AN ANALYSIS OF AIRCRAFT OPERATING AND SUPPORT COST ELEMENT STRUCTURES AND THEIR CONTRIBUTION TO TOTAL COSTS

THESIS

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AFIT-ENV-MS-18-M-227

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Wright-Patterson Air Force Base, Ohio

AFIT-ENV-MS-18-M-227

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THESIS

Presented to the Faculty

Department of Systems Engineering and Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Cost Analysis

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March 2018

AFIT-ENV-MS-18-M-227

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AFIT-ENV-MS-18-M-227

Abstract

As the cost of DoD Weapon Systems continue to increase, the ability to more accurately predict the Operating and Support (O&S) costs for the various weapon systems has become more vital for long run affordability. The investigation into the O&S arena has been overshadowed by the research and development (R&D) and acquisition fields. This research focuses on the O&S portion of the total life cycle costs, specifically the OSD-CAPE Cost Element Structure (CES) elements and sub-elements. The research investigates seven categories of 52 aircrafts and their cost expenditures within the CES from the years 1996-2016. The first portion of the analysis investigates the descriptive statistics for the 52 aircrafts and their respective categories. The second portion focused on utilizing statistical tests to compare and contrasts the findings from question one to illustrate the similarities and differences by cost expenditures depending on aircraft category. Lastly, we investigate if the elements/sub-elements could be used as metrics to each other through a multivariate correlation analysis. DoD Cost Estimators and stakeholders alike can benefit from this research by utilizing the results as baselines for future analogy based estimates.

Dedication

This Thesis is dedicated to my family, friends, and professors who have supported me throughout my educational career. Especially to those who have never given up on me and encouraged me to always strive to do better.

Acknowledgments

I would like to deeply thank my research advisor, Lt Col (Ret.) Daniel Ritschel for his guidance and support throughout this thesis process. I appreciate his advice and encouragement while also holding me accountable to produce a thesis that will benefit the cost analysis community. I would also like to thank Dr. Edward White for his in-depth expertise within the field of statistics. His in-depth knowledge in the field allowed to complete this thesis research. I would also like to thank my sponsor, Captain Gregory Brown, for his support and providing the initial questions in which we based this research on. Lastly, I would like to thank GCA 18M for making my AFIT experience enjoyable and a time I will cherish.

Garrett B. O'Hanlon

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Chapter I: Introduction

The United States Air Force (USAF) mission is to ensure unmatched capabilities in air, space and cyberspace. To accomplish this, a major focus since the inception of the Air Force has been the acquisition and procurement of aircraft, which ensures superior air capability and performance globally. Cost was often relegated as a secondary consideration to performance. While this approach has been strategically and operationally advantageous it has not been without long-term financial consequences. This approach has historically emphasized short-term costs (e.g. research and development or procurement) at the expense of long-term affordability considerations manifested in the aircraft's Operating and Support (O&S) costs (Ryan, Jacques, Ritschel, & Schubert, 2013). Likewise, there is an abundance of research focused on acquisition and research and development costs while minimal research specifically focused on O&S costs (Jones, White, Ritschel & Ryan, 2015). The U.S. Air Force and the entirety of the Department of Defense (DoD) historically emphasized acquisition costs while overlooking O&S costs within the Life-Cycle Costs (LCC) leading to years of unadjusted cost estimates, which can ultimately lead to future cost growths. However, more recently, the U.S. Air Force has emphasized the importance of accurate O&S cost estimates for its various fleet of weapon systems to determine a more accurate LCC (Congress, 2009). LCC is defined as the sum of four major cost categories: research and development, acquisition, O&S, and disposal costs (OSD-CAPE, 2014). O&S costs consists of sustainment costs incurred from the initial system deployment through the end of system operations (OSD-CAPE, 2014).

O&S costs, despite being within 50%-65% (dependent on type of fixed-wing aircraft) of an aircraft's LCC, simply did not historically generate the attention it truly deserved (Jones, 2015). The Nunn-McCurdy Act, signed into law by President Reagan with the 1983 Department of Defense Authorization Act (DoDAA), requires "DoD to report to Congress whenever a major defense acquisition program experiences cost overruns that exceed certain thresholds" (Schwartz, 2010). However, the Nunn-McCurdy act only applies to a program during the acquisition and production phase of the life-cycle. Though many analysts have praised the efforts of the act, others suggest "that Nunn-McCurdy is not a sufficiently comprehensive reporting mechanism because it does not apply to all elements of a weapon system's life-cycle costs, such as its operations, support, or disposal costs" (Schwartz, 2010). The United States House of Representatives have noted the weaknesses of the Nunn-McCurdy and amended it a number of times, however these amendments did not address the issues concerning O&S costs.

The most notable legislation change applicable to O&S costs is the Weapon Systems Acquisition Reform Act of 2009, commonly known as WSARA, an act that reformed the acquisition process within the Do D. WSARA highlighted the importance of accurate information and realistic estimates for DoD programs (Public Law, WSARA 2009). Additionally, WSARA created the office of Cost Assessment and Program Evaluation (OSD-CAPE) whose primary purpose is to evaluate and assess the accuracy and affordability of cost estimates for DoD programs. The Director of OSD-CAPE is "appointed by the President and is the principal advisor to the Secretary of Defense" (Public Law, 2009). In recent years, the "DoD mandated that each military service maintain an historical database of actual O&S costs for its systems" which has equipped the service member with the ability to research and analyze the O&S cost for weapon systems (Public Law, 2009).

Though WSARA is less than a decade old, the emphasis on accurate estimation has disseminated down to the program offices across the Air Force and to the Air Force Institute of Technology Cost Analysis Program. The Air Force Institute of Technology Cost Analysis Program is an organization that has been on the forefront of cost analysis research. The desire to find better techniques and more accurate methods in developing O&S estimates has been annotated by many Air Force officers that have participated in the research into O&S cost estimates and its numerous avenues of interpretation (Jones, 2015; Ryan, 2013). The primary focus of this thesis is the research into O&S cost estimating relationships (CER) and cost estimating techniques to derive more accurate estimates within the OSD-CAPE's cost element structure (CES).

Purpose

This research provides a better understanding of cost relationships within the Air Force aircrafts fleet to better predict the accuracy of future O&S costs. We utilize the OSD-CAPE's cost element structure which is composed of six major elements: Unit Level Manpower, Unit Operations, Maintenance, Sustaining Support, Continuing System Improvements, and Indirect Support (OSD-CAPE, 2014). However, these six elements are broken down into various sub-elements (See Figure 1). Extensive research into the actual costs incurred within these sub-elements are lacking despite the potential benefits they could provide in furthering the accuracy of future O&S estimates. The data available on the cost element structure is found in the Air Force Total Ownership Cost

(AFTOC) system, which is the Air Force's specific component within the Visibility and Management of Operating and Support Cost (VAMOSC) system. This research is broken down into three distinct sections. First, is to characterize the O&S data within the OSD-CAPE Cost Element Structure (CES) through descriptive statistics for USAF aircraft platforms. The second part is to compare and contrasts the categories (bomber, fighter, reconnaissance, special duty, trainer, transport/tanker and UAV/drone) within the cost element structure through statistical testing to better capture the relationships within the aircraft fleet. Third, is to identify cost drivers and cost estimating relationships within the cost element structure.

Second-Level/Third-Level
O&S Cost Estimating Structure

1. Unit-Level Manpower
   - 1.1 Operations
   - 1.2 Unit-Level Maintenance
   - 1. 3 Other Unit-Level
2. Unit Operations
   - 2.1 Operating Material
   - 2.2 Support Services
   - 2.3 Temporary Duty
   - 2.4 Transportation
3. Maintenance
   - 3.1 Consumable Materials and Repair Parts
   - 3.2 Depot Level Reparables
   - 3.3 Intermediate Maintenance (External to Unit-Level)
   - 3.4 Depot Maintenance
   - 3.5 Other Maintenance
4. Sustaining Support
   - 4.1 System Specific Training
   - 4.2 Support Equipment Replacement and Repair
   - 4.3 Sustaining/Systems Engineering
   - 4.4 Program Management
   - 4.5 Information Systems
   - 4.6 Data and Technical Publications
   - 4.7 Simulator Operations and Repair
   - 4.8 Other Sustaining Support
5. Continuing System Improvements
   - 5.1 Hardware Modifications
   - 5.2 Software Maintenance
6. Indirect Support
   - 6.1 Installation Support
   - 6.2 Personnel Support
     - 6.2.1 Personnel Administration
     - 6.2.2 Personnel Benefits
     - 6.2.3 Medical Support
   - 6.3 General Training and Education
     - 6.3.1 Recruit & Initial Officer Training
     - 6.3.2 General Skill Training
     - 6.3.3 Professional Military Education

Figure 1: Cost Element Structure elements & sub-elements (OSD-CAPE, 2014)

Research Questions

What are the expected mean/median/quartile ranges of the various aircrafts per the OSD-CAPE Cost Element Structure and their relationship to O&S costs? Determine the O&S cost element structure mean/median/quartile ranges for various aircrafts across platforms and categories to determine where within the CES the expenditures are incurred. Having a better understanding of where within the CES the costs are incurred, the decision makers will have statistical evidence to help make better and more applicable cost related decisions. The DoD acquisitions community and cost estimators alike will both benefit from understanding how our weapon systems are actually incurring costs.

Compare, contrast, and identify the relationships within the OSD-CAPE Cost Element Structure across the aircraft categories (bomber, fighter, reconnaissance, special duty, trainer, transport/tanker and UAV/drone). By evaluating the relationships between aircraft categories, future cost estimators receive a better understanding of the relationships that compose the entirety of the Air Force aircraft fleet. This provides a source for different program offices to compare and contrast their results with other program offices across the Air Force.

What are the potential cost drivers and cost estimating relationships within the OSD-CAPE Cost Element Structure? The research intends to find potential cost drivers (i.e. cost estimating relationships) in the O&S data. Within the six major cost elements, sub-elements exist and their cost could be derived using other elements/sub-elements as factors. We intend to identify these relationships within this research. Therefore, a quantitative understanding into the techniques and cost estimating methodology for this method will be researched, analyzed, and properly documented to provide future estimators a source for utilizing such techniques.

Methodology

The AFTOC database is utilized for this research. The database presents data broken down into the six OSD-CAPE's elements and sub-elements. We focus on fixed-wing aircrafts with available data provided within AFTOC. AFTOC allows the extraction of normalized data from 1996-2016 of all categories and platforms presented in this research broken down by the six elements (level one) along with their unique sub-elements (level two and level three). This enables us to capture the descriptive statistics needed to answer research question one for each aircraft platform and category. The second research question is achieved by utilizing statistical tests to compare the results of question one to develop a better understanding of the relationships between aircraft categories. The statistical test utilized to accomplish this is the Kruskal-Wallis test along with the Steel-Dwass test which is used to compare differences between two or more independent groups. Lastly, question three's cost drivers are identified using a correlation matrix using all elements and sub-elements as the independent variables.

Scope and Limitations

The scope of this research is limited to aircraft within the Air Force inventory present in the AFTOC system. The data utilized has a start date of 1996 as this was when the VAMOSC system originated. The data spans from 1996-2016 due to the data being actuals of how much was spent rather than estimates of how much was planned on spending. As a result, 2017 data is not included. With any service-wide database, AFTOC contains flaws due to human error and error based on consistency. The data presented in AFTOC is limited to the information provided by various program offices, however, AFTOC has normalized the data to limit the errors that can occur from different sources of input.

Though the data utilized is only USAF, the findings may be applicable to other services with similar platforms. Further research would be needed to compare and contrast similar platforms within different services however the information presented in this research will be without this type of exploration. Other limitations would be derived from incorrect data points and inconsistencies though we recognize that AFTOC updates the database regularly.

Summary

This research paper is broken down into five unique chapters: Introduction, Literature Review, Methodology, Results and Conclusion. The Literature Review contains information on past research that creates the foundation for this thesis. This chapter is integral in understanding why this research is being conducted and identifies the gap in the literature this thesis will fill. The Methodology section is a detailed section about the statistical techniques utilized to accomplish the goals of this research. In this section, you will find a step by step process to understand how the research was conducted. The Results section will specifically be a summary of the findings of the tests performed. Lastly, the conclusion will discuss the significance of the findings with respect to our research questions.

Chapter II: Literature Review

Chapter Overview

This Chapter offers insight into past research focused on Operating and Support Costs (O&S) for Department of Defense (DoD) Weapon Systems. It also provides background into the OSD-CAPE Cost Element Structure (CES) and the foundation to which this thesis builds upon. Additional information on terminology and definitions for the life-cycle cost structure components are essential to provide the background needed to understand the purpose and goal of this thesis research.

Nunn-McCurdy Act & Weapon Systems Acquisition Reform Act of 2009

The Nunn-McCurdy Act was established in 1983 and signed into law by President Reagan. The act required DoD officials to report cost overruns to Congress on Major Defense Acquisition Programs (MDAP) that exceed certain thresholds (Schwartz, 2010). The primary purpose of the Nunn-McCurdy Act was to hold Pentagon officials and defense contractors accountable and responsible for managing cost overruns for acquisition programs across the DoD during the procurement and acquisition process (Schwartz, 2010). Moshe Schwartz of the Congressional Research Service investigated the effectiveness and shortfalls of the Nunn-McCurdy act nearly three decades after its implementation. Schwartz states that the "GAO reported that 42% of programs in the FY2008 portfolio experienced acquisition unit cost growth of at least 25% compared to 37% of programs experiencing cost growth in the FY2000 portfolio" (Schwartz, 2010). Dr. Jonathan D. Ritschel of the Air Force Institute of Technology found that Nunn-McCurdy breaches rarely resulted in enforcement of the termination threat when breaches occur.

Rather, secondary effects, in the form of program restructuring were found to be prevalent, but not in those areas that most adversely affected the program (Ritschel, 2012). Though the Nunn-McCurdy Act has proved sufficient for reporting cost overruns during the acquisition process, analysts have suggested that it is not a comprehensive reporting tool because it does not apply to all phases of the life-cycle process such as O&S costs (Schwartz, 2010). One of the main findings of Schwartz's research is that DoD acquisition programs make key decisions during the acquisition phase to lower acquisition costs which could result in higher long-term O&S costs – ultimately leading to higher overall life-cycle costs (Schwartz, 2010).

The Weapon Systems Acquisition Reform Act of 2009 (WSARA 2009) is the most current congressional act that reemphasizes the importance of cost estimating and program evaluation across the DoD and the first act that put a significant focus on long term O&S costs. WSARA established the Office of the Secretary of Defense Cost Assessment and Program Evaluation (OSD-CAPE) whose director became the principal advisor to the Secretary of Defense for independent analysis and matters regarding long-term affordability of DoD acquisition programs (Public Law, WSARA 2009). OSD-CAPE was established to further strengthen the oversight on DoD acquisition programs after the acquisition phase of the life-cycle (Schwartz, 2010). The Public Law document published on 22 May 2009 details the functions of WSARA, which is relevant in this research for its emphasis on affordability after the acquisition phase and into the O&S phase. It complements the Nunn-McCurdy legislation by continuing the tracking of costs during the O&S phase and enabling the investigation on such programs that continue to exceed thresholds past the acquisition phase.

The importance of O&S cost and cost estimates has trickled down to various centers across the DoD and the Air Force specifically. The Air Force Cost Analysis Agency (AFCAA) at Andrews AFB established an O&S cost division in 2011 while the Air Force Space Command established an O&S cost section in 2015. AFCAA is currently in the process of developing an O&S specific guide to cost estimating while also establishing other guides such as *Legacy Aircraft Operations & Support Cost Estimating Guide* which is a "how-to" document offering guidance for developing cost estimates for legacy aircraft systems. The increased emphasis on operations and support in academia, DoD, and government supportive agency's alike is a result after the introduction of WSARA in 2009.

Definition of Life-Cycle Costs and Operating & Support Costs

First, we define the cost categories that make up Life-Cycle Costs. According to OSD-CAPE's Cost Estimating Guide, "Life-cycle costs is defined as the sum of four major categories: (1) research and development costs; (2) investment costs, consisting of procurement, military construction, and acquisition-related operations and maintenance (O&M) associated with production and deployment activities; (3) O&S costs; and (4) disposal costs" (OSD CAPE, 2014). Historically, O&S costs has been the largest cost component followed by R&D and investment costs, while, disposal costs have been fairly minute in regards to overall system life-cycle costs. Figure 2 illustrates this notional relationship between the cost components of life-cycle costs.

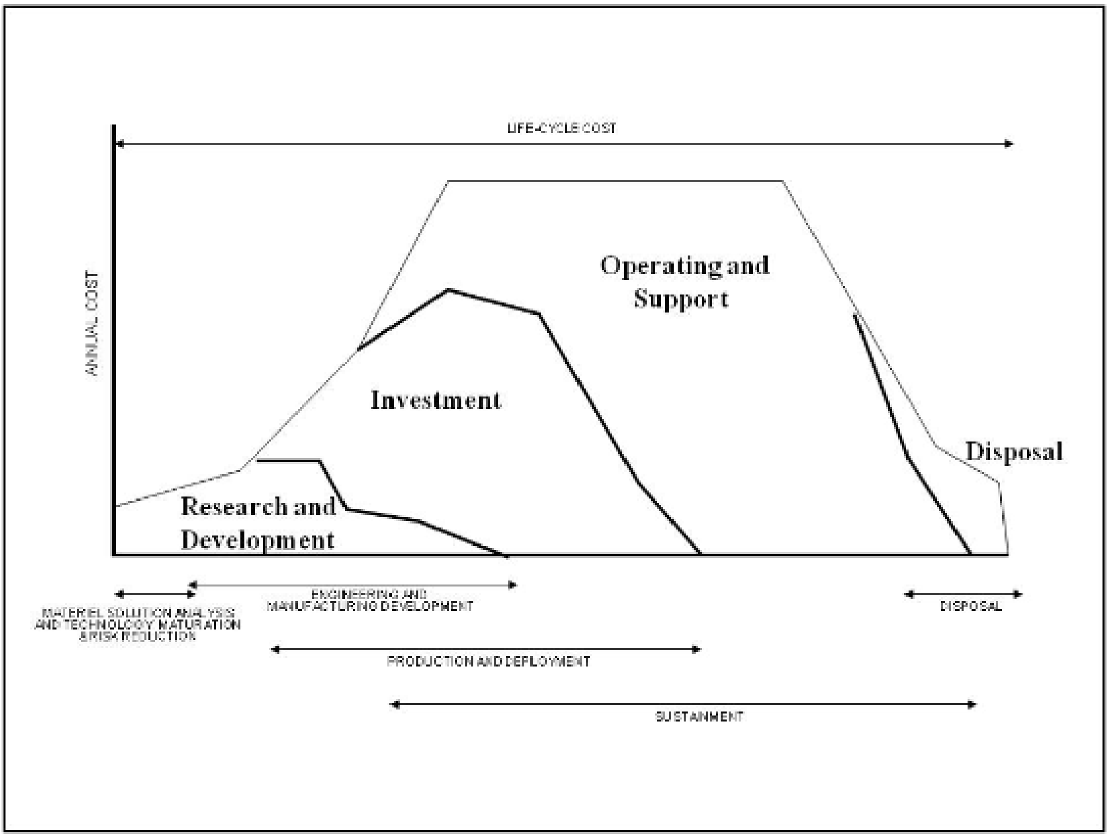


Figure 2: OSD-CAPE Cost Estimating Guide: Illustrative System Life Cycle

This research specifically analyzes O&S costs, the third cost component for a systems life-cycle. The 2014 Cost Estimating Guide describes O&S costs as:

> "Consists of sustainment costs incurred from the initial system deployment through the end of system operations. Includes all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, and otherwise supporting a system in the DoD inventory" (OSD CAPE, 2014).

The majority of O&S funding is primarily funded by Military Personnel (MILPERS) and Operations and Maintenance (O&M) appropriations (OSD CAPE, 2014). O&M appropriations (3400) are one-year appropriations meaning they must be obligated within the fiscal year issued, however then can be incrementally funded. The Defense Acquisition University (DAU) provides examples of what type of expense is funded through O&M appropriations:

> "Headquarters operations, civilian salaries and awards, travel, fuel, minor construction projects of $1M or less, expenses of operational military forces, training and education, recruiting, depot maintenance, purchases from Defense Working Capital Funds (e.g., spare parts), base operations support, and assets with a system unit cost less than the current expense/investment threshold ($250K)" (DAU, 2016).

O&S costs being funded specifically with O&M appropriations illustrates why specific weapon systems are sometimes over or underutilized. For example, if the price of fuel is near its historical highs, certain aircraft will be grounded and utilization rates drop compared to when fuel costs are lower. This example of the process of estimating years or even decades prior to when it is actually used is a fundamental issue with O&S estimating. Additionally, although the majority of O&S funding comes from O&M appropriations, not all cost incurred during the O&S phase is specific to O&M. The Operating and Support Cost Management Guidebook states that "Project Managers (PMs) must consider five appropriation categories when developing requests for program funding: RDT&E, Procurement, MILCON, MILPERS, and O&M" (DAU, 2016). This leads to additional levels of complexity when estimating for O&S costs years, even decades, before the cost is actually in the budgetary process. Quantitative techniques, inflation calculators, and historical trends are utilized to make the most accurate estimate, however, the estimation is merely an educated guess. The mass uncertainty in countless variables make O&S estimating extremely difficult and will continue to do so until more accurate techniques are established.

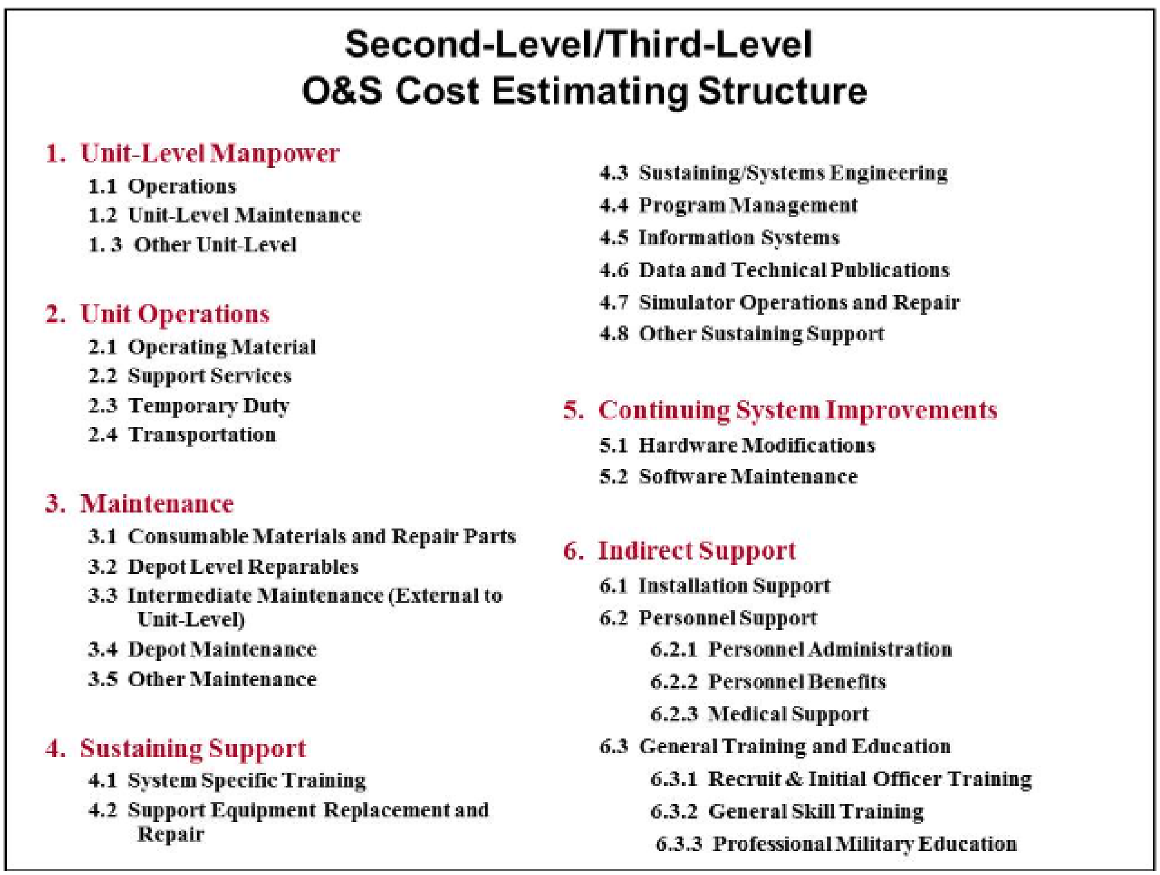
An accurate estimate would enable smoother preparation for the yearly budgetary process, however the budgetary process is not the most demanding concern within the O&S issue. By developing more accurate estimates, it enables decision makers to establish alternatives and to make more informed long-term financial decisions that can impact decades of appropriations. Developing less constrained budgetary situations start, on a foundational level, from accurate estimating to provide the decision makers the tools to make the most informed decisions they possibly can about weapon systems they are procuring.

Cost Element Structure Definition

When constructing O&S cost estimates, the Air Force utilizes the OSD-CAPE's cost element structure. It is defined by six overarching elements including various levels of sub-elements. According to the OSD-CAPE Cost Estimating Guide the "cost element describes and defines the specific elements to be included in the O&S cost estimate in a disciplined hierarchy" (OSD CAPE, 2014). This hierarchy is generalized and certain sub-elements may not apply to specific estimates depending on weapon system type. For example, if a sub element such as Training Munitions does not apply to a specific weapon system, that sub-element would be omitted. The following definitions are provided in the 2014 OSD-CAPE Cost Estimating Guide:

- **1.0 Unit-Level Manpower**. Cost of operators, maintainers, and other support manpower assigned to operating units. May include military, civilian, and/or contractor manpower.
- **2.0 Units Operations**. Cost of unit operating material (e.g., fuel, and training material), unit support services, and unit travel. Excludes material for maintenance and repair.
- **3.0 Maintenance**. Cost of all system maintenance other than maintenance manpower assigned to operating units. Consists of organic and contractor maintenance.
- **4.0 Sustaining Support**. Cost of system support activities that are provided by organizations other than the system's operating units.
- **5.0 Continuing System Improvements**. Cost of system hardware and software modifications.
- **6.0 Indirect Support.** Cost of support activities that provide general services that lack the visibility of actual support to specific force units or systems. Indirect support is generally provided by centrally managed activities that provide a wide range of support to multiple systems and associated manpower.

The OSD-CAPE guide provides a detailed description of each element. It also provides a visual example of certain sub-elements one level below the six overarching elements (See Figure 3). The sub-elements are composed as a hierarchy with each level broken down into another sub-element level. For example, the second element "Unit Operations" is broken down into four sub-elements, however, 2.1 "Operating Material" is broken down into 2.1.1 "Energy", 2.1.2 "Training Munitions," and 2.1.3 "Other Operational Material" (OSD CAPE, 2014). This type of hierarchy enables the estimators to provide a structural approach to cost estimating that covers the whole range of potential O&S costs.



Second-Level/Third-Level O&S Cost Estimating Structure

1. Unit-Level Manpower
   - 1.1 Operations
   - 1.2 Unit-Level Maintenance
   - 1. 3 Other Unit-Level
2. Unit Operations
   - 2.1 Operating Material
   - 2.2 Support Services
   - 2.3 Temporary Duty
   - 2.4 Transportation
3. Maintenance
   - 3.1 Consumable Materials and Repair Parts
   - 3.2 Depot Level Reparables
   - 3.3 Intermediate Maintenance (External to Unit-Level)
   - 3.4 Depot Maintenance
   - 3.5 Other Maintenance
4. Sustaining Support
   - 4.1 System Specific Training
   - 4.2 Support Equipment Replacement and Repair
   - 4.3 Sustaining/Systems Engineering
   - 4.4 Program Management
   - 4.5 Information Systems
   - 4.6 Data and Technical Publications
   - 4.7 Simulator Operations and Repair
   - 4.8 Other Sustaining Support
5. Continuing System Improvements
   - 5.1 Hardware Modifications
   - 5.2 Software Maintenance
6. Indirect Support
   - 6.1 Installation Support
   - 6.2 Personnel Support
     - 6.2.1 Personnel Administration
     - 6.2.2 Personnel Benefits
     - 6.2.3 Medical Support
   - 6.3 General Training and Education
     - 6.3.1 Recruit & Initial Officer Training
     - 6.3.2 General Skill Training
     - 6.3.3 Professional Military Education

Figure 3: Cost Estimating Guide Cost Element Structure

Relevant Research on Operation & Support Cost

Previous research into operating and support costs is minimal compared to the research into the acquisition costs of DoD weapon systems. Lt Col Ryan states that "between 1945 and 2009, there were over 130 separate studies and commissions focused on the acquisition of DoD systems…during this same time period, there appears not to be a single published study pertaining to how system costs behave during the O&S phase" (Ryan, Jacques, Colombi, & Schubert, 2012). However, other areas of O&S research has been traced back to at least 1975 by Marco Fiorello of the Rand Corporation who investigated the ratio of O&S costs to life-cycle cost (Ryan, 2015). Fiorella also published *Combat Vehicle System Operating and Support Costs: Guidelines for Analysis* in 1977 which discussed the increasing cost of operating DoD combat vehicle systems and researched an effective way of decreasing O&S costs during the life-cycle of a weapon system (Fiorello, 1977). The research was an analysis into O&S estimating methodologies and the development of O&S cost review procedures and guidelines for examining cost impacts for maintaining DoD weapon systems (Fiorello, 1977). However, Fiorello concluded that the accuracy of long term cost estimating were ill-founded (Fiorello, 1977).

In their published article *Trends in Weapon System Operating and Support Cost* (1997), the Institute for Defense Analysis (IDA) explains how the Under Secretary of Defense for Acquisition and Technology, concerned about the effect of shrinking modernization budgets, requested IDA to examine whether past efforts to reduce O&S costs have been effective (Graves, Domin, & Porten, 1997). Their study determined that O&S costs reduction efforts have not been successful, where fifty percent of the new weapon systems were more expensive to operate than their predecessor platform (Graves et al., 1997). However, Graves and the other authors also state that new weapon systems are more complex and have significantly more capability than the weapon systems they are replacing. Therefore it is not a technologically equivalent system, which makes direct comparisons difficult. Subsequently, DoD leadership believed the additional capability of these new weapon systems, which have a higher per unit cost, may have a lower absolute total O&S cost in the long run due to the smaller fleet size needed to accomplish the same job (Graves et al., 1997).

More recent research into O&S costs were investigated by USAF Lt Col Ryan and his coauthors Colombi, Jacques, & Schubert. An article published in 2012 titled *A Proposed Methodology to Characterize the Accuracy of Life Cycle Cost Estimates for DoD Programs* researched the accuracy of life-cycle cost estimates and how they behave over time while also utilizing data to address the deficiencies within the current analytical methodology approach to cost estimating (Ryan et al., 2012). The authors state "strategic decisions of program worth are often anchored in life cycle cost estimates, which simply cannot be validated if the reliability of the largest cost component is unknown" (Ryan et al, 2012). The authors continued to state that it "is essential the DoD develop a means of assessing the accuracy of its O&S cost estimates" and demonstrate their research utilizing a time-series evaluation of over three dozen MDAPS provides insight into the current accuracy, or lack thereof, of O&S cost estimates (Ryan et al., 2014). Ryan et al. then provide recommendations for improving these estimates (Ryan et al., 2012).

The article titled *Characterizing the Accuracy of DoD Operating and Support Cost Estimates* written by Lt Col Ryan, Jacques, Ritschel, and Schubert investigates the fundamental issue that the DoD has limited resources regarding O&S cost estimate accountability and how O&S cost estimates evolve across time (Ryan, Jacques, Ritschel, & Schubert, 2013). Lt Col Ryan and the other authors are the first recorded attempt to characterize O&S costs, and given the magnitude of dollars at stake within the O&S arena, they argue that this type of research is crucial (Ryan et al., 2013). Their research unveils foundational estimating discrepancies on Annual Unit O&S Cost (AUC) estimates and life-cycle cost estimates (LCC) estimates. The authors state that "on average, AUC estimates for aviation programs tend to be too low" while LCC estimates developed by the Air Force were also systematically low (Ryan et al., 2013). Figure 4 provides insight into deficiencies regarding the accuracy of AUC estimates across time. These findings strengthen their argument that there is a fundamental issue regarding the reliability and accuracy of O&S costs estimates. They conclude that this fundamental issue needs to be prioritized by the DoD, specifically the Air Force, in order to establish confidence and validity when establishing budgets or making decisions that can heavily alter future budgets.

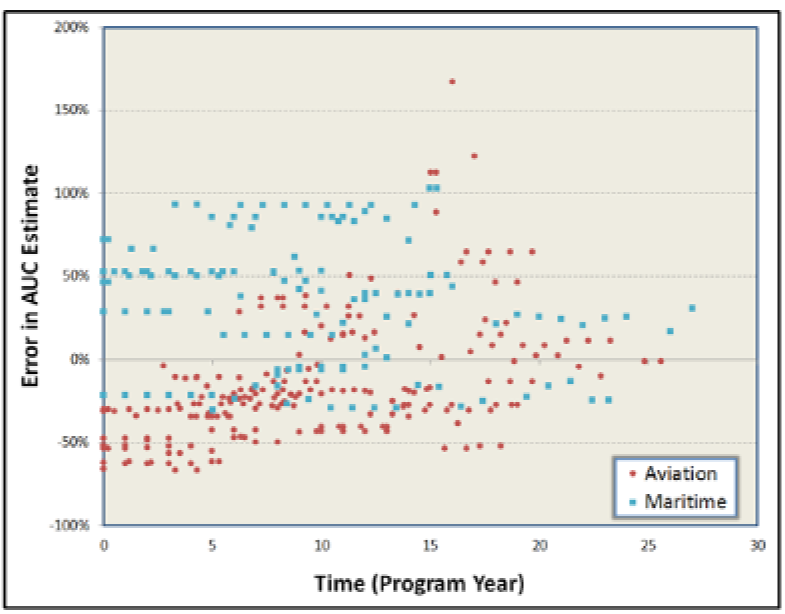


Figure 4: Mean AUC Estimate Errors as a Function of Time (Ryan et al., 2013)

USAF Capt. Gregory Ferry took a different approach into O&S cost research when he investigated cost growth above inflation (CGAI) for raw materials for aircraft within the Air Force inventory. The Air Force utilizes different inflation indices to calculate O&S cost estimations for future costs; however when these cost are growing faster than anticipated it puts even more complexity within the already constrained budgetary process. As Ferry states, quoting former Chairmen of the Joint Chiefs of Staff Admiral Mullens, "continually increasing debt is the biggest threat we have to our national security" (Ferry, 2013). Ferry concludes that raw materials, after the data was evaluated through statistical techniques, is a source of CGAI (Ferry, 2013). These findings affect previous estimates that did not take CGAI into account and the additional unaccounted cost increase will lead to cost growth over the life cycle of the program. The underestimated sustainment costs of the program will lead to increasing budgetary requests that will demand more resources from an already shrinking and constrained DoD budget. Another significant finding from this research is the inaccuracy of the inflation indices utilized by DoD estimators. If these indices are not accurately capturing the growth of raw materials, it raises uncertainty in other variables that may also be underestimated.

Adding to the recent research into O&S Costs, USAF Capt. Gary Jones (2014) investigates the ratio of O&S costs to life-cycle costs. Jones's research sought to determine the accuracy of the "golden ratio" of 30:70, acquisition to O&S costs. His findings determined that the golden ratio lacks foundational accuracy and determined that a single, fixed ratio is not appropriate due to the varying nature of DoD weapons system platforms. Jones characterizes the O&S data for eight different groups of weapon systems and found staggering means for O&S costs with missiles being the low mean of roughly 8% of life cycle cost and the high mean of 72% O&S costs for Unmanned Aerial Vehicles to life cycle cost (Jones et al, 2015). Additionally, he concludes the difficulty in estimating O&S costs derives from the varying nature of life expectancies for DoD weapon systems (Jones et al, 2015). He states that "illustrating the variability of life-cycle proportions among weapon system categories, … show a more realistic picture of what program analysts and portfolio managers can expect in terms of sustainment costs" (Jones et al, 2015). Therefore, the addition of varying life expectancies can allow for cost estimators to estimate for the various potential life expectancies of DoD weapon systems to better inform the decision maker of potential O&S costs for the respective system.

There is no doubt that the recent emphasis on O&S costs has led to increased research in the area. Table 1 outlines additional research with emphasis in O&S cost since the introduction of WSARA in 2009. With growing emphasis comes increased knowledge on root causes and fundamental issues into O&S cost estimating. This research adds to the growing literature by proving insight into techniques that result in more accurate O&S cost estimating.

Table 1: Additional Research into Operating and Support Costs

Publication & Title	Year	Authors	Main Findings
US GAO, *DoD Needs Better Information and Guidance to More Effectively Manage and Reduce Operating and Support Costs of Major Weapon Systems*	2010	US GAO	DoD lacks key information needed to effectively manage and reduce O&S costs for most of the weapon systems the GAO reviewed.
IDA, *WSARA 2009: Joint Strike Fighter Root Cause Analysis*	2010	Scot Arnold, Ji Byun, Harley Cloud, Alexander Gallo, Matthew Gonwa, Bruce Harmon, Prashant Patel, Colin Sullivan, John Hiller, & Patricia Broson	The findings list three quantifiable reasons which lead to Nunn-McCurdy breaches: Errors in the Milestone B estimate resulted in a 23 percent increase, The redesign effort increase the PAUC by 26 percent, and changes in the buy profile led to a 5 percent increase in the PAUC.
RAND Corporation, *Managing U.S. Air Force Aircraft Operating and Support Costs*	2012	Michal Boito, Thomas Light, Patrick Mills, & Laura Baldwin	Fuel costs drove 31% of overall O&S cost growth, unit-level personnel costs 30%, weapon system sustainment costs 27%, and modifications and other 12%.
US GAO, *Improvements Needed to Enhance Oversight of Estimated Long- term Costs for Operating and Supporting Major Weapon Systems. Study*	2012	US GAO	DoD reports on weapon system O&S estimates to Congress are often inconsistent and in some cases unreliable, limiting visibility needed for effective oversight of these O&S cost estimates.
Australian Government DoD, *The Impact of Increasing Acquisition Costs on the Operation and Support Budget for Military Equipment*	2013	Stephen Harrison	The analysis determined that the O&S costs for the various weapon systems examined are rising. Additionally, a parametric relationship between O&S costs and acquisition costs exist enabling more accurate O&S estimates during early acquisition phase.
Journal of Cost Analysis and Parametric, *A Macro-Stochastic Model for Improving the Accuracy of Department of Defense Life Cycle Cost Estimates*	2013	Erin Ryan, Christine Schubert Kabban, David Jacques, & Jonathan Ritschel	The authors provide a prognostic cost model which provides more accurate life cycle cost estimates for various DoD programs.
Naval Postgraduate School, *Analyzing the Effects of the Weapon Systems Acquisition Reform Act*	2014	Austin Banford, Brad Naegle, Edward Powley	The analysis concluded a correlation exists between WSARA implementation and improved cost and schedule performance.
Journal of Transportation Management, *Organic or Contract Support? Investigating Cost and Performance in Aircraft Sustainment*	2016	Jonathan Ritschel & Tamiko Ritschel	The authors find percentage of Contracted Logistics Support (CLS) employed in the maintenance strategy to be the primary driver in O&S maintenance costs.

Research into the Cost Element Structure Components

The OSD-CAPE Cost Estimating Guide version 2007, 2010, and 2014 provides an informative, detailed section on the Cost Element Structure. However, limited analysis into the CES and how estimates are derived within the CES exists. Few examples of research within the CES elements exist and this section is aimed to provide insight into those research topics.

A recent article by the Rand Corporation titled *Metrics to Compare Aircraft Operating and Support Costs in the Department of Defense* researched the effectiveness of a consistent definition of aircraft O&S cost per flying hour metric that can be utilized across all DoD platforms (Boito, Keating, Wallace, DeBlois, & Blum, 2015). This type of research is beneficial to the DoD because it allows for a more standardized method of comparison for cost per flying hour of different aircrafts. Specifically, Boito et al. focused on the cost element structure and defined which cost components had either a fixed or variable relationship to flying hours. The first five elements are self-explanatory and well defined according to the OSD-CAPE CES; however the last element, Indirect Support, is more vague and susceptible to individual interpretation. Boito describes Indirect Support as "costs that are those installation and personnel support costs that cannot be identified directly (in the budget or FYDP) to the units and personnel that operate and support the system being analyzed, but nevertheless can be logically attributed to the system and its associated manpower" (Boito et al., 2015). The importance of sharing Boito's insight into the indirect support element is that it is more subjective than the other elements, meaning what one program office determines indirect support may not be applicable to another program. Thus, the importance of clear definitions and proper documentations is essential in creating estimates within the CES. Additionally, the applicability of Boito's article to this research is the attempt to characterize cost data utilizing the CES. The information defining the CES is straight forward and provided by various sources (GAO, OSD CAPE, DoD etc.) however research into the cost estimating techniques when deriving the actual O&S cost estimates is lacking.

Aside from the definitional information provided in the GAO Cost Estimating & Assessment Guide and the OSD-CAPE Cost Estimating Guide, the research into the usage of the Cost Element Structure in cost estimating is lacking. The research by Boito et al. advanced knowledge into the characterization of the Cost Element Structure elements and sub-elements however more research is needed to analytically derive cost drivers within the CES and statistically determine which platforms are driving up the O&S costs within the Air Force.

Developing Cost Estimates

The GAO Cost Estimating and Assessment Guide and the OSD-CAPE's Cost Estimating Guide thoroughly discusses the development of an O&S cost estimate. They individually highlight on a macro perspective the importance of accurate definitions, scope, and a step-by-step coverage of what is essential within the O&S estimating process. The cost estimating guide also provides detailed definitions of the five primary estimating methods that are utilized in creating O&S cost estimates:

- **Parametric**. The parametric technique uses regression or other statistical methods to develop Cost Estimating Relationships (CERs). A CER is an equation or algorithm used to estimate a given cost element using an established relationship with one or more independent variables. The relationship may be mathematically simple or it may involve a complex equation (often derived from regression analysis of historical systems or subsystems). CERs should be current, applicable to the system or subsystem in question, and appropriate for the range of data being considered.

- **Analogy**. An analogy is a technique used to estimate a cost based on historical data for one (or occasionally two) analogous system(s). In this technique, a currently fielded system, similar in design and operation to the proposed system, is used as a basis for the analogy. The cost of the proposed system is then estimated by adjusting the historical cost of the current system to account for differences (between the proposed and current systems). Such adjustments can be made through the use of factors (sometimes called scaling parameters) that represent differences in size, performance, technology, reliability and maintainability, complexity, or other attributes. Adjustment factors based on quantitative data are usually preferable to adjustment factors based on judgments from subject-matter experts.
- **Engineering Estimate**. This technique uses discrete estimates of labor and material costs for maintenance and other support functions. The system being estimated normally is broken down into lower-level subsystems and components, each of which is estimated separately. The component costs, with additional factors for integration, are then aggregated using simple algebraic equations to estimate the cost of the entire system (hence the common name "bottom-up" estimate). For example, system maintenance costs could be calculated for each system component using data inputs such as system operating tempo, component mean time between maintenance action, component mean labor hours to repair, and component mean material cost per repair. Engineering estimates require

extensive knowledge of a system's (and its components') characteristics and a significant amount of detailed data (sometimes obtained from the system prime contractor). These methods are normally employed for mature programs.

- **Extrapolation of Actual Costs**. With this technique, actual cost experience or trends (from prototypes, engineering development models, and/or early production items) are used to project future costs for the same system. Such projections may be made at various levels of detail, depending on the availability of data. Such projections also may need to account for growth in reliability and maintainability.
- **Cost Factors**. Cost factors are applicable to certain cost elements not related to weapon system characteristics. Often, cost factors are simple per capita factors that are applied to direct (i.e., unit-level) manpower to estimate indirect cost elements such as base operations, military medical care, or general training and education (not associated with a specific weapon system).

As shown above, while the current estimating guides are useful for understanding the proper procedures and the textbook cost estimating methods of developing an estimate, they lack a practical approach to real time estimating. The explanation on the process, the strengths or weaknesses of the primary approaches, and a detailed definition for each method is present but it lacks a standardize process for real time estimating that could be utilized across program offices throughout the Air Force.

Currently, the Air Force doesn't proscribe a standardized method of estimating. It is largely dependent on which program office, center or organization is completing the cost estimate. This is primarily to ensure a broad scope in estimating to ensure the accuracy of each estimate. The Air Force has four primary types of cost estimates: Program Office Estimates (POEs), Non Advocate Cost Assessments (NACAs), Service Cost Positions (SCPs) and Independent Cost Estimates (ICEs) (Office of the Assistant Secretary, 2017). POEs are specific to the program office that will be supporting the project, NACAs are created by an organization that does not directly support the project and acts merely as a cross-check third party member. The reconciled POE and independent estimate becomes the official Air Force cost estimate called the SCP estimate. An ICE, similar to a NACA, is a product of OSD-CAPE when required by statute for ACAT ID and IAM programs according to DoDI 5000.02 (Office of the Assistant Secretary, 2017). All these estimates differ in methodology and process to ensure the Air Force broadly covers every avenue in the estimating process.

Though there is not a standardize method into O&S cost estimating, one reason could be due to the uniqueness of each cost estimate. Primarily O&S estimating methodologies differ when estimating for an existing weapon system from a new weapon system in the acquisition phase. Also, estimates are independent of each other from a macro perspective regarding which type of weapon system is being estimated. For example, the methodology and approach of estimating a fixed wing aircraft compared to a satellite differs tremendously therefore it is understandable that Air Force Space Command follows a different approach compared to Air Force Life Cycle Management Center at Wright Patterson AFB. Additionally, estimating intent and methods also differ in a micro perspective within the acquisition phase alone. For example, Figure 5 portrays how the intent of an estimate and the role it plays within different stages in the acquisition process.

Role of O&S Cost Estimates and Analyses

EVENT(S)	SUPPORTING ACTIVITIES
MS A	• Obtain enhanced visibility of O&S costs and key cost drivers – Support to trade-off studies – Support to Analysis of Alternatives • Establish initial affordability goal (average annual O&S cost per unit or system)
CDD Val Dev RFP Rel MS B	• Establish balanced requirements for sustainability and reliability, availability, and maintainability (RAM) • Assist the business case analysis supporting the Life-Cycle Sustainment Plan – Organic versus contractor logistics support • Ensure early influence on system design – Adequate attention and investment in logistics engineering efforts, RAM • Update O&S affordability analysis and establish as formal requirement ("cap")
MS C	• Track and assess current O&S estimate relative to prior estimates and affordability cap – Early use of T&E data with reliability/maintainability growth projections – Provide insights into sustainability shortfalls and help identify appropriate mitigation actions • Update product support business case analysis • Provide foundation for budgetary requirements (manpower, major O&M elements)
FRP Dec	• Track and assess current O&S estimate relative to prior estimates and affordability cap – Early use of O&S cost actual experience • Refine product support business case analysis • Update estimates of budgetary requirements
Post-IOC Review	• Assess and manage O&S trends for legacy systems • Assess needs for continuing system improvements/modifications or recapitalization • Assess adequacy of programmed sustainment funding (in context of proper readiness)

Figure 5: Role of O&S Estimates by Acquisition Event (OSD CAPE, 2014).

The intricate details that come along with O&S estimates is what makes them difficult. To truly establish a detailed instruction guide to creating O&S estimates would be beneficial but due to the subjective nature of some estimates it may serve only as a reference tool to developing O&S estimates.

Summary

The intent of this Chapter was to inform on the past research that focused on Operating and Support (O&S) Cost for Department of Defense Weapon Systems. The importance of accurate O&S cost estimates were emphasized after the introduction of WSARA in 2009 and the abundance of research to follow serves as evidence that Congress, the DoD and academia has taken interest in long-term sustainment cost of our major weapon systems. This Chapter also gave detailed information on the development of O&S cost estimates and the foundation to developing these estimates within the OSD CAPE Cost Element Structure. Also, the limited research into the characterization of O&S data within the cost element structure is displayed in the Chapter due to the minimal content regarding the subject. Additionally, the information on terminology and definitions that encompass O&S estimates are essential to provide the background needed to understand the purpose and goal of this thesis research. The next chapter follows the methodology of how the data was collected, analyzed, and interpreted.

Chapter III: Methodology

Chapter Overview

Chapter 3 is a detailed methodology focusing on the process of collecting data, utilizing statistical tools, and interpreting the outputs of the statistical test performed in the analysis of the data. First, we explain the research design followed by the research questions to inform why the following test were needed. Next, we describe the data collection process and the assumptions needed to conduct the research.

Research Design

The aircraft O&S data is from the Air Force Total Ownership Cost (AFTOC) system while being arranged in the OSD-CAPE Cost Element Structure. AFTOC allows for the extraction of actual O&S cost data ranging from 1996-2016 for the total aircraft inventory. The data enables us to complete statistical tests and provide descriptive statistics needed to characterize the O&S data for the various aircrafts. The data is integral in allowing us to answer the three research questions that are present in this thesis. Various tests and statistical tools (JMP Statistical Software & Microsoft Excel) are used to characterize this data. The data derived from AFTOC is raw and needs standardization and normalization to complete the statistical tests.

Table 2 portrays the screening methodology to derive aircraft platforms and categories that are examined during this research which is portrayed in Table 3. Each aircraft platform researched is an ACAT 1 program. AFTOC distinguished aircrafts by Mission Design (MD) and Mission Design Series (MDS). For example, the F-16's MD is F-16 while an example of the MDS is the F-16A. To develop a dataset of actual costs that can be characterized and statistically tested, we cleanse the data based on multiple factors. First, we omit aircrafts that have less than 10 aircrafts in their total average inventory for the years 1996-2016 decreasing the total MDS from the original of 274 to 146. This removes the platforms that are experimental and not mass produced. Second, this research investigated only fixed-wing aircrafts and omitted gliders, helicopters, and ground unit vehicles decreasing the MDS count by 26 equaling 120 MDS. Next, real time estimators normally conduct their estimates on a cost per flying hour (CPFH) basis, therefore we screen the data to exclude programs that are not incurring flying hours greater than 100 hours per year during the timeframe examined. This step brought down the MDS count from 120 to 90. However, we keep the platforms that are being phased-in and phased-out. Lastly, we screened the data based on years of available cost data. Platforms that were being phased-out with less than 10 years of cost data are omitted while platforms being phased-in with less than five years of cost data are omitted to ensure cost expenditures are stable. The last step in the cleansing decreased the total MDS from 90 to 52 total MDS.

Table 2: Screening Process for Aircrafts

Screen	Remaining MDS
AFTOC	274
MDS TAI > 10	146
MD = Fixed Wing Aircraft	126
Flying Hours > 100	90
Phasing Out > 10 Years/ Phasing In > 5 Years	52
Total Aircrafts Examined	**52**

The database from AFTOC provides the cost elements down to various different levels (second level, third level, fourth level etc.). However, for the purpose of this research we examine the cost elements down to the third level because it is typically the lowest level practitioner cost estimators utilize. Therefore, if the database presents cost at the fourth or fifth level we sum up the cost data to equal the third level. For example, the database has individual cost for 2.1.1.1 (AV Fuel), 2.1.1.2 (POL), and 2.1.1.3 (Electricity) that is accumulated to 2.1.1 (Energy) (according to the CAPE 2014 Cost Element Matrix on AFTOC). However, some cost is only presented at the second level, therefore, we are unable conduct analysis at the third element for these costs.

Table 3: Categories and Platforms Analyzed

Aircraft Categories/Platforms		
Reconnaissance	**Trainer**	**Fighter/Attack**
E-3B	AT-38B	A-10A
E-3C	T-1A	A-10C
E-8C	T-6A	F-15A
U-2S	T-37B	F-15B
Transport/Tanker	T-38A	F-15C
C-5A	T-38C	F-15D
C-5B	**Special Duty**	F-15E
C-5C	AC-130U	F-16A
C-17A	EC-130E	F-16B
C-21A	EC-130H	F-16C
C-130E	MC-130E	F-16D
C-130H	MC-130H	F-22A
C-130J	MC-130P	F-35A
HC-130N	WC-130H	F-117A
KC-10A	WC-130J	OA-10A
KC-135D	**Bomber**	**UAV/Drone**
KC-135E	B-1B	MQ-1B
KC-135R	B-2A	MQ-9A
KC-135T	B-52H	

Cost per Flying Hour

Once the database is established, in order to normalize the O&S cost, we calculate the cost per flying hour (CPFH) for each aircraft. CPFH is calculated by taking the annual cost for a certain element and dividing it by the flying hours for that certain platform for that respective year. This enables us to determine the cost per flying hour for each specific element. A benefit of calculating the CPFH is it normalizes the data regardless of years in which platforms were more utilized than other years.

Next, we calculate the percentages for each cost element to the encompassing cost element. For example, we divide the cost of 1.1 (Operations), 1.2 (Unit-Level Maintenance), and 1.3 (Other Unit – Level) by the total expenditures for 1.0 (Unit-Level Manpower) to derive the percentages per element 1.0 Unit-Level Manpower. This same methodology is utilized for deriving the cost percentages for the six overarching elements per total expenditures for that platform per year. Calculating CPFH, regardless of ramp-up or ramp-down, demilitarization, changes in operations tempo, or attrition, is a good indicator of how the O&S costs behave within the cost element.

$$Cost\ Per\ Flying\ Hour = \frac{Yearly\ Cost\ of\ Aircraft}{yearly\ flying\ hours}$$

Prior to calculating the CPFH, it is necessary to normalize costs for inflation. The Air Force recommends the usage of DoD inflation tables that are issued by the Secretary of the Air Force Office of Financial Management (SAF/FM) and the Office of Management and Budget (OMB). The O&S actual costs presented in AFTOC are provided in base-year (BY) and then-year (TY) dollars. The specific database retrieved from AFTOC is normalized to BY 2016 therefore inflation is already accounted for. This means, all cost regardless of respective year, is in base year (BY) for 2016.

Research Question and Hypotheses

What are the expected mean/median/quartile ranges of various aircrafts and their relationship to O&S costs? This is the primary goal of this thesis research. Despite increased research into O&S costs, the characterization of the cost data varying between platforms has yet to be examined. The output will portray which cost elements are costlier for specific platforms and where within the OSD-CAPE CES the cost is incurred. For example, the mean/median/quartile ranges will be calculated down to element 1.2.1 (Organizational Maintenance) which is a sub element of element 1.2 (Unit Level Maintenance) under the overarching element 1.0 (Unit Level Manpower). The descriptive statistics will be broken down by individual platform but also at the category level.

Descriptive Statistics

The formula for mean, which is the average of the variables being collected, used in this research is the general sum of all variables, $\sum x_i$ divided by the total number of variables that are used for the calculation, n.

$$mean = \frac{\sum x_i}{n}$$

After calculating the mean, the median cost is calculated to determine the middle cost of the data set. The median is calculated by ordering the costs in chronological order from least to greatest, then determining which cost lies directly in the middle. The median is not exclusively one number at times. When there is an even number of variables in a set, the median would then be two different, or the same, numbers.

$$median = \{(n + 1) \div 2\}th$$

Next, we determine the interquartile ranges (IQR) within the data set. The importance of calculating the IQR is to determine the middle 50% of the data while determining the upper (Q3) and lower (Q1) quartiles to determine the spread of the data set. This will measure the variability within our data. The calculation of mean/median/quartile ranges for the data set will help with the overall description of the data set. The combination of all three helps determine if the mean is representative of the data, or if not, then the spread of all the costs is too large and this indicates large differences within the cost data set.

$$IQR = Q_3 - Q_1$$

Compare, contrast, and identify the relationships within the OSD-CAPE Cost Element Structure across the aircraft categories (bomber, fighter, reconnaissance, special duty, trainer, transport/tanker and UAV/drone). This will determine the relationship between the different aircraft categories in relationship to the OSD-CAPE CES. Provided this information, it helps the decision makers make conscious decisions regarding the yearly budget and how to best plan for substantial increases/decreases within the O&S portion of the budgetary process. To ensure that the data is representative of the categories, we omitted certain actual costs for various reasons due to the assumption that it is not representative of true population trends. Some of these data may have logical reasons to why they do not represent the population in which they are cohorts. Other data points omitted did not have logical reasons to why they were not representative, therefore the omission of these data points will make the findings more credible. For example, the WC-130H incurred zero cost in element 1.0 Unit Level Manpower from the years 1996-1998 while incurring the majority of the costs in element 6.0 Indirect Support. This is not aligned with the population trend and allowing these costs to be remain in the data set would drive down the true representative percentage for this element. The purpose of this thesis is to educate estimators on the average expenditures percentages for these six elements for various platforms and categories and omitting certain data points could best serve this intent. The route of omitting these data points starts by producing distribution graphs from JPM of each independent element in reference to the seven categories. The distribution includes Box-and-Whisker Plots that show the median, upper quartile, the lower quartile, the maximum value excluding outliers, and the minimum value excluding outliers. The data points outside the maximum and minimum values are values that are more than a 1.5 multiplier than the upper or low quartile respectfully. These data points do not represent the population and therefore skew the descriptive statistics. To ensure accuracy and precision of the results, we omit these outliers.

Statistical Tests

First, we check if the data set is normally distributed. The JMP Statistical Software program accomplishes this by outputting a distribution for each independent category for each respective cost element. If normality is not passed, we treat the data set in its entirety as not-normal and utilize non-parametric statistical testing to compare the medians between categories.

To limit Type I errors, we are utilizing the Bonferroni Correction normally known as the Bonferroni Type Adjustment. This is a conservative approach to limiting Type I errors. A Type I error is the rejection of the null hypothesis in favor of the alternative hypothesis stating there is a difference between the medians when in truth there is no statistical difference between the medians. By limiting the probability of committing a Type I error it adds credibility to the results of the statistical tests that are run in the analysis. The Bonferroni correction tests each individual hypothesis at a p-value equal to α, which is the desired p value of .05, divided by the number of hypothesis, which in this case is 21 individual hypothesis per cost element. Therefore, each individual hypothesis will be evaluated at $p\ value \leq \frac{\propto}{m} = \frac{.05}{21} = .00238$.

To compare the medians within the data set, we utilize the Kruskal-Wallis and Steel Dwaas tests in JMP. The Kruskal-Wallis test is the appropriate test to use when comparing two or more groups. It is the non-parametric equivalence to the one-way analysis of variance (ANOVA) test utilized when the samples are normally distributed. This test is a rank based nonparametric test that can be used to "determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable" (Laerd Statistics, 2017). The same hypothesis test is used for each categorical comparison. If the p-value > 0.00238 we fail to reject the null, stating there is no difference between the median ranges of the categorical variables. However, if the p-value < 0.00238 we reject the null hypothesis and state that at least one median is statically different from the group.

Kruskal-Wallis Test

$$\mathrm{H_O}:\ \Delta_{1\mathrm{X}} = \Delta_{\mathrm{Y}}$$

$$H_a: \Delta_X \neq \Delta_Y$$

The Kruskal-Wallis tests combines all observation for all variables and ranks them appropriately. Next H is calculated, which is a ratio of the aggregate measure of group differences over the mean of the sampling distribution (Vassar College, 2017). The results derive a p-value which is compared to the family-wise error rate (α_e). If the p-value is rejected, we complete the Steel Dwaas test, which is the completion of multiple Mann Whitney tests in JMP, which is a non-parametric test that is used to compare two sample, or group, medians that come from the same population (Nachar, 2008).

Mann-Whitney Test

$$U = \sum_{j=1}^{n} \sum_{i=1}^{m} Z_{ij}$$

The Mann Whitney test derives where within the categories the differences lie within the medians. The Mann Whitney test calculates the test statistic, U. The results of the Mann Whitney will be compared to the comparison-wise error rate (α_c). The (α_c) is derived by dividing the (α_e) secondary tests in "accordance with statistical theory on multiple simultaneous comparisons and error rates known as the Bonferroni Method (Nachar, 2008). The n and m represent the two-different samples. Again, if the p-value < 0.00238, there is a statistical difference between the two different samples being compared. The output for the Steel Dwaas test in JMP includes the score mean difference as well as the p-value for the pair comparisons of n and m. The score difference portrays the strength of the difference while the p-value represents the threshold at which the pair is either statistically different or statistically the same.

What are the potential cost drivers and cost estimating relationships within the OSD-CAPE Cost Element Structure? This investigation is to determine where within the cost element structure relationships within cost elements/sub-elements exist. To determine if these relationships exist, we create a correlation table with all elements/sub-elements as independent variables. JMP Software allows for the creation of a correlation table to determine if the continuous variables are related to each other through multivariate analysis.

Prediction

Taking into account the range of complexity of an aircraft compared to another we assume that the mean/median/quartile ranges will vary between platforms, some significantly. However, we assume that variances between platforms should align closely with each other. Cost drivers are also expected to be unique to the platform/category. For example, a fighters cost driver may be totally different than a cargo aircrafts cost driver. The range in designated missions led to this assumption. On a macro level, the comparison between categories is also expected to result in different characterization of data and cost drivers.

Conclusion

The data collected is derived from AFTOC. The analysis and tests selected to normalize, standardize, and characterize the data reflect one approach. We recognize that other techniques could have been utilized. The decision to normalize to the CPFH is to maintain a level of homogeneity and is made after discussion with cost estimators in AFLCMC. Chapter Four will contain the results of the analysis.

Chapter IV: Analysis and Results

Chapter Overview

This Chapter is the accumulation of all results of the analysis to portray O&S costs characteristics of the various categories and platforms that were examined. Descriptive statistics is utilized to show the percentages incurred by the various elements in the OSD-CAPE 2014 Cost Element matrix format for various platforms and categories. The following chapter will include the three research questions and the analysis and results for each question. The first research question aims to characterize O&S cost for the seven categories and various platforms. The second research question utilizes statistical tools and statistical testing to derive if a difference exists between the different categories in relationship to the OSD-CAPE Cost Element Structure. The third research question focuses on using a correlation matrix including all the cost elements/sub-elements to derive which elements are correlated and if relationships exist.

Research Question I

What are the expected mean/median/quartile ranges of various aircrafts and their relationship to O&S costs? The first set of results is portrayed in Table 4. It depicts the mean percentages, median, and quartile ranges for the entirety of the aircrafts examined in this analysis. All the tests are performed and examined in Microsoft Excel and JMP

Statistical Software. The final dataset is comprised of 52 aircraft platforms and 916 rows of aircraft data. The first results to note is that the first three elements 1.0 Unit-Level Manpower, 2.0 Unit Operations, and 3.0 Maintenance accumulated the largest percentage of the mean for the aircraft costs over the years of 1996-2016 consuming 82.38% of total expenditures for the 52 aircraft.

Table 4: Summary Statistics for the 52 Aircrafts Analyzed

Level	Mean	Std Dev	Median	IQR
1.0 Unit Level Manpower	31.46%	13.02%	31.97%	17.88%
2.0 Unit Operations	19.58%	8.28%	18.25%	9.29%
3.0 Maintenance	31.35%	12.10%	30.31%	14.59%
4.0 Sustaining Support	1.94%	2.80%	1.31%	1.87%
5.0 Continuing System Improvements	9.05%	8.78%	6.60%	9.35%
6.0 Indirect Support	6.62%	7.96%	4.28%	4.34%

Tables 5-10 portray the percentages for the six OSD-CAPE cost elements for the seven aircraft categories that were examined. The categories cumulative cost for the first three elements are as follows: Bomber - 76.98%, Fighters – 87.42%, Reconnaissance – 86.49%, Special Duty – 82.18%, Trainer 64.62%, Transports – 84.73%, and UAV/Drone – 83.27%. Due to the first three elements consuming the majority of the expenditures, the discussion is heavily focuses on the descriptive statistics of these three elements.

Table 5: OSD-CAPE Cost Element Structure Mean Percentages for Bombers

Bomber					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	25.85%	4.0	Sustaining Support	4.96%
2.0	Unit Operations	15.17%	5.0	Continuing System Improvements	16.06%
3.0	Maintenance	35.95%	6.0	Indirect Support	2.01%

Table 6: OSD-CAPE Cost Element Structure Mean Percentages for Fighters

Fighter					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	33.78%	4.0	Sustaining Support	1.57%
2.0	Unit Operations	17.68%	5.0	Continuing System Improvements	7.14%
3.0	Maintenance	35.96%	6.0	Indirect Support	3.86%

Table 7: OSD-CAPE Cost Element Structure Mean Percentages for Reconnaissance

Reconnaissance					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	31.83%	4.0	Sustaining Support	1.74%
2.0	Unit Operations	14.13%	5.0	Continuing System Improvements	9.00%
3.0	Maintenance	40.53%	6.0	Indirect Support	2.77%

Table 8: OSD-CAPE Cost Element Structure Mean Percentages for Special Duty

Special Duty					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	42.82%	4.0	Sustaining Support	0.84%
2.0	Unit Operations	15.29%	5.0	Continuing System Improvements	10.05%
3.0	Maintenance	24.07%	6.0	Indirect Support	6.92%

Table 9: OSD-CAPE Cost Element Structure Mean Percentages for Trainer

Trainer					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	10.13%	4.0	Sustaining Support	3.40%
2.0	Unit Operations	27.50%	5.0	Continuing System Improvements	7.80%
3.0	Maintenance	26.98%	6.0	Indirect Support	24.17%

Table 10: OSD-CAPE Cost Element Structure Mean Percentages for Transport

Transport					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	32.18%	4.0	Sustaining Support	1.79%
2.0	Unit Operations	22.72%	5.0	Continuing System Improvements	8.84%
3.0	Maintenance	29.83%	6.0	Indirect Support	4.65%

Table 11: OSD-CAPE Cost Element Structure Mean Percentages for UAV/Drone

UAV/Drone					
OSD-CAPE Cost Element Structure					
1.0	Unit-Level Manpower	31.92%	4.0	Sustaining Support	0.57%
2.0	Unit Operations	21.48%	5.0	Continuing System Improvements	11.18%
3.0	Maintenance	29.87%	6.0	Indirect Support	4.98%

A trend to note is the increased cost in 3.0 Maintenance when the platform is being maintained by Contracted Logistics Support (CLS) rather than organically maintained by Air Force "Blue Suiters." Platforms can be maintained in three different ways: Organically, CLS, or a combination of both. When cost is being consumed by sub-element 3.7 Contractor Logistic Support, it is an indicator that the platform is either maintained by both organic/contracted means or fully contracted out to the third party. These findings align with the findings of Col. (Ret.) Jonathan D. Ritschel and Tamiko L. Ritschel in their analysis portrayed in the published work *Organic or Contract Support? Investigating Cost and Performance in Aircraft Sustainment.* The results of their analysis not only reveal that a difference in cost exist between the three maintenance sources but also that CLS is correlated as the most significant factor in aircraft maintenance cost (Ritschel & Ritschel, 2016).

From the results, an indicator that a platform is being modernized or introduced to the Air Force aircraft fleet is when cost element 5.0 Continuing System Improvements is incurring more cost than the category mean percentage for that element. An assumption is that these platforms are continually being upgraded/modernized and are equipped with more advanced hardware and more intricate software.

Bombers

Table 12: OSD-CAPE Cost Element Structure Mean Percentages for Bombers

Bomber					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**25.85%**	3.5	Other Maintenance	0.05%
1.1	Operations	20.18%	3.6	Interim Contractor Support	0.75%
1.2	Unit-Level Maintenance	62.02%	3.7	Contractor Logistics Support	9.50%
1.3	Other Unit-Level	17.79%	3.8	Other Contractor Support	0.06%
2	**Unit Operations**	**15.17%**	**4**	**Sustaining Support**	**4.96%**
2.1.1	Energy (Fuel, POL, Electricity)	66.15%	4.2	Support Equipment Replacement & Repair	3.26%
2.1.2	Training Munitions & Expendable Stores	4.48%	4.3	Sustaining/Systems Engineering	84.87%
2.1.3	Other Operational Material	5.35%	4.4	Program Management	0.35%
2.2	Support Services	20.28%	4.6	Data and Technical Publications	7.76%
2.3	TDY	2.41%	4.7	Simulator Operations & Repair	1.42%
2.4	Transportaion	1.33%	4.8.1	Other Sustaining Support (Testing)	2.34%
3	**Maintenance**	**35.95%**	**5**	**Continuing System Improvements**	**16.06%**
3.1.2	Repair Parts (GSD)	8.06%	5.1	Hardware Modifications	46.54%
3.2.1	DLR Fly	39.10%	5.2	Software Maintenance	53.46%
3.2.2	DLR NonFly	0.11%	**6**	**Indirect Support**	**2.01%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	34.54%	6.1	Installation Support	78.10%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.95%
3.4.3	Engine Overhaul/Rework Depot Repair	7.66%	6.3	General Training & Education	16.95%
3.4.4	Other Overhaul/Rework Depot Repair	0.18%			

The bombers category is represented by the B-52H, B-1B, and the B-2A. The Cost Elements 1.0 Unit-Level Manpower, 2.0 Unit Operations, and 3.0 Maintenance accumulate 76.98% of all O&S cost from the years 1996-2016 for the bombers category. Table 13 shows that of the three platforms, the B-52H is the only platform to fall outside +/- 1SD from the mean for all bombers in element 1.0. The B-52H is the primary driver for the mean percentages for elements 1.0 and 2.0. From the data, it appears that the older the aircraft the more cost it consumes in the top two elements. Additionally, for element

5.0, Continuing System Improvements, the B-52H significantly impacts the mean percentage and drives it down. It has a mean of 8.62% while category mean is nearly double that at 16.02%. If the B-52H was omitted the mean percentage would increase to 19.78%. The B-1B is nearly aligned with the category average at 16.88% while the B-2A surpassed the average within one standard deviations away at 22.68%. These results are not surprising due to the increased technological capabilities that are integrated into these two platforms. Also, newer planes are assumed to have increased software maintenance and hardware maintenance due to more integrated systems that are continually being upgraded. These B-1B and B-2A each reach initial operational capability (IOC) in 1986 and 1993 respectfully while the first version of the B-52 was introduced into the operational Air Force in 1954. The B-2A recorded the lowest mean for each of the top three categories with a mean of 22.12% for Unit-level Manpower (category mean of 25.85%), 11.09% for Unit Operations (category mean of 15.17%), and 34.02% for Maintenance (category mean of 35.95%).

Table 13: Summary Statistics for the OSD-CAPE Cost Elements for Bomber

1.0 Unit Level Manpower				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	25.85%	5.81%	24.46%	9.04%
B-1B	22.84%	3.34%	22.80%	5.92%
B-2A	22.13%	3.20%	22.23%	2.92%
B-52H	32.59%	3.37%	32.87%	4.87%

2.0 Unit Operations				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	15.17%	4.78%	15.14%	8.27%
B-1B	16.95%	4.60%	15.41%	7.61%
B-2A	11.09%	3.79%	9.87%	5.26%
B-52H	17.46%	3.01%	18.06%	4.53%

3.0 Maintenance				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	35.95%	7.39%	35.02%	6.67%
B-1B	38.07%	5.32%	36.25%	7.77%
B-2A	34.02%	10.99%	34.84%	12.55%
B-52H	35.76%	3.41%	34.53%	6.19%

4.0 Sustaining Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	4.96%	4.61%	3.81%	2.69%
B-1B	3.91%	1.77%	3.10%	2.33%
B-2A	7.74%	7.05%	5.58%	4.41%
B-52H	3.23%	0.82%	3.20%	1.44%

5.0 Continuing System Improvements				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	16.06%	8.24%	15.00%	11.97%
B-1B	16.88%	5.13%	17.86%	7.84%
B-2A	22.68%	8.26%	22.03%	10.85%
B-52H	8.62%	3.33%	8.61%	5.54%

6.0 Indirect Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Bomber	2.00%	0.80%	1.90%	0.80%
B-1B	1.35%	0.45%	1.20%	0.76%
B-2A	2.33%	0.49%	2.33%	0.77%
B-52H	2.34%	0.93%	1.99%	0.56%

Fighter

Table 14: OSD-CAPE Cost Element Structure Mean Percentages for Fighter

Fighter					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**33.78%**	3.5	Other Maintenance	0.19%
1.1	Operations	13.62%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	66.35%	3.7	Contractor Logistics Support	17.09%
1.3	Other Unit-Level	20.03%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.68%**	**4**	**Sustaining Support**	**1.57%**
2.1.1	Energy (Fuel, POL, Electricity)	60.78%	4.2	Support Equipment Replacement & Repair	15.18%
2.1.2	Training Munitions & Expendable Stores	11.52%	4.3	Sustaining/Systems Engineering	64.38%
2.1.3	Other Operational Material	7.00%	4.4	Program Management	1.61%
2.2	Support Services	13.86%	4.6	Data and Technical Publications	8.75%
2.3	TDY	5.80%	4.7	Simulator Operations & Repair	7.55%
2.4	Transportaion	1.02%	4.8.1	Other Sustaining Support (Testing)	2.54%
3	**Maintenance**	**35.96%**	**5**	**Continuing System Improvements**	**7.14%**
3.1.2	Repair Parts (GSD)	15.87%	5.1	Hardware Modifications	87.09%
3.2.1	DLR Fly	50.66%	5.2	Software Maintenance	12.91%
3.2.2	DLR NonFly	0.26%	**6**	**Indirect Support**	**3.86%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	11.60%	6.1	Installation Support	78.58%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.08%
3.4.3	Engine Overhaul/Rework Depot Repair	3.85%	6.3	General Training & Education	17.35%
3.4.4	Other Overhaul/Rework Depot Repair	0.59%			

As previously discussed, elements 1.0, 2.0, and 3.0 consumed 87.42% of the total expenditures for the Fighter category. The fighter category is represented by 15 weapon systems: A-10 (A, OA & C variation), F-15 (A-E variation), F-16 (A-D variation), F-117A, F-22A, and the F-35A. Of the 15 aircrafts, three platforms are maintained through CLS means: F-117A, F-22A, F-35A. These aircrafts are also the most modern aircrafts within the fighter categories reaching IOC in 1988, 2003, and 2013. As shown in Table

15, the three each have a maintenance mean percentage of 59.62%, 42.04%, and 37.65 respectfully while the category mean is 35.96%. However, only the F-117A exceeds two standard deviations, which is 57.16%, from the mean while the other two platforms are within one standard deviation.

The OA-10A Thunderbolt II, a specific derivative of the A-10's main design for forward air control, nearly exceeds two standardizations for element 1.0 at a mean percentage of 49.00%. The minimum for 1.0 for the years examined is higher than any other fighter platform mean percentage. The OA-10A was heavily utilized on a flying hour basis until it was phased out and no longer incurred any flying hours after 2008. The OA-10A began with an inventory of 146 platforms in 1996 and by 2009 zero platforms were operational.

The newest operational aircrafts in the inventory are the F-22A Raptor and F-35A Lightning II which started incurring O&S cost in 2003 and 2012 respectfully. However, both exceed one standard deviation away from the mean in 5.0. The mean for the F-22A is 14.90% and the F-35A is 15.42% while the fighter category mean is 7.14%. Within element 5.0, both platforms consume more in 5.1 (Hardware Modifications) with the F-22A consuming 99.78% and the F-35A consuming 78.92%. According to the OSD-CAPE O&S Cost-Estimating Guide 5.1 is "the cost of development, procurement, and installation of modifications kits" (OSD CAPE, 2014). It appears that when new fighter aircraft are being introduced to the Air Force fleet they are likely to need modifications in the early years of their O&S lifecycle phase.

Table 15: Summary Statistics for the OSD-CAPE Cost Elements for Fighter

1.0 Unit-Level Manpower				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Fighter/Attack	33.78%	8.79%	33.68%	13.02%
A-10A	37.07%	4.10%	37.32%	5.91%
A-10C	38.36%	5.26%	38.43%	7.77%
F-117A	20.24%	3.45%	18.71%	5.37%
F-15A	33.96%	4.24%	33.31%	7.64%
F-15B	34.84%	5.83%	33.37%	8.10%
F-15C	28.61%	2.27%	28.23%	2.81%
F-15D	26.90%	2.72%	26.14%	3.55%
F-15E	29.55%	3.89%	28.83%	3.92%
F-16A	44.54%	5.29%	44.25%	6.09%
F-16B	35.73%	8.47%	36.82%	11.49%
F-16C	40.67%	2.10%	41.04%	2.93%
F-16D	39.75%	2.53%	39.96%	2.98%
F-22A	20.24%	6.19%	22.11%	9.30%
F-35A	28.55%	5.52%	29.08%	10.74%
OA-10A	49.00%	3.69%	48.69%	5.32%

2.0 Unit Operations				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Fighter/Attack	17.68%	6.10%	16.95%	6.71%
A-10A	18.26%	3.96%	17.93%	5.31%
A-10C	21.07%	3.05%	22.46%	5.37%
F-117A	10.91%	2.03%	11.17%	3.22%
F-15A	17.23%	4.89%	16.18%	6.97%
F-15B	17.99%	4.97%	16.88%	7.87%
F-15C	15.99%	2.70%	15.54%	4.94%
F-15D	17.04%	2.77%	16.95%	4.36%
F-15E	19.87%	4.20%	20.93%	7.07%
F-16A	16.32%	3.94%	14.83%	7.31%
F-16B	20.70%	4.87%	19.03%	9.53%
F-16C	18.58%	3.41%	19.21%	6.84%
F-16D	19.44%	3.37%	19.51%	6.67%
F-22A	20.23%	18.10%	13.74%	5.31%
F-35A	9.71%	2.15%	10.28%	4.09%
OA-10A	16.11%	2.80%	16.73%	3.44%

3.0 Maintenance				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Fighter/Attack	35.96%	10.60%	33.92%	15.86%
A-10A	29.39%	3.04%	29.88%	4.97%
A-10C	26.53%	3.81%	26.84%	6.28%
F-117A	59.62%	1.48%	59.16%	2.67%
F-15A	38.38%	7.39%	41.78%	13.51%
F-15B	36.08%	9.62%	38.09%	9.60%
F-15C	41.84%	2.72%	42.02%	3.59%
F-15D	43.00%	3.52%	43.26%	4.34%
F-15E	40.75%	4.03%	39.96%	7.01%
F-16A	28.29%	6.32%	30.59%	3.73%
F-16B	32.94%	5.63%	32.83%	8.10%
F-16C	27.99%	1.89%	27.61%	3.00%
F-16D	27.69%	2.25%	27.31%	3.73%
F-22A	42.04%	17.66%	45.88%	18.98%
F-35A	37.65%	11.70%	35.83%	21.58%
OA-10A	24.49%	3.04%	23.69%	2.88%

4.0 Sustaining Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Fighter/Attack	1.57%	1.08%	1.44%	1.11%
A-10A	1.98%	0.98%	1.79%	1.44%
A-10C	2.28%	0.83%	2.09%	1.05%
F-117A	0.38%	0.18%	0.33%	0.32%
F-15A	2.23%	1.08%	1.73%	1.31%
F-15B	2.34%	1.07%	2.09%	1.74%
F-15C	2.02%	1.14%	1.88%	1.07%
F-15D	1.78%	1.27%	1.56%	0.73%
F-15E	0.97%	1.06%	0.78%	0.94%
F-16A	2.33%	0.63%	2.18%	0.91%
F-16B	2.54%	0.86%	2.52%	1.38%
F-16C	1.42%	0.35%	1.34%	0.47%
F-16D	1.36%	0.33%	1.29%	0.55%
F-22A	0.21%	0.18%	0.12%	0.35%
F-35A	0.96%	0.56%	1.26%	0.88%
OA-10A	0.75%	0.48%	0.60%	0.86%

5.0 Continuing System Improvements					6.0 Indirect Support				
Level	Mean	Std Dev	Median	IQR	Level	Mean	Std Dev	Median	IQR
Fighter/Attack	7.14%	5.26%	6.58%	5.99%	**Fighter/Attack**	3.86%	1.77%	3.84%	2.47%
A-10A	8.97%	4.98%	7.12%	7.15%	**A-10A**	4.33%	1.59%	4.15%	2.10%
A-10C	7.40%	5.49%	10.30%	10.66%	**A-10C**	4.36%	1.04%	4.48%	1.48%
F-117A	6.48%	4.11%	7.07%	5.93%	**F-117A**	2.36%	1.01%	1.98%	1.90%
F-15A	2.98%	1.99%	2.49%	3.51%	**F-15A**	5.22%	1.54%	5.33%	1.25%
F-15B	3.29%	2.10%	3.10%	3.52%	**F-15B**	5.46%	1.67%	5.67%	1.54%
F-15C	9.00%	4.51%	9.52%	7.49%	**F-15C**	2.54%	0.46%	2.39%	0.93%
F-15D	8.32%	4.60%	7.57%	6.82%	**F-15D**	2.96%	0.81%	2.72%	1.50%
F-15E	6.34%	2.65%	6.26%	2.85%	**F-15E**	2.53%	0.31%	2.53%	0.49%
F-16A	3.52%	3.59%	2.26%	7.10%	**F-16A**	5.00%	2.71%	5.64%	2.40%
F-16B	4.79%	4.40%	3.20%	8.57%	**F-16B**	3.31%	2.09%	3.89%	4.10%
F-16C	6.84%	2.05%	7.34%	2.94%	**F-16C**	4.51%	0.92%	4.26%	1.18%
F-16D	7.56%	2.14%	7.67%	2.37%	**F-16D**	4.20%	0.72%	3.92%	1.00%
F-22A	14.90%	8.21%	13.20%	12.10%	**F-22A**	2.38%	0.53%	2.27%	0.98%
F-35A	15.42%	13.70%	23.01%	26.02%	**F-35A**	7.71%	2.90%	6.72%	4.26%
OA-10A	4.70%	2.82%	3.99%	2.05%	**OA-10A**	4.95%	1.63%	4.21%	1.37%

Reconnaissance

Table 16: OSD-CAPE Cost Element Structure Mean Percentages for Reconnaissance

Reconnaissance					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**31.83%**	3.5	Other Maintenance	0.01%
1.1	Operations	36.02%	3.6	Interim Contractor Support	0.03%
1.2	Unit-Level Maintenance	48.60%	3.7	Contractor Logistics Support	47.43%
1.3	Other Unit-Level	15.38%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**14.13%**	**4**	**Sustaining Support**	**1.74%**
2.1.1	Energy (Fuel, POL, Electricity)	59.65%	4.2	Support Equipment Replacement & Repair	25.30%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	42.59%
2.1.3	Other Operational Material	5.92%	4.4	Program Management	5.17%
2.2	Support Services	22.42%	4.6	Data and Technical Publications	3.04%
2.3	TDY	11.15%	4.7	Simulator Operations & Repair	19.45%
2.4	Transportaion	0.87%	4.8.1	Other Sustaining Support (Testing)	4.45%
3	**Maintenance**	**40.53%**	**5**	**Continuing System Improvements**	**9.00%**
3.1.2	Repair Parts (GSD)	5.91%	5.1	Hardware Modifications	75.65%
3.2.1	DLR Fly	20.88%	5.2	Software Maintenance	24.35%
3.2.2	DLR NonFly	0.08%	**6**	**Indirect Support**	**2.77%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	16.89%	6.1	Installation Support	59.79%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	7.88%
3.4.3	Engine Overhaul/Rework Depot Repair	8.48%	6.3	General Training & Education	32.33%
3.4.4	Other Overhaul/Rework Depot Repair	0.29%			

The reconnaissance category is comprised of four platforms: E-3B, E-3C, E-8C, and the U-2S. The E-3B and E-3C are organically maintained by “blue-suiters” while the other two platforms are contracted out to a third party for its maintenance. The top three elements 1.0, 2.0, and 3.0 consumed 86.49% of the total expenditures from the years 1996-2016: E-3B 83.13%, E-3C 82.13%, E-8C 85.31%, and U-2S 94.70%. The reconnaissance category also simultaneously recorded the highest 3.0 Maintenance mean percentage and the lowest 2.0 Unit Operations mean percentage at 40.53% and 14.13% respectfully.

The findings for the reconnaissance platforms illustrate a unique trend. The E-3B and its other variant, the E-3C, were similar in regards to cost mean percentages for the various elements, however these two platforms costs behave differently compared to the other two platforms being examined, the U-2S and the E-8C. As shown in Table 17, for the top three elements the E-3B and E-3C were within one-unit percentage point away from each other but diverged significantly from the two other platforms. For 3.0 Maintenance, the other two platforms drove up the mean significantly, U-2S 67.15% and the E-8C at 43.12% while the reconnaissance mean was at 34.98%. This is largely due to sub-element 3.7 Contractor Logistics Support. Another finding to note is that Element 2.0 Unit Operations for U-2S is barely within one standard deviation away from the mean. This result is driven by sub-element 2.1.1., Energy, where the U-2S mean of 34.79% is significantly lower than the category average of 60.78%. According to the Air Force’s internet page af.mil, the U-2S’s “long and narrow wings give the U-2 glider-like characteristics” and is equipped with the fuel efficient General Electric F118-101 engine allowing the aircraft to stay airborne for extended periods of time without refueling (af.mil, 2017). For element 1.0, The U-2S exceeds one standard deviation away from the mean at 17.95% while the reconnaissance mean is 31.83%.

The standard deviations and IQR for all elements show that the data points are dispersed and that the mean is not a great indicator of a randomly selected data point from the sample. For example, element 1.0 has a mean of 31.83% with a standard deviation of 10.55% and an IQR 19.03%. Ideally, a smaller standard deviation and a much smaller IQR would give the findings more credibility. The results to take away from the reconnaissance category is that the E-3B and E-3C are characterize very similarly, however the E-8C and U-2S are significantly different than the other two platforms.

Table 17: Summary Statistics for the OSD-CAPE Cost Elements for Reconnaissance

1.0 Unit-Level Manpower					2.0 Unit Operations				
Level	**Mean**	**Std Dev**	**Median**	**IQR**	**Level**	**Mean**	**Std Dev**	**Median**	**IQR**
Reconnaissance	31.83%	10.55%	32.72%	19.03%	**Reconnaissance**	14.13%	5.68%	14.83%	9.24%
E-3B	40.10%	5.17%	41.08%	9.15%	**E-3B**	16.71%	4.18%	17.13%	6.86%
E-3C	41.14%	4.54%	42.54%	5.87%	**E-3C**	16.17%	2.97%	16.48%	3.75%
E-8C	28.14%	4.52%	27.60%	7.81%	**E-8C**	14.05%	6.10%	12.64%	6.04%
U-2S	17.95%	3.81%	17.39%	3.20%	**U-2S**	9.60%	6.13%	7.42%	2.71%

3.0 Maintenance					4.0 Sustaining Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**	**Level**	**Mean**	**Std Dev**	**Median**	**IQR**
Reconnaissance	40.53%	18.43%	32.24%	26.81%	**Reconnaissance**	1.74%	1.97%	1.09%	2.84%
E-3B	26.32%	4.39%	27.03%	6.89%	**E-3B**	3.31%	1.72%	2.50%	2.71%
E-3C	25.52%	6.24%	26.79%	7.96%	**E-3C**	3.31%	1.61%	3.07%	2.48%
E-8C	43.12%	9.17%	43.72%	12.38%	**E-8C**	0.24%	0.36%	0.10%	0.24%
U-2S	67.15%	8.19%	70.27%	11.86%	**U-2S**	0.11%	0.16%	0.07%	0.14%

5.0 Continuing System Improvements					6.0 Indirect Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**	**Level**	**Mean**	**Std Dev**	**Median**	**IQR**
Reconnaissance	9.00%	8.54%	8.34%	12.17%	**Reconnaissance**	2.77%	1.75%	2.17%	1.31%
E-3B	11.57%	9.04%	9.89%	12.95%	**E-3B**	1.99%	0.45%	2.04%	0.65%
E-3C	11.90%	9.14%	9.93%	12.79%	**E-3C**	1.96%	0.49%	2.09%	0.76%
E-8C	9.94%	7.73%	10.03%	10.32%	**E-8C**	4.51%	1.31%	4.20%	1.88%
U-2S	2.58%	4.21%	0.01%	5.40%	**U-2S**	2.61%	2.46%	2.03%	0.61%

Special Duty

Table 18: OSD-CAPE Cost Element Structure Mean Percentages for Special Duty

Special Duty					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**42.82%**	3.5	Other Maintenance	0.10%
1.1	Operations	31.74%	3.6	Interim Contractor Support	1.87%
1.2	Unit-Level Maintenance	43.21%	3.7	Contractor Logistics Support	19.16%
1.3	Other Unit-Level	25.06%	3.8	Other Contractor Support	1.87%
2	**Unit Operations**	**15.29%**	**4**	**Sustaining Support**	**0.84%**
2.1.1	Energy (Fuel, POL, Electricity)	47.71%	4.2	Support Equipment Replacement & Repair	19.66%
2.1.2	Training Munitions & Expendable Stores	2.81%	4.3	Sustaining/Systems Engineering	30.32%
2.1.3	Other Operational Material	10.89%	4.4	Program Management	7.53%
2.2	Support Services	24.32%	4.6	Data and Technical Publications	19.63%
2.3	TDY	13.29%	4.7	Simulator Operations & Repair	20.76%
2.4	Transportaion	0.98%	4.8.1	Other Sustaining Support (Testing)	2.10%
3	**Maintenance**	**24.07%**	**5**	**Continuing System Improvements**	**10.05%**
3.1.2	Repair Parts (GSD)	18.67%	5.1	Hardware Modifications	78.54%
3.2.1	DLR Fly	47.47%	5.2	Software Maintenance	21.46%
3.2.2	DLR NonFly	0.44%	**6**	**Indirect Support**	**6.92%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	5.45%	6.1	Installation Support	68.99%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	8.39%
3.4.3	Engine Overhaul/Rework Depot Repair	4.73%	6.3	General Training & Education	22.62%
3.4.4	Other Overhaul/Rework Depot Repair	0.25%			

The special duty category is composed of eight aircrafts: AC-130U, EC-130E, EC-130H, MC-130E, MC-130H, MC-130P. WC-130H, WC-130J. These eight aircrafts are all variants of the C-130 Hercules utilized for different missions. The AC-130U is utilized for ground-attack while the MC-130 variants are utilized by Air Force Special Operations Command (AFSOC) for different clandestine special operations missions. The E-C models are primarily flown for their electronic attack capabilities while the WC-130 variants are specially designed for weather based reconnaissance missions.

The first three elements consume 82.18% of the total expenditures for the special duty category. As shown in Table 19, the weather reconnaissance specific variances, the WC-130H and WC-130J, drive down the mean percentage for element 3.0 at 18.52% and 12.32% respectfully. The mean for 3.0 is 24.07%. Another interesting result to note is the differences between the EC-130 variants. They both have similar mission sets and eventually both were replaced by the EC-130J model, however, their O&S cost mean percentages are very different. For element 1.0, the difference is 16.18%, element 2.0 it is 9.69%, and element 3.0 it is 18.68%. These findings go against the traditional assumption that variants of the same platform would act similarly in expenditures.

Lastly, due to the mission and the hazardous conditions that these aircrafts are utilized, an assumption was that 3.0 would consume the largest percentage for special duty, however it was 1.0 Unit Level Manpower that consumed 42.82% of the total expenditures for the eight aircrafts.

Table 19: Summary Statistics for the OSD-CAPE Cost Elements Special Duty

1.0 Unit-Level Manpower				
Level	Mean	Std Dev	Median	IQR
Special Duty	42.82%	12.59%	42.78%	12.76%
AC-130U	41.73%	5.43%	41.06%	4.54%
EC-130E	50.10%	5.93%	50.14%	11.34%
EC-130H	33.92%	16.25%	29.05%	19.03%
MC-130E	44.27%	10.36%	45.28%	11.89%
MC-130H	40.78%	4.79%	41.24%	7.81%
MC-130P	44.28%	7.46%	41.82%	13.19%
WC-130H	40.69%	21.16%	48.39%	20.01%
WC-130J	55.65%	9.11%	53.97%	10.89%

2.0 Unit Operations				
Level	Mean	Std Dev	Median	IQR
Special Duty	15.29%	5.35%	14.78%	6.43%
AC-130U	15.46%	3.59%	15.45%	5.13%
EC-130E	21.12%	5.87%	20.75%	7.31%
EC-130H	11.42%	8.49%	8.99%	3.01%
MC-130E	13.54%	3.06%	13.62%	6.01%
MC-130H	14.01%	2.68%	14.21%	3.89%
MC-130P	14.52%	2.87%	14.40%	4.13%
WC-130H	18.43%	3.90%	18.30%	4.26%
WC-130J	19.67%	4.54%	19.11%	5.52%

3.0 Maintenance				
Level	Mean	Std Dev	Median	IQR
Special Duty	24.07%	9.94%	22.46%	12.15%
AC-130U	26.71%	6.80%	24.01%	12.09%
EC-130E	16.77%	2.14%	15.70%	4.29%
EC-130H	35.45%	12.04%	39.46%	16.71%
MC-130E	22.42%	7.60%	20.98%	6.66%
MC-130H	27.90%	5.32%	27.07%	6.89%
MC-130P	22.12%	5.47%	20.48%	6.58%
WC-130H	18.52%	3.83%	18.69%	5.06%
WC-130J	12.32%	10.10%	8.15%	19.73%

4.0 Sustaining Support				
Level	Mean	Std Dev	Median	IQR
Special Duty	0.84%	0.57%	0.74%	0.57%
AC-130U	0.58%	0.48%	0.39%	0.39%
EC-130E	1.50%	0.70%	1.07%	1.31%
EC-130H	0.46%	0.25%	0.46%	0.40%
MC-130E	0.75%	0.56%	0.83%	1.14%
MC-130H	0.92%	0.48%	0.83%	0.53%
MC-130P	1.06%	0.62%	0.99%	0.56%
WC-130H	1.20%	0.66%	0.98%	0.33%
WC-130J	0.76%	0.29%	0.64%	0.27%

5.0 Continuing System Improvements				
Level	Mean	Std Dev	Median	IQR
Special Duty	10.05%	8.79%	7.28%	11.41%
AC-130U	9.04%	5.67%	7.71%	10.26%
EC-130E	6.08%	2.59%	7.28%	4.16%
EC-130H	15.12%	14.84%	15.18%	22.15%
MC-130E	12.31%	9.41%	9.61%	16.58%
MC-130H	8.79%	5.74%	8.05%	9.72%
MC-130P	10.53%	7.34%	10.01%	13.82%
WC-130H	8.11%	6.50%	5.87%	5.78%
WC-130J	6.45%	7.16%	4.79%	8.88%

6.0 Indirect Support				
Level	Mean	Std Dev	Median	IQR
Special Duty	6.92%	7.42%	6.14%	3.18%
AC-130U	6.48%	0.90%	6.37%	1.21%
EC-130E	4.44%	2.08%	5.40%	3.63%
EC-130H	3.63%	2.14%	2.35%	3.66%
MC-130E	6.70%	3.46%	5.30%	2.03%
MC-130H	7.60%	1.25%	7.64%	1.54%
MC-130P	7.50%	1.41%	7.60%	2.47%
WC-130H	13.04%	20.15%	5.91%	7.30%
WC-130J	5.15%	3.62%	3.97%	5.89%

Trainer

Table 20: OSD-CAPE Cost Element Structure Mean Percentages for Trainer

Trainer					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**10.13%**	3.5	Other Maintenance	1.18%
1.1	Operations	45.23%	3.6	Interim Contractor Support	2.97%
1.2	Unit-Level Maintenance	35.64%	3.7	Contractor Logistics Support	40.06%
1.3	Other Unit-Level	19.12%	3.8	Other Contractor Support	2.97%
2	**Unit Operations**	**27.50%**	**4**	**Sustaining Support**	**3.40%**
2.1.1	Energy (Fuel, POL, Electricity)	43.36%	4.2	Support Equipment Replacement & Repair	29.31%
2.1.2	Training Munitions & Expendable Stores	3.17%	4.3	Sustaining/Systems Engineering	20.95%
2.1.3	Other Operational Material	3.47%	4.4	Program Management	17.74%
2.2	Support Services	46.54%	4.6	Data and Technical Publications	2.05%
2.3	TDY	3.31%	4.7	Simulator Operations & Repair	12.66%
2.4	Transportaion	0.14%	4.8.1	Other Sustaining Support (Testing)	17.29%
3	**Maintenance**	**26.98%**	**5**	**Continuing System Improvements**	**7.80%**
3.1.2	Repair Parts (GSD)	21.73%	5.1	Hardware Modifications	83.55%
3.2.1	DLR Fly	22.12%	5.2	Software Maintenance	16.45%
3.2.2	DLR NonFly	0.75%	**6**	**Indirect Support**	**24.17%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	2.61%	6.1	Installation Support	14.75%
3.4.2	Missile Overhaul/Rework Depot Repair	2.97%	6.2	Personnel Support	2.95%
3.4.3	Engine Overhaul/Rework Depot Repair	0.08%	6.3	General Training & Education	82.30%
3.4.4	Other Overhaul/Rework Depot Repair	2.55%			

The Trainers category is represented by five platforms: AT-38B, T-1A, T-6A, T-37B, T-38A, T-38C. An interesting finding to note is the top three categories only accumulated 64.62% of the total expenditures. More investigation found that 24.17% of the total expenditures were contributed to 6.0 Indirect Support, specifically, 6.3 General Training and Education comprising 82.30% of the 24.17%. This is unique to the trainer category because of the specific mission for the Air Force's Pilot Training Program utilizing these specific aircrafts.

Three of six of the platforms are either fully maintained through CLS or a combination of both CLS and organic means. The three CLS maintained mean percentages for T-1A (30.94%), T-6A (27.49%), and T-38C (30.03%) are all higher than the category mean percentage for 3.0. Maintenance at 26.98%. These findings are aligned with the work completed by Ritschel and Ritschel (2016). The aircraft driving down the mean percentage for 3.0 is the AT-38B (17.62%) a specific variant utilized during weapons training. However, 23.30% of the total expenditures for the AT-38B was incurred in element 5.0, Continuing System Improvements, while the category mean percentage is significantly lower at 7.80%. This could be due to the specificity of the aircraft and its training requirements. According to the Air Force main website, the AT-38B was used to “test experimental equipment such as electrical and weapon systems” (AF.mil, 2017). Therefore, the increased cost in 5.0 is directly related to its unique weapons training mission.

Lastly, the trainer category recorded the lowest mean percentage of the seven categories in 1.0 Unit-Level Manpower at 10.13%. According to OSD CAPE, “Unit-Level Manpower includes the costs of all operators, maintenance, and other support manpower at operating units” (OSD-CAPE, 2014). Though the trainer category is heavily utilized in Air Education & Training Command (AETC), it is still considered an operational wing. However, the nature of the specific training requirements may be the reason why element 1.0 doesn’t incur cost like the other aircraft categories.

Table 21: Summary Statistics for the OSD-CAPE Cost Elements Trainer

1.0 Unit-Level Manpower				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	10.13%	4.78%	10.09%	6.72%
AT-38B	10.13%	5.47%	13.15%	11.22%
T-1A	6.20%	2.07%	5.49%	3.49%
T-37B	10.35%	1.60%	10.71%	1.80%
T-38A	14.45%	5.05%	13.08%	6.62%
T-38C	11.28%	5.33%	12.61%	9.45%
T-6A	8.15%	2.20%	8.25%	3.74%

2.0 Unit Operations				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	27.50%	5.88%	26.56%	6.10%
AT-38B	32.85%	5.02%	32.87%	9.12%
T-1A	25.74%	3.48%	26.38%	3.85%
T-37B	29.18%	5.77%	26.22%	9.31%
T-38A	30.91%	5.68%	30.31%	7.67%
T-38C	26.22%	5.44%	27.42%	3.21%
T-6A	21.66%	3.06%	21.24%	4.82%

3.0 Maintenance				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	26.98%	10.01%	24.82%	11.99%
AT-38B	17.62%	3.31%	17.47%	4.80%
T-1A	30.94%	6.95%	30.69%	9.26%
T-37B	24.02%	5.53%	23.29%	8.76%
T-38A	26.91%	10.27%	22.35%	16.57%
T-38C	30.03%	16.32%	24.64%	14.10%
T-6A	27.49%	4.57%	26.42%	7.15%

4.0 Sustaining Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	3.40%	2.16%	2.68%	3.49%
AT-38B	1.72%	0.67%	1.72%	1.15%
T-1A	2.86%	0.88%	2.75%	0.57%
T-37B	5.62%	0.93%	5.46%	1.23%
T-38A	1.86%	0.96%	1.50%	1.33%
T-38C	2.21%	1.22%	2.02%	1.78%
T-6A	6.70%	1.52%	6.60%	0.35%

5.0 Continuing System Improvements				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	7.80%	10.87%	2.80%	10.80%
AT-38B	23.30%	17.60%	24.97%	34.56%
T-1A	2.37%	4.14%	0.53%	4.53%
T-37B	0.03%	0.05%	0.00%	0.06%
T-38A	10.70%	9.73%	5.36%	18.67%
T-38C	11.40%	8.65%	6.55%	16.75%
T-6A	3.23%	4.95%	2.28%	1.69%

6.0 Indirect Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Trainer	24.17%	9.94%	26.63%	14.13%
AT-38B	14.38%	8.09%	12.00%	16.49%
T-1A	31.89%	4.65%	31.99%	4.99%
T-37B	30.81%	3.27%	30.21%	3.93%
T-38A	15.17%	7.61%	13.63%	11.78%
T-38C	18.86%	6.86%	19.63%	8.36%
T-6A	32.77%	5.10%	34.12%	6.58%

Transport

Table 22: OSD-CAPE Cost Element Structure Mean Percentages for Transport

Transport					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**32.18%**	3.5	Other Maintenance	0.35%
1.1	Operations	26.73%	3.6	Interim Contractor Support	0.25%
1.2	Unit-Level Maintenance	49.46%	3.7	Contractor Logistics Support	29.06%
1.3	Other Unit-Level	23.81%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**22.72%**	**4**	**Sustaining Support**	**1.79%**
2.1.1	Energy (Fuel, POL, Electricity)	69.48%	4.2	Support Equipment Replacement & Repair	18.59%
2.1.2	Training Munitions & Expendable Stores	0.09%	4.3	Sustaining/Systems Engineering	44.49%
2.1.3	Other Operational Material	5.96%	4.4	Program Management	2.57%
2.2	Support Services	11.77%	4.6	Data and Technical Publications	11.24%
2.3	TDY	10.26%	4.7	Simulator Operations & Repair	22.71%
2.4	Transportaion	2.44%	4.8.1	Other Sustaining Support (Testing)	0.40%
3	**Maintenance**	**29.83%**	**5**	**Continuing System Improvements**	**8.84%**
3.1.2	Repair Parts (GSD)	11.09%	5.1	Hardware Modifications	92.01%
3.2.1	DLR Fly	21.87%	5.2	Software Maintenance	7.99%
3.2.2	DLR NonFly	0.17%	**6**	**Indirect Support**	**4.65%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	25.05%	6.1	Installation Support	77.92%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.58%
3.4.3	Engine Overhaul/Rework Depot Repair	12.00%	6.3	General Training & Education	17.50%
3.4.4	Other Overhaul/Rework Depot Repair	0.16%			

The transport category is composed of 14 aircrafts: C-130E, C-130H, C-130J, C-17A, C-21A, C-5A, C-5B, C-5C, HC-130N, KC-10A, KC-135D, KC-135E, KC-135R, KC-135T. The first three cost elements consume 84.73% of the total expenditures. Like previous categories, CLS or organic maintenance is both utilized in this category. However, of the four platforms utilizing the CLS means to maintenance, only one platform, the KC-10A with a mean percentage of 36.10%, exceeds the mean percentage for the category for element 3.0 with 29.83%. The other three platforms, the C-130J, C-17A, and the C-21A all have lower mean percentages for 3.0. These results are unlike the other categories results. The three platforms that are driving the maintenance mean percentage up is the C-5 series (variation A, B & C). With a mean percentage of 35.09%, 35.86%, and 37.15%, the C-5 series just within one standard deviation from the category mean.

The variability within the data set is apparent in Table 23. The IQR for all elements show the dispersion of the middle 50% of the data points within this category. These large IQRs suggest that a randomly selected data point from the population may not be representative of the population. With a mean of 32.18% and an IQR of 14.19% for element 1.0, a randomly selected variable may not be representative of the whole population.

Table 23: Summary Statistics for the OSD-CAPE Cost Elements Bomber

1.0 Unit-Level Manpower				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Transport/Tanker	32.18%	9.57%	32.07%	14.19%
C-130E	39.11%	7.28%	41.90%	4.36%
C-130H	40.38%	4.80%	38.81%	7.21%
C-130J	40.20%	10.29%	39.29%	13.93%
C-17A	23.24%	4.59%	22.80%	8.58%
C-21A	36.46%	5.95%	35.85%	6.40%
C-5A	24.17%	6.26%	24.24%	7.72%
C-5B	25.12%	8.14%	24.26%	5.01%
C-5C	28.50%	6.45%	29.70%	12.64%
HC-130N	38.82%	7.15%	39.78%	11.68%
KC-10A	19.24%	3.29%	19.26%	6.07%
KC-135D	40.12%	8.67%	38.99%	8.25%
KC-135E	37.39%	9.09%	36.26%	12.54%
KC-135R	33.14%	2.80%	33.61%	4.52%
KC-135T	31.88%	5.17%	31.67%	4.78%

2.0 Unit Operations				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Transport/Tanker	22.72%	9.51%	20.08%	11.94%
C-130E	17.94%	3.47%	16.95%	4.79%
C-130H	19.08%	2.33%	18.70%	2.01%
C-130J	16.86%	3.17%	16.69%	4.46%
C-17A	38.42%	4.59%	37.73%	6.88%
C-21A	25.14%	6.70%	26.60%	12.43%
C-5A	17.74%	3.43%	17.20%	6.25%
C-5B	21.18%	3.76%	21.02%	7.02%
C-5C	15.13%	4.60%	15.40%	4.70%
HC-130N	13.59%	3.94%	12.84%	5.46%
KC-10A	38.35%	9.94%	38.51%	17.85%
KC-135D	18.32%	6.47%	19.42%	9.47%
KC-135E	18.15%	5.50%	18.12%	6.79%
KC-135R	24.68%	6.54%	24.71%	9.98%
KC-135T	28.19%	8.09%	27.87%	11.58%

3.0 Maintenance				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Transport/Tanker	29.83%	8.59%	29.52%	11.19%
C-130E	24.95%	5.36%	26.04%	6.33%
C-130H	27.45%	3.33%	28.61%	5.41%
C-130J	24.55%	7.68%	26.25%	5.88%
C-17A	27.47%	7.57%	28.03%	10.01%
C-21A	28.20%	5.31%	27.86%	9.62%
C-5A	35.09%	11.28%	40.04%	12.99%
C-5B	35.86%	8.35%	39.10%	11.56%
C-5C	37.15%	9.85%	38.49%	12.70%
HC-130N	27.12%	7.73%	26.56%	13.91%
KC-10A	36.10%	4.43%	34.70%	8.02%
KC-135D	22.22%	11.95%	20.57%	13.70%
KC-135E	25.78%	10.26%	26.54%	19.44%
KC-135R	30.57%	4.50%	29.52%	6.02%
KC-135T	29.13%	5.09%	28.84%	7.63%

4.0 Sustaining Support				
Level	**Mean**	**Std Dev**	**Median**	**IQR**
Transport/Tanker	1.79%	3.69%	1.24%	1.57%
C-130E	7.02%	12.07%	2.30%	2.94%
C-130H	1.29%	0.90%	0.98%	1.47%
C-130J	1.35%	0.92%	1.12%	1.38%
C-17A	0.12%	0.08%	0.09%	0.14%
C-21A	0.44%	0.57%	0.26%	0.58%
C-5A	1.48%	0.71%	1.26%	1.30%
C-5B	1.86%	0.67%	1.65%	1.20%
C-5C	2.62%	0.90%	2.33%	1.62%
HC-130N	1.13%	0.73%	1.00%	1.27%
KC-10A	1.72%	2.22%	0.14%	3.88%
KC-135D	1.97%	1.03%	1.55%	1.31%
KC-135E	1.43%	0.63%	1.26%	0.88%
KC-135R	1.30%	0.64%	0.99%	0.95%
KC-135T	1.49%	0.81%	1.08%	1.52%

5.0 Continuing System Improvements				
Level	Mean	Std Dev	Median	IQR
Transport/Tanker	8.84%	9.28%	6.03%	7.84%
C-130E	4.51%	2.63%	4.68%	3.56%
C-130H	5.50%	2.60%	5.34%	3.16%
C-130J	10.59%	8.75%	7.81%	11.79%
C-17A	8.24%	5.25%	7.59%	5.38%
C-21A	3.36%	6.09%	1.14%	3.94%
C-5A	17.39%	16.76%	8.16%	20.81%
C-5B	13.39%	13.47%	5.40%	18.50%
C-5C	12.78%	11.52%	6.87%	18.68%
HC-130N	12.22%	8.83%	9.49%	12.69%
KC-10A	3.53%	2.77%	4.15%	5.16%
KC-135D	11.38%	5.57%	10.40%	11.31%
KC-135E	10.15%	5.56%	10.27%	9.29%
KC-135R	5.97%	5.68%	3.70%	9.05%
KC-135T	6.71%	6.46%	3.80%	11.41%

6.0 Indirect Support				
Level	Mean	Std Dev	Median	IQR
Transport/Tanker	4.65%	3.18%	4.32%	3.60%
C-130E	6.48%	2.53%	7.21%	1.50%
C-130H	6.30%	2.00%	5.75%	1.01%
C-130J	6.46%	1.37%	5.96%	2.37%
C-17A	2.51%	0.91%	2.25%	1.33%
C-21A	6.40%	5.81%	5.01%	1.43%
C-5A	4.12%	3.27%	3.08%	1.41%
C-5B	2.58%	0.95%	2.61%	1.17%
C-5C	3.82%	1.40%	3.49%	1.96%
HC-130N	7.13%	2.95%	7.34%	4.24%
KC-10A	1.06%	0.56%	0.94%	0.46%
KC-135D	5.99%	4.95%	6.97%	7.46%
KC-135E	7.09%	2.47%	6.89%	3.64%
KC-135R	4.34%	0.76%	4.45%	1.31%
KC-135T	2.59%	0.52%	2.59%	0.61%

UAV/Drone

Table 24: OSD-CAPE Cost Element Structure Mean Percentages for UAV/Drone

UAV/Drone					
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**31.92%**	3.5	Other Maintenance	0.00%
1.1	Operations	44.78%	3.6	Interim Contractor Support	0.06%
1.2	Unit-Level Maintenance	36.79%	3.7	Contractor Logistics Support	94.26%
1.3	Other Unit-Level	18.43%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**21.48%**	**4**	**Sustaining Support**	**0.57%**
2.1.1	Energy (Fuel, POL, Electricity)	1.38%	4.2	Support Equipment Replacement & Repair	47.10%
2.1.2	Training Munitions & Expendable Stores	3.62%	4.3	Sustaining/Systems Engineering	10.81%
2.1.3	Other Operational Material	7.29%	4.4	Program Management	32.66%
2.2	Support Services	80.05%	4.6	Data and Technical Publications	0.00%
2.3	TDY	7.07%	4.7	Simulator Operations & Repair	5.33%
2.4	Transportaion	0.60%	4.8.1	Other Sustaining Support (Testing)	4.09%
3	**Maintenance**	**29.87%**	**5**	**Continuing System Improvements**	**11.18%**
3.1.2	Repair Parts (GSD)	5.45%	5.1	Hardware Modifications	89.64%
3.2.1	DLR Fly	0.03%	5.2	Software Maintenance	10.36%
3.2.2	DLR NonFly	0.20%	**6**	**Indirect Support**	**4.98%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	77.92%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	13.19%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	8.89%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

The UAV/Drone category is composed of two unmanned aerial vehicles: the MQ-1B Predator and the MQ-9A Reaper. The Predator started incurring O&S cost in 1997 while the Reaper started incurring cost in 2008 and reaching IOC in 2014. Similar to the manned-aircrafts, the MQ-1B and the MQ-9A incurs the majority of their total expenditures, 83.27%, in the first three elements 31.92%, 21.48%, and 29.87% respectfully. Both vehicles utilize CLS maintenance and the Predator uses 30.69% and the Reaper 28.03% of their total expenditures in 3.0 maintenance. A finding that is unique to UAV's is the majority of 2.0 (21.48%) is not consumed in 2.1.1 Energy, which makes it unique from the other vehicle categories. Instead, the majority of the costs occur in element 2.2 which is support services. AFTOC includes examples of certain costs that would be incurred in 2.2 which includes food services, lease costs for special facilities, and transportation of personnel and material to remote operating sites for operations, maintenance or support (AFTOC).

For all elements, all the means fall within one standard deviation from the mean. However, with a large IQR, for example for element 1.0, the IQR is 19.70% which is an indicator that the mean is not a good representative for the data set. With a more dispersed data set it drives up the standard deviation and variance indicating that there is a lot of variability within the data points. However, this could be due to the UAV/Drone category only having two platforms that are included in this analysis.

Table 25: Summary Statistics for the OSD-CAPE Cost Elements UAV/Drone

1.0 Unit-Level Manpower					2.0 Unit Operatioins				
Level	Mean	Std Dev	Median	IQR	Level	Mean	Std Dev	Median	IQR
UAV	31.92%	10.79%	31.41%	19.07%	UAV	21.48%	8.91%	21.15%	12.11%
MQ-1B	33.05%	10.21%	32.45%	18.52%	MQ-1B	24.55%	8.08%	22.82%	9.46%
MQ-9A	29.41%	12.24%	31.41%	23.84%	MQ-9A	14.66%	6.85%	14.78%	9.45%

3.0 Maintenance				
Level	Mean	Std Dev	Median	IQR
UAV	29.87%	10.62%	30.60%	10.79%
MQ-1B	30.69%	12.02%	32.15%	10.16%
MQ-9A	28.03%	6.79%	25.00%	8.22%

4.0 Sustaining Support				
Level	Mean	Std Dev	Median	IQR
UAV	0.58%	0.93%	0.18%	0.66%
MQ-1B	0.30%	0.31%	0.18%	0.43%
MQ-9A	1.20%	1.47%	0.19%	2.80%

5.0 Continuing System Improvements				
Level	Mean	Std Dev	Median	IQR
UAV	11.18%	10.96%	7.78%	15.77%
MQ-1B	6.76%	6.76%	5.44%	10.95%
MQ-9A	21.00%	12.42%	20.60%	23.56%

6.0 Indirect Support				
Level	Mean	Std Dev	Median	IQR
UAV	4.98%	2.77%	4.01%	4.72%
MQ-1B	4.65%	2.55%	3.75%	4.31%
MQ-9A	5.71%	3.25%	6.32%	6.55%

Research Question II

Compare, contrast, and identify the relationships within the OSD-CAPE Cost Element Structure across the aircraft categories (bomber, fighter, reconnaissance, special duty, trainer, transport/tanker and UAV/drone). To compare the medians for the categories, we utilized the Kruskal-Wallis and Steel Dwaas tests in JMP. As stated in Chapter III, we could not perform t-tests comparison because the data is not normally distributed. Therefore, we are utilizing non-parametric testing. The null hypothesis of the Kruskal-Wallis test is that all medians are statistically the same and the alternative hypothesis is that at least one median is statistically differentiable.

$$H_O:\ \Delta_X = \Delta_Y \ldots. = \ \Delta_n$$

$$H_a: \Delta_X \neq \Delta_Y \ldots. \neq \ \Delta_n$$

For elements 1.0 Unit Level Manpower, 2.0 Unit Operations, 3.0 Maintenance, 4.0 Sustaining Support, 5.0 Continuing System Improvement, and 6.0 Indirect Support, the Kruskal-Wallis test resulted in a p-value < 0.00238 meaning the null hypothesis is rejected because at least one median is statistically different from the other medians.

However, the Kruskal-Wallis test does not identify where within the data set the differences lie.

Specifically, for element 1.0 Manpower, 897 platforms were entered in the Kruskal-Wallis and the Steel Dwaas test. As stated above, the Kruskal-Wallis test resulted in the rejection of the null hypothesis in support of the alternative hypothesis, stating at least one median is statistically different. Next, the Steel Dwaas test results are shown in Table 27 which delineates where within the data set the differences lie. We can conclude from Table 27 that the transport/tanker category medians are statistically different from the trainer category with a p-value < 0.00238 however the test could not statistically differentiate the transport/tanker category between the UAV/drone categories for cost element 1.0 with a p-value > 0.00238. Another important result to identify is the score mean difference. For example, referencing Table 27, as stated the trainer is significantly different than the transport/tanker category additionally the trainer is also significantly different from the fighter category. When the mean difference is furthest away from zero it entails the strength of the difference between the two categories.

Table 26: Kruskal Wallis Test Element 1.0

1.0 Unit Level Manpower					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	63	19363	28287	307.349	-4.5
Fighter/Attack	221	109896	99229	497.267	3.19
Reconnaissance	84	39186	37716	466.5	0.65
Special Duty	132	92077	59268	697.553	11.935
Trainer	99	5560	44451	56.162	-15.995
Transport/Tanker	269	123295	120781	458.346	0.707
UAV/Drone	29	13376	13021	461.241	0.258

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
376.3871	6	**<.0001***

Table 27: Steel Dwaas Test Element 1.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehm	Lower CL	Upper CL
Transport/Tanker	Trainer	181.589	12.5048	14.5215	<.0001*	0.220374	0.191598	0.248239
Special Duty	Fighter/Attack	96.484	11.22542	8.5952	<.0001*	0.101045	0.068351	0.13033
Special Duty	Bomber	84.287	8.64201	9.7531	<.0001*	0.179042	0.143255	0.212817
Fighter/Attack	Bomber	77.655	11.72961	6.6204	<.0001*	0.076203	0.046744	0.109654
Transport/Tanker	Bomber	66.294	13.43455	4.9346	<.0001*	0.060523	0.024404	0.096038
UAV/Drone	Trainer	60.723	7.83245	7.7528	<.0001*	0.22185	0.162346	0.282193
Special Duty	Reconnaissance	59.269	8.72301	6.7946	<.0001*	0.111441	0.06438	0.160236
Reconnaissance	Bomber	24.403	7.09656	3.4387	0.0105*	0.067054	0.010495	0.117468
UAV/Drone	Bomber	16.617	5.99197	2.7733	0.0811	0.064062	-0.00333	0.126559
UAV/Drone	Transport/Tanker	1.031	16.84171	0.0612	1	0.00114	-0.06224	0.063772
UAV/Drone	Reconnaissance	-0.765	7.0567	-0.1085	1	-0.002426	-0.07529	0.072623
Transport/Tanker	Reconnaissance	-2.539	12.75469	-0.199	1	-0.002508	-0.04235	0.037878
Reconnaissance	Fighter/Attack	-9.521	11.30405	-0.8423	0.9805	-0.011663	-0.05534	0.027261
UAV/Drone	Fighter/Attack	-10.688	14.28207	-0.7484	0.9895	-0.015877	-0.07823	0.041802
Transport/Tanker	Fighter/Attack	-25.799	12.85505	-2.0069	0.4101	-0.017846	-0.04332	0.008012
UAV/Drone	Special Duty	-45.15	9.56108	-4.7223	<.0001*	-0.115208	-0.18207	-0.04555
Trainer	Bomber	-79.792	7.56015	-10.5543	<.0001*	-0.15653	-0.18383	-0.13016
Trainer	Reconnaissance	-88.76	7.858	-11.2955	<.0001*	-0.230301	-0.27465	-0.17861
Trainer	Special Duty	-113.688	8.88507	-12.7954	<.0001*	-0.335769	-0.36424	-0.30797
Transport/Tanker	Special Duty	-120.73	12.31696	-9.802	<.0001*	-0.116607	-0.14789	-0.08483
Trainer	Fighter/Attack	-158.662	11.18918	-14.1799	<.0001*	-0.237993	-0.2656	-0.21082

We utilized 895 of the 916 platforms when performing the statistical tests for element 2.0 Unit Operations. Similar to Table 26, Table 28 illustrates the Kruskal Wallis test results in a p- value < 0.0001. Therefore, at least one median is different from the other medians. The Steel Dwaas test (Table 29) is conducted and the results portray where within the categories the differences lie. A result to note is that the bomber category, median 15.14%, and the special duty category, median 14.78%, are the most similar statistically in regards to their score mean difference of -5.331. Also, the UAV/drone category is not statistically different from the transport/tanker category with a score mean difference of -6.5 however these two categories are extremely different in regards to mission and size of the average platform within each category.

Table 28: Kruskal Wallis Test Element 2.0

2.0 Unit Operations					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	63	19753	28224	313.54	-4.282
Fighter/Attack	227	93563	101696	412.172	-2.417
Reconnaissance	83	22199	37184	267.458	-6.68
Special Duty	135	38917	60480	288.274	-7.79
Trainer	96	71852	43008	748.458	12.052
Transport/Tanker	263	140261	117824	533.312	6.369
UAV/Drone	28	14415	12544	514.821	1.389

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
273.627	6	**<.0001***

Table 29: Steel Dwaas Test Element 2.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Trainer	Fighter/Attack	139.111	11.36936	12.2356	<.0001*	0.095515	0.077216	0.113015
Trainer	Special Duty	109.538	8.92201	12.2773	<.0001*	0.122436	0.104536	0.141094
Transport/Tanker	Special Duty	108.005	12.17963	8.8677	<.0001*	0.057441	0.038631	0.078494
Transport/Tanker	Reconnaissance	97.607	12.59312	7.7508	<.0001*	0.069456	0.04342	0.096468
Trainer	Reconnaissance	85.355	7.76648	10.9902	<.0001*	0.131144	0.106292	0.155958
Transport/Tanker	Bomber	77.816	13.22065	5.8859	<.0001*	0.055158	0.028554	0.084074
Trainer	Bomber	74.387	7.46553	9.964	<.0001*	0.119136	0.094446	0.143406
Transport/Tanker	Fighter/Attack	69.526	12.8279	5.4199	<.0001*	0.030997	0.013964	0.048597
UAV/Drone	Special Duty	40.34	9.80106	4.1159	0.0008*	0.057506	0.01703	0.097926
Fighter/Attack	Bomber	37.92	11.94182	3.1754	0.0252*	0.023637	0.001876	0.045281
UAV/Drone	Fighter/Attack	33.359	14.7733	2.2581	0.2647	0.029343	-0.009381	0.067596
UAV/Drone	Reconnaissance	28.92	7.03434	4.1113	0.0008*	0.065949	0.020386	0.10948
UAV/Drone	Bomber	20.351	5.99923	3.3923	0.0123*	0.053561	0.007388	0.095713
Special Duty	Reconnaissance	9.436	8.79796	1.0725	0.9362	0.007667	-0.013951	0.029626
Special Duty	Bomber	-5.331	8.74307	-0.6098	0.9965	-0.00478	-0.027275	0.018392
UAV/Drone	Transport/Tanker	-6.5	16.72773	-0.3886	0.9997	-0.006459	-0.056072	0.040103
Reconnaissance	Bomber	-9.772	7.06662	-1.3829	0.8112	-0.013085	-0.039992	0.014863
UAV/Drone	Trainer	-33.791	7.71918	-4.3775	0.0002*	-0.067528	-0.1093	-0.023839
Reconnaissance	Fighter/Attack	-58.969	11.49739	-5.1289	<.0001*	-0.036439	-0.056586	-0.016084
Special Duty	Fighter/Attack	-60.257	11.37343	-5.298	<.0001*	-0.027877	-0.043314	-0.012552
Transport/Tanker	Trainer	-84.581	12.3749	-6.8349	<.0001*	-0.065502	-0.086406	-0.041773

We utilized 900 of the 916 platforms when performing the statistical tests for element 3.0 Maintenance. Referencing to Table 31, it also shows where the differences lie between the medians for all categories. Referencing the scored mean difference of -102.481, the fighter and special duty category have the most statistically different medians when compared to each other. While, like element 2.0, the UAV/drone category is statistically similar to the transport/tanker category. Referencing to the results in

Question 1, the transport/tanker category has a median of 29.52% for element 3.0 maintenance while the UAV/drone category has category median 30.60%.

Table 30: Kruskal Wallis Test Element 3.0

3.0 Manpower					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	57	36221	25678.5	635.456	5.55
Fighter/Attack	229	125867	103165	549.638	6.684
Reconnaissance	84	47155	37842	561.369	4.105
Special Duty	138	37809	62169	273.978	-8.669
Trainer	99	31444	44599.5	317.616	-5.391
Transport/Tanker	267	115108	120284	431.116	-1.453
UAV/Drone	26	11846	11713	455.615	0.101

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
168.4398	6	**<.0001***

Table 31: Steel Dwaas Test Element 3.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Transport/Tanker	Special Duty	81.795	12.27248	6.66489	<.0001*	0.065143	0.038135	0.091307
Transport/Tanker	Trainer	53.945	12.44945	4.33315	0.0003*	0.043588	0.014498	0.071804
UAV/Drone	Special Duty	40.154	10.15241	3.95516	0.0015*	0.073893	0.021118	0.123901
UAV/Drone	Trainer	24.403	7.98363	3.05659	0.0363*	0.052026	0.002452	0.101807
Trainer	Special Duty	16.662	9.03003	1.8452	0.5172	0.020747	-0.011898	0.054622
Reconnaissance	Fighter/Attack	12.342	11.54413	1.06911	0.9371	0.017951	-0.032196	0.091399
UAV/Drone	Transport/Tanker	9.138	17.40638	0.52497	0.9985	0.008094	-0.039396	0.053212
Reconnaissance	Bomber	-6.935	7.00964	-0.98937	0.9565	-0.023919	-0.071563	0.084218
UAV/Drone	Reconnaissance	-12.869	7.15875	-1.7976	0.5496	-0.04744	-0.186167	0.029319
Fighter/Attack	Bomber	-16.871	12.24225	-1.37811	0.8137	-0.01892	-0.056163	0.026244
UAV/Drone	Bomber	-23.438	5.70431	-4.10887	0.0008*	-0.062154	-0.101496	-0.019657
UAV/Drone	Fighter/Attack	-33.856	15.26389	-2.21803	0.2856	-0.046418	-0.103417	0.016733
Trainer	Reconnaissance	-44.815	7.858	-5.70307	<.0001*	-0.100035	-0.173439	-0.05033
Transport/Tanker	Reconnaissance	-49.65	12.69383	-3.91134	0.0018*	-0.059723	-0.125427	-0.013657
Trainer	Bomber	-57.363	7.51154	-7.63667	<.0001*	-0.1152	-0.146418	-0.080076
Special Duty	Reconnaissance	-63.649	8.88865	-7.16069	<.0001*	-0.123716	-0.202315	-0.073932
Special Duty	Bomber	-72.598	8.88577	-8.17017	<.0001*	-0.136084	-0.166106	-0.103178
Transport/Tanker	Fighter/Attack	-73.098	12.9091	-5.66255	<.0001*	-0.050409	-0.07839	-0.024255
Trainer	Fighter/Attack	-81.078	11.40633	-7.10813	<.0001*	-0.092695	-0.127088	-0.061262
Transport/Tanker	Bomber	-87.541	13.66794	-6.40485	<.0001*	-0.067932	-0.096542	-0.039258
Special Duty	Fighter/Attack	-102.481	11.43252	-8.96395	<.0001*	-0.112897	-0.14954	-0.080229

We utilized 885 of the 916 platforms when performing the statistical tests for Element 4.0 Sustaining Support. Table 32 illustrates at least one median that is statistically different from the others. The Steel Dwaas results in Table 33, when referencing the score mean difference, portray that the bomber and the transport/tanker category are the most different platforms regarding 4.0 sustaining support. Additionally, the reconnaissance and transport/tanker categories are statistically the same with a score mean difference of 7.422 and a p-value = .9971. The mean and median expenditure percentages are the lowest for all six elements at 1.94% and 1.31%.

Table 32: Kruskal Wallis Test Element 4.0

4.0 Sustaining Support					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	58	42603	25694	734.534	8.985
Fighter/Attack	221	98850.5	97903	447.287	0.288
Reconnaissance	84	33336	37212	396.857	-1.739
Special Duty	132	37004	58476	280.333	-7.926
Trainer	101	68316	44743	676.396	9.749
Transport/Tanker	263	108581	116509	412.856	-2.281
UAV/Drone	26	3364.5	11518	129.404	-6.349

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
258.6839	6	**<.0001***

Table 33: Steel Dwaas Test Element 4.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Trainer	Special Duty	102.422	8.91098	11.494	<.0001*	0.019971	0.015962	0.024964
Trainer	Fighter/Attack	96.509	11.18175	8.631	<.0001*	0.014207	0.009837	0.020928
Transport/Tanker	Special Duty	65.498	12.17835	5.3782	<.0001*	0.004677	0.002058	0.007385
Trainer	Reconnaissance	44.233	7.90733	5.5939	<.0001*	0.015662	0.009199	0.023854
Transport/Tanker	Reconnaissance	7.422	12.57193	0.5903	0.9971	0.000549	-0.005185	0.005158
Special Duty	Reconnaissance	-8.873	8.72292	-1.0172	0.9503	-0.002461	-0.011865	0.002593
Reconnaissance	Fighter/Attack	-13.793	11.30399	-1.2202	0.8866	-0.001733	-0.00725	0.004697
Trainer	Bomber	-14.209	7.58563	-1.8732	0.4983	-0.006324	-0.015425	0.003588
Transport/Tanker	Fighter/Attack	-20.068	12.76295	-1.5724	0.7001	-0.001327	-0.003812	0.001209
UAV/Drone	Reconnaissance	-20.474	7.15785	-2.8603	0.0641	-0.007714	-0.02326	0.000047
UAV/Drone	Bomber	-40.134	5.75702	-6.9713	<.0001*	-0.032747	-0.045178	-0.023958
Reconnaissance	Bomber	-40.703	7.02257	-5.796	<.0001*	-0.022621	-0.030723	-0.013019
UAV/Drone	Special Duty	-51.078	9.81728	-5.2029	<.0001*	-0.004779	-0.007182	-0.002174
UAV/Drone	Trainer	-61.831	8.09414	-7.639	<.0001*	-0.024285	-0.039826	-0.017406
Special Duty	Bomber	-83.994	8.66321	-9.6954	<.0001*	-0.028408	-0.036158	-0.022416
Special Duty	Fighter/Attack	-86.187	11.22542	-7.6778	<.0001*	-0.006601	-0.008712	-0.004295
UAV/Drone	Fighter/Attack	-97.665	14.81321	-6.5931	<.0001*	-0.011332	-0.015326	-0.007184
UAV/Drone	Transport/Tanker	-99.891	17.18061	-5.8141	<.0001*	-0.009163	-0.014977	-0.004516
Fighter/Attack	Bomber	-108.995	11.90371	-9.1564	<.0001*	-0.022474	-0.029174	-0.016547
Transport/Tanker	Trainer	-112.874	12.31736	-9.1638	<.0001*	-0.016084	-0.022176	-0.011263
Transport/Tanker	Bomber	-123.6	13.46322	-9.1806	<.0001*	-0.023512	-0.03002	-0.017948

We utilized 885 of the 916 platforms when performing the statistical tests for Element 5.0 Continuing System Improvements. The results portray that the majority of categories when compared to each other are not distinguishable from one another. The bomber category stands out as statistically different from five categories: reconnaissance, special duty, trainer, transport/tanker, and fighter. The only other category that is different is the trainer category which is statistically different from the fighter, special duty and transport/tanker category. However, the mean and median percentages for element 5.0 is 9.05% and 6.60% respectfully, therefore it incurs only a small percentage of the expenditures compared to the top three elements.

Table 34: Kruskal Wallis Test Element 5.0

5.0 Continuing System Improvements					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	62	42836	27156	690.903	8.175
Fighter/Attack	220	90819.5	96360	412.816	-1.708
Reconnaissance	82	36511.5	35916	445.262	0.273
Special Duty	136	66491	59568	488.904	2.556
Trainer	95	29505	41610	310.579	-5.205
Transport/Tanker	251	102928	109938	410.072	-2.073
UAV/Drone	29	14159	12702	488.241	1.088

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
98.2312	6	**<.0001***

Table 35: Steel Dwaas Test Element 5.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Transport/Tanker	Trainer	49.422	12.04817	4.10206	0.0008*	0.020683	0.00558	0.036636
Special Duty	Fighter/Attack	31.442	11.22507	2.80101	0.0753	0.016109	-0.000877	0.035745
UAV/Drone	Transport/Tanker	24.157	15.88117	1.52112	0.7322	0.019905	-0.017085	0.072738
UAV/Drone	Fighter/Attack	22.461	14.22454	1.57901	0.6959	0.019905	-0.017001	0.075682
UAV/Drone	Trainer	19.489	7.60877	2.56138	0.138	0.040676	-0.001497	0.090344
Reconnaissance	Fighter/Attack	16.205	11.29293	1.43496	0.7829	0.009812	-0.011238	0.03516
Special Duty	Reconnaissance	10.605	8.81791	1.20265	0.8934	0.010825	-0.019908	0.037629
UAV/Drone	Reconnaissance	5.485	6.94155	0.79012	0.986	0.013778	-0.035416	0.075682
UAV/Drone	Special Duty	1.192	9.77183	0.12202	1	0.001619	-0.040031	0.057023
Transport/Tanker	Fighter/Attack	-5.54	12.5701	-0.44072	0.9994	-0.001787	-0.014598	0.010192
Transport/Tanker	Reconnaissance	-11.689	12.24513	-0.95462	0.9634	-0.0087	-0.036213	0.012685
UAV/Drone	Bomber	-16.575	5.942	-2.78953	0.0777	-0.058781	-0.117923	0.004784
Trainer	Reconnaissance	-20.006	7.70669	-2.59596	0.1271	-0.027255	-0.058565	0.000215
Transport/Tanker	Special Duty	-35.91	11.9105	-3.01498	0.0411*	-0.016525	-0.034277	-0.00038
Reconnaissance	Bomber	-37.26	7.01769	-5.3095	<.0001*	-0.074852	-0.114229	-0.035838
Trainer	Fighter/Attack	-42.269	11.17483	-3.7825	0.0030*	-0.024088	-0.042182	-0.003968
Trainer	Special Duty	-46.352	8.93433	-5.18807	<.0001*	-0.033825	-0.055915	-0.014512
Special Duty	Bomber	-46.835	8.78083	-5.33375	<.0001*	-0.063752	-0.100915	-0.030453
Trainer	Bomber	-52.924	7.41909	-7.13351	<.0001*	-0.103687	-0.138594	-0.067632
Fighter/Attack	Bomber	-99.393	11.72457	-8.47729	<.0001*	-0.087683	-0.118274	-0.059781
Transport/Tanker	Bomber	-105.523	12.8347	-8.22172	<.0001*	-0.085949	-0.117734	-0.057703

We utilized 888 of the 916 platforms when performing the statistical tests for element 6.0 Indirect Support. Like the previous five elements, the Kruskal-Wallis test resulted in a p-value <0.0001. The Steel Dwaas results were aligned with our assumption that the trainer category would be significantly different from all seven categories. The trainer median for element 6.0 is 26.63% while the median for all platforms is 4.28%. This is because trainer category incurring significantly more expenditures in 6.3: General Training and Education than any other category due to the nature of the mission for these platforms.

Table 36: Kruskal Wallis Test Element 6.0

6.0 Indirect Support					
Wilcoxon / Kruskal-Wallis Tests (Rank Sums)					
Level	**Count**	**Score Sum**	**Expected Score**	**Score Mean**	**(Mean-Mean0)/Std0**
Bomber	60	8861	26670	147.683	-9.283
Fighter/Attack	225	88083	100013	391.48	-3.588
Reconnaissance	76	15775	33782	207.566	-8.421
Special Duty	133	73111	59118.5	549.707	5.13
Trainer	101	82756	44894.5	819.366	15.602
Transport/Tanker	264	112487	117348	426.087	-1.391
UAV/Drone	29	13643	12890.5	470.448	0.554

1-Way Test, ChiSquare Approximation		
ChiSquare	DF	Prob>ChiSq
394.5995	6	**<.0001***

Table 37: Steel Dwaas Test Element 6.0

Level	Level	Score Mean Difference	Std Err Dif	Z	p-Value	Hodges-Lehmann	Lower CL	Upper CL
Trainer	Fighter/Attack	158.775	11.28883	14.0648	<.0001*	0.225779	0.195665	0.247349
Transport/Tanker	Bomber	108.665	13.39734	8.1109	<.0001*	0.022548	0.013637	0.031208
Fighter/Attack	Bomber	107.403	11.97486	8.969	<.0001*	0.018502	0.012431	0.024833
Trainer	Special Duty	104.327	8.93455	11.6768	<.0001*	0.204617	0.172509	0.229662
Transport/Tanker	Reconnaissance	92.651	12.79548	7.2409	<.0001*	0.017386	0.010244	0.026675
Trainer	Reconnaissance	88.396	7.78082	11.3608	<.0001*	0.243603	0.200579	0.267799
Special Duty	Fighter/Attack	86.925	11.31938	7.6793	<.0001*	0.021626	0.014369	0.0285
Trainer	Bomber	80.487	7.599	10.5918	<.0001*	0.247524	0.201397	0.272902
Special Duty	Reconnaissance	74.881	8.69626	8.6107	<.0001*	0.037891	0.029988	0.044217
Special Duty	Bomber	73.899	8.68693	8.5069	<.0001*	0.041848	0.034292	0.049064
UAV/Drone	Bomber	33.682	5.84314	5.7644	<.0001*	0.023018	0.009908	0.048656
UAV/Drone	Reconnaissance	32.038	6.64731	4.8197	<.0001*	0.018932	0.006126	0.045142
Transport/Tanker	Fighter/Attack	25.952	12.82103	2.0242	0.3991	0.00384	-0.001851	0.009598
UAV/Drone	Fighter/Attack	23.434	14.49516	1.6167	0.6715	0.00827	-0.00574	0.026326
Reconnaissance	Bomber	19.759	6.80497	2.9036	0.0568	0.003071	-0.000082	0.006932
UAV/Drone	Transport/Tanker	16.552	16.57485	0.9986	0.9545	0.005152	-0.010362	0.021093
UAV/Drone	Special Duty	-11.466	9.61376	-1.1927	0.8972	-0.009097	-0.028726	0.010215
UAV/Drone	Trainer	-59.519	7.93649	-7.4994	<.0001*	-0.210291	-0.253237	-0.154505
Transport/Tanker	Special Duty	-65.166	12.20151	-5.3408	<.0001*	-0.015868	-0.024577	-0.007397
Reconnaissance	Fighter/Attack	-89.288	11.54732	-7.7323	<.0001*	-0.014307	-0.020135	-0.008389
Transport/Tanker	Trainer	-172.446	12.34469	-13.9692	<.0001*	-0.218487	-0.242215	-0.189156

Table 38 summarizes the findings of the Steel Dwaas tests for question two across all six elements. It sums up the total times the category was statistically different across the six elements. It illustrates that the Trainer category is the most statistically different category when compared to the other six categories while the UAV/Drone and Reconnaissance categories were the most non-distinguishable across all seven categories.

Table 38: Summary of Question II's Significant Results

Level	Bomber	Fighter/Attack	Reconnaissance	Special Duty	Trainer	Transport/Tanker	UAV/Drone
1.0 Unit Level Manpower	4	3	2	5	6	3	1
2.0 Unit Operations	2	4	4	4	6	5	3
3.0 Maintenance	4	3	3	5	5	6	3
4.0 Sustaining Support	5	4	2	5	5	4	5
5.0 Continuing System Improvements	4	2	1	2	4	2	0
6.0 Indirect Support	5	4	5	5	6	4	3
Total	**24**	**20**	**17**	**26**	**32**	**24**	**15**

Table 39 color coordinates the results from the six Steel Dwaas tests. When a category is highlighted red, this indicates the category is statistically more expensive than the category it is compared too, the blue highlighted categories. However, if the categories are both highlighted green it indicates that test results indicate the two category's expenditures are statistically not differentiable.

Table 39: Results from the Steel Dwaas Tests

1.0 Unit Level Manpower		2.0 Unit Operations		3.0 Maintenance	
Level	**Level**	**Level**	**Level**	**Level**	**Level**
Transport/Tanker	Trainer	Trainer	Fighter/Attack	Transport/Tanker	Special Duty
Special Duty	Fighter/Attack	Trainer	Special Duty	Transport/Tanker	Trainer
Special Duty	Bomber	Transport/Tanker	Special Duty	UAV/Drone	Special Duty
Fighter/Attack	Bomber	Transport/Tanker	Reconnaissance	UAV/Drone	Trainer
Transport/Tanker	Bomber	Trainer	Reconnaissance	Trainer	Special Duty
UAV/Drone	Trainer	Transport/Tanker	Bomber	Reconnaissance	Fighter/Attack
Special Duty	Reconnaissance	Trainer	Bomber	UAV/Drone	Transport/Tanker
Reconnaissance	Bomber	Transport/Tanker	Fighter/Attack	Reconnaissance	Bomber
UAV/Drone	Bomber	UAV/Drone	Special Duty	UAV/Drone	Reconnaissance
UAV/Drone	Transport/Tanker	Fighter/Attack	Bomber	Fighter/Attack	Bomber
UAV/Drone	Reconnaissance	UAV/Drone	Fighter/Attack	UAV/Drone	Fighter/Attack
Transport/Tanker	Reconnaissance	UAV/Drone	Reconnaissance	UAV/Drone	Bomber
Reconnaissance	Fighter/Attack	UAV/Drone	Bomber	Trainer	Reconnaissance
UAV/Drone	Fighter/Attack	Special Duty	Reconnaissance	Transport/Tanker	Reconnaissance
Transport/Tanker	Fighter/Attack	Special Duty	Bomber	Trainer	Bomber
UAV/Drone	Special Duty	UAV/Drone	Transport/Tanker	Special Duty	Reconnaissance
Trainer	Bomber	Reconnaissance	Bomber	Special Duty	Bomber
Trainer	Reconnaissance	UAV/Drone	Trainer	Transport/Tanker	Fighter/Attack
Trainer	Special Duty	Reconnaissance	Fighter/Attack	Trainer	Fighter/Attack
Transport/Tanker	Special Duty	Special Duty	Fighter/Attack	Transport/Tanker	Bomber
Trainer	Fighter/Attack	Transport/Tanker	Trainer	Special Duty	Fighter/Attack

4.0 Sustaining Support		5.0 Continuing System Improvements		6.0 Indirect Support	
Level	Level	Level	Level	Level	Level
Trainer	Special Duty	Transport/Tanker	Trainer	Trainer	Fighter/Attack
Trainer	Fighter/Attack	Special Duty	Fighter/Attack	Transport/Tanker	Bomber
Transport/Tanker	Special Duty	UAV/Drone	Transport/Tanker	Fighter/Attack	Bomber
Trainer	Reconnaissance	UAV/Drone	Fighter/Attack	Trainer	Special Duty
Transport/Tanker	Reconnaissance	UAV/Drone	Trainer	Transport/Tanker	Reconnaissance
Special Duty	Reconnaissance	Reconnaissance	Fighter/Attack	Trainer	Reconnaissance
Reconnaissance	Fighter/Attack	Special Duty	Reconnaissance	Special Duty	Fighter/Attack
Trainer	Bomber	UAV/Drone	Reconnaissance	Trainer	Bomber
Transport/Tanker	Fighter/Attack	UAV/Drone	Special Duty	Special Duty	Reconnaissance
UAV/Drone	Reconnaissance	Transport/Tanker	Fighter/Attack	Special Duty	Bomber
UAV/Drone	Bomber	Transport/Tanker	Reconnaissance	UAV/Drone	Bomber
Reconnaissance	Bomber	UAV/Drone	Bomber	UAV/Drone	Reconnaissance
UAV/Drone	Special Duty	Trainer	Reconnaissance	Transport/Tanker	Fighter/Attack
UAV/Drone	Trainer	Transport/Tanker	Special Duty	UAV/Drone	Fighter/Attack
Special Duty	Bomber	Trainer	Fighter/Attack	Reconnaissance	Bomber
Special Duty	Fighter/Attack	Reconnaissance	Bomber	UAV/Drone	Transport/Tanker
UAV/Drone	Fighter/Attack	Trainer	Special Duty	UAV/Drone	Special Duty
UAV/Drone	Transport/Tanker	Special Duty	Bomber	UAV/Drone	Trainer
Fighter/Attack	Bomber	Trainer	Bomber	Transport/Tanker	Special Duty
Transport/Tanker	Trainer	Fighter/Attack	Bomber	Reconnaissance	Fighter/Attack
Transport/Tanker	Bomber	Transport/Tanker	Bomber	Transport/Tanker	Trainer

Research Question III

What are the potential cost drivers and cost estimating relationships within the OSD-CAPE Cost Element Structure? On a micro level, cost drivers and cost estimating relationships are unique to each individual platform and category as illustrated in research question one. However, on a macro level when the individual cost elements are all treated as independent variables when creating a correlation matrix (provided in the Appendix A-D due to the size), we are able to identify which elements/sub-elements were closely correlated. As aligned with our assumptions, sub-element 1.2 Unit Level Maintenance is negatively correlated with sub-element 1.1 Operations. This illustrates that as sub-element 1.1 increases than sub-element 1.2 will decrease. Also aligned with our assumption, sub-element 3.2.1 DLR Fly is negatively correlated with sub-element 3.7 Contractor Logistics Support. DLR Fly incurs cost when maintenance is done organically at the unit level by “blue suiters”, however Contractor Logistics Support incurs cost when the maintenance is contracted out to a third party. Therefore, if sub-element 3.7 is incurring substantial cost than the weapon system is most likely not going to incur cost in sub-element 3.2.1, unless the weapon system is both maintained organically and contractor support. The most correlated relationship is sub-element 6.1 Installation Support to sub-element 6.3 General Training & Education at -.96. The only sub-element that is correlated to a level one element is 3.4.2 Missile Overhaul/Rework Depot Repair which is correlated to element 6.0 Indirect Support at .72. However, there is no clear reason for the correlation therefore it could be a spurious relationship with no direct casual connection.

Summary

This chapter outlines the results of the research questions. It provides the results from the descriptive statistics methods and statistical tests that were outlined in the third chapter. First it shows the mean/median/quartile ranges for all categories and platforms. Followed by the results of the Kruskal-Wallis and Steel Dwaas tests that identified the categories that were statistically different when compared to each other. Lastly, it provided insight into the correlations between elements and sub-elements. Chapter Five utilizes these results presented in Chapter Four to derive our conclusion.

Chapter V: Conclusions

Chapter Overview

The purpose of this chapter is to provide the conclusions to the three research questions and our recommendations regarding each. The chapter also outlines the importance from the findings and how the findings can benefit the acquisition and cost analysis community. The major findings include the characterization of the different aircraft categories and platforms based on the OSD-CAPE Cost Element Structure (CES), the statistical comparisons between the aircraft categories, and some insight into the correlations between the cost elements/sub-elements.

Research Question I

Question one is the driving research question into investigating the cost expenditures within the OSD-CAPE CES for the various aircraft categories and platforms. As illustrated in chapter four and the graphs/tables regarding the individual aircraft platforms and categories, the individual platforms within a category vary greatly from one another. Therefore, for example, when creating an analogy based estimate it is important to identify the most similar aircraft within the category. The variability of the data also show that these aircrafts are more unique than originally assumed prior to this research. Our assumption when starting this thesis was that aircrafts within the same category should be similar with small variability, however as noted in the results for the various categories, specifically the bomber category, aircrafts within the same category are sometimes on the opposite ends of the spectrum.

The major finding of research question one is that the majority of cost is incurred in the first three elements: 1.0 Unit Level Manpower, 2.0 Unit Operations and 3.0 Maintenance. For all 52 aircrafts analyzed, the top three elements incurred a mean percentage of 82.38% of the total expenditures. Table 40 illustrates the summary statistics for all 52 aircrafts analyzed. As portrayed by Table 40, the first three elements are the cost passengers. Therefore, the majority of the analysis focuses on the results of these elements. The belief within the Department of Defense acquisition community that these three elements accumulated the majority of O&S cost incurred is aligned with the results of question one.

Table 40: Summary Statistics for the 52 Aircrafts Analyzed

Level	Mean	Std Dev	Median	IQR
1.0 Unit Level Manpower	31.46%	13.02%	31.97%	17.88%
2.0 Unit Operations	19.58%	8.28%	18.25%	9.29%
3.0 Maintenance	31.35%	12.10%	30.31%	14.59%
4.0 Sustaining Support	1.94%	2.80%	1.31%	1.87%
5.0 Continuing System Improvements	9.05%	8.78%	6.60%	9.35%
6.0 Indirect Support	6.62%	7.96%	4.28%	4.34%

The results also illustrate a trend that when maintenance is contracted out, identified if cost is accumulated in 3.7 Contactor Logistic Support, the overarching element 3.0 Maintenance incurs more of the expenditures than if the platform was organically maintained. In this constrained budgetary environment, these findings can be beneficial for decision makers when deciding if new platforms should be organically maintained by “blue-suiters” or contracted out.

Research Question II

The findings of question one directly leads to our search in identifying the relationships between each category (bomber, fighter, reconnaissance, special duty, trainer, transport/tanker and UAV/drone) in question two. The results of question two is aligned with our assumptions during the investigation phase of this research. We assume that the median percentage would vary greatly between platforms and in some cases, according to Table 41 regarding the Steel Dwaas results, it does. Table 41 conveys how many times a category was statistically different from another category per cost element. The trainer category was the most significantly different category with 32 instances in which the Steel Dwaas test concluded it was statistically different from another category across all six elements. In contrast, the UAV/Drone category resulted in the least statistically different results when compared across the other six categories with a total of 15 different instances.

Table 41: Summary of Question II's Significant Results

Level	Bomber	Fighter/Attack	Reconnaissance	Special Duty	Trainer	Transport/Tanker	UAV/Drone
1.0 Unit Level Manpower	4	3	2	5	6	3	1
2.0 Unit Operations	2	4	4	4	6	5	3
3.0 Maintenance	4	3	3	5	5	6	3
4.0 Sustaining Support	5	4	2	5	5	4	5
5.0 Continuing System Improvements	4	2	1	2	4	2	0
6.0 Indirect Support	5	4	5	5	6	4	3
Total	**24**	**20**	**17**	**26**	**32**	**24**	**15**

Another result to note is the magnitude of the difference when comparing categories. Depending on the element, some of these categories are statistically different from one another and the difference varies significantly. When the score mean difference is further away from 0, regardless of sign (positive/negative), it signifies the strength of the difference between the two platforms being compared. However, the results also outline the similarities between different categories. These findings are valuable to cost estimators regardless of program office. The intent of this question is to enable cost estimators to have a baseline comparison when creating estimates. For example, in some cases highlighted in the Wilcoxon-Man-Whitney test for Element 1.0 Unit Level Manpower, the UAV/drone category incurs cost very similarly to the transport/tanker category. Therefore, if needed, one program office can contact the other to seek advice if a problem was to occur during the estimation process, adding an additional outlet for guidance and educational purposes.

Research Question III

The results from question three were not as fruitful as originally anticipated. Before the research began, one of our assumptions followed the idea that cost sub-elements could potentially have cost estimating relationships and significant correlations with the other overarching level one elements. This thought led to the belief that certain elements can be used as metrics for sub-elements. However, only a few significant correlations were found. In these cases where correlations are present, the majority of these correlations are expected given the relationship of the CES. For example, as stated in chapter four, sub-element 1.2 Unit Level Maintenance is negatively correlated with sub-element 1.1 Operations. This conveys that the more 1.1 incurs in expenditures the less 1.2 incurs. Therefore, these findings are not as useful as originally anticipated. According to the correlation table, no sub-element (level two or level three) is significantly correlated to any of the six-overarching level one elements.

Significance of Research

This research provides decision makers and cost estimators a better understanding on where within the OSD-CAPE CES the expenditures truly lie for the various categories and platforms. Also, where within the CES the majority of the cost exists. Through referencing the variability of each category, cost estimators have a more realistic picture of how different the platforms within a category are from one another. Lastly, this research could benefit cost estimators across the various program offices in the Air Force by understanding how their specific program incurs cost and how it relates to the other programs Air Force wide. Only when cost estimators truly understand how these platforms incur costs can we achieve more efficient ways to estimate and cut costs in this limited resource environment.

Limitations

One of the first limitations is the accuracy of the data set. The data set was pulled from the Air Force Total Ownership Cost (AFTOC) database however some costs were zeroed out for no identifiable reason. For example, the WC-130H, from the years 1996-1998 did not incur any costs in 1.0 Unit Level Manpower. However, the aircraft incurred flying hours during these years which undoubtedly requires manpower. Therefore, during the investigation process we had to exclude those years. Another limitation is the inconsistency of the number of platforms investigated for each category. The more data the more reliable the results are. However, the UAV/drone only had two platforms, the bomber category had three platforms, while the fighter and transport/tanker categories each had fifteen and fourteen platforms respectfully. This limitation is due to the availability in the Air Force arsenal. In the years to come, when more UAV/drones are in the arsenal, cost estimators will have more information and more data to get a better indicator of where the cost is truly incurred within the CES. Lastly, when a platform is either being phased-in or phased-out, the costs act sporadically. Therefore, the results for the platforms being phased in (F-35A, A-10C and MQ-9A etc.) act differently than platforms that have reached stability. The data for the various other stable platforms illustrate a small standard deviation between a single element year to year while platforms being phased in/out have large variability from year to year.

Recommendations for Future Research

Multiple avenues for future research can be taken to continue on this research into the investigation of cost expenditures within the OSD-CAPE Cost Element Structure. First, some platforms within the same category vary greatly from one another per CES. We recommend an investigation into the root differences between these platforms due to the belief it would help cost estimators and decision makers alike. Deriving the conclusions on why this variability occurs can supplements this research and the results of this thesis because we identified the descriptive statistics for the various platforms and categories however did not deeply investigate into the reasoning of the variability. Second, we suggest future researchers perform a deeper investigation into Cost Estimating Relationships (CERs) as highlighted in question three. Perhaps a regression model to derive CERs can potentially lead to significant findings. Lastly, an investigation into why certain categories and platforms incur cost differently. For example, element 1.0 Unit Level Manpower for special duty category incurs 42.82% of the total expenditures while the trainer category incurs only 10.13% of total expenditures for manpower. An investigation to why this is could be beneficial to cost estimators, stakeholders, and decision-makers alike.

Summary

The descriptive statistics and statistical significant results that were derived from the investigation into the cost incurred within the OSD-CAPE Cost Element Structure are beneficial to all stakeholders within the cost estimating community. Though AFTOC was established in 1996, the exploration into the descriptive statistics based on the OSD-CAPE CES is nonexistent to date. Therefore, these findings are instrumental in establishing baselines for various categories and platforms based on the data.

In order to understand the complexity of cost estimating each weapon system, the DoD and other stakeholders must understand where the true cost lies within each platform and category. The data needed to understand the true actual costs and the relationships within the expenditures for each platform are present within AFTOC. Utilizing AFTOC to study the historical cost to predict the future costs of our weapon systems will serve essential for cost estimators and stakeholders alike. In today's environment, weapon systems continue to grow in price and costs while the budget for our nation's defense is continuing to decline. Therefore, understanding and investigating the information provided about our arsenal is more essential now than ever before.

Appendix A: Level One Element Correlation Table

	1	2	3	4	5	6
1	1.00	-0.28	-0.43	-0.16	-0.21	-0.41
2	-0.28	1.00	-0.31	-0.03	-0.26	0.19
3	-0.43	-0.31	1.00	-0.12	-0.19	-0.25
4	-0.16	-0.03	-0.12	1.00	-0.02	0.15
5	-0.21	-0.26	-0.19	-0.02	1.00	-0.18
6	-0.41	0.19	-0.25	0.15	-0.18	1.00
1.1	-0.17	0.21	-0.18	0.01	0.00	0.32
1.2	0.00	-0.15	0.37	-0.05	0.06	-0.46
1.3	0.33	-0.08	-0.29	0.07	-0.10	0.05
2.1.1	-0.04	0.14	0.14	-0.14	0.04	-0.28
2.1.2	0.17	-0.05	-0.10	-0.01	-0.06	0.01
2.1.3	0.38	-0.40	-0.12	0.10	0.00	-0.06
2.2	-0.26	0.09	-0.06	0.10	0.01	0.37
2.3	0.37	-0.35	-0.07	0.14	-0.07	-0.09
2.4	0.13	-0.03	-0.02	-0.07	-0.07	-0.05
3.1.2	0.31	0.11	-0.51	0.08	-0.04	0.17
3.2.1	0.33	-0.17	-0.16	0.03	0.01	-0.15
3.2.2	0.02	0.13	-0.16	-0.05	-0.03	0.12
3.4.1	0.04	-0.11	0.07	0.10	0.14	-0.25
3.4.2	-0.40	0.16	-0.11	0.29	-0.16	0.72
3.4.3	0.15	-0.09	-0.03	0.18	0.02	-0.19
3.4.4	-0.22	0.20	-0.19	0.04	0.16	0.25
3.5	-0.07	0.05	-0.10	0.03	0.12	0.08
3.6	-0.03	0.05	-0.18	0.10	-0.04	0.28
3.7	-0.37	0.12	0.34	-0.17	-0.06	0.10
3.8	-0.04	0.09	-0.23	0.10	-0.05	0.34
4.2	-0.14	0.20	0.02	-0.15	-0.08	0.14
4.3	0.15	-0.20	0.05	0.09	0.12	-0.28
4.4	-0.28	0.09	0.08	0.00	-0.04	0.28
4.6	0.16	-0.04	-0.06	-0.03	-0.03	-0.09
4.7	0.15	0.02	-0.18	0.06	0.06	-0.06
4.8.1	-0.35	0.03	0.07	0.12	-0.10	0.50
5.1	-0.02	0.03	-0.11	-0.14	0.28	-0.10
5.2	0.13	-0.07	-0.04	0.16	-0.12	-0.01
6.1	0.47	-0.17	0.00	-0.12	0.01	-0.55
6.2	0.23	0.03	-0.09	0.15	-0.09	-0.22
6.3	-0.53	0.16	0.03	0.07	0.02	0.60

Appendix B: Elements 1.0 & 2.0 Sub-Elements Correlation Table

	1.1	1.2	1.3	2.1.1	2.1.2	2.1.3	2.2	2.3	2.4
1	-0.17	0.00	0.33	-0.04	0.17	0.38	-0.26	0.37	0.13
2	0.21	-0.15	-0.08	0.14	-0.05	-0.40	0.09	-0.35	-0.03
3	-0.18	0.37	-0.29	0.14	-0.10	-0.12	-0.06	-0.07	-0.02
4	0.01	-0.05	0.07	-0.14	-0.01	0.10	0.10	0.14	-0.07
5	0.00	0.06	-0.10	0.04	-0.06	0.00	0.01	-0.07	-0.07
6	0.32	-0.46	0.05	-0.28	0.01	-0.06	0.37	-0.09	-0.05
1.1	1.00	-0.77	-0.26	-0.25	-0.11	-0.16	0.34	0.01	0.13
1.2	-0.77	1.00	-0.32	0.30	0.14	-0.04	-0.31	-0.12	-0.15
1.3	-0.26	-0.32	1.00	-0.09	-0.04	0.33	-0.05	0.20	0.05
2.1.1	-0.25	0.30	-0.09	1.00	-0.19	-0.40	-0.82	-0.32	-0.16
2.1.2	-0.11	0.14	-0.04	-0.19	1.00	0.09	-0.14	-0.18	-0.08
2.1.3	-0.16	-0.04	0.33	-0.40	0.09	1.00	0.01	0.44	-0.02
2.2	0.34	-0.31	-0.05	-0.82	-0.14	0.01	1.00	-0.04	0.00
2.3	0.01	-0.12	0.20	-0.32	-0.18	0.44	-0.04	1.00	0.14
2.4	0.13	-0.15	0.05	-0.16	-0.08	-0.02	0.00	0.14	1.00
3.1.2	-0.11	0.04	0.04	-0.15	0.25	0.15	0.02	0.08	-0.10
3.2.1	-0.37	0.31	0.06	0.16	0.25	0.11	-0.29	0.00	-0.08
3.2.2	0.08	-0.03	-0.07	-0.12	0.04	-0.04	0.14	-0.02	-0.03
3.4.1	-0.19	0.17	0.05	0.37	-0.11	-0.16	-0.33	0.00	-0.09
3.4.2	0.34	-0.35	0.04	-0.22	0.08	-0.12	0.31	-0.15	-0.09
3.4.3	-0.12	0.09	0.06	0.17	-0.13	0.04	-0.24	0.24	-0.01
3.4.4	0.10	-0.02	-0.10	-0.07	0.03	-0.09	0.16	-0.13	-0.09
3.5	-0.02	0.02	0.00	-0.06	-0.01	-0.01	0.08	-0.01	-0.04
3.6	0.07	-0.23	0.25	-0.13	-0.01	0.06	0.17	-0.07	-0.05
3.7	0.38	-0.27	-0.14	-0.24	-0.18	-0.07	0.36	-0.07	0.16
3.8	0.10	-0.26	0.24	-0.12	-0.01	0.08	0.15	-0.06	-0.06
4.2	0.17	-0.22	0.06	-0.26	-0.08	0.06	0.28	0.04	0.15
4.3	-0.38	0.41	-0.06	0.28	0.16	-0.08	-0.30	-0.13	-0.08
4.4	0.27	-0.20	-0.08	-0.22	0.01	-0.06	0.28	-0.03	-0.09
4.6	0.01	0.10	-0.16	0.06	0.02	0.11	-0.13	0.10	-0.02
4.7	0.02	-0.15	0.20	0.08	-0.16	0.08	-0.08	0.15	-0.10
4.8.1	0.24	-0.20	-0.04	-0.14	0.04	-0.08	0.22	-0.13	-0.07
5.1	-0.04	-0.04	0.11	0.15	-0.11	0.06	-0.16	0.06	-0.03
5.2	0.08	0.04	-0.17	-0.07	0.16	-0.05	0.03	-0.01	0.04
6.1	-0.45	0.26	0.25	0.18	0.08	0.18	-0.34	0.15	0.04
6.2	0.02	0.00	-0.01	-0.11	-0.06	0.10	0.08	0.16	-0.07
6.3	0.43	-0.25	-0.24	-0.15	-0.06	-0.20	0.31	-0.20	-0.01

Appendix C: Element 3.0 Sub-Elements Correlation Table

	3.1.2	3.2.1	3.2.2	3.4.1	3.4.2	3.4.3	3.4.4	3.5	3.6	3.7	3.8
1	0.31	0.33	0.02	0.04	-0.40	0.15	-0.22	-0.07	-0.03	-0.37	-0.04
2	0.11	-0.17	0.13	-0.11	0.16	-0.09	0.20	0.05	0.05	0.12	0.09
3	-0.51	-0.16	-0.16	0.07	-0.11	-0.03	-0.19	-0.10	-0.18	0.34	-0.23
4	0.08	0.03	-0.05	0.10	0.29	0.18	0.04	0.03	0.10	-0.17	0.10
5	-0.04	0.01	-0.03	0.14	-0.16	0.02	0.16	0.12	-0.04	-0.06	-0.05
6	0.17	-0.15	0.12	-0.25	0.72	-0.19	0.25	0.08	0.28	0.10	0.34
1.1	-0.11	-0.37	0.08	-0.19	0.34	-0.12	0.10	-0.02	0.07	0.38	0.10
1.2	0.04	0.31	-0.03	0.17	-0.35	0.09	-0.02	0.02	-0.23	-0.27	-0.26
1.3	0.04	0.06	-0.07	0.05	0.04	0.06	-0.10	0.00	0.25	-0.14	0.24
2.1.1	-0.15	0.16	-0.12	0.37	-0.22	0.17	-0.07	-0.06	-0.13	-0.24	-0.12
2.1.2	0.25	0.25	0.04	-0.11	0.08	-0.13	0.03	-0.01	-0.01	-0.18	-0.01
2.1.3	0.15	0.11	-0.04	-0.16	-0.12	0.04	-0.09	-0.01	0.06	-0.07	0.08
2.2	0.02	-0.29	0.14	-0.33	0.31	-0.24	0.16	0.08	0.17	0.36	0.15
2.3	0.08	0.00	-0.02	0.00	-0.15	0.24	-0.13	-0.01	-0.07	-0.07	-0.06
2.4	-0.10	-0.08	-0.03	-0.09	-0.09	-0.01	-0.09	-0.04	-0.05	0.16	-0.06
3.1.2	1.00	0.24	0.24	-0.17	0.00	-0.05	0.26	0.08	-0.05	-0.46	-0.03
3.2.1	0.24	1.00	-0.07	-0.01	-0.18	-0.01	0.09	0.01	-0.14	-0.73	-0.14
3.2.2	0.24	-0.07	1.00	-0.10	0.05	-0.02	0.08	0.04	0.03	-0.03	0.04
3.4.1	-0.17	-0.01	-0.10	1.00	-0.18	0.32	-0.11	-0.01	-0.11	-0.47	-0.15
3.4.2	0.00	-0.18	0.05	-0.18	1.00	-0.15	0.13	0.04	0.34	0.13	0.41
3.4.3	-0.05	-0.01	-0.02	0.32	-0.15	1.00	-0.11	0.02	-0.12	-0.36	-0.12
3.4.4	0.26	0.09	0.08	-0.11	0.13	-0.11	1.00	0.19	0.01	-0.14	0.02
3.5	0.08	0.01	0.04	-0.01	0.04	0.02	0.19	1.00	0.02	-0.09	0.01
3.6	-0.05	-0.14	0.03	-0.11	0.34	-0.12	0.01	0.02	1.00	0.01	0.84
3.7	-0.46	-0.73	-0.03	-0.47	0.13	-0.36	-0.14	-0.09	0.01	1.00	0.02
3.8	-0.03	-0.14	0.04	-0.15	0.41	-0.12	0.02	0.01	0.84	0.02	1.00
4.2	-0.10	-0.21	-0.01	-0.32	0.10	-0.26	0.07	0.00	0.09	0.38	0.13
4.3	0.15	0.31	0.05	0.37	-0.28	0.20	-0.08	-0.09	-0.18	-0.45	-0.22
4.4	-0.15	-0.29	0.05	-0.26	0.36	-0.18	0.00	-0.01	0.09	0.39	0.12
4.6	0.04	0.18	-0.08	0.07	-0.12	0.05	-0.05	-0.06	-0.09	-0.16	-0.09
4.7	0.06	0.02	-0.06	0.06	-0.07	0.17	0.07	0.19	0.10	-0.13	0.08
4.8.1	-0.10	-0.23	0.06	-0.21	0.58	-0.19	0.06	0.01	0.20	0.28	0.22
5.1	-0.07	-0.05	-0.02	-0.01	-0.18	0.04	0.05	0.04	-0.03	0.07	-0.03
5.2	0.10	0.12	-0.02	0.13	0.05	0.07	-0.04	-0.02	0.00	-0.20	-0.02
6.1	-0.07	0.19	-0.10	0.27	-0.51	0.26	-0.33	-0.10	-0.16	-0.22	-0.22
6.2	0.18	-0.04	-0.02	-0.04	-0.15	-0.03	-0.11	-0.08	-0.02	0.00	-0.02
6.3	0.02	-0.17	0.10	-0.25	0.54	-0.24	0.35	0.12	0.16	0.22	0.22

Appendix D: Element 4.0, 5.0 & 6.0 Sub-Elements Correlation Table

	4.2	4.3	4.4	4.6	4.7	4.8.1	5.1	5.2	6.1	6.2	6.3
1	-0.14	0.15	-0.28	0.16	0.15	-0.35	-0.02	0.13	0.47	0.23	-0.53
2	0.20	-0.20	0.09	-0.04	0.02	0.03	0.03	-0.07	-0.17	0.03	0.16
3	0.02	0.05	0.08	-0.06	-0.18	0.07	-0.11	-0.04	0.00	-0.09	0.03
4	-0.15	0.09	0.00	-0.03	0.06	0.12	-0.14	0.16	-0.12	0.15	0.07
5	-0.08	0.12	-0.04	-0.03	0.06	-0.10	0.28	-0.12	0.01	-0.09	0.02
6	0.14	-0.28	0.28	-0.09	-0.06	0.50	-0.10	-0.01	-0.55	-0.22	0.60
1.1	0.17	-0.38	0.27	0.01	0.02	0.24	-0.04	0.08	-0.45	0.02	0.43
1.2	-0.22	0.41	-0.20	0.10	-0.15	-0.20	-0.04	0.04	0.26	0.00	-0.25
1.3	0.06	-0.06	-0.08	-0.16	0.20	-0.04	0.11	-0.17	0.25	-0.01	-0.24
2.1.1	-0.26	0.28	-0.22	0.06	0.08	-0.14	0.15	-0.07	0.18	-0.11	-0.15
2.1.2	-0.08	0.16	0.01	0.02	-0.16	0.04	-0.11	0.16	0.08	-0.06	-0.06
2.1.3	0.06	-0.08	-0.06	0.11	0.08	-0.08	0.06	-0.05	0.18	0.10	-0.20
2.2	0.28	-0.30	0.28	-0.13	-0.08	0.22	-0.16	0.03	-0.34	0.08	0.31
2.3	0.04	-0.13	-0.03	0.10	0.15	-0.13	0.06	-0.01	0.15	0.16	-0.20
2.4	0.15	-0.08	-0.09	-0.02	-0.10	-0.07	-0.03	0.04	0.04	-0.07	-0.01
3.1.2	-0.10	0.15	-0.15	0.04	0.06	-0.10	-0.07	0.10	-0.07	0.18	0.02
3.2.1	-0.21	0.31	-0.29	0.18	0.02	-0.23	-0.05	0.12	0.19	-0.04	-0.17
3.2.2	-0.01	0.05	0.05	-0.08	-0.06	0.06	-0.02	-0.02	-0.10	-0.02	0.10
3.4.1	-0.32	0.37	-0.26	0.07	0.06	-0.21	-0.01	0.13	0.27	-0.04	-0.25
3.4.2	0.10	-0.28	0.36	-0.12	-0.07	0.58	-0.18	0.05	-0.51	-0.15	0.54
3.4.3	-0.26	0.20	-0.18	0.05	0.17	-0.19	0.04	0.07	0.26	-0.03	-0.24
3.4.4	0.07	-0.08	0.00	-0.05	0.07	0.06	0.05	-0.04	-0.33	-0.11	0.35
3.5	0.00	-0.09	-0.01	-0.06	0.19	0.01	0.04	-0.02	-0.10	-0.08	0.12
3.6	0.09	-0.18	0.09	-0.09	0.10	0.20	-0.03	0.00	-0.16	-0.02	0.16
3.7	0.38	-0.45	0.39	-0.16	-0.13	0.28	0.07	-0.20	-0.22	0.00	0.22
3.8	0.13	-0.22	0.12	-0.09	0.08	0.22	-0.03	-0.02	-0.22	-0.02	0.22
4.2	1.00	-0.52	-0.01	-0.22	-0.11	0.01	0.14	-0.24	-0.14	0.02	0.13
4.3	-0.52	1.00	-0.35	-0.12	-0.38	-0.28	-0.09	0.12	0.26	-0.01	-0.25
4.4	-0.01	-0.35	1.00	-0.15	-0.15	0.36	-0.06	-0.01	-0.26	-0.01	0.26
4.6	-0.22	-0.12	-0.15	1.00	-0.13	-0.12	-0.07	0.18	-0.02	0.04	0.01
4.7	-0.11	-0.38	-0.15	-0.13	1.00	-0.16	0.18	-0.10	0.13	0.03	-0.14
4.8.1	0.01	-0.28	0.36	-0.12	-0.16	1.00	-0.15	0.06	-0.40	-0.11	0.42
5.1	0.14	-0.09	-0.06	-0.07	0.18	-0.15	1.00	-0.66	0.06	-0.02	-0.05
5.2	-0.24	0.12	-0.01	0.18	-0.10	0.06	-0.66	1.00	0.01	0.00	-0.01
6.1	-0.14	0.26	-0.26	-0.02	0.13	-0.40	0.06	0.01	1.00	-0.07	-0.96
6.2	0.02	-0.01	-0.01	0.04	0.03	-0.11	-0.02	0.00	-0.07	1.00	-0.22
6.3	0.13	-0.25	0.26	0.01	-0.14	0.42	-0.05	-0.01	-0.96	-0.22	1.00

Appendix E: Cost Element Structure Mean Percentages for Bomber Platforms

B-1B			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**22.84%**	3.5	Other Maintenance	0.02%
1.1	Operations	19.73%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	69.26%	3.7	Contractor Logistics Support	1.88%
1.3	Other Unit-Level	11.02%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.95%**	**4**	**Sustaining Support**	**3.91%**
2.1.1	Energy (Fuel, POL, Electricity)	79.15%	4.2	Support Equipment Replacement & Repair	5.20%
2.1.2	Training Munitions & Expendable Stores	2.88%	4.3	Sustaining/Systems Engineering	83.97%
2.1.3	Other Operational Material	4.33%	4.4	Program Management	0.49%
2.2	Support Services	10.62%	4.6	Data and Technical Publications	9.99%
2.3	TDY	2.38%	4.7	Simulator Operations & Repair	0.26%
2.4	Transportaion	0.65%	4.8.1	Other Sustaining Support (Testing)	0.09%
3	**Maintenance**	**38.07%**	**5**	**Continuing System Improvements**	**16.88%**
3.1.2	Repair Parts (GSD)	11.78%	5.1	Hardware Modifications	44.95%
3.2.1	DLR Fly	62.20%	5.2	Software Maintenance	55.05%
3.2.2	DLR NonFly	0.06%	**6**	**Indirect Support**	**1.35%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	20.21%	6.1	Installation Support	74.66%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	6.29%
3.4.3	Engine Overhaul/Rework Depot Repair	3.62%	6.3	General Training & Education	19.05%
3.4.4	Other Overhaul/Rework Depot Repair	0.24%			

B-2A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**22.13%**	3.5	Other Maintenance	0.03%
1.1	Operations	17.42%	3.6	Interim Contractor Support	2.22%
1.2	Unit-Level Maintenance	61.66%	3.7	Contractor Logistics Support	23.55%
1.3	Other Unit-Level	20.92%	3.8	Other Contractor Support	0.17%
2	**Unit Operations**	**11.09%**	**4**	**Sustaining Support**	**7.74%**
2.1.1	Energy (Fuel, POL, Electricity)	40.05%	4.2	Support Equipment Replacement & Repair	1.77%
2.1.2	Training Munitions & Expendable Stores	4.27%	4.3	Sustaining/Systems Engineering	86.04%
2.1.3	Other Operational Material	6.78%	4.4	Program Management	0.17%
2.2	Support Services	44.50%	4.6	Data and Technical Publications	6.45%
2.3	TDY	3.17%	4.7	Simulator Operations & Repair	0.08%
2.4	Transportaion	1.22%	4.8.1	Other Sustaining Support (Testing)	5.49%
3	**Maintenance**	**34.02%**	**5**	**Continuing System Improvements**	**22.68%**
3.1.2	Repair Parts (GSD)	6.27%	5.1	Hardware Modifications	43.05%
3.2.1	DLR Fly	21.98%	5.2	Software Maintenance	56.95%
3.2.2	DLR NonFly	0.06%	**6**	**Indirect Support**	**2.33%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	40.91%	6.1	Installation Support	80.54%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.78%
3.4.3	Engine Overhaul/Rework Depot Repair	4.73%	6.3	General Training & Education	14.68%
3.4.4	Other Overhaul/Rework Depot Repair	0.09%			

B-52H			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**32.59%**	3.5	Other Maintenance	0.11%
1.1	Operations	23.40%	3.6	Interim Contractor Support	0.04%
1.2	Unit-Level Maintenance	55.15%	3.7	Contractor Logistics Support	3.08%
1.3	Other Unit-Level	21.45%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.46%**	**4**	**Sustaining Support**	**3.23%**
2.1.1	Energy (Fuel, POL, Electricity)	79.26%	4.2	Support Equipment Replacement & Repair	2.80%
2.1.2	Training Munitions & Expendable Stores	6.30%	4.3	Sustaining/Systems Engineering	84.58%
2.1.3	Other Operational Material	4.92%	4.4	Program Management	0.39%
2.2	Support Services	5.72%	4.6	Data and Technical Publications	6.85%
2.3	TDY	1.66%	4.7	Simulator Operations & Repair	3.93%
2.4	Transportaion	2.13%	4.8.1	Other Sustaining Support (Testing)	1.44%
3	**Maintenance**	**35.76%**	**5**	**Continuing System Improvements**	**8.62%**
3.1.2	Repair Parts (GSD)	6.11%	5.1	Hardware Modifications	51.62%
3.2.1	DLR Fly	33.11%	5.2	Software Maintenance	48.38%
3.2.2	DLR NonFly	0.21%	**6**	**Indirect Support**	**2.34%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	42.51%	6.1	Installation Support	79.10%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.77%
3.4.3	Engine Overhaul/Rework Depot Repair	14.63%	6.3	General Training & Education	17.12%
3.4.4	Other Overhaul/Rework Depot Repair	0.21%			

Appendix F: Cost Element Structure Mean Percentages for Fighter Platforms

A-10A			1996-2011		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**37.05%**	3.5	Other Maintenance	0.93%
1.1	Operations	15.13%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	61.17%	3.7	Contractor Logistics Support	0.97%
1.3	Other Unit-Level	23.70%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**18.37%**	**4**	**Sustaining Support**	**1.98%**
2.1.1	Energy (Fuel, POL, Electricity)	48.90%	4.2	Support Equipment Replacement & Repair	21.92%
2.1.2	Training Munitions & Expendable Stores	28.85%	4.3	Sustaining/Systems Engineering	69.06%
2.1.3	Other Operational Material	7.29%	4.4	Program Management	0.21%
2.2	Support Services	8.61%	4.6	Data and Technical Publications	3.78%
2.3	TDY	5.92%	4.7	Simulator Operations & Repair	5.01%
2.4	Transportaion	0.42%	4.8.1	Other Sustaining Support (Testing)	0.02%
3	**Maintenance**	**29.30%**	**5**	**Continuing System Improvements**	**8.97%**
3.1.2	Repair Parts (GSD)	17.52%	5.1	Hardware Modifications	74.37%
3.2.1	DLR Fly	55.64%	5.2	Software Maintenance	25.63%
3.2.2	DLR NonFly	0.06%	**6**	**Indirect Support**	**4.33%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	23.14%	6.1	Installation Support	82.11%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	6.10%
3.4.3	Engine Overhaul/Rework Depot Repair	1.71%	6.3	General Training & Education	11.79%
3.4.4	Other Overhaul/Rework Depot Repair	0.33%			

A-10C			2008-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**38.36%**	3.5	Other Maintenance	0.06%
1.1	Operations	25.84%	3.6	Interim Contractor Support	0.01%
1.2	Unit-Level Maintenance	55.92%	3.7	Contractor Logistics Support	4.43%
1.3	Other Unit-Level	18.24%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**21.08%**	**4**	**Sustaining Support**	**2.28%**
2.1.1	Energy (Fuel, POL, Electricity)	46.65%	4.2	Support Equipment Replacement & Repair	1.96%
2.1.2	Training Munitions & Expendable Stores	33.57%	4.3	Sustaining/Systems Engineering	81.08%
2.1.3	Other Operational Material	6.77%	4.4	Program Management	2.59%
2.2	Support Services	6.66%	4.6	Data and Technical Publications	5.85%
2.3	TDY	5.06%	4.7	Simulator Operations & Repair	3.85%
2.4	Transportaion	1.30%	4.8.1	Other Sustaining Support (Testing)	4.68%
3	**Maintenance**	**26.52%**	**5**	**Continuing System Improvements**	**7.40%**
3.1.2	Repair Parts (GSD)	16.86%	5.1	Hardware Modifications	68.55%
3.2.1	DLR Fly	51.74%	5.2	Software Maintenance	31.45%
3.2.2	DLR NonFly	0.02%	**6**	**Indirect Support**	**4.36%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	22.83%	6.1	Installation Support	83.52%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.09%
3.4.3	Engine Overhaul/Rework Depot Repair	3.23%	6.3	General Training & Education	13.38%
3.4.4	Other Overhaul/Rework Depot Repair	0.88%			

F-15A			1996-2010		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**34.39%**	3.5	Other Maintenance	0.14%
1.1	Operations	6.33%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	65.97%	3.7	Contractor Logistics Support	5.56%
1.3	Other Unit-Level	27.70%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.45%**	**4**	**Sustaining Support**	**2.25%**
2.1.1	Energy (Fuel, POL, Electricity)	72.11%	4.2	Support Equipment Replacement & Repair	12.16%
2.1.2	Training Munitions & Expendable Stores	4.29%	4.3	Sustaining/Systems Engineering	87.15%
2.1.3	Other Operational Material	7.89%	4.4	Program Management	0.13%
2.2	Support Services	6.29%	4.6	Data and Technical Publications	0.40%
2.3	TDY	8.42%	4.7	Simulator Operations & Repair	0.15%
2.4	Transportaion	1.00%	4.8.1	Other Sustaining Support (Testing)	0.01%
3	**Maintenance**	**38.85%**	**5**	**Continuing System Improvements**	**1.77%**
3.1.2	Repair Parts (GSD)	10.88%	5.1	Hardware Modifications	94.65%
3.2.1	DLR Fly	65.86%	5.2	Software Maintenance	5.35%
3.2.2	DLR NonFly	0.18%	**6**	**Indirect Support**	**5.29%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	12.98%	6.1	Installation Support	95.08%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.25%
3.4.3	Engine Overhaul/Rework Depot Repair	4.12%	6.3	General Training & Education	2.67%
3.4.4	Other Overhaul/Rework Depot Repair	0.33%			

F-15B			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**35.20%**	3.5	Other Maintenance	0.15%
1.1	Operations	5.88%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	67.72%	3.7	Contractor Logistics Support	7.13%
1.3	Other Unit-Level	26.41%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**18.16%**	**4**	**Sustaining Support**	**2.35%**
2.1.1	Energy (Fuel, POL, Electricity)	70.66%	4.2	Support Equipment Replacement & Repair	13.70%
2.1.2	Training Munitions & Expendable Stores	6.91%	4.3	Sustaining/Systems Engineering	85.14%
2.1.3	Other Operational Material	7.12%	4.4	Program Management	0.60%
2.2	Support Services	6.01%	4.6	Data and Technical Publications	0.55%
2.3	TDY	8.29%	4.7	Simulator Operations & Repair	0.00%
2.4	Transportaion	1.01%	4.8.1	Other Sustaining Support (Testing)	0.01%
3	**Maintenance**	**36.47%**	**5**	**Continuing System Improvements**	**2.32%**
3.1.2	Repair Parts (GSD)	9.98%	5.1	Hardware Modifications	93.80%
3.2.1	DLR Fly	62.10%	5.2	Software Maintenance	6.20%
3.2.2	DLR NonFly	0.21%	**6**	**Indirect Support**	**5.51%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	15.30%	6.1	Installation Support	95.53%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.01%
3.4.3	Engine Overhaul/Rework Depot Repair	4.79%	6.3	General Training & Education	2.47%
3.4.4	Other Overhaul/Rework Depot Repair	0.35%			

F-15C			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**28.62%**	3.5	Other Maintenance	0.03%
1.1	Operations	12.68%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	74.06%	3.7	Contractor Logistics Support	5.33%
1.3	Other Unit-Level	13.26%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.00%**	**4**	**Sustaining Support**	**2.02%**
2.1.1	Energy (Fuel, POL, Electricity)	75.82%	4.2	Support Equipment Replacement & Repair	8.00%
2.1.2	Training Munitions & Expendable Stores	4.52%	4.3	Sustaining/Systems Engineering	79.44%
2.1.3	Other Operational Material	5.21%	4.4	Program Management	0.92%
2.2	Support Services	10.42%	4.6	Data and Technical Publications	11.18%
2.3	TDY	3.34%	4.7	Simulator Operations & Repair	0.00%
2.4	Transportaion	0.69%	4.8.1	Other Sustaining Support (Testing)	0.46%
3	**Maintenance**	**41.82%**	**5**	**Continuing System Improvements**	**9.00%**
3.1.2	Repair Parts (GSD)	9.13%	5.1	Hardware Modifications	97.21%
3.2.1	DLR Fly	61.09%	5.2	Software Maintenance	2.79%
3.2.2	DLR NonFly	0.03%	**6**	**Indirect Support**	**2.54%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	21.28%	6.1	Installation Support	75.68%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	5.41%
3.4.3	Engine Overhaul/Rework Depot Repair	2.62%	6.3	General Training & Education	18.91%
3.4.4	Other Overhaul/Rework Depot Repair	0.57%			

F-15E			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**29.55%**	3.5	Other Maintenance	0.00%
1.1	Operations	18.08%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	73.05%	3.7	Contractor Logistics Support	1.88%
1.3	Other Unit-Level	8.87%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**19.88%**	**4**	**Sustaining Support**	**0.97%**
2.1.1	Energy (Fuel, POL, Electricity)	78.51%	4.2	Support Equipment Replacement & Repair	26.23%
2.1.2	Training Munitions & Expendable Stores	10.31%	4.3	Sustaining/Systems Engineering	45.27%
2.1.3	Other Operational Material	4.14%	4.4	Program Management	1.33%
2.2	Support Services	3.27%	4.6	Data and Technical Publications	24.11%
2.3	TDY	3.36%	4.7	Simulator Operations & Repair	0.47%
2.4	Transportaion	0.41%	4.8.1	Other Sustaining Support (Testing)	2.58%
3	**Maintenance**	**40.73%**	**5**	**Continuing System Improvements**	**6.34%**
3.1.2	Repair Parts (GSD)	10.80%	5.1	Hardware Modifications	85.05%
3.2.1	DLR Fly	68.80%	5.2	Software Maintenance	14.95%
3.2.2	DLR NonFly	0.07%	**6**	**Indirect Support**	**2.53%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	16.38%	6.1	Installation Support	46.29%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	5.65%
3.4.3	Engine Overhaul/Rework Depot Repair	1.86%	6.3	General Training & Education	48.06%
3.4.4	Other Overhaul/Rework Depot Repair	0.26%			

F-15D			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**26.90%**	3.5	Other Maintenance	0.03%
1.1	Operations	12.35%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	71.79%	3.7	Contractor Logistics Support	5.27%
1.3	Other Unit-Level	15.86%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.04%**	**4**	**Sustaining Support**	**1.78%**
2.1.1	Energy (Fuel, POL, Electricity)	71.36%	4.2	Support Equipment Replacement & Repair	11.17%
2.1.2	Training Munitions & Expendable Stores	5.50%	4.3	Sustaining/Systems Engineering	77.59%
2.1.3	Other Operational Material	5.16%	4.4	Program Management	1.22%
2.2	Support Services	14.50%	4.6	Data and Technical Publications	9.41%
2.3	TDY	3.00%	4.7	Simulator Operations & Repair	0.08%
2.4	Transportaion	0.48%	4.8.1	Other Sustaining Support (Testing)	0.52%
3	**Maintenance**	**42.99%**	**5**	**Continuing System Improvements**	**8.33%**
3.1.2	Repair Parts (GSD)	9.27%	5.1	Hardware Modifications	96.73%
3.2.1	DLR Fly	59.92%	5.2	Software Maintenance	3.27%
3.2.2	DLR NonFly	0.03%	**6**	**Indirect Support**	**2.96%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	22.78%	6.1	Installation Support	74.18%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.79%
3.4.3	Engine Overhaul/Rework Depot Repair	2.21%	6.3	General Training & Education	22.03%
3.4.4	Other Overhaul/Rework Depot Repair	0.54%			

F-15E			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**29.55%**	3.5	Other Maintenance	0.00%
1.1	Operations	18.08%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	73.05%	3.7	Contractor Logistics Support	1.88%
1.3	Other Unit-Level	8.87%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**19.88%**	**4**	**Sustaining Support**	**0.97%**
2.1.1	Energy (Fuel, POL, Electricity)	78.51%	4.2	Support Equipment Replacement & Repair	26.23%
2.1.2	Training Munitions & Expendable Stores	10.31%	4.3	Sustaining/Systems Engineering	45.27%
2.1.3	Other Operational Material	4.14%	4.4	Program Management	1.33%
2.2	Support Services	3.27%	4.6	Data and Technical Publications	24.11%
2.3	TDY	3.36%	4.7	Simulator Operations & Repair	0.47%
2.4	Transportaion	0.41%	4.8.1	Other Sustaining Support (Testing)	2.58%
3	**Maintenance**	**40.73%**	**5**	**Continuing System Improvements**	**6.34%**
3.1.2	Repair Parts (GSD)	10.80%	5.1	Hardware Modifications	85.05%
3.2.1	DLR Fly	68.80%	5.2	Software Maintenance	14.95%
3.2.2	DLR NonFly	0.07%	**6**	**Indirect Support**	**2.53%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	16.38%	6.1	Installation Support	46.29%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	5.65%
3.4.3	Engine Overhaul/Rework Depot Repair	1.86%	6.3	General Training & Education	48.06%
3.4.4	Other Overhaul/Rework Depot Repair	0.26%			

F-16A			1996-2007		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**44.55%**	3.5	Other Maintenance	0.69%
1.1	Operations	5.43%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	49.84%	3.7	Contractor Logistics Support	4.59%
1.3	Other Unit-Level	44.73%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.33%**	**4**	**Sustaining Support**	**2.33%**
2.1.1	Energy (Fuel, POL, Electricity)	50.63%	4.2	Support Equipment Replacement & Repair	21.45%
2.1.2	Training Munitions & Expendable Stores	7.09%	4.3	Sustaining/Systems Engineering	58.33%
2.1.3	Other Operational Material	8.11%	4.4	Program Management	0.63%
2.2	Support Services	19.58%	4.6	Data and Technical Publications	0.00%
2.3	TDY	13.13%	4.7	Simulator Operations & Repair	19.58%
2.4	Transportaion	1.47%	4.8.1	Other Sustaining Support (Testing)	0.01%
3	**Maintenance**	**28.27%**	**5**	**Continuing System Improvements**	**3.52%**
3.1.2	Repair Parts (GSD)	15.34%	5.1	Hardware Modifications	94.27%
3.2.1	DLR Fly	63.22%	5.2	Software Maintenance	5.73%
3.2.2	DLR NonFly	0.29%	**6**	**Indirect Support**	**5.00%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	5.18%	6.1	Installation Support	92.57%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.80%
3.4.3	Engine Overhaul/Rework Depot Repair	9.70%	6.3	General Training & Education	4.63%
3.4.4	Other Overhaul/Rework Depot Repair	1.09%			

F-16B			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**35.73%**	3.5	Other Maintenance	0.61%
1.1	Operations	6.28%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	59.66%	3.7	Contractor Logistics Support	3.46%
1.3	Other Unit-Level	34.05%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**20.70%**	**4**	**Sustaining Support**	**2.54%**
2.1.1	Energy (Fuel, POL, Electricity)	62.01%	4.2	Support Equipment Replacement & Repair	28.56%
2.1.2	Training Munitions & Expendable Stores	4.33%	4.3	Sustaining/Systems Engineering	45.57%
2.1.3	Other Operational Material	5.67%	4.4	Program Management	2.32%
2.2	Support Services	20.11%	4.6	Data and Technical Publications	0.00%
2.3	TDY	6.97%	4.7	Simulator Operations & Repair	23.53%
2.4	Transportaion	0.91%	4.8.1	Other Sustaining Support (Testing)	0.01%
3	**Maintenance**	**32.93%**	**5**	**Continuing System Improvements**	**4.79%**
3.1.2	Repair Parts (GSD)	13.17%	5.1	Hardware Modifications	97.72%
3.2.1	DLR Fly	65.74%	5.2	Software Maintenance	2.28%
3.2.2	DLR NonFly	0.28%	**6**	**Indirect Support**	**3.31%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	9.35%	6.1	Installation Support	91.46%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.00%
3.4.3	Engine Overhaul/Rework Depot Repair	6.81%	6.3	General Training & Education	5.54%
3.4.4	Other Overhaul/Rework Depot Repair	0.66%			

F-16C			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.67%**	3.5	Other Maintenance	0.20%
1.1	Operations	10.88%	3.6	Interim Contractor Support	0.02%
1.2	Unit-Level Maintenance	67.50%	3.7	Contractor Logistics Support	3.34%
1.3	Other Unit-Level	21.63%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**18.58%**	**4**	**Sustaining Support**	**1.42%**
2.1.1	Energy (Fuel, POL, Electricity)	60.38%	4.2	Support Equipment Replacement & Repair	15.03%
2.1.2	Training Munitions & Expendable Stores	14.71%	4.3	Sustaining/Systems Engineering	54.21%
2.1.3	Other Operational Material	6.62%	4.4	Program Management	1.27%
2.2	Support Services	9.96%	4.6	Data and Technical Publications	8.99%
2.3	TDY	6.12%	4.7	Simulator Operations & Repair	15.67%
2.4	Transportaion	2.21%	4.8.1	Other Sustaining Support (Testing)	4.83%
3	**Maintenance**	**27.99%**	**5**	**Continuing System Improvements**	**6.84%**
3.1.2	Repair Parts (GSD)	17.74%	5.1	Hardware Modifications	77.58%
3.2.1	DLR Fly	65.51%	5.2	Software Maintenance	22.42%
3.2.2	DLR NonFly	0.11%	**6**	**Indirect Support**	**4.51%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	4.70%	6.1	Installation Support	82.43%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.95%
3.4.3	Engine Overhaul/Rework Depot Repair	7.42%	6.3	General Training & Education	13.62%
3.4.4	Other Overhaul/Rework Depot Repair	0.97%			

F-16D			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**39.75%**	3.5	Other Maintenance	0.12%
1.1	Operations	11.71%	3.6	Interim Contractor Support	0.02%
1.2	Unit-Level Maintenance	71.28%	3.7	Contractor Logistics Support	3.56%
1.3	Other Unit-Level	17.01%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**19.44%**	**4**	**Sustaining Support**	**1.36%**
2.1.1	Energy (Fuel, POL, Electricity)	55.90%	4.2	Support Equipment Replacement & Repair	17.24%
2.1.2	Training Munitions & Expendable Stores	19.42%	4.3	Sustaining/Systems Engineering	49.77%
2.1.3	Other Operational Material	6.48%	4.4	Program Management	2.54%
2.2	Support Services	11.60%	4.6	Data and Technical Publications	9.50%
2.3	TDY	5.05%	4.7	Simulator Operations & Repair	17.97%
2.4	Transportaion	1.55%	4.8.1	Other Sustaining Support (Testing)	2.96%
3	**Maintenance**	**27.69%**	**5**	**Continuing System Improvements**	**7.56%**
3.1.2	Repair Parts (GSD)	15.99%	5.1	Hardware Modifications	78.59%
3.2.1	DLR Fly	67.16%	5.2	Software Maintenance	21.41%
3.2.2	DLR NonFly	0.09%	**6**	**Indirect Support**	**4.20%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	5.63%	6.1	Installation Support	74.31%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.56%
3.4.3	Engine Overhaul/Rework Depot Repair	6.38%	6.3	General Training & Education	22.14%
3.4.4	Other Overhaul/Rework Depot Repair	1.05%			

F-35A			2012-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**28.55%**	3.5	Other Maintenance	0.00%
1.1	Operations	26.42%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	66.03%	3.7	Contractor Logistics Support	99.45%
1.3	Other Unit-Level	7.55%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**9.71%**	**4**	**Sustaining Support**	**0.96%**
2.1.1	Energy (Fuel, POL, Electricity)	53.65%	4.2	Support Equipment Replacement & Repair	0.00%
2.1.2	Training Munitions & Expendable Stores	0.44%	4.3	Sustaining/Systems Engineering	41.47%
2.1.3	Other Operational Material	12.55%	4.4	Program Management	0.00%
2.2	Support Services	25.67%	4.6	Data and Technical Publications	18.28%
2.3	TDY	7.22%	4.7	Simulator Operations & Repair	0.12%
2.4	Transportaion	0.47%	4.8.1	Other Sustaining Support (Testing)	40.14%
3	**Maintenance**	**37.65%**	**5**	**Continuing System Improvements**	**15.42%**
3.1.2	Repair Parts (GSD)	0.21%	5.1	Hardware Modifications	78.92%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	21.08%
3.2.2	DLR NonFly	0.00%	**6**	**Indirect Support**	**7.71%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.01%	6.1	Installation Support	70.55%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.77%
3.4.3	Engine Overhaul/Rework Depot Repair	0.03%	6.3	General Training & Education	26.67%
3.4.4	Other Overhaul/Rework Depot Repair	0.29%			

F-22A			2003-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**20.24%**	3.5	Other Maintenance	0.00%
1.1	Operations	10.77%	3.6	Interim Contractor Support	0.01%
1.2	Unit-Level Maintenance	76.25%	3.7	Contractor Logistics Support	97.48%
1.3	Other Unit-Level	12.99%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**20.23%**	**4**	**Sustaining Support**	**0.21%**
2.1.1	Energy (Fuel, POL, Electricity)	56.52%	4.2	Support Equipment Replacement & Repair	32.84%
2.1.2	Training Munitions & Expendable Stores	3.42%	4.3	Sustaining/Systems Engineering	25.13%
2.1.3	Other Operational Material	6.41%	4.4	Program Management	4.28%
2.2	Support Services	29.05%	4.6	Data and Technical Publications	21.51%
2.3	TDY	4.04%	4.7	Simulator Operations & Repair	9.57%
2.4	Transportaion	0.55%	4.8.1	Other Sustaining Support (Testing)	6.67%
3	**Maintenance**	**42.04%**	**5**	**Continuing System Improvements**	**14.90%**
3.1.2	Repair Parts (GSD)	1.95%	5.1	Hardware Modifications	99.78%
3.2.1	DLR Fly	0.19%	5.2	Software Maintenance	0.22%
3.2.2	DLR NonFly	0.05%	**6**	**Indirect Support**	**2.38%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.14%	6.1	Installation Support	69.83%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.07%
3.4.3	Engine Overhaul/Rework Depot Repair	0.01%	6.3	General Training & Education	26.10%
3.4.4	Other Overhaul/Rework Depot Repair	0.18%			

F-117A			1996-2008		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**20.38%**	3.5	Other Maintenance	0.00%
1.1	Operations	15.32%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	69.12%	3.7	Contractor Logistics Support	98.59%
1.3	Other Unit-Level	15.56%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**10.98%**	**4**	**Sustaining Support**	**0.21%**
2.1.1	Energy (Fuel, POL, Electricity)	38.51%	4.2	Support Equipment Replacement & Repair	0.00%
2.1.2	Training Munitions & Expendable Stores	0.38%	4.3	Sustaining/Systems Engineering	86.76%
2.1.3	Other Operational Material	9.02%	4.4	Program Management	4.90%
2.2	Support Services	45.21%	4.6	Data and Technical Publications	0.00%
2.3	TDY	4.58%	4.7	Simulator Operations & Repair	8.33%
2.4	Transportaion	2.30%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**59.52%**	**5**	**Continuing System Improvements**	**6.53%**
3.1.2	Repair Parts (GSD)	1.07%	5.1	Hardware Modifications	99.98%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	0.02%
3.2.2	DLR NonFly	0.27%	**6**	**Indirect Support**	**2.38%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	75.32%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.35%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	20.33%
3.4.4	Other Overhaul/Rework Depot Repair	0.08%			

OA-10A			1996-2008		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**60.12%**	3.5	Other Maintenance	0.00%
1.1	Operations	35.31%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	45.57%	3.7	Contractor Logistics Support	1.96%
1.3	Other Unit-Level	19.11%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**19.83%**	**4**	**Sustaining Support**	**0.61%**
2.1.1	Energy (Fuel, POL, Electricity)	37.81%	4.2	Support Equipment Replacement & Repair	0.00%
2.1.2	Training Munitions & Expendable Stores	28.79%	4.3	Sustaining/Systems Engineering	78.37%
2.1.3	Other Operational Material	14.44%	4.4	Program Management	1.52%
2.2	Support Services	10.27%	4.6	Data and Technical Publications	11.37%
2.3	TDY	8.30%	4.7	Simulator Operations & Repair	8.55%
2.4	Transportaion	0.39%	4.8.1	Other Sustaining Support (Testing)	0.19%
3	**Maintenance**	**7.61%**	**5**	**Continuing System Improvements**	**5.78%**
3.1.2	Repair Parts (GSD)	90.73%	5.1	Hardware Modifications	69.66%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	30.34%
3.2.2	DLR NonFly	2.74%	**6**	**Indirect Support**	**6.05%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	88.05%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	5.89%
3.4.3	Engine Overhaul/Rework Depot Repair	4.65%	6.3	General Training & Education	6.06%
3.4.4	Other Overhaul/Rework Depot Repair	1.05%			

Appendix G: Cost Element Structure Mean Percentages for Reconnaissance Platforms

E-3B			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.10%**	3.5	Other Maintenance	0.01%
1.1	Operations	47.38%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	39.44%	3.7	Contractor Logistics Support	4.06%
1.3	Other Unit-Level	13.18%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.71%**	**4**	**Sustaining Support**	**3.31%**
2.1.1	Energy (Fuel, POL, Electricity)	70.20%	4.2	Support Equipment Replacement & Repair	5.20%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	83.97%
2.1.3	Other Operational Material	3.66%	4.4	Program Management	0.49%
2.2	Support Services	16.35%	4.6	Data and Technical Publications	9.99%
2.3	TDY	9.50%	4.7	Simulator Operations & Repair	0.26%
2.4	Transportaion	0.29%	4.8.1	Other Sustaining Support (Testing)	0.09%
3	**Maintenance**	**26.32%**	**5**	**Continuing System Improvements**	**11.57%**
3.1.2	Repair Parts (GSD)	10.66%	5.1	Hardware Modifications	61.82%
3.2.1	DLR Fly	36.97%	5.2	Software Maintenance	38.18%
3.2.2	DLR NonFly	0.00%	**6**	**Indirect Support**	**1.99%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	35.15%	6.1	Installation Support	63.51%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	9.98%
3.4.3	Engine Overhaul/Rework Depot Repair	13.16%	6.3	General Training & Education	26.52%
3.4.4	Other Overhaul/Rework Depot Repair	0.02%			

E-3C			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**41.14%**	3.5	Other Maintenance	0.02%
1.1	Operations	47.94%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	39.50%	3.7	Contractor Logistics Support	4.36%
1.3	Other Unit-Level	12.56%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.17%**	**4**	**Sustaining Support**	**3.31%**
2.1.1	Energy (Fuel, POL, Electricity)	71.61%	4.2	Support Equipment Replacement & Repair	5.20%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	83.97%
2.1.3	Other Operational Material	3.55%	4.4	Program Management	0.49%
2.2	Support Services	15.31%	4.6	Data and Technical Publications	9.99%
2.3	TDY	9.23%	4.7	Simulator Operations & Repair	0.26%
2.4	Transportaion	0.30%	4.8.1	Other Sustaining Support (Testing)	0.09%
3	**Maintenance**	**25.52%**	**5**	**Continuing System Improvements**	**11.90%**
3.1.2	Repair Parts (GSD)	9.06%	5.1	Hardware Modifications	44.95%
3.2.1	DLR Fly	39.70%	5.2	Software Maintenance	55.05%
3.2.2	DLR NonFly	0.00%	**6**	**Indirect Support**	**1.96%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	32.43%	6.1	Installation Support	74.66%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	6.29%
3.4.3	Engine Overhaul/Rework Depot Repair	14.40%	6.3	General Training & Education	19.05%
3.4.4	Other Overhaul/Rework Depot Repair	0.03%			

E-8C			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**28.14%**	3.5	Other Maintenance	0.00%
1.1	Operations	38.51%	3.6	Interim Contractor Support	0.11%
1.2	Unit-Level Maintenance	42.36%	3.7	Contractor Logistics Support	82.73%
1.3	Other Unit-Level	19.14%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**14.05%**	**4**	**Sustaining Support**	**0.24%**
2.1.1	Energy (Fuel, POL, Electricity)	61.98%	4.2	Support Equipment Replacement & Repair	46.56%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	45.77%
2.1.3	Other Operational Material	7.42%	4.4	Program Management	6.25%
2.2	Support Services	20.01%	4.6	Data and Technical Publications	1.41%
2.3	TDY	9.30%	4.7	Simulator Operations & Repair	0.00%
2.4	Transportaion	1.29%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**43.12%**	**5**	**Continuing System Improvements**	**9.94%**
3.1.2	Repair Parts (GSD)	3.22%	5.1	Hardware Modifications	97.53%
3.2.1	DLR Fly	6.47%	5.2	Software Maintenance	2.47%
3.2.2	DLR NonFly	0.05%	**6**	**Indirect Support**	**4.51%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	54.18%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.31%
3.4.3	Engine Overhaul/Rework Depot Repair	6.36%	6.3	General Training & Education	42.51%
3.4.4	Other Overhaul/Rework Depot Repair	1.06%			

U-2S			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**17.95%**	3.5	Other Maintenance	0.00%
1.1	Operations	10.24%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	73.11%	3.7	Contractor Logistics Support	98.56%
1.3	Other Unit-Level	16.65%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**9.60%**	**4**	**Sustaining Support**	**0.11%**
2.1.1	Energy (Fuel, POL, Electricity)	34.79%	4.2	Support Equipment Replacement & Repair	5.20%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	83.97%
2.1.3	Other Operational Material	9.06%	4.4	Program Management	0.49%
2.2	Support Services	38.00%	4.6	Data and Technical Publications	9.99%
2.3	TDY	16.56%	4.7	Simulator Operations & Repair	0.26%
2.4	Transportaion	1.59%	4.8.1	Other Sustaining Support (Testing)	0.09%
3	**Maintenance**	**67.15%**	**5**	**Continuing System Improvements**	**2.58%**
3.1.2	Repair Parts (GSD)	0.71%	5.1	Hardware Modifications	90.87%
3.2.1	DLR Fly	0.39%	5.2	Software Maintenance	9.13%
3.2.2	DLR NonFly	0.28%	**6**	**Indirect Support**	**2.61%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	56.97%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	6.93%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	36.10%
3.4.4	Other Overhaul/Rework Depot Repair	0.07%			

Appendix H: Cost Element Structure Mean Percentages for Special Duty Platforms

EC-130H			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**33.92%**	3.5	Other Maintenance	0.20%
1.1	Operations	40.91%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	42.80%	3.7	Contractor Logistics Support	64.57%
1.3	Other Unit-Level	16.29%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**11.42%**	**4**	**Sustaining Support**	**0.46%**
2.1.1	Energy (Fuel, POL, Electricity)	51.12%	4.2	Support Equipment Replacement & Repair	7.82%
2.1.2	Training Munitions & Expendable Stores	1.00%	4.3	Sustaining/Systems Engineering	46.39%
2.1.3	Other Operational Material	6.59%	4.4	Program Management	38.09%
2.2	Support Services	25.95%	4.6	Data and Technical Publications	0.41%
2.3	TDY	13.90%	4.7	Simulator Operations & Repair	0.00%
2.4	Transportaion	1.44%	4.8.1	Other Sustaining Support (Testing)	7.29%
3	**Maintenance**	**35.45%**	**5**	**Continuing System Improvements**	**15.12%**
3.1.2	Repair Parts (GSD)	7.07%	5.1	Hardware Modifications	92.67%
3.2.1	DLR Fly	17.25%	5.2	Software Maintenance	7.33%
3.2.2	DLR NonFly	2.12%	**6**	**Indirect Support**	**3.63%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	2.09%	6.1	Installation Support	42.71%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	9.91%
3.4.3	Engine Overhaul/Rework Depot Repair	6.70%	6.3	General Training & Education	47.37%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

MC-130E			1996-2013		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**44.27%**	3.5	Other Maintenance	0.00%
1.1	Operations	19.13%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	44.94%	3.7	Contractor Logistics Support	0.97%
1.3	Other Unit-Level	35.93%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**13.54%**	**4**	**Sustaining Support**	**0.75%**
2.1.1	Energy (Fuel, POL, Electricity)	48.75%	4.2	Support Equipment Replacement & Repair	25.88%
2.1.2	Training Munitions & Expendable Stores	0.04%	4.3	Sustaining/Systems Engineering	29.70%
2.1.3	Other Operational Material	19.37%	4.4	Program Management	7.03%
2.2	Support Services	13.44%	4.6	Data and Technical Publications	3.11%
2.3	TDY	17.64%	4.7	Simulator Operations & Repair	28.67%
2.4	Transportaion	0.77%	4.8.1	Other Sustaining Support (Testing)	5.60%
3	**Maintenance**	**22.42%**	**5**	**Continuing System Improvements**	**12.31%**
3.1.2	Repair Parts (GSD)	22.18%	5.1	Hardware Modifications	93.27%
3.2.1	DLR Fly	71.54%	5.2	Software Maintenance	6.73%
3.2.2	DLR NonFly	0.07%	**6**	**Indirect Support**	**6.70%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	3.24%	6.1	Installation Support	84.38%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.21%
3.4.3	Engine Overhaul/Rework Depot Repair	2.00%	6.3	General Training & Education	12.41%
3.4.4	Other Overhaul/Rework Depot Repair	0.10%			

MC-130H			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.78%**	3.5	Other Maintenance	0.04%
1.1	Operations	39.65%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	41.75%	3.7	Contractor Logistics Support	2.11%
1.3	Other Unit-Level	18.61%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**14.01%**	**4**	**Sustaining Support**	**0.92%**
2.1.1	Energy (Fuel, POL, Electricity)	43.39%	4.2	Support Equipment Replacement & Repair	9.04%
2.1.2	Training Munitions & Expendable Stores	0.54%	4.3	Sustaining/Systems Engineering	23.49%
2.1.3	Other Operational Material	9.99%	4.4	Program Management	1.30%
2.2	Support Services	29.71%	4.6	Data and Technical Publications	50.98%
2.3	TDY	15.51%	4.7	Simulator Operations & Repair	15.13%
2.4	Transportaion	0.86%	4.8.1	Other Sustaining Support (Testing)	0.07%
3	**Maintenance**	**27.90%**	**5**	**Continuing System Improvements**	**8.79%**
3.1.2	Repair Parts (GSD)	17.09%	5.1	Hardware Modifications	60.14%
3.2.1	DLR Fly	57.37%	5.2	Software Maintenance	39.86%
3.2.2	DLR NonFly	0.07%	**6**	**Indirect Support**	**7.60%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	13.49%	6.1	Installation Support	62.73%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	8.64%
3.4.3	Engine Overhaul/Rework Depot Repair	9.40%	6.3	General Training & Education	28.63%
3.4.4	Other Overhaul/Rework Depot Repair	0.46%			

MC-130P			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**44.28%**	3.5	Other Maintenance	0.08%
1.1	Operations	34.42%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	45.44%	3.7	Contractor Logistics Support	1.01%
1.3	Other Unit-Level	20.14%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**14.52%**	**4**	**Sustaining Support**	**1.06%**
2.1.1	Energy (Fuel, POL, Electricity)	45.48%	4.2	Support Equipment Replacement & Repair	9.92%
2.1.2	Training Munitions & Expendable Stores	0.35%	4.3	Sustaining/Systems Engineering	20.73%
2.1.3	Other Operational Material	9.30%	4.4	Program Management	1.07%
2.2	Support Services	29.15%	4.6	Data and Technical Publications	50.06%
2.3	TDY	14.92%	4.7	Simulator Operations & Repair	16.59%
2.4	Transportaion	0.79%	4.8.1	Other Sustaining Support (Testing)	1.63%
3	**Maintenance**	**22.12%**	**5**	**Continuing System Improvements**	**10.53%**
3.1.2	Repair Parts (GSD)	18.29%	5.1	Hardware Modifications	60.72%
3.2.1	DLR Fly	48.51%	5.2	Software Maintenance	39.28%
3.2.2	DLR NonFly	0.24%	**6**	**Indirect Support**	**7.50%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	17.73%	6.1	Installation Support	70.44%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	7.31%
3.4.3	Engine Overhaul/Rework Depot Repair	13.51%	6.3	General Training & Education	22.25%
3.4.4	Other Overhaul/Rework Depot Repair	0.63%			

AC-130U			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**41.73%**	3.5	Other Maintenance	0.02%
1.1	Operations	41.48%	3.6	Interim Contractor Support	0.13%
1.2	Unit-Level Maintenance	42.67%	3.7	Contractor Logistics Support	22.44%
1.3	Other Unit-Level	15.86%	3.8	Other Contractor Support	0.13%
2	**Unit Operations**	**15.46%**	**4**	**Sustaining Support**	**0.58%**
2.1.1	Energy (Fuel, POL, Electricity)	33.37%	4.2	Support Equipment Replacement & Repair	9.67%
2.1.2	Training Munitions & Expendable Stores	16.65%	4.3	Sustaining/Systems Engineering	52.37%
2.1.3	Other Operational Material	9.72%	4.4	Program Management	3.37%
2.2	Support Services	26.60%	4.6	Data and Technical Publications	24.83%
2.3	TDY	12.75%	4.7	Simulator Operations & Repair	9.67%
2.4	Transportaion	0.90%	4.8.1	Other Sustaining Support (Testing)	0.09%
3	**Maintenance**	**26.71%**	**5**	**Continuing System Improvements**	**9.04%**
3.1.2	Repair Parts (GSD)	21.66%	5.1	Hardware Modifications	58.25%
3.2.1	DLR Fly	55.34%	5.2	Software Maintenance	41.75%
3.2.2	DLR NonFly	0.02%	**6**	**Indirect Support**	**6.48%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	63.26%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	8.36%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	28.39%
3.4.4	Other Overhaul/Rework Depot Repair	0.44%			

EC-130E			1996-2002		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**50.10%**	3.5	Other Maintenance	0.68%
1.1	Operations	33.48%	3.6	Interim Contractor Support	3.13%
1.2	Unit-Level Maintenance	42.41%	3.7	Contractor Logistics Support	10.18%
1.3	Other Unit-Level	24.10%	3.8	Other Contractor Support	3.13%
2	**Unit Operations**	**21.12%**	**4**	**Sustaining Support**	**1.50%**
2.1.1	Energy (Fuel, POL, Electricity)	60.68%	4.2	Support Equipment Replacement & Repair	35.45%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	26.99%
2.1.3	Other Operational Material	6.24%	4.4	Program Management	0.00%
2.2	Support Services	15.82%	4.6	Data and Technical Publications	2.07%
2.3	TDY	16.30%	4.7	Simulator Operations & Repair	35.45%
2.4	Transportaion	0.95%	4.8.1	Other Sustaining Support (Testing)	0.05%
3	**Maintenance**	**16.77%**	**5**	**Continuing System Improvements**	**6.08%**
3.1.2	Repair Parts (GSD)	27.89%	5.1	Hardware Modifications	83.73%
3.2.1	DLR Fly	53.30%	5.2	Software Maintenance	16.27%
3.2.2	DLR NonFly	1.60%	**6**	**Indirect Support**	**4.44%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	89.30%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	7.69%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	3.01%
3.4.4	Other Overhaul/Rework Depot Repair	0.09%			

WC-130H			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.69%**	3.5	Other Maintenance	0.06%
1.1	Operations	16.57%	3.6	Interim Contractor Support	1.95%
1.2	Unit-Level Maintenance	44.94%	3.7	Contractor Logistics Support	8.22%
1.3	Other Unit-Level	38.50%	3.8	Other Contractor Support	1.95%
2	**Unit Operations**	**18.43%**	**4**	**Sustaining Support**	**1.20%**
2.1.1	Energy (Fuel, POL, Electricity)	54.41%	4.2	Support Equipment Replacement & Repair	34.53%
2.1.2	Training Munitions & Expendable Stores	0.04%	4.3	Sustaining/Systems Engineering	30.52%
2.1.3	Other Operational Material	9.91%	4.4	Program Management	0.00%
2.2	Support Services	26.08%	4.6	Data and Technical Publications	0.42%
2.3	TDY	7.99%	4.7	Simulator Operations & Repair	34.53%
2.4	Transportaion	1.58%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**18.52%**	**5**	**Continuing System Improvements**	**8.11%**
3.1.2	Repair Parts (GSD)	28.47%	5.1	Hardware Modifications	96.62%
3.2.1	DLR Fly	59.27%	5.2	Software Maintenance	3.38%
3.2.2	DLR NonFly	0.05%	**6**	**Indirect Support**	**13.04%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	89.02%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.26%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	7.71%
3.4.4	Other Overhaul/Rework Depot Repair	0.03%			

WC-130J			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**55.65%**	3.5	Other Maintenance	0.05%
1.1	Operations	16.91%	3.6	Interim Contractor Support	14.56%
1.2	Unit-Level Maintenance	40.03%	3.7	Contractor Logistics Support	39.29%
1.3	Other Unit-Level	43.06%	3.8	Other Contractor Support	14.56%
2	**Unit Operations**	**19.67%**	**4**	**Sustaining Support**	**0.76%**
2.1.1	Energy (Fuel, POL, Electricity)	58.43%	4.2	Support Equipment Replacement & Repair	50.00%
2.1.2	Training Munitions & Expendable Stores	0.02%	4.3	Sustaining/Systems Engineering	0.00%
2.1.3	Other Operational Material	15.41%	4.4	Program Management	0.00%
2.2	Support Services	19.33%	4.6	Data and Technical Publications	0.00%
2.3	TDY	6.32%	4.7	Simulator Operations & Repair	50.00%
2.4	Transportaion	0.50%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**12.32%**	**5**	**Continuing System Improvements**	**6.45%**
3.1.2	Repair Parts (GSD)	14.21%	5.1	Hardware Modifications	99.91%
3.2.1	DLR Fly	17.19%	5.2	Software Maintenance	0.09%
3.2.2	DLR NonFly	0.14%	**6**	**Indirect Support**	**5.15%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	71.41%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	20.25%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	8.34%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

Appendix I: Cost Element Structure Mean Percentages for Trainer Platforms

T-38A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**14.45%**	3.5	Other Maintenance	1.50%
1.1	Operations	31.01%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	53.72%	3.7	Contractor Logistics Support	8.08%
1.3	Other Unit-Level	15.26%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**30.91%**	**4**	**Sustaining Support**	**1.86%**
2.1.1	Energy (Fuel, POL, Electricity)	47.10%	4.2	Support Equipment Replacement & Repair	31.75%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	46.03%
2.1.3	Other Operational Material	2.85%	4.4	Program Management	3.32%
2.2	Support Services	45.98%	4.6	Data and Technical Publications	4.21%
2.3	TDY	3.90%	4.7	Simulator Operations & Repair	14.27%
2.4	Transportaion	0.17%	4.8.1	Other Sustaining Support (Testing)	0.43%
3	**Maintenance**	**26.91%**	**5**	**Continuing System Improvements**	**10.70%**
3.1.2	Repair Parts (GSD)	41.81%	5.1	Hardware Modifications	92.63%
3.2.1	DLR Fly	40.04%	5.2	Software Maintenance	7.37%
3.2.2	DLR NonFly	1.05%	**6**	**Indirect Support**	**15.17%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	4.28%	6.1	Installation Support	14.10%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	10.86%
3.4.3	Engine Overhaul/Rework Depot Repair	0.11%	6.3	General Training & Education	75.05%
3.4.4	Other Overhaul/Rework Depot Repair	3.13%			

T-38C			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**11.28%**	3.5	Other Maintenance	0.90%
1.1	Operations	37.06%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	46.74%	3.7	Contractor Logistics Support	33.57%
1.3	Other Unit-Level	16.20%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**26.22%**	**4**	**Sustaining Support**	**2.21%**
2.1.1	Energy (Fuel, POL, Electricity)	46.66%	4.2	Support Equipment Replacement & Repair	31.77%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	42.67%
2.1.3	Other Operational Material	2.85%	4.4	Program Management	0.05%
2.2	Support Services	47.98%	4.6	Data and Technical Publications	5.19%
2.3	TDY	2.21%	4.7	Simulator Operations & Repair	19.45%
2.4	Transportaion	0.30%	4.8.1	Other Sustaining Support (Testing)	0.87%
3	**Maintenance**	**30.03%**	**5**	**Continuing System Improvements**	**11.40%**
3.1.2	Repair Parts (GSD)	30.39%	5.1	Hardware Modifications	91.12%
3.2.1	DLR Fly	28.37%	5.2	Software Maintenance	8.88%
3.2.2	DLR NonFly	0.13%	**6**	**Indirect Support**	**18.86%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	2.56%	6.1	Installation Support	20.58%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	1.84%
3.4.3	Engine Overhaul/Rework Depot Repair	0.11%	6.3	General Training & Education	77.58%
3.4.4	Other Overhaul/Rework Depot Repair	3.98%			

AT-38B			1996-2006		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**10.13%**	3.5	Other Maintenance	4.56%
1.1	Operations	42.13%	3.6	Interim Contractor Support	1.18%
1.2	Unit-Level Maintenance	47.67%	3.7	Contractor Logistics Support	14.38%
1.3	Other Unit-Level	10.20%	3.8	Other Contractor Support	1.18%
2	**Unit Operations**	**32.85%**	**4**	**Sustaining Support**	**1.72%**
2.1.1	Energy (Fuel, POL, Electricity)	50.57%	4.2	Support Equipment Replacement & Repair	11.66%
2.1.2	Training Munitions & Expendable Stores	0.63%	4.3	Sustaining/Systems Engineering	30.91%
2.1.3	Other Operational Material	3.33%	4.4	Program Management	11.66%
2.2	Support Services	42.69%	4.6	Data and Technical Publications	1.41%
2.3	TDY	2.70%	4.7	Simulator Operations & Repair	32.68%
2.4	Transportaion	0.07%	4.8.1	Other Sustaining Support (Testing)	11.66%
3	**Maintenance**	**17.62%**	**5**	**Continuing System Improvements**	**23.30%**
3.1.2	Repair Parts (GSD)	20.86%	5.1	Hardware Modifications	99.35%
3.2.1	DLR Fly	36.34%	5.2	Software Maintenance	0.65%
3.2.2	DLR NonFly	2.13%	**6**	**Indirect Support**	**14.38%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	10.82%	6.1	Installation Support	10.94%
3.4.2	Missile Overhaul/Rework Depot Repair	1.18%	6.2	Personnel Support	0.11%
3.4.3	Engine Overhaul/Rework Depot Repair	0.30%	6.3	General Training & Education	88.95%
3.4.4	Other Overhaul/Rework Depot Repair	7.09%			

T-1A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**6.70%**	3.5	Other Maintenance	0.00%
1.1	Operations	63.82%	3.6	Interim Contractor Support	2.72%
1.2	Unit-Level Maintenance	10.30%	3.7	Contractor Logistics Support	91.07%
1.3	Other Unit-Level	25.88%	3.8	Other Contractor Support	2.72%
2	**Unit Operations**	**26.02%**	**4**	**Sustaining Support**	**2.92%**
2.1.1	Energy (Fuel, POL, Electricity)	56.29%	4.2	Support Equipment Replacement & Repair	31.44%
2.1.2	Training Munitions & Expendable Stores	3.41%	4.3	Sustaining/Systems Engineering	0.01%
2.1.3	Other Operational Material	3.53%	4.4	Program Management	31.44%
2.2	Support Services	33.79%	4.6	Data and Technical Publications	0.06%
2.3	TDY	2.89%	4.7	Simulator Operations & Repair	5.61%
2.4	Transportaion	0.09%	4.8.1	Other Sustaining Support (Testing)	31.44%
3	**Maintenance**	**32.89%**	**5**	**Continuing System Improvements**	**1.05%**
3.1.2	Repair Parts (GSD)	0.14%	5.1	Hardware Modifications	74.34%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	25.66%
3.2.2	DLR NonFly	0.33%	**6**	**Indirect Support**	**30.42%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.12%	6.1	Installation Support	14.41%
3.4.2	Missile Overhaul/Rework Depot Repair	2.72%	6.2	Personnel Support	0.67%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	84.92%
3.4.4	Other Overhaul/Rework Depot Repair	0.18%			

T-37B			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**10.35%**	3.5	Other Maintenance	1.54%
1.1	Operations	34.29%	3.6	Interim Contractor Support	7.14%
1.2	Unit-Level Maintenance	52.41%	3.7	Contractor Logistics Support	1.18%
1.3	Other Unit-Level	13.30%	3.8	Other Contractor Support	7.14%
2	**Unit Operations**	**29.18%**	**4**	**Sustaining Support**	**5.62%**
2.1.1	Energy (Fuel, POL, Electricity)	31.61%	4.2	Support Equipment Replacement & Repair	29.83%
2.1.2	Training Munitions & Expendable Stores	5.93%	4.3	Sustaining/Systems Engineering	2.93%
2.1.3	Other Operational Material	3.70%	4.4	Program Management	29.83%
2.2	Support Services	55.09%	4.6	Data and Technical Publications	0.56%
2.3	TDY	3.58%	4.7	Simulator Operations & Repair	7.03%
2.4	Transportaion	0.08%	4.8.1	Other Sustaining Support (Testing)	29.83%
3	**Maintenance**	**24.02%**	**5**	**Continuing System Improvements**	**0.02%**
3.1.2	Repair Parts (GSD)	37.74%	5.1	Hardware Modifications	0.00%
3.2.1	DLR Fly	34.50%	5.2	Software Maintenance	100.00%
3.2.2	DLR NonFly	0.97%	**6**	**Indirect Support**	**30.81%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.13%	6.1	Installation Support	16.69%
3.4.2	Missile Overhaul/Rework Depot Repair	7.14%	6.2	Personnel Support	0.09%
3.4.3	Engine Overhaul/Rework Depot Repair	0.05%	6.3	General Training & Education	83.22%
3.4.4	Other Overhaul/Rework Depot Repair	2.46%			

T-6A			2001-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**8.15%**	3.5	Other Maintenance	0.00%
1.1	Operations	61.53%	3.6	Interim Contractor Support	7.82%
1.2	Unit-Level Maintenance	9.96%	3.7	Contractor Logistics Support	75.58%
1.3	Other Unit-Level	28.51%	3.8	Other Contractor Support	7.82%
2	**Unit Operations**	**21.66%**	**4**	**Sustaining Support**	**6.70%**
2.1.1	Energy (Fuel, POL, Electricity)	25.68%	4.2	Support Equipment Replacement & Repair	31.86%
2.1.2	Training Munitions & Expendable Stores	9.92%	4.3	Sustaining/Systems Engineering	0.00%
2.1.3	Other Operational Material	5.08%	4.4	Program Management	31.86%
2.2	Support Services	55.17%	4.6	Data and Technical Publications	0.05%
2.3	TDY	4.04%	4.7	Simulator Operations & Repair	4.36%
2.4	Transportaion	0.11%	4.8.1	Other Sustaining Support (Testing)	31.86%
3	**Maintenance**	**27.49%**	**5**	**Continuing System Improvements**	**3.23%**
3.1.2	Repair Parts (GSD)	0.57%	5.1	Hardware Modifications	99.86%
3.2.1	DLR Fly	0.01%	5.2	Software Maintenance	0.14%
3.2.2	DLR NonFly	0.09%	**6**	**Indirect Support**	**32.77%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	9.88%
3.4.2	Missile Overhaul/Rework Depot Repair	7.82%	6.2	Personnel Support	1.37%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	88.75%
3.4.4	Other Overhaul/Rework Depot Repair	0.30%			

Appendix J: Cost Element Structure Mean Percentages for Transport Platforms

C-130E			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**39.11%**	3.5	Other Maintenance	0.38%
1.1	Operations	25.71%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	51.34%	3.7	Contractor Logistics Support	4.11%
1.3	Other Unit-Level	22.95%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.94%**	**4**	**Sustaining Support**	**7.02%**
2.1.1	Energy (Fuel, POL, Electricity)	44.40%	4.2	Support Equipment Replacement & Repair	8.93%
2.1.2	Training Munitions & Expendable Stores	0.05%	4.3	Sustaining/Systems Engineering	42.87%
2.1.3	Other Operational Material	13.90%	4.4	Program Management	0.21%
2.2	Support Services	14.12%	4.6	Data and Technical Publications	29.09%
2.3	TDY	21.00%	4.7	Simulator Operations & Repair	18.43%
2.4	Transportaion	6.53%	4.8.1	Other Sustaining Support (Testing)	0.46%
3	**Maintenance**	**24.95%**	**5**	**Continuing System Improvements**	**4.51%**
3.1.2	Repair Parts (GSD)	20.02%	5.1	Hardware Modifications	95.28%
3.2.1	DLR Fly	44.05%	5.2	Software Maintenance	4.72%
3.2.2	DLR NonFly	0.09%	**6**	**Indirect Support**	**6.48%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	13.13%	6.1	Installation Support	60.49%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	8.90%
3.4.3	Engine Overhaul/Rework Depot Repair	18.15%	6.3	General Training & Education	30.61%
3.4.4	Other Overhaul/Rework Depot Repair	0.07%			

C-130H			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.38%**	3.5	Other Maintenance	0.23%
1.1	Operations	22.53%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	43.15%	3.7	Contractor Logistics Support	8.07%
1.3	Other Unit-Level	34.32%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**19.08%**	**4**	**Sustaining Support**	**1.29%**
2.1.1	Energy (Fuel, POL, Electricity)	58.04%	4.2	Support Equipment Replacement & Repair	12.08%
2.1.2	Training Munitions & Expendable Stores	0.32%	4.3	Sustaining/Systems Engineering	50.61%
2.1.3	Other Operational Material	7.24%	4.4	Program Management	1.19%
2.2	Support Services	18.15%	4.6	Data and Technical Publications	9.79%
2.3	TDY	13.27%	4.7	Simulator Operations & Repair	25.33%
2.4	Transportaion	2.98%	4.8.1	Other Sustaining Support (Testing)	1.00%
3	**Maintenance**	**27.45%**	**5**	**Continuing System Improvements**	**5.50%**
3.1.2	Repair Parts (GSD)	17.73%	5.1	Hardware Modifications	99.08%
3.2.1	DLR Fly	39.17%	5.2	Software Maintenance	0.92%
3.2.2	DLR NonFly	0.17%	**6**	**Indirect Support**	**6.30%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	21.40%	6.1	Installation Support	88.86%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.85%
3.4.3	Engine Overhaul/Rework Depot Repair	13.19%	6.3	General Training & Education	6.29%
3.4.4	Other Overhaul/Rework Depot Repair	0.04%			

C-130J			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.20%**	3.5	Other Maintenance	0.31%
1.1	Operations	19.60%	3.6	Interim Contractor Support	3.71%
1.2	Unit-Level Maintenance	45.86%	3.7	Contractor Logistics Support	50.32%
1.3	Other Unit-Level	34.54%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**16.86%**	**4**	**Sustaining Support**	**1.35%**
2.1.1	Energy (Fuel, POL, Electricity)	61.70%	4.2	Support Equipment Replacement & Repair	18.32%
2.1.2	Training Munitions & Expendable Stores	0.12%	4.3	Sustaining/Systems Engineering	37.96%
2.1.3	Other Operational Material	7.31%	4.4	Program Management	0.07%
2.2	Support Services	19.20%	4.6	Data and Technical Publications	21.04%
2.3	TDY	9.00%	4.7	Simulator Operations & Repair	22.55%
2.4	Transportaion	2.67%	4.8.1	Other Sustaining Support (Testing)	0.06%
3	**Maintenance**	**24.55%**	**5**	**Continuing System Improvements**	**10.59%**
3.1.2	Repair Parts (GSD)	10.46%	5.1	Hardware Modifications	89.68%
3.2.1	DLR Fly	17.05%	5.2	Software Maintenance	10.32%
3.2.2	DLR NonFly	0.09%	**6**	**Indirect Support**	**6.46%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	17.87%	6.1	Installation Support	65.07%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	4.62%
3.4.3	Engine Overhaul/Rework Depot Repair	0.01%	6.3	General Training & Education	30.31%
3.4.4	Other Overhaul/Rework Depot Repair	0.18%			

C-17A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**23.24%**	3.5	Other Maintenance	0.00%
1.1	Operations	32.36%	3.6	Interim Contractor Support	0.01%
1.2	Unit-Level Maintenance	55.05%	3.7	Contractor Logistics Support	81.46%
1.3	Other Unit-Level	12.58%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**38.42%**	**4**	**Sustaining Support**	**0.12%**
2.1.1	Energy (Fuel, POL, Electricity)	87.43%	4.2	Support Equipment Replacement & Repair	51.66%
2.1.2	Training Munitions & Expendable Stores	0.03%	4.3	Sustaining/Systems Engineering	14.87%
2.1.3	Other Operational Material	2.29%	4.4	Program Management	0.00%
2.2	Support Services	5.92%	4.6	Data and Technical Publications	20.31%
2.3	TDY	4.28%	4.7	Simulator Operations & Repair	13.17%
2.4	Transportaion	0.05%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**27.47%**	**5**	**Continuing System Improvements**	**8.24%**
3.1.2	Repair Parts (GSD)	9.81%	5.1	Hardware Modifications	96.23%
3.2.1	DLR Fly	7.55%	5.2	Software Maintenance	3.77%
3.2.2	DLR NonFly	1.07%	**6**	**Indirect Support**	**2.51%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.08%	6.1	Installation Support	69.13%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.79%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	28.09%
3.4.4	Other Overhaul/Rework Depot Repair	0.01%			

C-21A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**36.46%**	3.5	Other Maintenance	0.00%
1.1	Operations	59.84%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	18.75%	3.7	Contractor Logistics Support	98.44%
1.3	Other Unit-Level	21.41%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**25.14%**	**4**	**Sustaining Support**	**0.44%**
2.1.1	Energy (Fuel, POL, Electricity)	34.63%	4.2	Support Equipment Replacement & Repair	99.69%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	0.00%
2.1.3	Other Operational Material	3.34%	4.4	Program Management	0.00%
2.2	Support Services	34.07%	4.6	Data and Technical Publications	0.01%
2.3	TDY	12.48%	4.7	Simulator Operations & Repair	0.30%
2.4	Transportaion	15.47%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**28.20%**	**5**	**Continuing System Improvements**	**3.36%**
3.1.2	Repair Parts (GSD)	0.91%	5.1	Hardware Modifications	78.68%
3.2.1	DLR Fly	0.16%	5.2	Software Maintenance	21.32%
3.2.2	DLR NonFly	0.12%	**6**	**Indirect Support**	**6.40%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.36%	6.1	Installation Support	70.54%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	1.29%
3.4.3	Engine Overhaul/Rework Depot Repair	0.02%	6.3	General Training & Education	28.17%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

C-5A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**24.17%**	3.5	Other Maintenance	0.53%
1.1	Operations	13.24%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	59.53%	3.7	Contractor Logistics Support	3.50%
1.3	Other Unit-Level	27.23%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**17.74%**	**4**	**Sustaining Support**	**1.48%**
2.1.1	Energy (Fuel, POL, Electricity)	84.74%	4.2	Support Equipment Replacement & Repair	5.14%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	69.15%
2.1.3	Other Operational Material	3.85%	4.4	Program Management	0.00%
2.2	Support Services	5.85%	4.6	Data and Technical Publications	2.62%
2.3	TDY	5.28%	4.7	Simulator Operations & Repair	23.10%
2.4	Transportaion	0.27%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**35.09%**	**5**	**Continuing System Improvements**	**17.39%**
3.1.2	Repair Parts (GSD)	13.54%	5.1	Hardware Modifications	96.84%
3.2.1	DLR Fly	30.30%	5.2	Software Maintenance	3.16%
3.2.2	DLR NonFly	0.03%	**6**	**Indirect Support**	**4.12%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	33.19%	6.1	Installation Support	87.68%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	1.40%
3.4.3	Engine Overhaul/Rework Depot Repair	18.90%	6.3	General Training & Education	10.92%
3.4.4	Other Overhaul/Rework Depot Repair	0.02%			

C-5B			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**25.12%**	3.5	Other Maintenance	0.21%
1.1	Operations	22.53%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	62.97%	3.7	Contractor Logistics Support	6.75%
1.3	Other Unit-Level	14.50%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**21.18%**	**4**	**Sustaining Support**	**1.86%**
2.1.1	Energy (Fuel, POL, Electricity)	81.57%	4.2	Support Equipment Replacement & Repair	2.14%
2.1.2	Training Munitions & Expendable Stores	0.06%	4.3	Sustaining/Systems Engineering	62.45%
2.1.3	Other Operational Material	3.50%	4.4	Program Management	0.00%
2.2	Support Services	7.96%	4.6	Data and Technical Publications	15.58%
2.3	TDY	6.58%	4.7	Simulator Operations & Repair	19.83%
2.4	Transportaion	0.34%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**35.86%**	**5**	**Continuing System Improvements**	**13.39%**
3.1.2	Repair Parts (GSD)	13.67%	5.1	Hardware Modifications	86.56%
3.2.1	DLR Fly	36.35%	5.2	Software Maintenance	13.44%
3.2.2	DLR NonFly	0.03%	**6**	**Indirect Support**	**2.58%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	23.55%	6.1	Installation Support	84.69%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.08%
3.4.3	Engine Overhaul/Rework Depot Repair	19.44%	6.3	General Training & Education	12.22%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

C-5C			1996-2015		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**28.50%**	3.5	Other Maintenance	0.42%
1.1	Operations	25.44%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	63.21%	3.7	Contractor Logistics Support	9.34%
1.3	Other Unit-Level	11.35%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**15.13%**	**4**	**Sustaining Support**	**2.62%**
2.1.1	Energy (Fuel, POL, Electricity)	64.68%	4.2	Support Equipment Replacement & Repair	2.10%
2.1.2	Training Munitions & Expendable Stores	0.03%	4.3	Sustaining/Systems Engineering	59.31%
2.1.3	Other Operational Material	5.65%	4.4	Program Management	0.00%
2.2	Support Services	15.44%	4.6	Data and Technical Publications	17.95%
2.3	TDY	13.22%	4.7	Simulator Operations & Repair	20.64%
2.4	Transportaion	0.97%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**37.15%**	**5**	**Continuing System Improvements**	**12.78%**
3.1.2	Repair Parts (GSD)	5.95%	5.1	Hardware Modifications	80.42%
3.2.1	DLR Fly	18.48%	5.2	Software Maintenance	19.58%
3.2.2	DLR NonFly	0.05%	**6**	**Indirect Support**	**3.82%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	35.99%	6.1	Installation Support	82.96%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	0.79%
3.4.3	Engine Overhaul/Rework Depot Repair	29.77%	6.3	General Training & Education	16.24%
3.4.4	Other Overhaul/Rework Depot Repair	0.01%			

HC-130N			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**38.82%**	3.5	Other Maintenance	0.29%
1.1	Operations	24.76%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	43.04%	3.7	Contractor Logistics Support	13.47%
1.3	Other Unit-Level	32.20%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**13.59%**	**4**	**Sustaining Support**	**1.13%**
2.1.1	Energy (Fuel, POL, Electricity)	55.84%	4.2	Support Equipment Replacement & Repair	13.45%
2.1.2	Training Munitions & Expendable Stores	0.52%	4.3	Sustaining/Systems Engineering	54.11%
2.1.3	Other Operational Material	12.96%	4.4	Program Management	0.31%
2.2	Support Services	18.64%	4.6	Data and Technical Publications	6.68%
2.3	TDY	9.93%	4.7	Simulator Operations & Repair	24.96%
2.4	Transportaion	2.11%	4.8.1	Other Sustaining Support (Testing)	0.49%
3	**Maintenance**	**27.12%**	**5**	**Continuing System Improvements**	**12.22%**
3.1.2	Repair Parts (GSD)	20.46%	5.1	Hardware Modifications	98.35%
3.2.1	DLR Fly	39.63%	5.2	Software Maintenance	1.65%
3.2.2	DLR NonFly	0.17%	**6**	**Indirect Support**	**7.13%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	18.60%	6.1	Installation Support	64.12%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	5.38%
3.4.3	Engine Overhaul/Rework Depot Repair	7.20%	6.3	General Training & Education	30.51%
3.4.4	Other Overhaul/Rework Depot Repair	0.17%			

KC-10A			1996-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**19.24%**	3.5	Other Maintenance	0.00%
1.1	Operations	40.83%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	46.72%	3.7	Contractor Logistics Support	98.47%
1.3	Other Unit-Level	12.45%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**38.35%**	**4**	**Sustaining Support**	**1.72%**
2.1.1	Energy (Fuel, POL, Electricity)	95.25%	4.2	Support Equipment Replacement & Repair	17.22%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	1.53%
2.1.3	Other Operational Material	0.95%	4.4	Program Management	29.85%
2.2	Support Services	0.54%	4.6	Data and Technical Publications	0.00%
2.3	TDY	3.25%	4.7	Simulator Operations & Repair	48.50%
2.4	Transportaion	0.00%	4.8.1	Other Sustaining Support (Testing)	2.90%
3	**Maintenance**	**36.10%**	**5**	**Continuing System Improvements**	**3.53%**
3.1.2	Repair Parts (GSD)	0.53%	5.1	Hardware Modifications	99.99%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	0.01%
3.2.2	DLR NonFly	0.01%	**6**	**Indirect Support**	**1.06%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.99%	6.1	Installation Support	86.62%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	11.58%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	1.80%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

KC-135D			1996-2007		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**40.12%**	3.5	Other Maintenance	1.68%
1.1	Operations	8.24%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	54.47%	3.7	Contractor Logistics Support	4.86%
1.3	Other Unit-Level	37.29%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**18.32%**	**4**	**Sustaining Support**	**1.97%**
2.1.1	Energy (Fuel, POL, Electricity)	65.30%	4.2	Support Equipment Replacement & Repair	10.95%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	45.66%
2.1.3	Other Operational Material	11.09%	4.4	Program Management	0.00%
2.2	Support Services	6.42%	4.6	Data and Technical Publications	0.54%
2.3	TDY	16.70%	4.7	Simulator Operations & Repair	42.86%
2.4	Transportaion	0.48%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**22.22%**	**5**	**Continuing System Improvements**	**11.38%**
3.1.2	Repair Parts (GSD)	16.74%	5.1	Hardware Modifications	99.96%
3.2.1	DLR Fly	13.90%	5.2	Software Maintenance	0.04%
3.2.2	DLR NonFly	0.23%	**6**	**Indirect Support**	**5.99%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	33.54%	6.1	Installation Support	77.28%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	2.79%
3.4.3	Engine Overhaul/Rework Depot Repair	28.55%	6.3	General Training & Education	19.93%
3.4.4	Other Overhaul/Rework Depot Repair	0.50%			

KC-135E			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**37.39%**	3.5	Other Maintenance	1.24%
1.1	Operations	11.34%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	44.01%	3.7	Contractor Logistics Support	3.69%
1.3	Other Unit-Level	44.65%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**18.15%**	**4**	**Sustaining Support**	**1.43%**
2.1.1	Energy (Fuel, POL, Electricity)	71.48%	4.2	Support Equipment Replacement & Repair	17.88%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	50.58%
2.1.3	Other Operational Material	7.98%	4.4	Program Management	0.15%
2.2	Support Services	6.38%	4.6	Data and Technical Publications	0.42%
2.3	TDY	13.62%	4.7	Simulator Operations & Repair	30.98%
2.4	Transportaion	0.54%	4.8.1	Other Sustaining Support (Testing)	0.00%
3	**Maintenance**	**25.78%**	**5**	**Continuing System Improvements**	**10.15%**
3.1.2	Repair Parts (GSD)	11.20%	5.1	Hardware Modifications	99.97%
3.2.1	DLR Fly	18.76%	5.2	Software Maintenance	0.03%
3.2.2	DLR NonFly	0.19%	**6**	**Indirect Support**	**7.09%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	48.07%	6.1	Installation Support	97.51%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	1.80%
3.4.3	Engine Overhaul/Rework Depot Repair	16.39%	6.3	General Training & Education	0.69%
3.4.4	Other Overhaul/Rework Depot Repair	0.45%			

KC-135R			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**33.14%**	3.5	Other Maintenance	0.48%
1.1	Operations	21.45%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	53.17%	3.7	Contractor Logistics Support	2.01%
1.3	Other Unit-Level	25.38%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**24.68%**	**4**	**Sustaining Support**	**1.30%**
2.1.1	Energy (Fuel, POL, Electricity)	81.98%	4.2	Support Equipment Replacement & Repair	9.81%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	60.93%
2.1.3	Other Operational Material	3.89%	4.4	Program Management	0.50%
2.2	Support Services	4.74%	4.6	Data and Technical Publications	10.01%
2.3	TDY	9.21%	4.7	Simulator Operations & Repair	18.69%
2.4	Transportaion	0.18%	4.8.1	Other Sustaining Support (Testing)	0.07%
3	**Maintenance**	**30.57%**	**5**	**Continuing System Improvements**	**5.97%**
3.1.2	Repair Parts (GSD)	9.50%	5.1	Hardware Modifications	89.17%
3.2.1	DLR Fly	18.81%	5.2	Software Maintenance	10.83%
3.2.2	DLR NonFly	0.07%	**6**	**Indirect Support**	**4.34%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	55.55%	6.1	Installation Support	77.07%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.83%
3.4.3	Engine Overhaul/Rework Depot Repair	13.23%	6.3	General Training & Education	19.10%
3.4.4	Other Overhaul/Rework Depot Repair	0.36%			

KC-135T			1996-2009		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**31.88%**	3.5	Other Maintenance	0.15%
1.1	Operations	30.37%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	52.18%	3.7	Contractor Logistics Support	2.12%
1.3	Other Unit-Level	17.45%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**28.19%**	**4**	**Sustaining Support**	**1.49%**
2.1.1	Energy (Fuel, POL, Electricity)	81.65%	4.2	Support Equipment Replacement & Repair	8.53%
2.1.2	Training Munitions & Expendable Stores	0.00%	4.3	Sustaining/Systems Engineering	62.51%
2.1.3	Other Operational Material	3.37%	4.4	Program Management	0.27%
2.2	Support Services	4.07%	4.6	Data and Technical Publications	13.52%
2.3	TDY	10.83%	4.7	Simulator Operations & Repair	15.15%
2.4	Transportaion	0.08%	4.8.1	Other Sustaining Support (Testing)	0.03%
3	**Maintenance**	**29.13%**	**5**	**Continuing System Improvements**	**6.71%**
3.1.2	Repair Parts (GSD)	7.79%	5.1	Hardware Modifications	83.96%
3.2.1	DLR Fly	16.97%	5.2	Software Maintenance	16.04%
3.2.2	DLR NonFly	0.12%	**6**	**Indirect Support**	**2.59%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	59.48%	6.1	Installation Support	82.58%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	9.18%
3.4.3	Engine Overhaul/Rework Depot Repair	12.73%	6.3	General Training & Education	8.24%
3.4.4	Other Overhaul/Rework Depot Repair	0.64%			

Appendix K: Cost Element Structure Mean Percentages for UAV/Drone Platforms

MQ-1B			1997-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**33.05%**	3.5	Other Maintenance	0.00%
1.1	Operations	51.31%	3.6	Interim Contractor Support	0.08%
1.2	Unit-Level Maintenance	28.85%	3.7	Contractor Logistics Support	91.98%
1.3	Other Unit-Level	19.84%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**24.55%**	**4**	**Sustaining Support**	**0.30%**
2.1.1	Energy (Fuel, POL, Electricity)	0.74%	4.2	Support Equipment Replacement & Repair	67.09%
2.1.2	Training Munitions & Expendable Stores	1.07%	4.3	Sustaining/Systems Engineering	8.68%
2.1.3	Other Operational Material	7.58%	4.4	Program Management	16.26%
2.2	Support Services	82.93%	4.6	Data and Technical Publications	0.00%
2.3	TDY	6.93%	4.7	Simulator Operations & Repair	7.30%
2.4	Transportaion	0.75%	4.8.1	Other Sustaining Support (Testing)	5.05%
3	**Maintenance**	**30.69%**	**5**	**Continuing System Improvements**	**6.76%**
3.1.2	Repair Parts (GSD)	7.61%	5.1	Hardware Modifications	84.99%
3.2.1	DLR Fly	0.05%	5.2	Software Maintenance	15.01%
3.2.2	DLR NonFly	0.28%	**6**	**Indirect Support**	**4.65%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	78.4%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	17.7%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	3.9%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

MQ-9A			2008-2016		
OSD-CAPE Cost Element Structure					
1	**Unit-Level Manpower**	**29.41%**	3.5	Other Maintenance	0.00%
1.1	Operations	30.27%	3.6	Interim Contractor Support	0.00%
1.2	Unit-Level Maintenance	54.44%	3.7	Contractor Logistics Support	99.34%
1.3	Other Unit-Level	15.29%	3.8	Other Contractor Support	0.00%
2	**Unit Operations**	**14.66%**	**4**	**Sustaining Support**	**1.20%**
2.1.1	Energy (Fuel, POL, Electricity)	2.80%	4.2	Support Equipment Replacement & Repair	10.05%
2.1.2	Training Munitions & Expendable Stores	9.28%	4.3	Sustaining/Systems Engineering	15.88%
2.1.3	Other Operational Material	6.64%	4.4	Program Management	71.60%
2.2	Support Services	73.66%	4.6	Data and Technical Publications	0.00%
2.3	TDY	7.37%	4.7	Simulator Operations & Repair	0.65%
2.4	Transportaion	0.26%	4.8.1	Other Sustaining Support (Testing)	1.82%
3	**Maintenance**	**28.03%**	**5**	**Continuing System Improvements**	**21.00%**
3.1.2	Repair Parts (GSD)	0.64%	5.1	Hardware Modifications	97.92%
3.2.1	DLR Fly	0.00%	5.2	Software Maintenance	2.08%
3.2.2	DLR NonFly	0.02%	**6**	**Indirect Support**	**5.71%**
3.4.1	Aircraft Overhaul/Rework Depot Repair	0.00%	6.1	Installation Support	76.8%
3.4.2	Missile Overhaul/Rework Depot Repair	0.00%	6.2	Personnel Support	3.2%
3.4.3	Engine Overhaul/Rework Depot Repair	0.00%	6.3	General Training & Education	20.0%
3.4.4	Other Overhaul/Rework Depot Repair	0.00%			

Bibliography

Arnold, S., Byun, J., Cloud, H., Gallo, A., Gonwa, M., Harmon, B., Patel, P., Sullivan, C., Hiller, J., & Broson, P. (2010). Institute for Defense Analyses. *WSARA 2009: Joint Strike Root Cause Analysis*

Banford, A., Naegle, B., & Powley, E. (2014). Naval Postgraduate School. *Analyzing the Effects of the Weapon Systems Acquisition Reform Act.*

Boito, M., Keating, E. G., Wallace, J., & Deblois, B. (n.d.). *Metrics to Compare Aircraft Operating and Support Costs in the Department of Defense*.

Boito, M., Light, T., Mills, P.,& Baldwin, L. (2012). RAND Corporation. *Managing U.S. Air Force Aircraft Operating and Support Costs.*

Fiorello, M. R. (1975). *Getting "Real" Data for Life-Cycle Costing.* RAND.

Fiorello, M. R. (1975). *Combat Vehicle System Operating and Support Costs: Guidelines for Analysis.* RAND.

Graves, T. J., Leader, P., Domin, J. S., & Porten, R. E. (1997). Trend in Weapon System Operating and Support Costs

Harrison, S. (2013). The Impact of Increasing Acquisition Costs on the Operation and Support Budget for Military Equipment. *Australian Defense Science and Technology Organisation,* (June).

Jones, G., White, E., Ryan, E. T., & Ritschel, J. D. (2014). Investigation Into the Ratio of OS to Life-Cycle Costs for DoD Weapon Systems. *Defense Acquistion Review Journal*, *21*(1), 442–464.

Nachar, Nadim (2008). *The Mann-Whitney U: A Test for Assessing Whether Two Independent Samples Come from the Same Distribution.* Tutorials in Quantitative Methods for Psychology

Office of the Secretary of Defense: Cost Analysis Improvement Group. (2007). *Operating and Support Cost-Estimating Guide*

Office of the Secretary of Defense: Cost Assessment and Program Evaluation. (2010). *Operating and Support Cost-Estimating Guide*

Office of the Secretary of Defense: Cost Assessment and Program Evaluation. (2014). *Operating and Support Cost-Estimating Guide*

Petter, J. (2014). *An Analysis of Stability Properties in Earned Value Managements Cost Performance Index and Earned Schedules Schedule Performance Index*. Air Force Institute of Technology.

Ritschel, J.D. (2012). Efficacy of US Legislation in Military Acquisition Programs: Nunn–McCurdy Act Unveiled. *Economic Papers,* 31(4), 491-500.

Ritschel, J.D. (2016). Organic or Contract Support: Investigating Cost and Performance in Aircraft Sustainment. *Journal of Transportation Management.*

Ryan, E. T, Jacques, D. R, Colombi, J. A, & Schubert, C. M. (2012). A Proposed Methodology to Characterize the Accuracy of Life Cycle Cost Estimates for DoD Programs. *Procedia Computer Science*, *8*, 361–369.

Ryan, E. T., Jacques, D. R., Ritschel, J. D., & Schubert, C. M. (2013). Characterizing The Accuracy of DOD Operating and Support Cost Estimates. *Journal of Public Procurement*, *13*(1), 103–132.

Ryan, E., Kabban S. C., Jacques, D., & Ritschel, J. (2013). A Macro-Stochastic Model for Improving the Accuracy of Department of Defense Life Cycle Cost Estimates. *Journal of Cost Analysis and Parametric.*

Schwartz, M. (2010). The Nunn-McCurdy Act : Background , Analysis , and Issues for Congress.

US GAO. (2009). *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs.* Retrieved August 2017

US GAO. (2010). *Defense Management: DOD Needs Better Information and Guidance to More Effectively Manage and Reduce Operating and Support Costs of Major Weapon Systems*. Study. Retrieved August 2017

US GAO (2012). *Defense Logistics: Improvements Needed to Enhance Oversight of Estimated Long- Term Costs for Operating and Supporting Major Weapon Systems*. Study. Retrieved August 2017

US GAO. (2010). *DoD Needs Better Information and Guidance to More Effectively Manage and Reduce Opeating and Support Costs of Major Weapon Systems.*

US GAO. (2012). *Improvements Needed to Enhance Oversight of Estimated Long-term Costs for Operating and Supporting Major Weapon Systems.* Study.

Weapon Systems Acquisition Reform Act of 2009, Pub. L.–31. 111-13, 123 Stat. 1704, codified as amended at 10 U.S.C.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 074-0188*

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From – To)*
22-03-2018	Master's Thesis	October 2016 – March 2018

TITLE AND SUBTITLE

An Analysis of Aircraft Operating and Support Cost Element Structures and Their Contribution to Total Costs

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

O'Hanlon, Garrett B., 1st Lieutenant, USAF

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER

AFIT-ENV-MS-18-M-227

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10. SPONSOR/MONITOR'S ACRONYM(S)

AFLCMC

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
DISTRUBTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

13. SUPPLEMENTARY NOTES
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14. ABSTRACT
As the cost of DoD Weapon Systems continue to increase, the ability to more accurately predict the Operating and Support (O&S) costs for the various weapon systems has become more vital for long run affordability. The investigation into the O&S arena has been overshadowed by the research and development (R&D) and acquisition fields. This research focuses on the O&S portion of the total life cycle costs, specifically the OSD-CAPE Cost Element Structure (CES) elements and sub-elements. The research investigates seven categories of 52 aircrafts and their cost expenditures within the CES from the years 1996-2016. The first portion of the analysis investigates the descriptive statistics for the 52 aircrafts and their respective categories. The second portion focused on utilizing statistical tests to compare and contrasts the findings from question one to illustrate the similarities and differences by cost expenditures depending on aircraft category. Lastly, we investigate if the elements/sub-elements could be used as metrics to each other through a multivariate correlation analysis. DoD Cost Estimators and stakeholders alike can benefit from this research by utilizing the results as baselines for future analogy based estimates.

15. SUBJECT TERMS
Operating and Support (O&S), Office of the Secretary of Defense Cost Assessment Program Evaluation (OSD-CAPE)

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Dr. Daniel Ritschel, AFIT/ENV
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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18