,000.00	0.3%
Software Sustainment	6	1	$40,000.00	1.0%	$42,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$252,000.00	0.8%
Integrated Product Support Team	7	1	$35,000.00	0.9%	$40,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$245,000.00	0.6%	$280,000.00	0.9%
Provisioning and Initial Spares Lay-in	4	1	$40,000.00	1.0%	$17,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.4%	$68,000.00	0.2%
Contracting Strategy	4	1	$20,000.00	0.5%	$13,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$80,000.00	0.2%	$52,000.00	0.2%
Full Scale Production	3	1	$30,000.00	0.8%	$9,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$90,000.00	0.2%	$27,000.00	0.1%
Other: _____	1	1	$40,000.00	1.0%	$17,500.00	1.1%	$0.00	0.0%	$0.00	0.0%	$40,000.00	0.1%	$17,500.00	0.1%
Design Interface	69	11	$509,000.00	13.3%	$24,500.00	1.5%	$0.00	0.0%	$0.00	0.0%	$3,138,000.00	7.1%	$190,500.00	0.6%
Technology development (TRL2 to TRL4)	3	1	$54,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$162,000.00	0.4%	$0.00	0.0%
Materiel development and LRIP (TRL5 to TRL7)	5	1	$65,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$325,000.00	0.7%	$0.00	0.0%
Operational Test (TRL8)	6	1	$34,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$0.00	0.0%
Combat system integration (software changes)	7	1	$54,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$0.00	0.0%
Reliability Growth Program	7	1	$32,000.00	0.8%	$5,500.00	0.3%	$0.00	0.0%	$0.00	0.0%	$224,000.00	0.5%	$38,500.00	0.1%
Technology Refresh (P3I, emerging threats, obsolescence...)	8	1	$35,000.00	0.9%	$19,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.6%	$152,000.00	0.5%
Technology Roadmap	6	1	$38,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$228,000.00	0.5%	$0.00	0.0%
Design for Maintainability	7	1	$42,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$294,000.00	0.7%	$0.00	0.0%
Modularity	8	1	$54,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$432,000.00	1.0%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	7	1	$53,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$371,000.00	0.8%	$0.00	0.0%
Other: _____	5	1	$48,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$0.00	0.0%

Figure 83.   System D: Recurring Cost Inputs, Section 2

Supply Support	63	12	$364,000.00	9.5%	$251,500.00	15.3%	$0.00	0.0%	$0.00	0.0%	$1,843,000.00	4.2%	$1,300,000.00	4.1%
Wholesale and Retail Supply Chain Management	6	1	$40,000.00	1.0%	$30,500.00	1.9%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$183,000.00	0.6%
Spares Worldwide Transportation	7	1	$12,000.00	0.3%	$30,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$84,000.00	0.2%	$210,000.00	0.7%
Spares Warehousing	8	1	$34,000.00	0.9%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$272,000.00	0.6%	$160,000.00	0.5%
Consumable Spares Replenishment	6	1	$19,000.00	0.5%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$114,000.00	0.3%	$120,000.00	0.4%
Provisioning and Initial Spares Lay-in	5	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$160,000.00	0.4%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	4	1	$24,000.00	0.6%	$33,000.00	2.0%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$132,000.00	0.4%
Contracting Strategy	6	1	$18,000.00	0.5%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$108,000.00	0.2%	$90,000.00	0.3%
Decreasing Economies of Scale	7	1	$45,000.00	1.2%	$21,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.7%	$147,000.00	0.5%
Battle Damage	3	1	$32,000.00	0.8%	$17,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$51,000.00	0.2%
Initial Fielding Support	4	1	$35,000.00	0.9%	$9,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$140,000.00	0.3%	$36,000.00	0.1%
Prepositioned Stock	6	1	$29,000.00	0.8%	$23,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$174,000.00	0.4%	$138,000.00	0.4%
Other: _____	1	1	$44,000.00	1.1%	$33,000.00	2.0%	$0.00	0.0%	$0.00	0.0%	$44,000.00	0.1%	$33,000.00	0.1%
Support Equipment	35	8	$367,000.00	9.6%	$260,000.00	15.8%	$71,000.00	72.1%	$59,500.00	50.0%	$1,711,000.00	3.9%	$1,924,500.00	6.1%
Depot Activation	1	1	$43,000.00	1.1%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$43,000.00	0.1%	$35,000.00	0.1%
Software Sustainment	4	1	$36,000.00	0.9%	$30,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$144,000.00	0.3%	$120,000.00	0.4%
Special Tools & Equipment	5	1	$45,000.00	1.2%	$70,000.00	4.3%	$35,000.00	35.5%	$16,500.00	13.9%	$225,000.00	0.5%	$607,500.00	1.9%
Ancillary Equipment	6	1	$53,000.00	1.4%	$43,000.00	2.6%	$25,000.00	25.4%	$43,000.00	36.2%	$318,000.00	0.7%	$666,000.00	2.1%
Support Equipment Sustainment	7	1	$65,000.00	1.7%	$23,000.00	1.4%	$11,000.00	11.2%	$0.00	0.0%	$455,000.00	1.0%	$238,000.00	0.8%
Initial Fielding Support	1	1	$34,000.00	0.9%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$34,000.00	0.1%	$15,000.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$37,000.00	1.0%	$23,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$222,000.00	0.5%	$138,000.00	0.4%
Other: _____	5	1	$54,000.00	1.4%	$21,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$105,000.00	0.3%
Packaging, Handling, Storage and Transportation	24	4	$144,000.00	3.8%	$56,000.00	3.4%	$0.00	0.0%	$0.00	0.0%	$843,000.00	1.9%	$325,000.00	1.0%
Transportability Requirements	5	1	$44,000.00	1.1%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$220,000.00	0.5%	$100,000.00	0.3%
Transportation Limitations	6	1	$34,000.00	0.9%	$12,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$72,000.00	0.2%
Initial Fielding Support	7	1	$23,000.00	0.6%	$9,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$161,000.00	0.4%	$63,000.00	0.2%
Other: _____	6	1	$43,000.00	1.1%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$90,000.00	0.3%
Computer Resources	37	6	$321,000.00	8.4%	$191,000.00	11.6%	$0.00	0.0%	$0.00	0.0%	$1,951,000.00	4.4%	$1,167,000.00	3.7%
Manning and military occupational series training	5	1	$80,000.00	2.1%	$45,000.00	2.7%	$0.00	0.0%	$0.00	0.0%	$400,000.00	0.9%	$225,000.00	0.7%
Depot Activation	6	1	$40,000.00	1.0%	$25,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$150,000.00	0.5%
Software Sustainment	7	1	$60,000.00	1.6%	$39,000.00	2.4%	$0.00	0.0%	$0.00	0.0%	$420,000.00	1.0%	$273,000.00	0.9%
O-level publications and new equipment training	6	1	$40,000.00	1.0%	$20,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.5%	$120,000.00	0.4%
Initial Fielding Support	6	1	$56,000.00	1.5%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$336,000.00	0.8%	$210,000.00	0.7%
Other: _____	7	1	$45,000.00	1.2%	$27,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.7%	$189,000.00	0.6%
Manpower and Personnel	34	6	$237,000.00	6.2%	$217,000.00	13.2%	$0.00	0.0%	$0.00	0.0%	$1,339,000.00	3.0%	$1,242,000.00	4.0%
Program Management Office Team	5	1	$60,000.00	1.6%	$60,000.00	3.6%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$300,000.00	1.0%
Manning and military occupational series training	6	1	$45,000.00	1.2%	$43,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$258,000.00	0.8%
Depot Activation	7	1	$32,000.00	0.8%	$35,000.00	2.1%	$0.00	0.0%	$0.00	0.0%	$224,000.00	0.5%	$245,000.00	0.8%
Software Sustainment	7	1	$37,000.00	1.0%	$31,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$259,000.00	0.6%	$217,000.00	0.7%
Initial Fielding Support	4	1	$29,000.00	0.8%	$18,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$116,000.00	0.3%	$72,000.00	0.2%
Other: _____	5	1	$34,000.00	0.9%	$30,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$170,000.00	0.4%	$150,000.00	0.5%

Figure 84.   System D: Recurring Cost Inputs, Section 3

Maintenance Planning and Management	114	15	$430,000.00	11.2%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$3,317,000.00	7.5%	$0.00	0.0%
System Support Strategy	10	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$400,000.00	0.9%	$0.00	0.0%
Title 10 Core 50/50	12	1	$30,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.8%	$0.00	0.0%
Depot Activation	10	1	$25,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$250,000.00	0.6%	$0.00	0.0%
Software Sustainment	7	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.6%	$0.00	0.0%
Depot Repair and Overhaul	1	1	$30,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$30,000.00	0.1%	$0.00	0.0%
Manning and military occupational series training	7	1	$35,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$245,000.00	0.6%	$0.00	0.0%
O-level publications and new equipment training	9	1	$23,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$207,000.00	0.5%	$0.00	0.0%
Sustainment Planning and Data Procurement	8	1	$12,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$0.00	0.0%
Provisioning and Initial Spares Lay-in	7	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$301,000.00	0.7%	$0.00	0.0%
Demilitarization and Disposal	8	1	$23,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$184,000.00	0.4%	$0.00	0.0%
Full Scale Production	10	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$400,000.00	0.9%	$0.00	0.0%
Decreasing Economies of Scale	4	1	$16,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$64,000.00	0.1%	$0.00	0.0%
Initial Fielding Support	7	1	$20,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$140,000.00	0.3%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	8	1	$21,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$168,000.00	0.4%	$0.00	0.0%
Other: _____	6	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.4%	$0.00	0.0%
Training and Training Support	47	8	$490,000.00	12.8%	$141,000.00	8.6%	$0.00	0.0%	$0.00	0.0%	$2,955,000.00	6.7%	$848,000.00	2.7%
Depot Activation	5	1	$79,000.00	2.1%	$19,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$395,000.00	0.9%	$95,000.00	0.3%
Software Sustainment	6	1	$65,000.00	1.7%	$7,500.00	0.5%	$0.00	0.0%	$0.00	0.0%	$390,000.00	0.9%	$45,000.00	0.1%
Manning and military occupational series training	5	1	$42,000.00	1.1%	$30,500.00	1.9%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$152,500.00	0.5%
O-level publications and new equipment training	7	1	$87,000.00	2.3%	$39,500.00	2.4%	$0.00	0.0%	$0.00	0.0%	$609,000.00	1.4%	$276,500.00	0.9%
Sustainment Planning and Data Procurement	8	1	$62,000.00	1.6%	$12,500.00	0.8%	$0.00	0.0%	$0.00	0.0%	$496,000.00	1.1%	$100,000.00	0.3%
Transportability Requirements	7	1	$72,000.00	1.9%	$17,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$504,000.00	1.1%	$119,000.00	0.4%
Initial Fielding Support	5	1	$19,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$95,000.00	0.2%	$0.00	0.0%
Other: _____	4	1	$64,000.00	1.7%	$15,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$256,000.00	0.6%	$60,000.00	0.2%
Facilities and Infrastructure	25	4	$162,000.00	4.2%	$60,000.00	3.6%	$27,000.00	27.4%	$0.00	0.0%	$937,000.00	2.1%	$554,000.00	1.8%
Ship alteration for initial fielding	5	1	$55,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$275,000.00	0.6%	$0.00	0.0%
Depot Activation	6	1	$65,000.00	1.7%	$33,000.00	2.0%	$11,000.00	11.2%	$0.00	0.0%	$390,000.00	0.9%	$264,000.00	0.8%
Software Sustainment	6	1	$32,000.00	0.8%	$17,500.00	1.1%	$9,500.00	9.6%	$0.00	0.0%	$192,000.00	0.4%	$162,000.00	0.5%
Other: _____	8	1	$10,000.00	0.3%	$9,500.00	0.6%	$6,500.00	6.6%	$0.00	0.0%	$80,000.00	0.2%	$128,000.00	0.4%
Technical Data Management	31	7	$390,000.00	10.2%	$155,200.00	9.4%	$0.00	0.0%	$0.00	0.0%	$1,914,000.00	4.3%	$883,000.00	2.8%
Depot Activation	8	1	$66,000.00	1.7%	$64,000.00	3.9%	$0.00	0.0%	$0.00	0.0%	$528,000.00	1.2%	$512,000.00	1.6%
Software Sustainment	4	1	$72,000.00	1.9%	$31,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$288,000.00	0.7%	$124,000.00	0.4%
Manning and military occupational series training	3	1	$35,000.00	0.9%	$13,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.2%	$39,000.00	0.1%
O-level publications and new equipment training	5	1	$78,000.00	2.0%	$13,500.00	0.8%	$0.00	0.0%	$0.00	0.0%	$390,000.00	0.9%	$67,500.00	0.2%
Sustainment Planning and Data Procurement	5	1	$62,000.00	1.6%	$15,700.00	1.0%	$0.00	0.0%	$0.00	0.0%	$310,000.00	0.7%	$78,500.00	0.2%
Contracting Strategy	5	1	$54,000.00	1.4%	$11,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$270,000.00	0.6%	$55,000.00	0.2%
Other: _____	1	1	$23,000.00	0.6%	$7,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$23,000.00	0.1%	$7,000.00	0.0%

Figure 85. System D: Recurring Cost Inputs, Section 4

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 86.   System D: Nonrecurring and End-of-Life-Cycle Cost Inputs Section

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$731,395.50	$769,890.00	$808,384.50	$769,890.00	$770,426.25	$810,975.00	$851,523.75	$810,975.00
Wide Field of View (WFOV) Sensors	$3,667,950.00	$3,861,000.00	$4,054,050.00	$3,861,000.00	$2,435,372.50	$2,563,550.00	$2,691,727.50	$2,563,550.00
EO/IR Sensor Manager (ESM)	$2,852,850.00	$3,003,000.00	$3,153,150.00	$3,003,000.00	$2,876,153.50	$3,027,530.00	$3,178,906.50	$3,027,530.00
Human Machine Interface (HMI)	$14,212,000.00	$14,960,000.00	$15,708,000.00	$14,960,000.00	$14,317,649.50	$15,071,210.00	$15,824,770.50	$15,071,210.00
Product Support Management	$1,581,750.00	$1,665,000.00	$1,748,250.00	$1,665,000.00	$1,434,975.00	$1,510,500.00	$1,586,025.00	$1,510,500.00
Design Interface	$2,981,100.00	$3,138,000.00	$3,294,900.00	$3,138,000.00	$180,975.00	$190,500.00	$200,025.00	$190,500.00
Supply Support	$1,750,850.00	$1,843,000.00	$1,935,150.00	$1,843,000.00	$1,235,000.00	$1,300,000.00	$1,365,000.00	$1,300,000.00
Support Equipment	$1,625,450.00	$1,711,000.00	$1,796,550.00	$1,711,000.00	$1,828,275.00	$1,924,500.00	$2,020,725.00	$1,924,500.00
Packaging, Handling, Storage and Transportation	$800,850.00	$843,000.00	$885,150.00	$843,000.00	$308,750.00	$325,000.00	$341,250.00	$325,000.00
Computer Resources	$1,853,450.00	$1,951,000.00	$2,048,550.00	$1,951,000.00	$1,108,650.00	$1,167,000.00	$1,225,350.00	$1,167,000.00
Manpower and Personnel	$1,272,050.00	$1,339,000.00	$1,405,950.00	$1,339,000.00	$1,179,900.00	$1,242,000.00	$1,304,100.00	$1,242,000.00
Maintenance Planning and Management	$3,151,150.00	$3,317,000.00	$3,482,850.00	$3,317,000.00	$0.00	$0.00	$0.00	$0.00
Training and Training Support	$2,807,250.00	$2,955,000.00	$3,102,750.00	$2,955,000.00	$805,600.00	$848,000.00	$890,400.00	$848,000.00
Facilities and Infrastructure	$890,150.00	$937,000.00	$983,850.00	$937,000.00	$526,300.00	$554,000.00	$581,700.00	$554,000.00
Technical Data Management	$1,818,300.00	$1,914,000.00	$2,009,700.00	$1,914,000.00	$838,850.00	$883,000.00	$927,150.00	$883,000.00
Acquisition Costs	$444,410.00	$467,800.00	$491,190.00	$467,800.00				
End of Life Disposition Costs	$103,550.00	$109,000.00	$114,450.00	$109,000.00				

Year	Acquisition	1	2	3	4	5	6	7
Cash Flow	$44,674,690.00	$31,417,765.00	$31,889,031.48	$32,367,366.95	$32,852,877.45	$33,345,670.61	$33,845,855.67	$34,353,543.51
Present Value of Cash Flow	$44,674,690.00	$30,502,684.47	$30,058,470.61	$29,620,725.90	$29,189,356.10	$28,764,268.39	$28,345,371.28	$27,932,574.61
Year	8	9	10	11	12	13	14	15
Cash Flow	$34,868,846.66	$35,391,879.36	$35,922,757.55	$36,461,598.91	$37,008,522.90	$37,563,650.74	$38,127,105.50	$38,699,012.08
	$27,525,789.54	$27,124,928.53	$26,729,905.30	$26,340,634.83	$25,957,033.36	$25,579,018.31	$25,206,508.33	$24,839,423.26
Year	16	17	18	19	20	21	22	23
Cash Flow	$39,279,497.27	$39,868,689.72	$40,466,720.07	$41,073,720.87	$41,689,826.68	$42,315,174.08	$42,949,901.70	$43,594,150.22
	$24,477,684.09	$24,121,212.96	$23,769,933.16	$23,423,769.08	$23,082,646.23	$22,746,491.19	$22,415,231.61	$22,088,796.20
Year	24	25	26	27	28	29	30	Disposition
Cash Flow	$44,248,062.47	$44,911,783.41	$45,585,460.16	$46,269,242.07	$46,963,280.70	$47,667,729.91	$48,382,745.86	$109,000.00
	$21,767,114.70	$21,450,117.88	$21,137,737.53	$20,829,906.40	$20,526,558.25	$20,227,627.79	$19,933,050.68	$109,000.00

Total Acquisition Cost for System D	$44,674,690.00

Figure 87.   System D: Monte Carlo Simulation Uncertainty Ranges, Section 1

	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
List of Total Lifetime Cost for System D	$206,656,401.49	$381,039,284.24	$568,899,174.37	$771,277,628.99	$989,296,700.88	$1,224,165,159.57
List of Present Value Lifetime Cost for System D	$192,904,219.83	$330,549,870.97	$458,461,345.77	$577,326,978.99	$687,786,438.92	$790,434,167.10

Total Lifetime Cost for System D (20 Years)	$771,277,628.99	20 Years
Total PV Lifetime Cost for System D (20 Years)	$577,326,978.99	

Figure 88.   System D: Monte Carlo Simulation Uncertainty Ranges, Section 2

APPENDIX E. SYSTEM E EXCEL SPREADSHEET DATA

Appendix E contains the model's Excel spreadsheet for System E, shown in Figures 89-95. This spreadsheet includes the recurring cost inputs, the nonrecurring cost inputs, the end-of-life-cycle cost inputs, and the risk-based Monte Carlo simulation uncertainty ranges.

Select Uncertainty Range: | Use Small +/− 5% Range |

Name:	**System E**	Discount Rate: 3.00% Economic Life: 20 Years
Notes:		
Annual Growth or Decline Curve:	1.50%	

Categories	Number of Units per System	Number of Platforms	Acquisition Cost (Unit)	%	Operational Costs (Unit) Per Year	%	Maintenance (Unit) Per Year	%	Replacement (Unit) Per Year	%	Total Acquisition Cost	%	Total Annual O&M	%
Grand Total			**$4,086,710.00**		**$1,520,321.00**		**$117,329.00**		**$105,280.00**		**$41,629,850.00**		**$23,247,190.00**	
Narrow-Medium Field of View (NFOV) Sensors	**43**	**935**	**$7,110.00**	**0.2%**	**$113.00**	**0.0%**	**$174.00**	**0.1%**	**$4,880.00**	**4.6%**	**$960,850.00**	**2.3%**	**$705,155.00**	**3.0%**
NF-DIR (NFOV Director)	2	55	$400.00	0.0%	$5.00	0.0%	$6.00	0.0%	$300.00	0.3%	$44,000.00	0.1%	$34,210.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #1	3	55	$350.00	0.0%	$6.00	0.0%	$5.00	0.0%	$150.00	0.1%	$57,750.00	0.1%	$26,565.00	0.1%
NF-TIS (Thermal Imaging Sensor) - TIS #2	2	55	$460.00	0.0%	$5.00	0.0%	$7.00	0.0%	$300.00	0.3%	$50,600.00	0.1%	$34,320.00	0.1%
NF-EOS (Electro-Optic Sensor) - EOS #1	3	55	$230.00	0.0%	$7.00	0.0%	$9.00	0.0%	$200.00	0.2%	$37,950.00	0.1%	$35,640.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #2	3	55	$340.00	0.0%	$8.00	0.0%	$8.00	0.0%	$220.00	0.2%	$56,100.00	0.1%	$38,940.00	0.2%
NF-EOS (Electro-Optic Sensor) - EOS #3	3	55	$450.00	0.0%	$8.00	0.0%	$6.00	0.0%	$250.00	0.2%	$74,250.00	0.2%	$43,560.00	0.2%
NF-LRF (Laser Rangefinder)	2	55	$560.00	0.0%	$5.00	0.0%	$7.00	0.0%	$560.00	0.5%	$61,600.00	0.1%	$62,920.00	0.3%
NF-LDR (Laser Designator/Rangefinder)	2	55	$430.00	0.0%	$8.00	0.0%	$10.00	0.0%	$220.00	0.2%	$47,300.00	0.1%	$26,180.00	0.1%
NF-LDRFI (Laser Designator/Rangefinder/Illuminator)	2	55	$460.00	0.0%	$7.00	0.0%	$21.00	0.0%	$140.00	0.1%	$50,600.00	0.1%	$18,480.00	0.1%
NF-LP (Laser Pointer)	5	55	$450.00	0.0%	$9.00	0.0%	$34.00	0.0%	$270.00	0.3%	$123,750.00	0.3%	$86,075.00	0.4%
NF-LOI (Laser Optical/Ocular Interrupter)	1	55	$560.00	0.0%	$4.00	0.0%	$5.00	0.0%	$320.00	0.3%	$30,800.00	0.1%	$18,095.00	0.1%
NF-LI (Laser Illuminator)	3	55	$430.00	0.0%	$9.00	0.0%	$5.00	0.0%	$540.00	0.5%	$70,950.00	0.2%	$91,410.00	0.4%
NF-IRU (Inertial Reference Unit)	2	55	$430.00	0.0%	$3.00	0.0%	$8.00	0.0%	$450.00	0.4%	$47,300.00	0.1%	$50,710.00	0.2%
NF-BSM (Boresight Module)	1	55	$230.00	0.0%	$7.00	0.0%	$9.00	0.0%	$220.00	0.2%	$12,650.00	0.0%	$12,980.00	0.1%
NF-EU (Electronics Unit)	2	55	$670.00	0.0%	$8.00	0.0%	$8.00	0.0%	$330.00	0.3%	$73,700.00	0.2%	$38,060.00	0.2%
Ancillary Material (cabling, mounting hardware, etc.)	3	55	$430.00	0.0%	$4.00	0.0%	$14.00	0.0%	$200.00	0.2%	$70,950.00	0.2%	$35,970.00	0.2%
Other: _____	4	55	$230.00	0.0%	$10.00	0.0%	$12.00	0.0%	$210.00	0.2%	$50,600.00	0.1%	$51,040.00	0.2%
Wide Field of View (WFOV) Sensors	**20**	**385**	**$28,400.00**	**0.7%**	**$64.00**	**0.0%**	**$57.00**	**0.0%**	**$24,100.00**	**22.9%**	**$4,532,000.00**	**10.9%**	**$3,598,705.00**	**15.5%**
WF-DIR (Director)	3	55	$6,000.00	0.1%	$10.00	0.0%	$8.00	0.0%	$3,000.00	2.8%	$990,000.00	2.4%	$497,970.00	2.1%
WF-TIS (Thermal Imaging Sensor)	2	55	$2,300.00	0.1%	$17.00	0.0%	$6.00	0.0%	$5,000.00	4.7%	$253,000.00	0.6%	$552,530.00	2.4%
WF-EOS (Electro-Optic Sensor)	1	55	$4,300.00	0.1%	$13.00	0.0%	$7.00	0.0%	$3,200.00	3.0%	$236,500.00	0.6%	$177,100.00	0.8%
WF-IRU (Inertial Reference Unit)	2	55	$4,500.00	0.1%	$5.00	0.0%	$9.00	0.0%	$3,200.00	3.0%	$495,000.00	1.2%	$353,540.00	1.5%
WF-EU (Electronics Unit)	3	55	$2,300.00	0.1%	$6.00	0.0%	$10.00	0.0%	$4,300.00	4.1%	$379,500.00	0.9%	$712,140.00	3.1%
Ancillary Material (cabling, mounting hardware, etc.)	4	55	$5,400.00	0.1%	$6.00	0.0%	$9.00	0.0%	$3,400.00	3.2%	$1,188,000.00	2.9%	$751,300.00	3.2%
Other: _____	5	55	$3,600.00	0.1%	$7.00	0.0%	$8.00	0.0%	$2,000.00	1.9%	$990,000.00	2.4%	$554,125.00	2.4%
EO/IR Sensor Manager (ESM)	**24**	**330**	**$14,200.00**	**0.3%**	**$91.00**	**0.0%**	**$68.00**	**0.1%**	**$10,800.00**	**10.3%**	**$3,003,000.00**	**7.2%**	**$2,243,835.00**	**9.7%**
Processing Equipment	6	55	$1,200.00	0.0%	$12.00	0.0%	$8.00	0.0%	$1,000.00	0.9%	$396,000.00	1.0%	$336,600.00	1.4%
Processing Software	5	55	$3,400.00	0.1%	$13.00	0.0%	$9.00	0.0%	$2,000.00	1.9%	$935,000.00	2.2%	$556,050.00	2.4%
Recording Equipment	4	55	$2,100.00	0.1%	$15.00	0.0%	$8.00	0.0%	$1,500.00	1.4%	$462,000.00	1.1%	$335,060.00	1.4%
Docking Station Equipment	4	55	$1,900.00	0.0%	$16.00	0.0%	$7.00	0.0%	$1,300.00	1.2%	$418,000.00	1.0%	$291,060.00	1.3%
Ancillary Material (video converters, encoders, ethernet switches, racks, cabling, etc.)	3	55	$3,200.00	0.1%	$17.00	0.0%	$24.00	0.0%	$3,000.00	2.8%	$528,000.00	1.3%	$501,765.00	2.2%
Other: _____	2	55	$2,400.00	0.1%	$18.00	0.0%	$12.00	0.0%	$2,000.00	1.9%	$264,000.00	0.6%	$223,300.00	1.0%

Figure 89.   System E: Recurring Cost Inputs, Section 1

Human Machine Interface (HMI)	35	275	$30,000.00	0.7%	$53.00	0.0%	$30.00	0.0%	$20,000.00	19.0%	$12,265,000.00	29.5%	$8,118,495.00	34.9%
HMI-B (HMI Bridge/Cockpit)	5	55	$6,000.00	0.1%	$20.00	0.0%	$7.00	0.0%	$4,000.00	3.8%	$1,650,000.00	4.0%	$1,107,425.00	4.8%
HMI-C (HMI Combat Information Center/Cabin)	17	55	$7,000.00	0.2%	$12.00	0.0%	$6.00	0.0%	$5,000.00	4.7%	$6,545,000.00	15.7%	$4,691,830.00	20.2%
HMI-I (HMI Intel)	2	55	$5,000.00	0.1%	$6.00	0.0%	$5.00	0.0%	$5,000.00	4.7%	$550,000.00	1.3%	$551,210.00	2.4%
Ancillary Material (additional displays, control panel switches, cabling, mounts, etc.	6	55	$4,000.00	0.1%	$7.00	0.0%	$4.00	0.0%	$2,000.00	1.9%	$1,320,000.00	3.2%	$663,630.00	2.9%
Other: _____	5	55	$8,000.00	0.2%	$8.00	0.0%	$8.00	0.0%	$4,000.00	3.8%	$2,200,000.00	5.3%	$1,104,400.00	4.8%
Product Support Management	48	9	$447,000.00	10.9%	$339,000.00	22.3%	$0.00	0.0%	$0.00	0.0%	$2,263,000.00	5.4%	$1,686,500.00	7.3%
Program Management Office Team	4	1	$75,000.00	1.8%	$75,000.00	4.9%	$0.00	0.0%	$0.00	0.0%	$300,000.00	0.7%	$300,000.00	1.3%
Sustainment Planning and Data Procurement	5	1	$45,000.00	1.1%	$45,000.00	3.0%	$0.00	0.0%	$0.00	0.0%	$225,000.00	0.5%	$225,000.00	1.0%
Depot Activation	6	1	$56,000.00	1.4%	$50,000.00	3.3%	$0.00	0.0%	$0.00	0.0%	$336,000.00	0.8%	$300,000.00	1.3%
Software Sustainment	5	1	$65,000.00	1.6%	$55,000.00	3.6%	$0.00	0.0%	$0.00	0.0%	$325,000.00	0.8%	$275,000.00	1.2%
Integrated Product Support Team	6	1	$43,000.00	1.1%	$40,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$258,000.00	0.6%	$240,000.00	1.0%
Provisioning and Initial Spares Lay-in	6	1	$23,000.00	0.6%	$19,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$138,000.00	0.3%	$114,000.00	0.5%
Contracting Strategy	7	1	$47,000.00	1.2%	$15,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$329,000.00	0.8%	$105,000.00	0.5%
Full Scale Production	8	1	$37,000.00	0.9%	$12,500.00	0.8%	$0.00	0.0%	$0.00	0.0%	$296,000.00	0.7%	$100,000.00	0.4%
Other: _____	1	1	$56,000.00	1.4%	$27,500.00	1.8%	$0.00	0.0%	$0.00	0.0%	$56,000.00	0.1%	$27,500.00	0.1%
Design Interface	63	11	$320,000.00	7.8%	$18,000.00	1.2%	$0.00	0.0%	$0.00	0.0%	$1,839,000.00	4.4%	$85,000.00	0.4%
Technology development (TRL2 to TRL4)	3	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$0.00	0.0%
Materiel development and LRIP (TRL5 to TRL7)	3	1	$12,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$36,000.00	0.1%	$0.00	0.0%
Operational Test (TRL8)	7	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.6%	$0.00	0.0%
Combat system integration (software changes)	8	1	$19,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$152,000.00	0.4%	$0.00	0.0%
Reliability Growth Program	4	1	$32,000.00	0.8%	$5,000.00	0.3%	$0.00	0.0%	$0.00	0.0%	$128,000.00	0.3%	$20,000.00	0.1%
Technology Refresh (P3I, emerging threats, obsolescence...)	5	1	$24,000.00	0.6%	$13,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$65,000.00	0.3%
Technology Roadmap	6	1	$18,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$108,000.00	0.3%	$0.00	0.0%
Design for Maintainability	7	1	$45,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.8%	$0.00	0.0%
Modularity	8	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$256,000.00	0.6%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	3	1	$35,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.3%	$0.00	0.0%
Other: _____	9	1	$29,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$261,000.00	0.6%	$0.00	0.0%

Figure 90.   System E: Recurring Cost Inputs, Section 2

Supply Support	64	12	$364,000.00	8.9%	$260,000.00	17.1%	$0.00	0.0%	$0.00	0.0%	$1,934,000.00	4.6%	$1,475,000.00	6.3%
Wholesale and Retail Supply Chain Management	7	1	$40,000.00	1.0%	$20,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$280,000.00	0.7%	$140,000.00	0.6%
Spares Worldwide Transportation	5	1	$12,000.00	0.3%	$14,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$60,000.00	0.1%	$70,000.00	0.3%
Spares Warehousing	6	1	$34,000.00	0.8%	$75,000.00	4.9%	$0.00	0.0%	$0.00	0.0%	$204,000.00	0.5%	$450,000.00	1.9%
Consumable Spares Replenishment	4	1	$19,000.00	0.5%	$20,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$76,000.00	0.2%	$80,000.00	0.3%
Provisioning and Initial Spares Lay-in	3	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$24,000.00	0.6%	$25,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$144,000.00	0.3%	$150,000.00	0.6%
Contracting Strategy	8	1	$18,000.00	0.4%	$17,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$144,000.00	0.3%	$136,000.00	0.6%
Decreasing Economies of Scale	7	1	$45,000.00	1.1%	$25,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.8%	$175,000.00	0.8%
Battle Damage	6	1	$32,000.00	0.8%	$17,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.5%	$102,000.00	0.4%
Initial Fielding Support	5	1	$35,000.00	0.9%	$9,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$175,000.00	0.4%	$45,000.00	0.2%
Prepositioned Stock	4	1	$29,000.00	0.7%	$13,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$116,000.00	0.3%	$52,000.00	0.2%
Other: _____	3	1	$44,000.00	1.1%	$25,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$132,000.00	0.3%	$75,000.00	0.3%
Support Equipment	36	8	$422,000.00	10.3%	$238,000.00	15.7%	$70,000.00	59.7%	$45,500.00	43.2%	$1,866,000.00	4.5%	$1,493,000.00	6.4%
Depot Activation	6	1	$44,000.00	1.1%	$30,000.00	2.0%	$0.00	0.0%	$0.00	0.0%	$264,000.00	0.6%	$180,000.00	0.8%
Software Sustainment	7	1	$34,000.00	0.8%	$20,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.6%	$140,000.00	0.6%
Special Tools & Equipment	4	1	$56,000.00	1.4%	$45,000.00	3.0%	$30,000.00	25.6%	$10,500.00	10.0%	$224,000.00	0.5%	$342,000.00	1.5%
Ancillary Equipment	3	1	$76,000.00	1.9%	$47,000.00	3.1%	$25,000.00	21.3%	$35,000.00	33.2%	$228,000.00	0.5%	$321,000.00	1.4%
Support Equipment Sustainment	6	1	$67,000.00	1.6%	$33,000.00	2.2%	$15,000.00	12.8%	$0.00	0.0%	$402,000.00	1.0%	$288,000.00	1.2%
Initial Fielding Support	2	1	$35,000.00	0.9%	$15,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$70,000.00	0.2%	$30,000.00	0.1%
Obsolescence Mitigation (Cost should be escalated)	4	1	$34,000.00	0.8%	$23,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$136,000.00	0.3%	$92,000.00	0.4%
Other: _____	4	1	$76,000.00	1.9%	$25,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$304,000.00	0.7%	$100,000.00	0.4%
Packaging, Handling, Storage and Transportation	18	4	$175,000.00	4.3%	$60,000.00	3.9%	$0.00	0.0%	$0.00	0.0%	$807,000.00	1.9%	$279,000.00	1.2%
Transportability Requirements	6	1	$62,000.00	1.5%	$24,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$372,000.00	0.9%	$144,000.00	0.6%
Transportation Limitations	3	1	$40,000.00	1.0%	$15,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$45,000.00	0.2%
Initial Fielding Support	4	1	$50,000.00	1.2%	$15,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.5%	$60,000.00	0.3%
Other: _____	5	1	$23,000.00	0.6%	$6,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$115,000.00	0.3%	$30,000.00	0.1%
Computer Resources	35	6	$237,000.00	5.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$1,328,000.00	3.2%	$0.00	0.0%
Manning and military occupational series training	4	1	$60,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.6%	$0.00	0.0%
Depot Activation	5	1	$45,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$225,000.00	0.5%	$0.00	0.0%
Software Sustainment	6	1	$32,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$192,000.00	0.5%	$0.00	0.0%
O-level publications and new equipment training	7	1	$37,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$259,000.00	0.6%	$0.00	0.0%
Initial Fielding Support	6	1	$29,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$174,000.00	0.4%	$0.00	0.0%
Other: _____	7	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$238,000.00	0.6%	$0.00	0.0%
Manpower and Personnel	33	6	$296,000.00	7.2%	$278,000.00	18.3%	$0.00	0.0%	$0.00	0.0%	$1,680,000.00	4.0%	$1,566,000.00	6.7%
Program Management Office Team	3	1	$23,000.00	0.6%	$25,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$69,000.00	0.2%	$75,000.00	0.3%
Manning and military occupational series training	4	1	$54,000.00	1.3%	$51,000.00	3.4%	$0.00	0.0%	$0.00	0.0%	$216,000.00	0.5%	$204,000.00	0.9%
Depot Activation	6	1	$59,000.00	1.4%	$57,000.00	3.7%	$0.00	0.0%	$0.00	0.0%	$354,000.00	0.9%	$342,000.00	1.5%
Software Sustainment	5	1	$62,000.00	1.5%	$55,000.00	3.6%	$0.00	0.0%	$0.00	0.0%	$310,000.00	0.7%	$275,000.00	1.2%
Initial Fielding Support	7	1	$53,000.00	1.3%	$50,000.00	3.3%	$0.00	0.0%	$0.00	0.0%	$371,000.00	0.9%	$350,000.00	1.5%
Other: _____	8	1	$45,000.00	1.1%	$40,000.00	2.6%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.9%	$320,000.00	1.4%

Figure 91.   System E: Recurring Cost Inputs, Section 3

Maintenance Planning and Management	78	15	$717,000.00	17.5%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$3,728,000.00	9.0%	$0.00	0.0%
System Support Strategy	3	1	$78,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$234,000.00	0.6%	$0.00	0.0%
Title 10 Core 50/50	4	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$100,000.00	0.2%	$0.00	0.0%
Depot Activation	6	1	$70,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$420,000.00	1.0%	$0.00	0.0%
Software Sustainment	7	1	$76,000.00	1.9%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$532,000.00	1.3%	$0.00	0.0%
Depot Repair and Overhaul	8	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$344,000.00	0.8%	$0.00	0.0%
Manning and military occupational series training	2	1	$65,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$130,000.00	0.3%	$0.00	0.0%
O-level publications and new equipment training	5	1	$16,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$80,000.00	0.2%	$0.00	0.0%
Sustainment Planning and Data Procurement	6	1	$25,000.00	0.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$150,000.00	0.4%	$0.00	0.0%
Provisioning and Initial Spares Lay-in	8	1	$34,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$272,000.00	0.7%	$0.00	0.0%
Demilitarization and Disposal	7	1	$54,000.00	1.3%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$378,000.00	0.9%	$0.00	0.0%
Full Scale Production	4	1	$15,000.00	0.4%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$60,000.00	0.1%	$0.00	0.0%
Decreasing Economies of Scale	2	1	$39,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$78,000.00	0.2%	$0.00	0.0%
Initial Fielding Support	5	1	$43,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$215,000.00	0.5%	$0.00	0.0%
Obsolescence Mitigation (Cost should be escalated)	6	1	$65,000.00	1.6%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$390,000.00	0.9%	$0.00	0.0%
Other: _____	5	1	$69,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$345,000.00	0.8%	$0.00	0.0%
Training and Training Support	29	8	$298,000.00	7.3%	$99,000.00	6.5%	$0.00	0.0%	$0.00	0.0%	$1,064,000.00	2.6%	$358,000.00	1.5%
Depot Activation	1	1	$42,000.00	1.0%	$11,000.00	0.7%	$0.00	0.0%	$0.00	0.0%	$42,000.00	0.1%	$11,000.00	0.0%
Software Sustainment	3	1	$32,000.00	0.8%	$7,000.00	0.5%	$0.00	0.0%	$0.00	0.0%	$96,000.00	0.2%	$21,000.00	0.1%
Manning and military occupational series training	4	1	$34,000.00	0.8%	$23,000.00	1.5%	$0.00	0.0%	$0.00	0.0%	$136,000.00	0.3%	$92,000.00	0.4%
O-level publications and new equipment training	5	1	$25,000.00	0.6%	$14,000.00	0.9%	$0.00	0.0%	$0.00	0.0%	$125,000.00	0.3%	$70,000.00	0.3%
Sustainment Planning and Data Procurement	3	1	$35,000.00	0.9%	$12,000.00	0.8%	$0.00	0.0%	$0.00	0.0%	$105,000.00	0.3%	$36,000.00	0.2%
Transportability Requirements	4	1	$60,000.00	1.5%	$17,500.00	1.2%	$0.00	0.0%	$0.00	0.0%	$240,000.00	0.6%	$70,000.00	0.3%
Initial Fielding Support	5	1	$40,000.00	1.0%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$200,000.00	0.5%	$0.00	0.0%
Other: _____	4	1	$30,000.00	0.7%	$14,500.00	1.0%	$0.00	0.0%	$0.00	0.0%	$120,000.00	0.3%	$58,000.00	0.2%
Facilities and Infrastructure	25	4	$250,000.00	6.1%	$67,500.00	4.4%	$47,000.00	40.1%	$0.00	0.0%	$1,560,000.00	3.7%	$667,500.00	2.9%
Ship alteration for initial fielding	7	1	$70,000.00	1.7%	$0.00	0.0%	$0.00	0.0%	$0.00	0.0%	$490,000.00	1.2%	$0.00	0.0%
Depot Activation	6	1	$50,000.00	1.2%	$33,000.00	2.2%	$13,000.00	11.1%	$0.00	0.0%	$300,000.00	0.7%	$276,000.00	1.2%
Software Sustainment	7	1	$60,000.00	1.5%	$15,500.00	1.0%	$9,000.00	7.7%	$0.00	0.0%	$420,000.00	1.0%	$171,500.00	0.7%
Other: _____	5	1	$70,000.00	1.7%	$19,000.00	1.2%	$25,000.00	21.3%	$0.00	0.0%	$350,000.00	0.8%	$220,000.00	0.9%
Technical Data Management	39	7	$481,000.00	11.8%	$160,500.00	10.6%	$0.00	0.0%	$0.00	0.0%	$2,800,000.00	6.7%	$971,000.00	4.2%
Depot Activation	7	1	$67,000.00	1.6%	$55,000.00	3.6%	$0.00	0.0%	$0.00	0.0%	$469,000.00	1.1%	$385,000.00	1.7%
Software Sustainment	5	1	$63,000.00	1.5%	$27,000.00	1.8%	$0.00	0.0%	$0.00	0.0%	$315,000.00	0.8%	$135,000.00	0.6%
Manning and military occupational series training	8	1	$120,000.00	2.9%	$21,000.00	1.4%	$0.00	0.0%	$0.00	0.0%	$960,000.00	2.3%	$168,000.00	0.7%
O-level publications and new equipment training	6	1	$35,000.00	0.9%	$12,500.00	0.8%	$0.00	0.0%	$0.00	0.0%	$210,000.00	0.5%	$75,000.00	0.3%
Sustainment Planning and Data Procurement	5	1	$57,000.00	1.4%	$17,000.00	1.1%	$0.00	0.0%	$0.00	0.0%	$285,000.00	0.7%	$85,000.00	0.4%
Contracting Strategy	5	1	$72,000.00	1.8%	$19,500.00	1.3%	$0.00	0.0%	$0.00	0.0%	$360,000.00	0.9%	$97,500.00	0.4%
Other: _____	3	1	$67,000.00	1.6%	$8,500.00	0.6%	$0.00	0.0%	$0.00	0.0%	$201,000.00	0.5%	$25,500.00	0.1%

Figure 92.   System E: Recurring Cost Inputs, Section 4

Nonrecurring Acquisition and End of Lifecycle Costs	Total	%
Acquisition and Procurement	**$467,800.00**	
Bid Specifications Development	$10,000.00	2.1%
Proposal Evaluation	$2,000.00	0.4%
Data Collection	$40,000.00	8.6%
Data Analysis	$12,000.00	2.6%
Contracts Development	$3,000.00	0.6%
Program Planning	$4,000.00	0.9%
Hardware Purchases	$10,000.00	2.1%
Personal Computers	$10,000.00	2.1%
Peripherals	$15,000.00	3.2%
Storage	$60,000.00	12.8%
Networking	$23,000.00	4.9%
Related Equipment	$35,000.00	7.5%
Other costs	$10,000.00	2.1%
Administrative Cost	$34,000.00	7.3%
Asset Management	$15,000.00	3.2%
Overseeing Contractor Services	$4,000.00	0.9%
In-House Training for Staff	$5,000.00	1.1%
Product Maintenance	$2,000.00	0.4%
Help Desk Support	$10,000.00	2.1%
IT Support for Database Management	$20,000.00	4.3%
Network Management Support	$42,000.00	9.0%
Software Upgrades	$12,000.00	2.6%
Hardware Upgrades	$2,100.00	0.4%
Internet and Network Access Cost	$14,000.00	3.0%
Furniture and Equipment	$10,000.00	2.1%
Energy Costs	$3,400.00	0.7%
Informal Training	$4,300.00	0.9%
Downtime Support and Outsource	$24,000.00	5.1%
Other costs	$32,000.00	6.8%

Nonrecurring End of Lifecycle Costs	Total	%
End of Lifecycle	**$109,000.00**	
Administrative Cost	$40,000.00	36.7%
Asset Management	$20,000.00	18.3%
Vendor Contract Procurement	$4,000.00	3.7%
Staging, Sanitizing, Testing	$10,000.00	9.2%
Follow-Up Support	$10,000.00	9.2%
Recycling and Disposal Fees	$5,000.00	4.6%
Value of Sold Products and Materials	$20,000.00	18.3%

Figure 93.   System E: Nonrecurring and End-of-Life-Cycle Cost Inputs Section

Risk-Based Monte Carlo Simulation on Uncertainty Ranges

	Acquisition Cost (Low)	Acquisition Cost (Mid)	Acquisition Cost (High)	Simulation	Operations and Maintenance with Replacement Costs (Low) Per Year	Operations and Maintenance with Replacement Costs (Mid) Per Year	Operations and Maintenance with Replacement Costs (High) Per Year	Simulation
Narrow-Medium Field of View (NFOV) Sensors	$912,807.50	$960,850.00	$1,008,892.50	$960,850.00	$669,897.25	$705,155.00	$740,412.75	$705,155.00
Wide Field of View (WFOV) Sensors	$4,305,400.00	$4,532,000.00	$4,758,600.00	$4,532,000.00	$3,418,769.75	$3,598,705.00	$3,778,640.25	$3,598,705.00
EO/IR Sensor Manager (ESM)	$2,852,850.00	$3,003,000.00	$3,153,150.00	$3,003,000.00	$2,131,643.25	$2,243,835.00	$2,356,026.75	$2,243,835.00
Human Machine Interface (HMI)	$11,651,750.00	$12,265,000.00	$12,878,250.00	$12,265,000.00	$7,712,570.25	$8,118,495.00	$8,524,419.75	$8,118,495.00
Product Support Management	$2,149,850.00	$2,263,000.00	$2,376,150.00	$2,263,000.00	$1,602,175.00	$1,686,500.00	$1,770,825.00	$1,686,500.00
Design Interface	$1,747,050.00	$1,839,000.00	$1,930,950.00	$1,839,000.00	$80,750.00	$85,000.00	$89,250.00	$85,000.00
Supply Support	$1,837,300.00	$1,934,000.00	$2,030,700.00	$1,934,000.00	$1,401,250.00	$1,475,000.00	$1,548,750.00	$1,475,000.00
Support Equipment	$1,772,700.00	$1,866,000.00	$1,959,300.00	$1,866,000.00	$1,418,350.00	$1,493,000.00	$1,567,650.00	$1,493,000.00
Packaging, Handling, Storage and Transportation	$766,650.00	$807,000.00	$847,350.00	$807,000.00	$265,050.00	$279,000.00	$292,950.00	$279,000.00
Computer Resources	$1,261,600.00	$1,328,000.00	$1,394,400.00	$1,328,000.00	$0.00	$0.00	$0.00	$0.00
Manpower and Personnel	$1,596,000.00	$1,680,000.00	$1,764,000.00	$1,680,000.00	$1,487,700.00	$1,566,000.00	$1,644,300.00	$1,566,000.00
Maintenance Planning and Management	$3,541,600.00	$3,728,000.00	$3,914,400.00	$3,728,000.00	$0.00	$0.00	$0.00	$0.00
Training and Training Support	$1,010,800.00	$1,064,000.00	$1,117,200.00	$1,064,000.00	$340,100.00	$358,000.00	$375,900.00	$358,000.00
Facilities and Infrastructure	$1,482,000.00	$1,560,000.00	$1,638,000.00	$1,560,000.00	$634,125.00	$667,500.00	$700,875.00	$667,500.00
Technical Data Management	$2,660,000.00	$2,800,000.00	$2,940,000.00	$2,800,000.00	$922,450.00	$971,000.00	$1,019,550.00	$971,000.00
Acquisition Costs	$444,410.00	$467,800.00	$491,190.00	$467,800.00				
End of Life Disposition Costs	$103,550.00	$109,000.00	$114,450.00	$109,000.00				

Year	Acquisition	1	2	3	4	5	6	7
Cash Flow	$42,097,650.00	$23,247,190.00	$23,595,897.85	$23,949,836.32	$24,309,083.86	$24,673,720.12	$25,043,825.92	$25,419,483.31
Present Value of Cash Flow	$42,097,650.00	$22,570,087.38	$22,241,396.79	$21,917,492.95	$21,598,306.16	$21,283,767.72	$20,973,809.94	$20,668,366.10
Year	8	9	10	11	12	13	14	15
Cash Flow	$25,800,775.56	$26,187,787.19	$26,580,604.00	$26,979,313.06	$27,384,002.76	$27,794,762.80	$28,211,684.24	$28,634,859.51
	$20,367,370.48	$20,070,758.29	$19,778,465.69	$19,490,429.78	$19,206,588.57	$18,926,880.97	$18,651,246.78	$18,379,626.69
Year	16	17	18	19	20	21	22	23
Cash Flow	$29,064,382.40	$29,500,348.13	$29,942,853.36	$30,391,996.16	$30,847,876.10	$31,310,594.24	$31,780,253.15	$32,256,956.95
	$18,111,962.22	$17,848,195.78	$17,588,270.60	$17,332,130.73	$17,079,721.06	$16,830,987.26	$16,585,875.80	$16,344,333.92
Year	24	25	26	27	28	29	30	Disposition
Cash Flow	$32,740,811.30	$33,231,923.47	$33,730,402.33	$34,236,358.36	$34,749,903.74	$35,271,152.29	$35,800,219.58	$109,000.00
	$16,106,309.64	$15,871,751.73	$15,640,609.71	$15,412,833.84	$15,188,375.10	$14,967,185.17	$14,749,216.45	$109,000.00

Total Acquisition Cost for System E	$42,097,650.00							

Figure 94.   System E: Monte Carlo Simulation Uncertainty Ranges, Section1

	5 Years	10 Years	15 Years	20 Years	25 Years	30 Years
List of Total Lifetime Cost for System E	$161,982,378.15	$291,014,854.14	$430,019,476.51	$579,766,932.65	$741,087,471.77	$914,875,508.07
List of Present Value Lifetime Cost for System E	$151,802,725.35	$253,648,577.73	$348,292,207.24	$436,242,875.34	$517,973,842.03	$593,924,909.86

Total Lifetime Cost for System E (20 Years)	$579,766,932.65	20 Years
Total PV Lifetime Cost for System E (20 Years)	$436,242,875.34	

Figure 95.   System E: Monte Carlo Simulation Uncertainty Ranges, Section 2

APPENDIX F. MODEL SUMMARY EXCEL SPREADSHEET DATA

Appendix F includes the model's Excel spreadsheet for the summary data used to produce the Total Net Life-Cycle Cost and Present Value of Discounted Total Net Life-Cycle Cost graphs (shown in Figures 96-98).

System A	Discount Rate	3.00%										
	Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10
Cash Flow	$46,331,300.00	$109,000.00	$28,266,870.00	$28,690,873.05	$29,121,236.15	$29,558,054.69	$30,001,425.51	$30,451,446.89	$30,908,218.59	$31,371,841.87	$31,842,419.50	$32,320,055.79
Manual Adjustment												
Net Cash Flow	$46,331,300.00	$109,000.00	$28,266,870.00	$28,690,873.05	$29,121,236.15	$29,558,054.69	$30,001,425.51	$30,451,446.89	$30,908,218.59	$31,371,841.87	$31,842,419.50	$32,320,055.79
PV Cash Flows	$46,331,300.00		$28,266,870.00	$28,690,873.05	$29,121,236.15	$29,558,054.69	$30,001,425.51	$30,451,446.89	$30,908,218.59	$31,371,841.87	$31,842,419.50	$32,320,055.79
System B	Discount Rate	3.00%										
	Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10
Cash Flow	$44,861,210.00	$109,000.00	$30,080,095.00	$30,531,296.43	$30,989,265.87	$31,454,104.86	$31,925,916.43	$32,404,805.18	$32,890,877.26	$33,384,240.42	$33,885,004.02	$34,393,279.08
Manual Adjustment												
Net Cash Flow	$44,861,210.00	$109,000.00	$30,080,095.00	$30,531,296.43	$30,989,265.87	$31,454,104.86	$31,925,916.43	$32,404,805.18	$32,890,877.26	$33,384,240.42	$33,885,004.02	$34,393,279.08
PV Cash Flows	$44,861,210.00		$30,080,095.00	$30,531,296.43	$30,989,265.87	$31,454,104.86	$31,925,916.43	$32,404,805.18	$32,890,877.26	$33,384,240.42	$33,885,004.02	$34,393,279.08
System C	Discount Rate	3.00%										
	Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10
Cash Flow	$44,333,430.00	$109,000.00	$22,054,830.00	$22,385,652.45	$22,721,437.24	$23,062,258.80	$23,408,192.68	$23,759,315.57	$24,115,705.30	$24,477,440.88	$24,844,602.49	$25,217,271.53
Manual Adjustment												
Net Cash Flow	$44,333,430.00	$109,000.00	$22,054,830.00	$22,385,652.45	$22,721,437.24	$23,062,258.80	$23,408,192.68	$23,759,315.57	$24,115,705.30	$24,477,440.88	$24,844,602.49	$25,217,271.53
PV Cash Flows	$44,333,430.00		$22,054,830.00	$22,385,652.45	$22,721,437.24	$23,062,258.80	$23,408,192.68	$23,759,315.57	$24,115,705.30	$24,477,440.88	$24,844,602.49	$25,217,271.53
System D	Discount Rate	3.00%										
	Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10
Cash Flow	$44,674,690.00	$109,000.00	$31,417,765.00	$31,889,031.48	$32,367,366.95	$32,852,877.45	$33,345,670.61	$33,845,855.67	$34,353,543.51	$34,868,846.66	$35,391,879.36	$35,922,757.55
Manual Adjustment												
Net Cash Flow	$44,674,690.00	$109,000.00	$31,417,765.00	$31,889,031.48	$32,367,366.95	$32,852,877.45	$33,345,670.61	$33,845,855.67	$34,353,543.51	$34,868,846.66	$35,391,879.36	$35,922,757.55
PV Cash Flows	$44,674,690.00		$31,417,765.00	$31,889,031.48	$32,367,366.95	$32,852,877.45	$33,345,670.61	$33,845,855.67	$34,353,543.51	$34,868,846.66	$35,391,879.36	$35,922,757.55
System E	Discount Rate	3.00%										
	Acquisition	Disposition	1	2	3	4	5	6	7	8	9	10
Cash Flow	$42,097,650.00	$109,000.00	$23,247,190.00	$23,595,897.85	$23,949,836.32	$24,309,083.86	$24,673,720.12	$25,043,825.92	$25,419,483.31	$25,800,775.56	$26,187,787.19	$26,580,604.00
Manual Adjustment												
Net Cash Flow	$42,097,650.00	$109,000.00	$23,247,190.00	$23,595,897.85	$23,949,836.32	$24,309,083.86	$24,673,720.12	$25,043,825.92	$25,419,483.31	$25,800,775.56	$26,187,787.19	$26,580,604.00
PV Cash Flows	$42,097,650.00		$23,247,190.00	$23,595,897.85	$23,949,836.32	$24,309,083.86	$24,673,720.12	$25,043,825.92	$25,419,483.31	$25,800,775.56	$26,187,787.19	$26,580,604.00

Figure 96.   Model Summary Data (Years 1–10)

System A

	11	12	13	14	15	16	17	18	19	20
Cash Flow	$32,804,856.63	$33,296,929.48	$33,796,383.42	$34,303,329.17	$34,817,879.11	$35,340,147.30	$35,870,249.51	$36,408,303.25	$36,954,427.80	$37,508,744.22
Manual Adjustment										
Net Cash Flow	$32,804,856.63	$33,296,929.48	$33,796,383.42	$34,303,329.17	$34,817,879.11	$35,340,147.30	$35,870,249.51	$36,408,303.25	$36,954,427.80	$37,508,744.22
PV Cash Flows	$23,698,926.41	$23,353,796.41	$23,013,692.58	$22,678,541.72	$22,348,271.69	$22,022,811.42	$21,702,090.87	$21,386,041.00	$21,074,593.80	$20,767,682.24

System B

	11	12	13	14	15	16	17	18	19	20
Cash Flow	$34,909,178.27	$35,432,815.94	$35,964,308.18	$36,503,772.80	$37,051,329.40	$37,607,099.34	$38,171,205.83	$38,743,773.91	$39,324,930.52	$39,914,804.48
Manual Adjustment										
Net Cash Flow	$34,909,178.27	$35,432,815.94	$35,964,308.18	$36,503,772.80	$37,051,329.40	$37,607,099.34	$38,171,205.83	$38,743,773.91	$39,324,930.52	$39,914,804.48
PV Cash Flows	$25,219,133.13	$24,851,864.20	$24,489,943.85	$24,133,294.18	$23,781,838.44	$23,435,500.99	$23,094,207.28	$22,757,883.88	$22,426,458.38	$22,099,859.47

System C

	11	12	13	14	15	16	17	18	19	20
Cash Flow	$25,595,530.60	$25,979,463.56	$26,369,155.52	$26,764,692.85	$27,166,163.24	$27,573,655.69	$27,987,260.53	$28,407,069.43	$28,833,175.48	$29,265,673.11
Manual Adjustment										
Net Cash Flow	$25,595,530.60	$25,979,463.56	$26,369,155.52	$26,764,692.85	$27,166,163.24	$27,573,655.69	$27,987,260.53	$28,407,069.43	$28,833,175.48	$29,265,673.11
PV Cash Flows	$18,490,755.89	$18,221,473.04	$17,956,111.78	$17,694,615.01	$17,436,926.44	$17,182,990.62	$16,932,752.89	$16,686,159.40	$16,443,157.08	$16,203,693.63

System D

	11	12	13	14	15	16	17	18	19	20
Cash Flow	$36,461,598.91	$37,008,522.90	$37,563,650.74	$38,127,105.50	$38,699,012.08	$39,279,497.27	$39,868,689.72	$40,466,720.07	$41,073,720.87	$41,689,826.68
Manual Adjustment										
Net Cash Flow	$36,461,598.91	$37,008,522.90	$37,563,650.74	$38,127,105.50	$38,699,012.08	$39,279,497.27	$39,868,689.72	$40,466,720.07	$41,073,720.87	$41,689,826.68
PV Cash Flows	$26,340,634.83	$25,957,033.36	$25,579,018.31	$25,206,508.33	$24,839,423.26	$24,477,684.09	$24,121,212.96	$23,769,933.16	$23,423,769.08	$23,082,646.23

System E

	11	12	13	14	15	16	17	18	19	20
Cash Flow	$26,979,313.06	$27,384,002.76	$27,794,762.80	$28,211,684.24	$28,634,859.51	$29,064,382.40	$29,500,348.13	$29,942,853.36	$30,391,996.16	$30,847,876.10
Manual Adjustment										
Net Cash Flow	$26,979,313.06	$27,384,002.76	$27,794,762.80	$28,211,684.24	$28,634,859.51	$29,064,382.40	$29,500,348.13	$29,942,853.36	$30,391,996.16	$30,847,876.10
PV Cash Flows	$19,490,429.78	$19,206,588.57	$18,926,880.97	$18,651,246.78	$18,379,626.69	$18,111,962.22	$17,848,195.78	$17,588,270.60	$17,332,130.73	$17,079,721.06

Figure 97. Model Summary Data (Years 11–20)

System A

	21	22	23	24	25	26	27	28	29	30
Cash Flow	$38,071,375.38	$38,642,446.01	$39,222,082.70	$39,810,413.94	$40,407,570.15	$41,013,683.70	$41,628,888.96	$42,253,322.29	$42,887,122.13	$43,530,428.96
Manual Adjustment										
Net Cash Flow	$38,071,375.38	$38,642,446.01	$39,222,082.70	$39,810,413.94	$40,407,570.15	$41,013,683.70	$41,628,888.96	$42,253,322.29	$42,887,122.13	$43,530,428.96
PV Cash Flows	$20,465,240.27	$20,167,202.79	$19,873,505.66	$19,584,085.67	$19,298,880.54	$19,017,828.89	$18,740,870.21	$18,467,944.92	$18,198,994.26	$17,933,960.37

System B

	21	22	23	24	25	26	27	28	29	30
Cash Flow	$40,513,526.55	$41,121,229.45	$41,738,047.89	$42,364,118.61	$42,999,580.39	$43,644,574.09	$44,299,242.70	$44,963,731.34	$45,638,187.31	$46,322,760.12
Manual Adjustment										
Net Cash Flow	$40,513,526.55	$41,121,229.45	$41,738,047.89	$42,364,118.61	$42,999,580.39	$43,644,574.09	$44,299,242.70	$44,963,731.34	$45,638,187.31	$46,322,760.12
PV Cash Flows	$21,778,016.86	$21,460,861.28	$21,148,324.46	$20,840,339.15	$20,536,839.07	$20,237,758.89	$19,943,034.24	$19,652,601.71	$19,366,398.77	$19,084,363.83

System C

	21	22	23	24	25	26	27	28	29	30
Cash Flow	$29,704,658.20	$30,150,228.08	$30,602,481.50	$31,061,518.72	$31,527,441.50	$32,000,353.12	$32,480,358.42	$32,967,563.80	$33,462,077.25	$33,964,008.41
Manual Adjustment										
Net Cash Flow	$29,704,658.20	$30,150,228.08	$30,602,481.50	$31,061,518.72	$31,527,441.50	$32,000,353.12	$32,480,358.42	$32,967,563.80	$33,462,077.25	$33,964,008.41
PV Cash Flows	$15,967,717.51	$15,735,177.93	$15,506,024.86	$15,280,208.96	$15,057,681.65	$14,838,395.02	$14,622,301.89	$14,409,355.74	$14,199,510.76	$13,992,721.77

System D

	21	22	23	24	25	26	27	28	29	30
Cash Flow	$42,315,174.08	$42,949,901.70	$43,594,150.22	$44,248,062.47	$44,911,783.41	$45,585,460.16	$46,269,242.07	$46,963,280.70	$47,667,729.91	$48,382,745.86
Manual Adjustment										
Net Cash Flow	$42,315,174.08	$42,949,901.70	$43,594,150.22	$44,248,062.47	$44,911,783.41	$45,585,460.16	$46,269,242.07	$46,963,280.70	$47,667,729.91	$48,382,745.86
PV Cash Flows	$22,746,491.19	$22,415,231.61	$22,088,796.20	$21,767,114.70	$21,450,117.88	$21,137,737.53	$20,829,906.40	$20,526,558.25	$20,227,627.79	$19,933,050.68

System E

	21	22	23	24	25	26	27	28	29	30
Cash Flow	$31,310,594.24	$31,780,253.15	$32,256,956.95	$32,740,811.30	$33,231,923.47	$33,730,402.33	$34,236,358.36	$34,749,903.74	$35,271,152.29	$35,800,219.58
Manual Adjustment										
Net Cash Flow	$31,310,594.24	$31,780,253.15	$32,256,956.95	$32,740,811.30	$33,231,923.47	$33,730,402.33	$34,236,358.36	$34,749,903.74	$35,271,152.29	$35,800,219.58
PV Cash Flows	$16,830,987.26	$16,585,875.80	$16,344,333.92	$16,106,309.64	$15,871,751.73	$15,640,609.71	$15,412,833.84	$15,188,375.10	$14,967,185.17	$14,749,216.45

Figure 98.   Model Summary Data (Years 21–30)

APPENDIX G. SIMULATION REPORT EXCEL SPREADSHEET

Appendix G contains the model's simulation report, including the assumptions and forecast charts, shown in Figures 99-148.

General

Number of Trials	10000
Stop Simulation on Error	No
Random Seed	Random
Enable Correlations	Yes

Figure 99.   General Assumptions

Name	**ield of View (NFOV) Sensors**	**Name**	**Wide Field of View (WFOV) Sensors**	**Name**	**/IR Sensor Manager (ESM)**
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V6	Cell	V7	Cell	V8
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	912807.5	Minimum	4028475	Minimum	268042.5
Most Likely	960850	Most Likely	4240500	Most Likely	282150
Maximum	1008892.5	Maximum	4452525	Maximum	296257.5

Name	**an Machine Interface (HMI)**	**Name**	**Product Support Management**	**Name**	**Design Interface**
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V9	Cell	V10	Cell	V11
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	14003000	Minimum	2707500	Minimum	1747050
Most Likely	14740000	Most Likely	2850000	Most Likely	1839000
Maximum	15477000	Maximum	2992500	Maximum	1930950

Figure 100.   Assumption Inputs, Section 1

Name	Supply Support		Name	Support Equipment		Name	Storage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1991200		Minimum	1926600		Minimum	803700
Most Likely	2096000		Most Likely	2028000		Most Likely	846000
Maximum	2200800		Maximum	2129400		Maximum	888300

Name	Computer Resources		Name	Maintenance Planning and Management		Name	Training and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1261600		Minimum	7913500		Minimum	1010800
Most Likely	1328000		Most Likely	8330000		Most Likely	1064000
Maximum	1394400		Maximum	8746500		Maximum	1117200

Figure 101.   Assumption Inputs, Section 2

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	ield of View (NFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	Z6
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1634000		Minimum	1748000		Minimum	716034
Most Likely	1720000		Most Likely	1840000		Most Likely	753720
Maximum	1806000		Maximum	1932000		Maximum	791406

Name	ield of View (WFOV) Sensors		Name	EO/IR Sensor Manager (ESM)		Name	an Machine Interface (HMI)
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z7		Cell	Z8		Cell	Z9
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2362745		Minimum	262190.5		Minimum	11201982
Most Likely	2487100		Most Likely	275990		Most Likely	11791560
Maximum	2611455		Maximum	289789.5		Maximum	12381138

Figure 102.   Assumption Inputs, Section 3

Name	oduct Support Management		Name	Design Interface		Name	Supply Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z10		Cell	Z11		Cell	Z12
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 3020050, Most Likely: 3179000, Maximum: 3337950)

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 109250, Most Likely: 115000, Maximum: 120750)

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 2303750, Most Likely: 2425000, Maximum: 2546250)

Name	Support Equipment		Name	, Handling, Storage and Transportation		Name	Computer Resources
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z13		Cell	Z14		Cell	Z15
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 2859500, Most Likely: 3010000, Maximum: 3160500)

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 272650, Most Likely: 287000, Maximum: 301350)

Range (Minimum: -Infinity, Maximum: Infinity) — **Distribution: Triangular** (Minimum: 1178950, Most Likely: 1241000, Maximum: 1303050)

Figure 103.   Assumption Inputs, Section 4

Name	Planning and Management	Name	Training and Training Support	Name	Facilities and Infrastructure
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	Z17	Cell	Z18	Cell	Z19
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
		Minimum	495425	Minimum	260300
		Most Likely	521500	Most Likely	274000
		Maximum	547575	Maximum	287700

Invalid Parameters

Name	'echnical Data Management	Name	Assumption (V22)	Name	Assumption (V23)
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	Z20	Cell	V22	Cell	V23
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	466450	Minimum	444410	Minimum	103550
Most Likely	491000	Most Likely	467800	Most Likely	109000
Maximum	515550	Maximum	491190	Maximum	114450

Figure 104.   Assumption Inputs, Section 5

Name	ield of View (NFOV) Sensors	Name	Wide Field of View (WFOV) Sensors	Name	/IR Sensor Manager (ESM)
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V6	Cell	V7	Cell	V8
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	954555.25	Minimum	4305400	Minimum	398824.25
Most Likely	1004795	Most Likely	4532000	Most Likely	419815
Maximum	1055034.75	Maximum	4758600	Maximum	440805.75

Name	an Machine Interface (HMI)	Name	Product Support Management	Name	Design Interface
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V9	Cell	V10	Cell	V11
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	15466000	Minimum	3127400	Minimum	2390200
Most Likely	16280000	Most Likely	3292000	Most Likely	2516000
Maximum	17094000	Maximum	3456600	Maximum	2641800

Figure 105. Assumption Inputs, Section 6

Name	Supply Support	Name	Support Equipment	Name	Storage and Transportation
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V12	Cell	V13	Cell	V14
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	2245800	Minimum	1337600	Minimum	766650
Most Likely	2364000	Most Likely	1408000	Most Likely	807000
Maximum	2482200	Maximum	1478400	Maximum	847350

Name	Computer Resources	Name	Maintenance Planning and Management	Name	ining and Training Support
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V15	Cell	V17	Cell	V18
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	1429560	Minimum	2963050	Minimum	1996900
Most Likely	1504800	Most Likely	3119000	Most Likely	2102000
Maximum	1580040	Maximum	3274950	Maximum	2207100

Figure 106.   Assumption Inputs, Section 7

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1482000		Minimum	1742300		Minimum	444410
Most Likely	1560000		Most Likely	1834000		Most Likely	467800
Maximum	1638000		Maximum	1925700		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ıld of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	103550		Minimum	879472		Minimum	3412238.5
Most Likely	109000		Most Likely	925760		Most Likely	3591830
Maximum	114450		Maximum	972048		Maximum	3771421.5

Figure 107.   Assumption Inputs, Section 8

Name	/IR Sensor Manager (ESM)		Name	Human Machine Interface (HMI)		Name	oduct Support Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z8		Cell	Z9		Cell	Z10
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	386754.5		Minimum	9367850.25		Minimum	1981225
Most Likely	407110		Most Likely	9860895		Most Likely	2085500
Maximum	427465.5		Maximum	10353939.75		Maximum	2189775

Name	Design Interface		Name	Supply Support		Name	Support Equipment
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z11		Cell	Z12		Cell	Z13
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	135375		Minimum	1276800		Minimum	1403150
Most Likely	142500		Most Likely	1344000		Most Likely	1477000
Maximum	149625		Maximum	1411200		Maximum	1550850

Figure 108.   Assumption Inputs, Section 9

Name	Storage and Transportation		Name	Computer Resources		Name	Planning and Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z14		Cell	Z15		Cell	Z17
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	336300		Minimum	3382000			
Most Likely	354000		Most Likely	3560000			
Maximum	371700		Maximum	3738000			

Invalid Parameters

Name	Training and Training Support		Name	Facilities and Infrastructure		Name	Technical Data Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z18		Cell	Z19		Cell	Z20
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	655500		Minimum	583775		Minimum	420850
Most Likely	690000		Most Likely	614500		Most Likely	443000
Maximum	724500		Maximum	645225		Maximum	465150

Figure 109.   Assumption Inputs, Section 10

Name	ield of View (NFOV) Sensors		Name	Wide Field of View (WFOV) Sensors		Name	/IR Sensor Manager (ESM)
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V6		Cell	V7		Cell	V8
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	972686		Minimum	3647050		Minimum	373587.5
Most Likely	1023880		Most Likely	3839000		Most Likely	393250
Maximum	1075074		Maximum	4030950		Maximum	412912.5

Name	an Machine Interface (HMI)		Name	Product Support Management		Name	Design Interface
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V9		Cell	V10		Cell	V11
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	14530725		Minimum	2149850		Minimum	2380700
Most Likely	15295500		Most Likely	2263000		Most Likely	2506000
Maximum	16060275		Maximum	2376150		Maximum	2631300

Figure 110.   Assumption Inputs, Section 11

Name	Supply Support		Name	Support Equipment		Name	Storage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2825300		Minimum	1638750		Minimum	525350
Most Likely	2974000		Most Likely	1725000		Most Likely	553000
Maximum	3122700		Maximum	1811250		Maximum	580650

Name	Computer Resources		Name	Maintenance Planning and Management		Name	Training and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1229300		Minimum	3541600		Minimum	2330350
Most Likely	1294000		Most Likely	3728000		Most Likely	2453000
Maximum	1358700		Maximum	3914400		Maximum	2575650

Figure 111.   Assumption Inputs, Section 12

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	1271100		Minimum	2660000		Minimum	444410
Most Likely	1338000		Most Likely	2800000		Most Likely	467800
Maximum	1404900		Maximum	2940000		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ild of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	103550		Minimum	744092.25		Minimum	2933158.25
Most Likely	109000		Most Likely	783255		Most Likely	3087535
Maximum	114450		Maximum	822417.75		Maximum	3241911.75

Figure 112.   Assumption Inputs, Section 13

Name	/IR Sensor Manager (ESM)
Enabled	Yes
Cell	Z8
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	313709
Most Likely	330220
Maximum	346731

Name	Human Machine Interface (HMI)
Enabled	Yes
Cell	Z9
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	7724849
Most Likely	8131420
Maximum	8537991

Name	oduct Support Management
Enabled	Yes
Cell	Z10
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1706200
Most Likely	1796000
Maximum	1885800

Name	Design Interface
Enabled	Yes
Cell	Z11
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	142975
Most Likely	150500
Maximum	158025

Name	Supply Support
Enabled	Yes
Cell	Z12
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1474305
Most Likely	1551900
Maximum	1629495

Name	Support Equipment
Enabled	Yes
Cell	Z13
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1377500
Most Likely	1450000
Maximum	1522500

Figure 113.   Assumption Inputs, Section 14

Name	Storage and Transportation		Name	Computer Resources		Name	Planning and Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z14		Cell	Z15		Cell	Z17
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	322050		Minimum	939550			
Most Likely	339000		Most Likely	989000			
Maximum	355950		Maximum	1038450			

Name	Training and Training Support		Name	Facilities and Infrastructure		Name	Technical Data Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z18		Cell	Z19		Cell	Z20
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	681150		Minimum	493525		Minimum	803225
Most Likely	717000		Most Likely	519500		Most Likely	845500
Maximum	752850		Maximum	545475		Maximum	887775

Figure 114.   Assumption Inputs, Section 15

Name	ield of View (NFOV) Sensors	Name	Wide Field of View (WFOV) Sensors	Name	/IR Sensor Manager (ESM)
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V6	Cell	V7	Cell	V8
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	731395.5	Minimum	3667950	Minimum	2852850
Most Likely	769890	Most Likely	3861000	Most Likely	3003000
Maximum	808384.5	Maximum	4054050	Maximum	3153150

Name	an Machine Interface (HMI)	Name	Product Support Management	Name	Design Interface
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V9	Cell	V10	Cell	V11
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	14212000	Minimum	1581750	Minimum	2981100
Most Likely	14960000	Most Likely	1665000	Most Likely	3138000
Maximum	15708000	Maximum	1748250	Maximum	3294900

Figure 115.   Assumption Inputs, Section 16

Name	Supply Support		Name	Support Equipment		Name	Storage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1750850		Minimum	1625450		Minimum	800850
Most Likely	1843000		Most Likely	1711000		Most Likely	843000
Maximum	1935150		Maximum	1796550		Maximum	885150

Name	Computer Resources		Name	Maintenance Planning and Management		Name	ining and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1853450		Minimum	3151150		Minimum	2807250
Most Likely	1951000		Most Likely	3317000		Most Likely	2955000
Maximum	2048550		Maximum	3482850		Maximum	3102750

Figure 116.   Assumption Inputs, Section 17

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	890150		Minimum	1818300		Minimum	444410
Most Likely	937000		Most Likely	1914000		Most Likely	467800
Maximum	983850		Maximum	2009700		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ald of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	103550		Minimum	770426.25		Minimum	2435372.5
Most Likely	109000		Most Likely	810975		Most Likely	2563550
Maximum	114450		Maximum	851523.75		Maximum	2691727.5

Figure 117.   Assumption Inputs, Section 18

Name	Supply Support		Name	Support Equipment		Name	Storage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1991200		Minimum	1926600		Minimum	803700
Most Likely	2096000		Most Likely	2028000		Most Likely	846000
Maximum	2200800		Maximum	2129400		Maximum	888300

Name	Computer Resources		Name	Maintenance Planning and Management		Name	ining and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1261600		Minimum	7913500		Minimum	1010800
Most Likely	1328000		Most Likely	8330000		Most Likely	1064000
Maximum	1394400		Maximum	8746500		Maximum	1117200

Figure 118.   Assumption Inputs, Section 19

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	ield of View (NFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	Z6
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1634000		Minimum	1748000		Minimum	716034
Most Likely	1720000		Most Likely	1840000		Most Likely	753720
Maximum	1806000		Maximum	1932000		Maximum	791406

Name	ield of View (WFOV) Sensors		Name	EO/IR Sensor Manager (ESM)		Name	an Machine Interface (HMI)
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z7		Cell	Z8		Cell	Z9
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2362745		Minimum	262190.5		Minimum	11201982
Most Likely	2487100		Most Likely	275990		Most Likely	11791560
Maximum	2611455		Maximum	289789.5		Maximum	12381138

Figure 119.   Assumption Inputs, Section 20

Name	oduct Support Management		Name	Design Interface		Name	Supply Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z10		Cell	Z11		Cell	Z12
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	3020050		Minimum	109250		Minimum	2303750
Most Likely	3179000		Most Likely	115000		Most Likely	2425000
Maximum	3337950		Maximum	120750		Maximum	2546250

Name	Support Equipment		Name	, Handling, Storage and Transportation		Name	Computer Resources
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z13		Cell	Z14		Cell	Z15
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2859500		Minimum	272650		Minimum	1178950
Most Likely	3010000		Most Likely	287000		Most Likely	1241000
Maximum	3160500		Maximum	301350		Maximum	1303050

Figure 120.   Assumption Inputs, Section 21

Planning and Management

Enabled	Yes
Cell	Z17
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular

Invalid Parameters

Training and Training Support

Enabled	Yes
Cell	Z18
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular
Minimum	495425
Most Likely	521500
Maximum	547575

Facilities and Infrastructure

Enabled	Yes
Cell	Z19
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular
Minimum	260300
Most Likely	274000
Maximum	287700

Technical Data Management

Enabled	Yes
Cell	Z20
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular
Minimum	466450
Most Likely	491000
Maximum	515550

Assumption (V22)

Enabled	Yes
Cell	V22
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular
Minimum	444410
Most Likely	467800
Maximum	491190

Assumption (V23)

Enabled	Yes
Cell	V23
Dynamic Simulation	No
Range	
Minimum	-Infinity
Maximum	Infinity
Distribution	Triangular
Minimum	103550
Most Likely	109000
Maximum	114450

Figure 121.   Assumption Inputs, Section 22

Name	ield of View (NFOV) Sensors
Enabled	Yes
Cell	V6
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	954555.25
Most Likely	1004795
Maximum	1055034.75

Name	Wide Field of View (WFOV) Sensors
Enabled	Yes
Cell	V7
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	4305400
Most Likely	4532000
Maximum	4758600

Name	/IR Sensor Manager (ESM)
Enabled	Yes
Cell	V8
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	398824.25
Most Likely	419815
Maximum	440805.75

Name	an Machine Interface (HMI)
Enabled	Yes
Cell	V9
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	15466000
Most Likely	16280000
Maximum	17094000

Name	Product Support Management
Enabled	Yes
Cell	V10
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	3127400
Most Likely	3292000
Maximum	3456600

Name	Design Interface
Enabled	Yes
Cell	V11
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	2390200
Most Likely	2516000
Maximum	2641800

Figure 122.   Assumption Inputs, Section 23

Name	Supply Support		Name	Support Equipment		Name	torage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2245800		Minimum	1337600		Minimum	766650
Most Likely	2364000		Most Likely	1408000		Most Likely	807000
Maximum	2482200		Maximum	1478400		Maximum	847350

Name	Computer Resources		Name	Maintenance Planning and Management		Name	ining and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1429560		Minimum	2963050		Minimum	1996900
Most Likely	1504800		Most Likely	3119000		Most Likely	2102000
Maximum	1580040		Maximum	3274950		Maximum	2207100

Figure 123.   Assumption Inputs, Section 24

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	1482000		Minimum	1742300		Minimum	444410
Most Likely	1560000		Most Likely	1834000		Most Likely	467800
Maximum	1638000		Maximum	1925700		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ild of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	103550		Minimum	879472		Minimum	3412238.5
Most Likely	109000		Most Likely	925760		Most Likely	3591830
Maximum	114450		Maximum	972048		Maximum	3771421.5

Figure 124.   Assumption Inputs, Section 25

Name	/IR Sensor Manager (ESM)
Enabled	Yes
Cell	Z8
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	386754.5
Most Likely	407110
Maximum	427465.5

Name	Human Machine Interface (HMI)
Enabled	Yes
Cell	Z9
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	9367850.25
Most Likely	9860895
Maximum	10353939.75

Name	oduct Support Management
Enabled	Yes
Cell	Z10
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1981225
Most Likely	2085500
Maximum	2189775

Name	Design Interface
Enabled	Yes
Cell	Z11
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	135375
Most Likely	142500
Maximum	149625

Name	Supply Support
Enabled	Yes
Cell	Z12
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1276800
Most Likely	1344000
Maximum	1411200

Name	Support Equipment
Enabled	Yes
Cell	Z13
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1403150
Most Likely	1477000
Maximum	1550850

Figure 125.   Assumption Inputs, Section 26

Name	Storage and Transportation		Name	Computer Resources		Name	Planning and Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z14		Cell	Z15		Cell	Z17
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	336300		Minimum	3382000			
Most Likely	354000		Most Likely	3560000			
Maximum	371700		Maximum	3738000			

Invalid Parameters

Name	Training and Training Support		Name	Facilities and Infrastructure		Name	Technical Data Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z18		Cell	Z19		Cell	Z20
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	655500		Minimum	583775		Minimum	420850
Most Likely	690000		Most Likely	614500		Most Likely	443000
Maximum	724500		Maximum	645225		Maximum	465150

Figure 126.   Assumption Inputs, Section 27

Name	ield of View (NFOV) Sensors		Name	Wide Field of View (WFOV) Sensors		Name	/IR Sensor Manager (ESM)
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V6		Cell	V7		Cell	V8
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	972686		Minimum	3647050		Minimum	373587.5
Most Likely	1023880		Most Likely	3839000		Most Likely	393250
Maximum	1075074		Maximum	4030950		Maximum	412912.5

Name	an Machine Interface (HMI)		Name	Product Support Management		Name	Design Interface
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V9		Cell	V10		Cell	V11
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	14530725		Minimum	2149850		Minimum	2380700
Most Likely	15295500		Most Likely	2263000		Most Likely	2506000
Maximum	16060275		Maximum	2376150		Maximum	2631300

Figure 127.   Assumption Inputs, Section 28

Name	Supply Support
Enabled	Yes
Cell	V12
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	2825300
Most Likely	2974000
Maximum	3122700

Name	Support Equipment
Enabled	Yes
Cell	V13
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1638750
Most Likely	1725000
Maximum	1811250

Name	Storage and Transportation
Enabled	Yes
Cell	V14
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	525350
Most Likely	553000
Maximum	580650

Name	Computer Resources
Enabled	Yes
Cell	V15
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1229300
Most Likely	1294000
Maximum	1358700

Name	Maintenance Planning and Management
Enabled	Yes
Cell	V17
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	3541600
Most Likely	3728000
Maximum	3914400

Name	Training and Training Support
Enabled	Yes
Cell	V18
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	2330350
Most Likely	2453000
Maximum	2575650

Figure 128.   Assumption Inputs, Section 29

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1271100		Minimum	2660000		Minimum	444410
Most Likely	1338000		Most Likely	2800000		Most Likely	467800
Maximum	1404900		Maximum	2940000		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ald of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	103550		Minimum	744092.25		Minimum	2933158.25
Most Likely	109000		Most Likely	783255		Most Likely	3087535
Maximum	114450		Maximum	822417.75		Maximum	3241911.75

Figure 129.   Assumption Inputs, Section 30

Name	/IR Sensor Manager (ESM)		Name	Human Machine Interface (HMI)		Name	oduct Support Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z8		Cell	Z9		Cell	Z10
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	313709		Minimum	7724849		Minimum	1706200
Most Likely	330220		Most Likely	8131420		Most Likely	1796000
Maximum	346731		Maximum	8537991		Maximum	1885800

Name	Design Interface		Name	Supply Support		Name	Support Equipment
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z11		Cell	Z12		Cell	Z13
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	142975		Minimum	1474305		Minimum	1377500
Most Likely	150500		Most Likely	1551900		Most Likely	1450000
Maximum	158025		Maximum	1629495		Maximum	1522500

Figure 130.   Assumption Inputs, Section 31

Name	Storage and Transportation		Name	Computer Resources		Name	Planning and Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z14		Cell	Z15		Cell	Z17
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	322050		Minimum	939550			
Most Likely	339000		Most Likely	989000			
Maximum	355950		Maximum	1038450			

Invalid Parameters

Name	Training and Training Support		Name	Facilities and Infrastructure		Name	Technical Data Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z18		Cell	Z19		Cell	Z20
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range			Range			Range	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity

Distribution	Triangular		Distribution	Triangular		Distribution	Triangular
Minimum	681150		Minimum	493525		Minimum	803225
Most Likely	717000		Most Likely	519500		Most Likely	845500
Maximum	752850		Maximum	545475		Maximum	887775

Figure 131.   Assumption Inputs, Section 32

Name	ield of View (NFOV) Sensors	Name	Wide Field of View (WFOV) Sensors	Name	/IR Sensor Manager (ESM)
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V6	Cell	V7	Cell	V8
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	731395.5	Minimum	3667950	Minimum	2852850
Most Likely	769890	Most Likely	3861000	Most Likely	3003000
Maximum	808384.5	Maximum	4054050	Maximum	3153150

Name	an Machine Interface (HMI)	Name	Product Support Management	Name	Design Interface
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V9	Cell	V10	Cell	V11
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	14212000	Minimum	1581750	Minimum	2981100
Most Likely	14960000	Most Likely	1665000	Most Likely	3138000
Maximum	15708000	Maximum	1748250	Maximum	3294900

Figure 132.   Assumption Inputs, Section 33

Name	Supply Support		Name	Support Equipment		Name	Storage and Transportation
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V12		Cell	V13		Cell	V14
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1750850		Minimum	1625450		Minimum	800850
Most Likely	1843000		Most Likely	1711000		Most Likely	843000
Maximum	1935150		Maximum	1796550		Maximum	885150

Name	Computer Resources		Name	Maintenance Planning and Management		Name	Training and Training Support
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V15		Cell	V17		Cell	V18
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1853450		Minimum	3151150		Minimum	2807250
Most Likely	1951000		Most Likely	3317000		Most Likely	2955000
Maximum	2048550		Maximum	3482850		Maximum	3102750

Figure 133.   Assumption Inputs, Section 34

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	890150		Minimum	1818300		Minimum	444410
Most Likely	937000		Most Likely	1914000		Most Likely	467800
Maximum	983850		Maximum	2009700		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ald of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	103550		Minimum	770426.25		Minimum	2435372.5
Most Likely	109000		Most Likely	810975		Most Likely	2563550
Maximum	114450		Maximum	851523.75		Maximum	2691727.5

Figure 134.   Assumption Inputs, Section 35

Name	/IR Sensor Manager (ESM)		Name	Human Machine Interface (HMI)		Name	oduct Support Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z8		Cell	Z9		Cell	Z10
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2876153.5		Minimum	14317649.5		Minimum	1434975
Most Likely	3027530		Most Likely	15071210		Most Likely	1510500
Maximum	3178906.5		Maximum	15824770.5		Maximum	1586025

Name	Design Interface		Name	Supply Support		Name	Support Equipment
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z11		Cell	Z12		Cell	Z13
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	180975		Minimum	1235000		Minimum	1828275
Most Likely	190500		Most Likely	1300000		Most Likely	1924500
Maximum	200025		Maximum	1365000		Maximum	2020725

Figure 135. Assumption Inputs, Section 36

Name	Storage and Transportation	Name	Computer Resources	Name	Planning and Management
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	Z14	Cell	Z15	Cell	Z17
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		Range		Range	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	Distribution	Triangular	Distribution	Triangular
Minimum	308750	Minimum	1108650		
Most Likely	325000	Most Likely	1167000		
Maximum	341250	Maximum	1225350		

Invalid Parameters

Name	ining and Training Support	Name	Facilities and Infrastructure	Name	echnical Data Management
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	Z18	Cell	Z19	Cell	Z20
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No

Range		Range		Range	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity

Distribution	Triangular	Distribution	Triangular	Distribution	Triangular
Minimum	805600	Minimum	526300	Minimum	838850
Most Likely	848000	Most Likely	554000	Most Likely	883000
Maximum	890400	Maximum	581700	Maximum	927150

Figure 136.   Assumption Inputs, Section 37

Name ield of View (NFOV) Sensors
Enabled: Yes
Cell: V6
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 912807.5
Most Likely: 960850
Maximum: 1008892.5

Name Wide Field of View (WFOV) Sensors
Enabled: Yes
Cell: V7
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 4305400
Most Likely: 4532000
Maximum: 4758600

Name /IR Sensor Manager (ESM)
Enabled: Yes
Cell: V8
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 2852850
Most Likely: 3003000
Maximum: 3153150

Name an Machine Interface (HMI)
Enabled: Yes
Cell: V9
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 11651750
Most Likely: 12265000
Maximum: 12878250

Name Product Support Management
Enabled: Yes
Cell: V10
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 2149850
Most Likely: 2263000
Maximum: 2376150

Name Design Interface
Enabled: Yes
Cell: V11
Dynamic Simulation: No

Range
Minimum: -Infinity
Maximum: Infinity

Distribution Triangular
Minimum: 1747050
Most Likely: 1839000
Maximum: 1930950

Figure 137. Assumption Inputs, Section 38

Name	Supply Support	Name	Support Equipment	Name	Storage and Transportation
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V12	Cell	V13	Cell	V14
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	1837300	Minimum	1772700	Minimum	766650
Most Likely	1934000	Most Likely	1866000	Most Likely	807000
Maximum	2030700	Maximum	1959300	Maximum	847350

Name	Computer Resources	Name	Maintenance Planning and Management	Name	ining and Training Support
Enabled	Yes	Enabled	Yes	Enabled	Yes
Cell	V15	Cell	V17	Cell	V18
Dynamic Simulation	No	Dynamic Simulation	No	Dynamic Simulation	No
Range		**Range**		**Range**	
Minimum	-Infinity	Minimum	-Infinity	Minimum	-Infinity
Maximum	Infinity	Maximum	Infinity	Maximum	Infinity
Distribution	Triangular	**Distribution**	Triangular	**Distribution**	Triangular
Minimum	1261600	Minimum	3541600	Minimum	1010800
Most Likely	1328000	Most Likely	3728000	Most Likely	1064000
Maximum	1394400	Maximum	3914400	Maximum	1117200

Figure 138.   Assumption Inputs, Section 39

Name	Facilities and Infrastructure		Name	Technical Data Management		Name	Acquisition Costs
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V19		Cell	V20		Cell	V22
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1482000		Minimum	2660000		Minimum	444410
Most Likely	1560000		Most Likely	2800000		Most Likely	467800
Maximum	1638000		Maximum	2940000		Maximum	491190

Name	nd of Life Disposition Costs		Name	w-Medium Field of View (NFOV) Sensors		Name	ıld of View (WFOV) Sensors
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V23		Cell	Z6		Cell	Z7
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	103550		Minimum	669897.25		Minimum	3418769.75
Most Likely	109000		Most Likely	705155		Most Likely	3598705
Maximum	114450		Maximum	740412.75		Maximum	3778640.25

Figure 139.   Assumption Inputs, Section 40

Name	/IR Sensor Manager (ESM)		Name	Human Machine Interface (HMI)		Name	oduct Support Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z8		Cell	Z9		Cell	Z10
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	2131643.25		Minimum	7712570.25		Minimum	1602175
Most Likely	2243835		Most Likely	8118495		Most Likely	1686500
Maximum	2356026.75		Maximum	8524419.75		Maximum	1770825

Name	Design Interface		Name	Supply Support		Name	Support Equipment
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z11		Cell	Z12		Cell	Z13
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	80750		Minimum	1401250		Minimum	1418350
Most Likely	85000		Most Likely	1475000		Most Likely	1493000
Maximum	89250		Maximum	1548750		Maximum	1567650

Figure 140.   Assumption Inputs, Section 41

Name	Storage and Transportation		Name	Computer Resources		Name	Planning and Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z14		Cell	Z15		Cell	Z17
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range
 Minimum -Infinity
 Maximum Infinity

Range
 Minimum -Infinity
 Maximum Infinity

Range
 Minimum -Infinity
 Maximum Infinity

Distribution Triangular
 Minimum 265050
 Most Likely 279000
 Maximum 292950

Distribution Triangular

Distribution Triangular

Invalid Parameters

Invalid Parameters

Name	ining and Training Support		Name	Facilities and Infrastructure		Name	echnical Data Management
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z18		Cell	Z19		Cell	Z20
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No

Range
 Minimum -Infinity
 Maximum Infinity

Range
 Minimum -Infinity
 Maximum Infinity

Range
 Minimum -Infinity
 Maximum Infinity

Distribution Triangular
 Minimum 340100
 Most Likely 358000
 Maximum 375900

Distribution Triangular
 Minimum 634125
 Most Likely 667500
 Maximum 700875

Distribution Triangular
 Minimum 922450
 Most Likely 971000
 Maximum 1019550

Figure 141.   Assumption Inputs, Section 42

Name	Manpower and Personnel		Name	Manpower and Personnel		Name	Manpower and Personnel
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	V16		Cell	Z16		Cell	V16
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	1614050		Minimum	1344250		Minimum	1567500
Most Likely	1699000		Most Likely	1415000		Most Likely	1650000
Maximum	1783950		Maximum	1485750		Maximum	1732500

Name	Manpower and Personnel		Name	Manpower and Personnel		Name	Manpower and Personnel
Enabled	Yes		Enabled	Yes		Enabled	Yes
Cell	Z16		Cell	V16		Cell	Z16
Dynamic Simulation	No		Dynamic Simulation	No		Dynamic Simulation	No
Range			**Range**			**Range**	
Minimum	-Infinity		Minimum	-Infinity		Minimum	-Infinity
Maximum	Infinity		Maximum	Infinity		Maximum	Infinity
Distribution	Triangular		**Distribution**	Triangular		**Distribution**	Triangular
Minimum	4354800		Minimum	1596000		Minimum	1295800
Most Likely	4584000		Most Likely	1680000		Most Likely	1364000
Maximum	4813200		Maximum	1764000		Maximum	1432200

Figure 142.   Assumption Inputs, Section 43

Name	Manpower and Personnel
Enabled	Yes
Cell	V16
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1272050
Most Likely	1339000
Maximum	1405950

Name	Manpower and Personnel
Enabled	Yes
Cell	Z16
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1179900
Most Likely	1242000
Maximum	1304100

Name	Manpower and Personnel
Enabled	Yes
Cell	V16
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1596000
Most Likely	1680000
Maximum	1764000

Name	Manpower and Personnel
Enabled	Yes
Cell	Z16
Dynamic Simulation	No

Range	
Minimum	-Infinity
Maximum	Infinity

Distribution	Triangular
Minimum	1487700
Most Likely	1566000
Maximum	1644300

Figure 143.   Assumption Inputs, Section 44

Name	'ost for System A (20 Years)	
Enabled	Yes	
Cell	S42	
Forecast Precision		
Precision Level	---	
Error Level	---	

Number of Datapoints	10000
Mean	700128499.5729
Median	700141006.8461
Standard Deviation	6257100.7952
Variance	39151310360874.4000
Coefficient of Variation	0.0089
Maximum	721408465.7244
Minimum	679850811.0946
Range	41557654.6298
Skewness	-0.0032
Kurtosis	-0.4009
25% Percentile	695719253.6707
75% Percentile	704532335.3674
Error Precision at 95%	0.0002
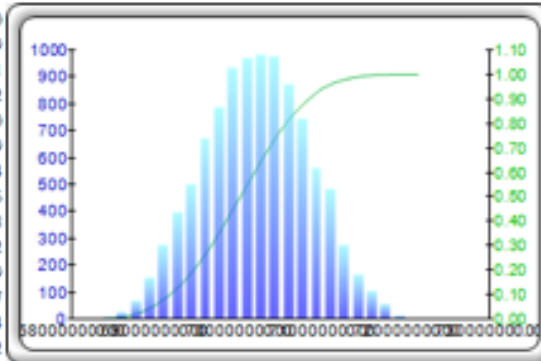
Name	'ost for System A (20 Years)	
Enabled	Yes	
Cell	S43	
Forecast Precision		
Precision Level	---	
Error Level	---	

Number of Datapoints	10000
Mean	525611374.4636
Median	525610342.2660
Standard Deviation	4594559.4320
Variance	21109976373830.8000
Coefficient of Variation	0.0087
Maximum	541361082.8890
Minimum	510709204.6509
Range	30651878.2380
Skewness	-0.0023
Kurtosis	-0.3995
25% Percentile	522378543.3457
75% Percentile	528851703.1087
Error Precision at 95%	0.0002
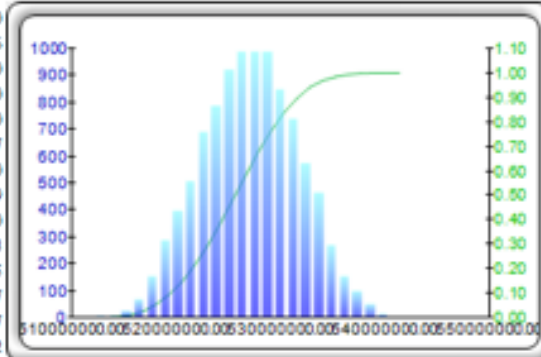
Figure 144.   System A Forecast Charts

Name	ost for System B (25 Years)		Number of Datapoints	10000
Enabled		Yes	Mean	554838179.4832
Cell		S43	Median	554835058.6244
			Standard Deviation	4292302.3489
Forecast Precision			Variance	18423859454217.4000
Precision Level		—	Coefficient of Variation	0.0077
Error Level		—	Maximum	569528468.1574
			Minimum	539393598.5255
			Range	30134869.6320
			Skewness	-0.0028
			Kurtosis	-0.2616
			25% Percentile	551839791.4676
			75% Percentile	557822109.3683
			Error Precision at 95%	0.0002

Name	ost for System C (20 Years)		Number of Datapoints	10000
Enabled		Yes	Mean	554392425.6018
Cell		S42	Median	554384371.6725
			Standard Deviation	4467888.2667
Forecast Precision			Variance	19962025563436.5000
Precision Level		—	Coefficient of Variation	0.0081
Error Level		—	Maximum	568380140.1370
			Minimum	540339232.6703
			Range	28040907.4667
			Skewness	-0.0148
			Kurtosis	-0.3281
			25% Percentile	551284478.5473
			75% Percentile	557526620.0829
			Error Precision at 95%	0.0002

Figure 145.   System B Forecast Charts

Name	lost for System C (20 Years)	Number of Datapoints	10000
Enabled	Yes	Mean	554392425.6018
Cell	S42	Median	554384371.6725
		Standard Deviation	4467888.2667
Forecast Precision		Variance	19962025563436.5000
Precision Level	---	Coefficient of Variation	0.0081
Error Level	---	Maximum	568380140.1370
		Minimum	540339232.6703
		Range	28040907.4667
		Skewness	-0.0148
		Kurtosis	-0.3281
		25% Percentile	551284478.5473
		75% Percentile	557526620.0829
		Error Precision at 95%	0.0002

Name	lost for System C (20 Years)	Number of Datapoints	10000
Enabled	Yes	Mean	418238633.1714
Cell	S43	Median	418245556.2109
		Standard Deviation	3283147.5083
Forecast Precision		Variance	10779057561551.8000
Precision Level	---	Coefficient of Variation	0.0078
Error Level	---	Maximum	428545963.6944
		Minimum	407787597.4511
		Range	20758366.2432
		Skewness	-0.0144
		Kurtosis	-0.3249
		25% Percentile	415958053.4937
		75% Percentile	420545180.5655
		Error Precision at 95%	0.0002

Figure 146.   System C Forecast Charts

Name	Cost for System D (10 Years)		Number of Datapoints	10000
Enabled	Yes		Mean	771338025.7674
Cell	S42		Median	771364875.2786
			Standard Deviation	7611267.4516
Forecast Precision			Variance	57931392219807.8000
Precision Level	—		Coefficient of Variation	0.0099
Error Level	—		Maximum	792265719.5161
			Minimum	748640296.9470
			Range	43625422.5691
			Skewness	-0.0026
			Kurtosis	-0.5003
			25% Percentile	765796106.3305
			75% Percentile	776618455.9241
			Error Precision at 95%	0.0002

Name	Cost for System D (10 Years)		Number of Datapoints	10000
Enabled	Yes		Mean	577371510.6202
Cell	S43		Median	577382472.4683
			Standard Deviation	5583858.7785
Forecast Precision			Variance	31179478858228.8000
Precision Level	—		Coefficient of Variation	0.0097
Error Level	—		Maximum	592883001.8592
			Minimum	560676945.0087
			Range	32206056.8506
			Skewness	-0.0026
			Kurtosis	-0.4998
			25% Percentile	573311007.8159
			75% Percentile	581253957.8264
			Error Precision at 95%	0.0002
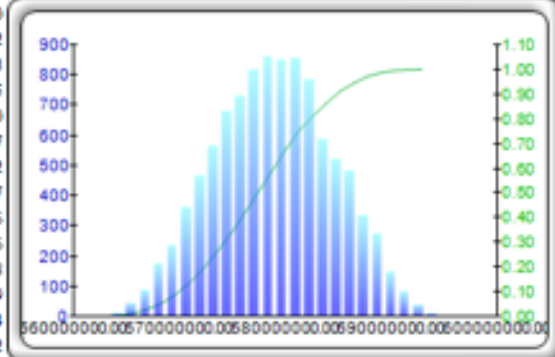
Figure 147.   System D Forecast Charts

Name	'ost for System E (15 Years)	Number of Datapoints	10000	
Enabled	Yes	Mean	579775293.6160	
Cell	S42	Median	579759448.5435	
		Standard Deviation	4630641.3669	
Forecast Precision		Variance	21442839468964.5000	
Precision Level	---	Coefficient of Variation	0.0080	
Error Level	---	Maximum	595514481.6637	
		Minimum	564025304.8221	
		Range	31489176.8416	
		Skewness	0.0087	
		Kurtosis	-0.3088	
		25% Percentile	576509002.8437	
		75% Percentile	582946797.5310	
		Error Precision at 95%	0.0002	
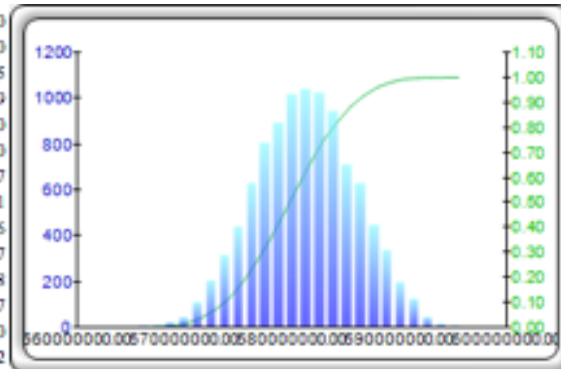
Name	'ost for System E (15 Years)	Number of Datapoints	10000	
Enabled	Yes	Mean	436248097.0794	
Cell	S43	Median	436233772.7799	
		Standard Deviation	3400790.3944	
Forecast Precision		Variance	11565375306498.5000	
Precision Level	---	Coefficient of Variation	0.0078	
Error Level	---	Maximum	447659644.9661	
		Minimum	424678356.3493	
		Range	22981288.6168	
		Skewness	0.0091	
		Kurtosis	-0.3093	
		25% Percentile	433851693.6435	
		75% Percentile	438577466.9908	
		Error Precision at 95%	0.0002	
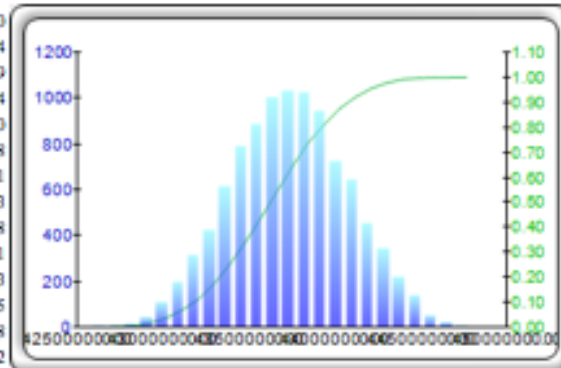
Figure 148. System E Forecast Charts

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APPENDIX H. TORNADO ANALYSIS REPORT EXCEL SPREADSHEET

Appendix H contains the model's Excel spreadsheet for the data used to produce the tornado chart, shown in Figure 149.

Tornado Charts

	Base Value:		$ 700,073,991.93	Input Changes		
	Output Downside	Output Upside	Effective Range	Input Downside	Input Upside	Base Case Value
Ancillary Material No. of Platforms	$ 686,113,489.85	$ 714,034,494.01	$ 27,921,004.16	49.5	60.5	55
Ancilliary Material No. Unit per System	$ 686,113,489.85	$ 714,034,494.01	$ 27,921,004.16	27	33	30
Ancilliary Material Replacement Parts per Year	$ 687,101,614.69	$ 713,046,369.18	$ 25,944,754.49	$3,060.00	$3,740.00	$3,400.00
HMI-C No. of Units per System	$ 689,832,070.89	$ 710,315,912.98	$ 20,483,842.10	13.5	16.5	15
HMI-C No. of Platforms	$ 689,832,070.89	$ 710,315,912.98	$ 20,483,842.10	49.5	60.5	55
Annual Growth or Decline Curve	$ 690,507,104.82	$ 709,816,462.93	$ 19,309,358.10	1.35%	1.65%	1.50%
HMI-C Replacement Parts per Year	$ 690,535,479.25	$ 709,612,504.61	$ 19,077,025.36	$4,500.00	$5,500.00	$5,000.00
Full Scale Production No. of Units per System	$ 696,515,441.87	$ 703,632,542.00	$ 7,117,100.13	27	33	30
Full Scale Production No. of Platforms	$ 696,515,441.87	$ 703,632,542.00	$ 7,117,100.13	0.9	1.1	1
Full Scale Production Operational Cost per Year	$ 696,605,441.87	$ 703,542,542.00	$ 6,937,100.13	$45,000.00	$55,000.00	$50,000.00
HMI-B No. of Platforms	$ 696,697,692.66	$ 703,450,291.20	$ 6,752,598.54	49.5	60.5	55
HMI-B No. of Units per System	$ 696,697,692.66	$ 703,450,291.20	$ 6,752,598.54	4.5	5.5	5
HMI-B Replacement Parts per Year	$ 696,894,487.71	$ 703,253,496.16	$ 6,359,008.45	$4,500.00	$5,500.00	$5,000.00
Ancillary Equipment No. of Units per System	$ 697,659,992.39	$ 702,487,991.48	$ 4,827,999.09	8.1	9.9	9
Ancillary Equipment No. of Platforms	$ 697,659,992.39	$ 702,487,991.48	$ 4,827,999.09	0.9	1.1	1
Special Tools & Equipment No. of Units per System	$ 697,892,565.09	$ 702,255,418.77	$ 4,362,853.68	7.2	8.8	8
Special Tools & Equipment No. of Platforms	$ 697,892,565.09	$ 702,255,418.77	$ 4,362,853.68	0.9	1.1	1
Other Wide Field of View (WFOV) Sensors No. of Platf	$ 698,074,257.39	$ 702,073,726.47	$ 3,999,469.08	49.5	60.5	55
Other Wide Field of View (WFOV) Sensors No. of Unit	$ 698,074,257.39	$ 702,073,726.47	$ 3,999,469.08	5.4	6.6	6
Other Wide Field of View (WFOV) Sensors Replacemen	$ 698,242,597.50	$ 701,905,386.37	$ 3,662,788.87	$2,160.00	$2,640.00	$2,400.00

Figure 149.   Tornado Chart Top 20 Variable Data

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