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EVALUATING THE IMPACT OF THE FULLY BURDENED COST OF FUEL

by

Robert M. Corley

September 2009

Thesis Advisor:	Daniel A. Nussbaum
Second Reader:	Douglas R. Burton

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Our analysis shows that there are potentially large variations in energy-related costs (burdens) associated with the required fuel delivery assets, the supporting infrastructure and associated manpower, and the assets providing force protection and security to the fuel delivery assets in both peacetime and operational scenarios. Recommendations for follow on studies are provided.

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EVALUATING THE IMPACT OF THE FULLY BURDENED COST OF FUEL

Robert M. Corley
Lieutenant Commander, Supply Corps, United States Navy
B.A., San Jose State University, 1998

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NAVAL POSTGRADUATE SCHOOL
September 2009

Author: Robert M. Corley

Approved by: Daniel A. Nussbaum
Thesis Advisor

Douglas R. Burton
Second Reader

Robert F. Dell
Chairman, Operations Research Department

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LIST OF ACRONYMS AND ABBREVIATIONS

ACAT	Acquisition Category
AIR	Naval Air
AOA	Analysis of Alternatives
ASN(RDA)	Assistant Secretary of the Navy (Research, Development and Acquisition)
C4I	Command, Control, Communications, Computers and Information
CNA	Center for Naval Analysis
CNO	Chief of Naval Operations
DAG	Defense Acquisition Guidebook
DASN	Deputy Assistant Secretary of the Navy
DDG	Guided Missile Destroyer
DDR&E	Director of Defense Research and Engineering
DESC	Defense Energy Supply Center
DFM	Diesel Fuel Marine
DoD	Department of Defense
DoDI	Department of Defense Instruction
DON	Department of the Navy
DSB	Defense Science Board
EOA	Evaluation of Alternatives
EXW	Expeditionary Warfare
FBCF	Fully Burdened Cost of Fuel
FRAGO	Fragmentary Order
FY	Fiscal Year
GAO	Government Accounting Office
JASON	The JASON Group
JCIDS	Joint Capabilities Integration Development System
KPP	Key Performance Parameter
LCC	Life-cycle Cost
LMI	LMI Government Consulting
MAIS	Major Automated Information System
MCO	Major Contingency Operations
MDA	Milestone Decision Authority

MDAP	Major Defense Acquisition Program
MILPERS	Military Personnel
NCCA	Naval Center for Cost Analysis
NDAA	National Defense Authorization Act
O&M	Operations and Maintenance
O&S	Operating and Support
OIF	Operation Iraqi Freedom
OPNAV N81	Assessment Division
OPTEMPO	Operating Tempo
OUSD(AT&L)	Office of the Under Secretary of Defense (Acquisition, Technology and Logistics)
OUSD(I&E)	Office of the Under Secretary of Defense (Installations and Environment)
PEO	Program Executive Office
PM	Program Manager
POS	Point of Sale
RDT&E	Research, Development, Test and Evaluation
SHIPS	Naval Ships
T-AO	Fleet Oiler—Military Sealift Command manned
VAMOSC	Visibility and Management of Operating and Support Costs
WCF	Working Capital Fund

EXECUTIVE SUMMARY

The purpose of this thesis is to illuminate the significance of the cost burdens associated with fueling our energy demanding weapons systems. These indirect costs - manpower, infrastructure, delivery assets, and security requirements - represent fiscally enormous multipliers above and beyond the Defense Energy Supply Center (DESC) standard price. This thesis performs the following analyses.

- Reviews current Department of the Navy (DON) Major Defense Acquisition Programs (MDAP) and provides an analysis of those that might be impacted by the Fully Burdened Costs of Fuel (FBCF).
- Implements a developmental model for calculating the FBCF and conducts an analysis of the estimates obtained.

Acquisition life-cycle cost estimation of energy demanding capabilities has historically focused on the commodity price of fuel as the determinant of life-cycle fuel costs. It has overlooked consideration of the costs of fuel delivery, storage and security functions specific to the capability, the supporting infrastructure and associated manpower, and the assets providing force protection and security to the fuel delivery assets.

The additional costs (burdens) summed with the commodity price of the fuel required to employ new capabilities make up the Fully Burdened Cost of Fuel (FBCF) and provide a more realistic figure of the fuel-related costs of capabilities. These fully burdened estimates of fuel-related life-cycle costs can be used to better assess trades during the Analysis of Alternatives (AOA) phase of the acquisition process.

The FBCF concept provides a measure to assess changes in vulnerabilities to the new system and its supporting assets, as a function of the new capability's fuel requirements. As the energy demands for a system increase, so do the demands (burdens) on the supporting logistics tail. Use of the FBCF during AOAs ensures these burdens are taken into consideration and enables a more realistic assessment of the trades under review before major production and fielding a new capability.

This study provides an analysis of the current Department of the Navy (DON) Major Defense Acquisition Programs (MDAP) to determine those most likely impacted by the FBCF. It finds that of the $805.7 billion (FY2009) DON MDAP budget, $728.9 billion (90.5 percent) is directly associated with programs most likely impacted by fuel-related cost and the FBCF.

Additionally, the FBCF for a notional DDG-51 fleet was estimated which found, in agreement with previous study findings, that the costs of fuel-related burdens can add significantly to the overall LCC costs of a capability. When accounted for prior to major milestone decisions, these additional costs can better inform decision makers of the trades being considered and their potential energy-related burdens.

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This work is dedicated to the memory of ETC(SS) Joseph John Zajac, Jr., USN, retired; a dedicated and loving husband to my mother, a brilliant mind and accomplished musician to the world, and a wonderful father to me—January 15, 1942 to June 10, 2008.

In accomplishment of this thesis, I wish to extend my sincere gratitude to Dr. Daniel Nussbaum and CDR Douglas Burton, for your keen advice, insights and guidance in accomplishment of this work. Special thanks to Dave King, Dave Bak, Tom Morehouse and Rick Cotman, for their strategic communications and developmental methodologies that created the foundation of this thesis.

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I. INTRODUCTION

The purpose of this thesis is to illuminate the significance of the cost burdens associated with fueling our energy demanding weapons systems. These indirect costs—manpower, infrastructure, delivery assets, and security—represent fiscally enormous multipliers above and beyond the Defense Energy Supply Center (DESC) standard price. This thesis performs the following analyses.

- Reviews current Department of the Navy (DON) Major Defense Acquisition Programs (MDAP) and provides an analysis of those that might be impacted by the Fully Burdened Costs of Fuel (FBCF).
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History illustrates that new capabilities, whether at the tactical tooth or within the logistics tail of our forces, are fielded with ever-greater demands for energy. As newly acquired energy demanding systems are brought on-line, increases in their associated operational logistics burdens providing their energy requirements are also realized. These burdens, which make up the logistics tail supporting the newly acquired capability, come in the form of additional infrastructure costs and personnel requirements, energy delivery asset operation and sustainment costs, environmental costs, and security costs to bring the energy to the system. The sum of these burdens do not necessarily represent a linear correlation to the energy requirements of the new capabilities alone, but rather increase as a function of the intrinsic energy-efficiency and unique logistics tail required to protect and sustain the energy demands to the newly fielded capability.

A. PREVIOUS STUDIES

Studies performed by the Defense Science Board (DSB), The JASON Group (JASON) and LMI Government Consulting (LMI) identified large indirect costs associated with infrastructure, equipment, transportation, operational environment, and security that, in certain environments, greatly increased the cost per unit of energy to the energy demanding system. Indirect costs, when added to the commodity price of fuel, form the basis for the Fully Burdened Cost of Fuel. These findings coupled with the increased energy demands of doing DON business, increased vulnerabilities associated with ever growing logistics tails, and the drive to reduce fossil fuel use substantiate exploration to formulate and quantify the FBCF for current and future acquisition programs, logistics models and life-cycle management of DON systems.

1. DSB Task Force on Improving Fuel-Efficiency of Weapons Systems

On June 18, 1999, the Office of the Under Secretary of Defense (Acquisition, Technology and Logistics) (OUSD(AT&L)) sponsored the DSB to form a Task Force to "identify technologies that improve fuel efficiency of the full range of weapons platforms (land, sea, and air) and assess their operational, logistics, cost and environmental impacts for a range of practical implementation scenarios" (OUSD(AT&L), 1999, p. 1). The Task Force was charged with evaluating fuel-efficient technologies in terms of operations, logistics, costs, and environmental impact with the greatest potential for implementation by 2010. The final report of the DSB Task Force on Improving Fuel Efficiency of Weapons Platforms titled *More Capable Warfighting through Reduced Fuel Burden* was published in January 2001. The study reported findings and recommendations that resonated that military requirements and acquisition processes were the areas offering the greatest impact in improving warfighting capability through reducing the burdens of fuel. The DBS's recommendation to base investment decisions on the true cost of delivered fuel when evaluating retrofits, conducting Analysis of Alternatives (AOA) for new capabilities, making Science and Technology decisions and determining Life Cycle Costs (LCC) is the basis for this thesis (DSB, 2001). Appendix A contains the findings and recommendations of the DSB Task force.

2. DSB Task Force on DoD Energy Strategy

Again, in March 2006, OUSD(AT&L) commissioned the DSB to form another Task Force to identify: 1) Opportunities to reduce fuel demand and assess the effects on cost, operations and force structure; 2) Opportunities to deploy renewable and alternative energy sources for facilities and deployed forces; 3) Institutional barriers to making the transitions recommended by the Task Force; 4) The potential national benefits from the

Department of Defense (DoD) deployment of new energy technologies. In February 2008, the DSB Task Force on DoD Energy Strategy published "More Fight—Less Fuel" and reported findings and recommendations. Of the findings, it was noted that two key recommendations from the 2001 DSB Task Force on energy had not been implemented—establishment of an energy key performance parameter (KPP) to constrain battlespace fuel demand, and establishment of the true cost of delivered fuel (FBCF) to guide acquisition investments (DSB, 2007). Appendix B contains the findings and recommendations of the 2006 DSB Task Force.

3. JASON Report JSR-06-135

In 2006, the Director of Defense Research and Engineering (DDR&E) sponsored JASON to assess ways and means to reduce DoD's dependence on fossil fuels. Among the findings and recommendations JASON reported, they found that DoD fuel use represented only a small fraction of the total DoD budget. However, they asserted that even though fuel costs accounted for only 2.5 to 3 percent of the overall FY05 DoD budget, there were compelling reasons to minimize fuel use: 1) Fuel costs represent a large portion of the total LCC of aircraft and non-nuclear ships; 2) Fuel use is characterized by large multipliers and co-factors—functions of the delivery assets, infrastructure, manpower, security of the fuel to end user (the burdens that make up the FBCF)—"it takes fuel to deliver fuel" (JASON, 2006, p. iv); 3) Fuel use imposes large logistical burdens, operational constraints and liabilities and vulnerabilities—factors of the FBCF (JASON, 2006).

JASON's analysis of the cost to deliver fuel air-to-air was estimated to be $20.00 to $25.00 per gallon in FY05 dollars. This range included the commodity price, which constituted the smallest fraction when compared to operations and maintenance (O&M) and acquisition costs of tanker aircraft amortized over a 40-year lifetime. A similar example determined that Army fuel delivery within the battlespace ranged from $100.00 to $600.00 per gallon depending on the distance of separation from source to end user, terrain, defense and logistics requirements. JASON's analysis showed that the commodity price of fuel is not the decision driver and that O&M costs comprise the greatest cost burdens associated with fuel delivery. They concluded that the reduction of fuel required to support the logistics elements supplying fuel, the fuel required to deliver fuel, was the most significant driver for reducing fuel use (JASON, 2006).

4. LMI Report FT602T1

Strategic consultants, LMI, published the 2007 study *Transforming the Way DoD Looks at Energy: An Approach to Establishing Energy Strategy* which provided findings and recommendations for transformation of DoD's energy strategy. The study "identified four areas of disconnect between DoD's current energy consumption practices and the capability requirements of its strategic goals" (LMI, 2007, p. 1–3)—strategic, operational, fiscal and environmental. Of the corporate process options LMI recommended to DoD, incorporation of "energy use and energy logistics support requirements in all future concept development, capability development and acquisition actions" targeted the FBCF concept (LMI, 2007, p. 5–3).

LMI discussed the operational and fiscal disconnects associated with the current DoD policies regarding the logistics forces required to provide the energy needs to sustain military capabilities. Regarding the operational disconnect, their report showed that the DESC estimated the manpower to deliver fuel during Operation Iraqi Freedom (OIF) was 20,000 soldiers at a cost to deliver of $1 million per day. These burdens were amplified in comments by Maj. Gen. Richard Zilmer, the senior Marine Corps officer in Iraq's Anbar Province, who requested urgent development of solar and wind power capabilities to reduce dangerous fuel transportation activities. "Reducing energy use at outlying bases reduces the frequency of logistics convoys required to provide their energy needs thereby reducing danger to the Marines, soldiers, and sailors" (LMI, 2007, p. E-25).

In terms of the fiscal disconnect, LMI stated that the "inability to account for energy considerations in operational and force development analysis impacts investment decisions." They identified that the "real cost of fuel to DoD was more than just the DESC standard price used for programming, budgeting and investment decisions" (LMI, 2007, p. 2–10). The cost of fuel was the sum of the commodity price plus all indirect burdens associated with its procurement, transportation and security—the FBCF. Furthermore, the FBCF was not being calculated nor considered in decision-making processes within the Joint Capabilities Integration Development System (JCIDS) (LMI, 2007).

B. DOD ENERGY POSTURE

Given the importance of the FBCF in requirements and acquisition planning as implied through previous studies, the 2009 National Defense Authorization Act (NDAA) directed that LCC analysis for new capabilities shall include the FBCF during the AOA and the Evaluation of Alternatives (EOA) phases in the acquisition process. This legislation provided the catalyst for forging a mechanism for forecasting operational energy-related burdens associated with fielding new capabilities to the warfighter. Its mandate that decision makers consider the anticipated energy-related burdens associated with fielding new, energy-demanding systems and the potential consequences of such energy burdens on the total force prior to full production was the catalyst for the Services to develop and apply methodologies using the FBCF (NDAA, 2009). Appendix C provides SEC. 332 of the NDAA addressing FBCF.

1. OUSD(AT&L): Leading the Charge

As the key DoD entity charged with acquisition policy implementation and oversight, OUSD(AT&L) has provided the strategic communications that has promoted recent revisions to DoD policy requiring the Services to formulate methodologies and means for application of the FBCF in trade space analysis within their respective program acquisition arenas. In March 2008, Deputy Under Secretary of Defense (Acquisition & Technology), Mr. Chris DiPetto, testified before the United States House Committee on Armed Services Readiness Subcommittee that "strategic planning and long-term costing should include not only the price of the fuel, but all the logistics effort" to deliver the fuel and that OUSD(AT&L)'s immediate focus was to "mature the methodology" for estimating the FBCF (DiPetto, 2008, p. 4).

Following the tremendous efforts of OUSD(AT&L) and previous evidence substantiating consideration for using FBCF in LCC estimation, the Defense acquisition Guidebook (DAG) was revised in 2008 per DoD Instruction 5000.02, *Operation of the Defense Acquisition System*. It directing that "the fully burdened cost of delivered energy shall be used in trade-off analysis for all DoD tactical systems with end items that create a demand for energy" and echoes the strategic importance of the FBCF (DoDI, 2008).

C. DON DIRECTION

The Center for Naval Analysis (CNA) published *The DON Energy Strategy* as a CNA analytical paper in December 2008. The report outlined areas of importance for forging a DON energy strategy in the near term and included specific recommendations for operational and policy changes which included incorporation of the FBCF in all acquisition and force structure decisions. CNA noted that "determination of the FBCF is necessary to inform our decision-making and that decision-making required well-defined metrics to account for energy use. They further amplified that DON acquisition practices will be required to embrace the integration of the FBCF per the NDAA (CNA, 2009).

Though no DON energy strategy has yet been published, the Chief of Naval Operations (CNO), Admiral Gary Roughead, places great importance on energy in his statements to "raise the visibility and awareness of energy as a strategic resource …and optimize energy considerations in budgeting and acquisition" in his 2009 guidance to the Navy (CNO, 2008, p. 3). He also directed the establishment of the Navy's first Task Force Energy whose charter is to develop metrics, processes, tools and organizational structure to "provide a Navy Energy Strategy that treats energy as a strategic resource thereby optimizing energy in planning, programming, budgeting, execution and acquisition processes" (CNO FRAGO, 2008, p. 2). His order amplifies findings from the previous studies, and is meant to correct the present lack of strategy, policies, metrics, information, and governance structure to manage energy risks

D. THESIS OBJECTIVES

This thesis performs the following analyses.

- Reviews current DON MDAPs and provides an analysis of those that might be impacted by the FBCF.
- Implements a developmental model for calculating the FBCF and conducts an analysis of the estimates obtained.

Previous work with the FBCF has been largely strategic communications at the highest levels of DoD and the Services in order to illuminate the significance of the cost burdens associated with fueling our energy demanding weapons systems. These indirect costs—manpower, infrastructure, delivery assets, and security requirements - represent fiscally enormous multipliers above and beyond the DESC standard price. More importantly, in addition to these indirect monetary costs are increases in vulnerabilities to weapon systems and energy supply network elements.

For every additional unit of energy-demand we place in the battlespace, whether in air, on land or at sea, the logistics tail providing the energy must be increased. Thus, the direction to address and utilize the FBCF in trade space analysis will offer program managers and their respective combatant commanders a view of the impact of a prospective weapon system's energy impact on the total force as well as a more accurate forecast of LCC.

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II. A METHODOLOGY IN DEVELOPMENT

A. FBCF DEFINED

The FBCF of a system is “the cost of the fuel itself … plus the apportioned cost of all of the fuel delivery logistics and related force protection required beyond the DESC point of sale (POS) to ensure refueling of this system” (DAG, 2009, p. 1).

B. DEVELOPING THE METHODOLOGY

OUSD(AT&L) guidance in the development of FBCF methodologies published in the DAG stem from observations that energy inefficiencies in the battlespace impose operational vulnerabilities as a result of sever fuel availability constraints (DSB, 2001). First, as energy demand in a battlespace increases, so does the size and energy demand of its logistics “tail”—the larger the “tail” the greater the constraint on our tactical and logistics forces. Second, logistics “tails” represent large, exposed targets from conventional, irregular and catastrophic threats, which become increasingly vulnerable as their intrinsic energy demands increase to support greater tactical energy requirements in the battlespace. Finally, the logistics energy “tail” represents potential increased investment in combat assets of greater energy efficiency.

The FBCF is meant to inform technological and design choices within the acquisition process and help DoD manage enterprise risks. It does not quantify operational challenges or specific obstacles fuel demand brings to warfighting, but compliments efforts in the force planning process and the KPP for energy efficiency to capture these risks when setting system capability goals and desired performance parameters (DAG, 2009).

C. FBCF ATTRIBUTES AND COST ELEMENTS

Two attributes are required to develop an FBCF estimate for a specific platform or system.

- First, the ratio of anticipated operational-to-nonoperational time over the life of the platform or system using a representative set of future operational and steady-state scenarios the given platform or system is being designed to support including its anticipated logistics and force protection requirements.

- Second, the proportion of the fuel logistics "tail" identified in the selected scenarios attributable to the platform or system in design. This provides the basis for apportioning the logistics "tail" and its elements required to provide the energy needs of the specific platform or system.

Though no definitive means to calculate FBCF estimates exists, the Services are expected to include realistic and justifiable approximations (DAG, 2009). Table 1 shows the cost elements that provide a basis for FBCF estimation as developed by OUSD(AT&L).

Element	Burden Description
Commodity Cost of Fuel	DESC standard price for the appropriate type or types of fuel
Primary Fuel Delivery Asset O&S Cost*	Cost of operating service-owned fuel delivery assets including the cost of military and civilian personnel dedicated to the fuel mission.
Depreciation Cost of Primary Fuel Delivery Assets*	Measures the decline in value of fuel delivery assets with finite service lives using straight-line depreciation over total service life
Direct Fuel Infrastructure O&S and Recapitalization Cost*	Cost of fuel infrastructure that is not operated by DESC and directly tied to energy delivery
Indirect Fuel Infrastructure*	Cost of base infrastructure that is shared proportionally among all base tenants
Environmental Cost*	Cost representing carbon trading credit prices, hazardous waste control and related subjects.
Other Service & Platform Delivery Specific Costs*	Includes potential cost associated with delivering fuel such as convoy escort, force protection, regulatory compliance, contracting and other costs as appropriate.

* These costs vary by Service and delivery method (ground, sea, air)

Table 1. OUSD(AT&L) defined cost elements for estimating the FBCF (DAG, 2009, p. 4)

1. Commodity Cost of Fuel: DESC is DoD's sole source for petroleum products, coal, natural gas, and electricity within the continental United States and serves as the integrated material Manager for all petroleum procurement and distribution from wholesale points to units of the Services. The commodity cost of fuel is the standard price, established by DESC, for fuel received at a retail POS and includes a surcharge to recover costs associated with storage and transportation of the fuel to the retail POS

(Figure 1). The Services receive delivered fuel through a reimbursable arrangement called the Defense Working Capital Fund (WCF). Current standard prices are found at the DESC Web site (http://www.desc.dla.mil/).

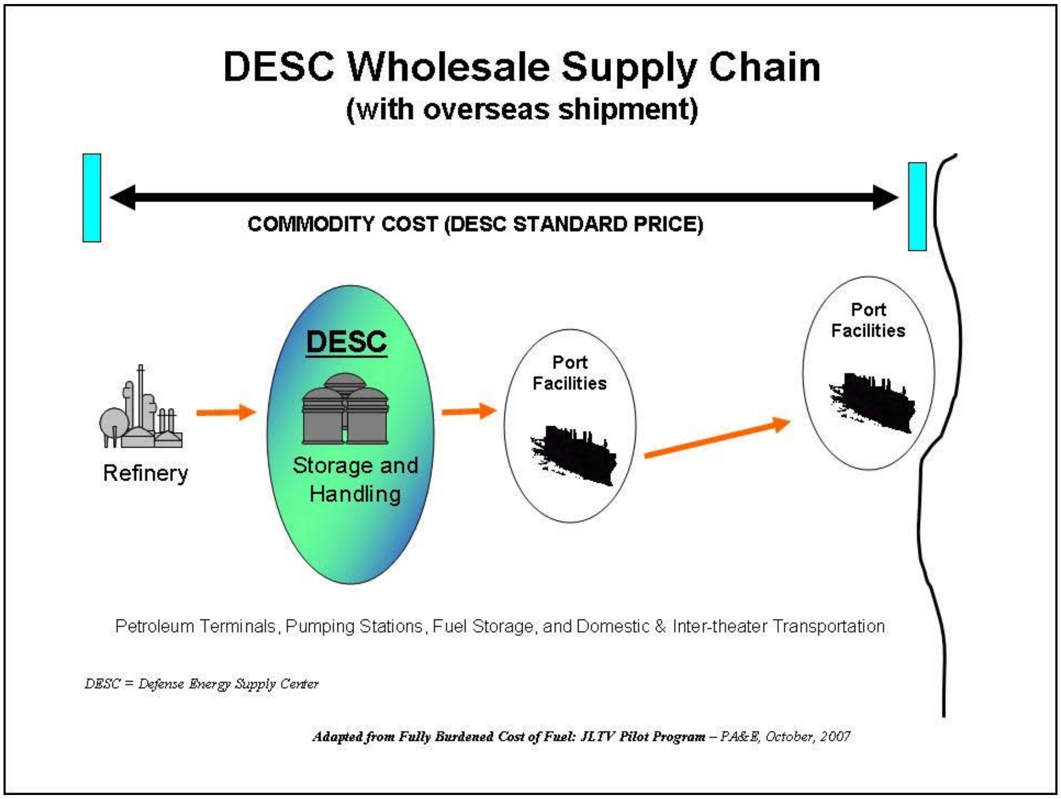

Figure 1. DESC wholesale supply chain (DAG, 2009, p. 5)

DESC's standard price for fuel is not a current market price for fuel, but a financial tool intended to insulate the Services from global fuel price volatility. The standard price is calculated far ahead of the fiscal year that it will be used based on an eighteen-month fuel price projection. Thus, during market swings the difference between market price and the standard price of fuel may result in a net gain or loss to the WCF (DAG, 2009).

2. Fuel Delivery Asset Operations & Support Cost: Operating & Support (O&S) costs are those costs associated with fuel delivery assets (major delivery vehicles such as oiler vessels, aerial refueling aircraft and tanker trucks) operated by the Services

from the retail POS after receipt from DESC. O&S costs consist of operations and maintenance (O&M) of the assets and the costs for military and civilian personnel dedicated to fuel delivery. For delivery assets that are major systems (e.g., oilers and aerial refueling aircraft) these costs are available via the Service-specific Visibility and Management of Operating and Support Costs (VAMOSC). For Navy, the information can be obtained at Web site (http://www.navyvamosc.com/).

3. Fuel Delivery Asset Depreciation Costs: Though most DoD studies assess equipment recapitalization, these costs provide a measure of the decline in capital value of the primary fuel delivery assets over time. OUSD(AT&L) suggests using straight line depreciation over the expected service life of the asset for calculating this cost element.

4. Direct Fuel Infrastructure: Applying only to infrastructure operated by the Services, this cost element captures the O&S and recapitalization costs for facilities in-theater and not operated by DESC. Data and associated cost factors for DoD infrastructure are centrally managed by the Office of the Under Secretary of Defense (Installations and Environment) (OUSD(I&E)). Data on all DoD world-wide facilities from the Facilities Assessment Database is available to registered users of the OUSD(I&E) Facilities Program Requirements Suite at Web site (http://www.acq.osd.mil/ie/).

5. Indirect Fuel Infrastructure Costs: This cost element captures the fair share of the total indirect O&S costs attributable to base-level fuel infrastructure functions. OUSD(AT&L) suggests these costs be based on a per capita basis for base-level O&S by dividing the total installation manpower by the total annual base O&S costs to derive a per capita factor. This factor can then be applied to the Fuel Delivery Asset O&S Costs (above) to estimate an annual indirect fuel infrastructure cost.

6. Environmental Costs: The costs of fuel consumption related to the environment are difficult to quantify. However, a proxy has been adopted by the Office of the Secretary of Defense (Program, Analysis and Evaluation) based on costs associated with DoD environmental clean-up and hazardous material control, and the potential costs of carbon emission offsets.

7. Other Service/Platform Unique Costs: Costs for special considerations peculiar to the platform or system to be fielded such as DoD force protection assets allocated to the fuel delivery forces and their respective O&S costs, direct fuel costs, depreciation and manpower costs make up the final cost element. As evidenced in previous studies and echoed by OUSD(AT&L), these costs can become significantly greater than all others combined in high-risk operational scenarios.

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III. DON MDAPS IMPACTED BY FUEL AND ENERGY BURDENS

A. DON MDAPS

A list of DON MDAPs was acquired from the December 9, 2008 Assistant Secretary of the Navy (Research, Development & Acquisition) (ASN(RDA)) Active Acquisition Category (ACAT) Report. MDAPs are those acquisition programs estimated to require research, development, test, and evaluation (RDT&E) expenditures exceeding $365.00 million in fiscal year (FY) 2000 constant dollars or procurement expenditures greater than $2.190 billion in FY 2000 constant dollars, or designated by Under Secretary of Defense (Acquisition and Technology) to be ACAT I under Title 10 of the United States Code 2430 (DoDI, 2008). Appendix D describes and defines DoD ACAT programs and their respective decision authorities.

The Active ACAT Report lists 225 DON programs within nine ACATs. Of the 225 programs, 48 are MDAPs which are distributed across four categories: ACAT IC, ACAT ID, ACAT IAC and ACAT IAM. Seven of the 48 MDAPs are ACAT IAC and ACAT IAM programs further defined as Major Automated Information Systems (MAIS). These programs will not be included in this thesis' analysis, as they are least likely generators of fuel burden. The remaining 41 ACAT IC and ACAT ID MDAPs, which represent primarily DON tactical and mobility weapon system programs currently in various stages of the acquisition process, form the basis for program analysis.

Appendix E, Table 13 provides each program's respective ACAT category, Program Name, Deputy Assistant Secretary of the Navy (DASN) under which the program resides, Program Executive Office (PEO) responsible for the program execution, and Total FY09$M representing the sum of each program's RDT&E plus procurement costs normalized to FY09 constant dollars. Normalization of all cost data to FY09 dollars was performed using the Naval Center for Cost Analysis (NCCA) Inflation Calculator available at their Web site (http://www.ncca.navy.mil/services/inflation.cfm).

RDT&E and Procurement costs were compiled from the March 2009 Government Accounting Office (GAO) Report to Congressional Committees *Defense Acquisitions: Assessment of Selected Weapon* Program (GAO, 2009) and a November 2008 OUSD(AT&L) Selected Acquisition Report. These sources do not provide O&S costs for all programs reported. Therefore, costs figures referred to in this thesis represent the sum of RDT&E and procurement costs only.

MDAP data is first broken down by DASN to determine where the predominance of program costs exists. DASN Air, DASN Command, Control, Communications, Computers, Information (C4I) and Space, DASN Expeditionary Warfare (EXW) and DASN Ships are the principal advisors to the ASN(RDA) on the programs within their purview. Appendix F provides an organizational chart of the DON PEO structure and the hierarchy of responsibility for each PEO up to the ASN(RDA) via their respective DASN. Figure 2 shows the total distribution of costs across the four DASNs responsible for the 41 MDAPs under study per DASN. DASN Air and DASN Ships account for approximately $757 billion or 94% of the total $805.7 billion DON FY09 MDAP budget.

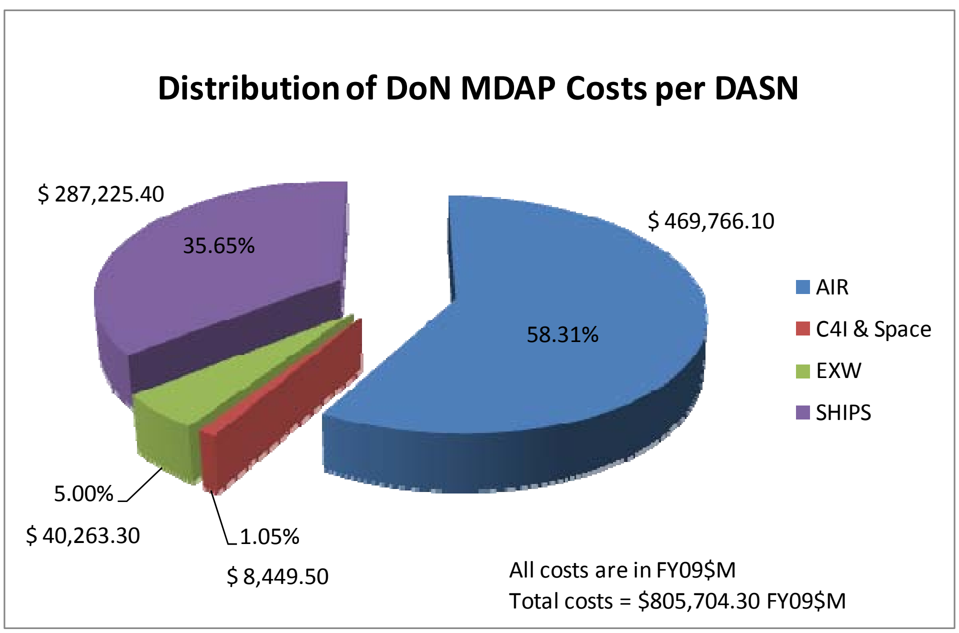

Figure 2. Distribution of DON MDAP costs

B. DON MDAPS MOST IMPACTED BY ENERGY AND FUEL-RELATED BURDENS

Though energy is required to field, maintain and support each of the platforms and systems under study, the programs which are most impacted and/or affected by the burdens of fuel are those which will ultimately require regular fuel resupply. For example, aircraft, land vehicles, ships and diesel generators will reach service with significant life-cycle fuel burdens; whereas satellites, missiles and bombs will not. To address the most fuel burdened programs, the list of 41 programs is refined to include only those which are most likely to be impacted by routine fuel-related burdens. This discrimination eliminates 16 programs and results in 25 remaining programs determined most dependent on and predicted to be the most constrained by fuel burdens (Appendix E, Table 14).

The costs of these 25 programs ($728,984.70 FY09$M) represent 90.48% of the total MDAP costs of the initial 41 programs ($805,704.30 FY094M) under study. Thus, our refined list captures more than 90% of the total costs with only 61% (25 of 41) of the total MDAPs currently in the process of acquisition. Figure 3 shows the distribution of MDAP costs across the DASNs for those most impacted by fuel.

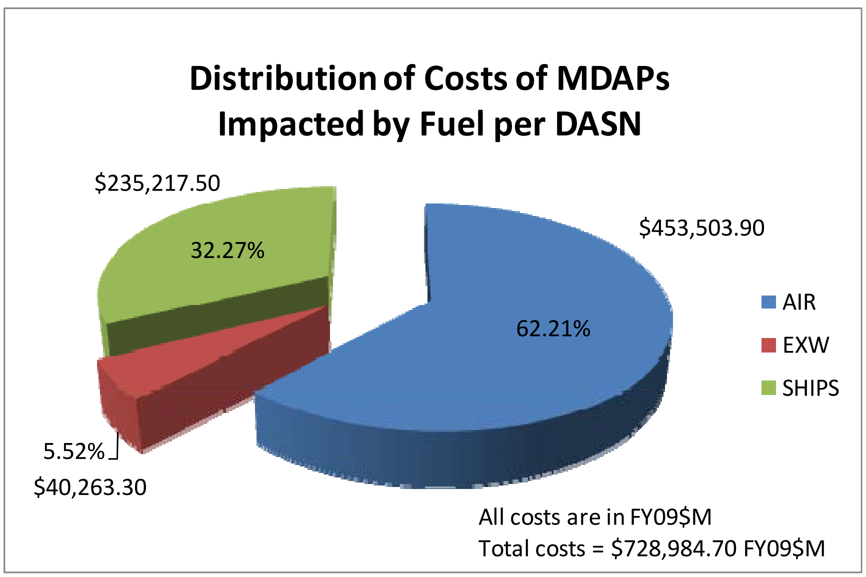

Figure 3. Distribution of Programs Impacted by Fuel

Of the 25 most fuel burdened MDAPs, DASN Air is responsible for providing oversight for 13 programs with budgets totaling $453.5 billion or 62.2% of the total DON MDAP costs attributable to programs most impacted by fuel burden. These 13 DASN Air programs impacted by fuel burden represent 96.6% ($469.7 billion) of the total DASN Air MDAP budget for their 22 total programs (includes those not impacted by fuel). This is clear evidence that DASN Air programs are predominately burdened by fuel.

Similar conclusions are deduced of DASN Ships and DASN EXW. 9 of the 15 (60%) DASN Ships MDAPs currently in the acquisition process are significant;y impacted by fuel burdens and account for 81.9% of the total DASN Ships MDAP budget ($235.2 billion of the total $287.2 billion). DASN EXW oversees 3 MDAPs, all of which are impacted by fuel burden and account for 100% of their $40.3 billion MDAP budget. DASNs Air, Ships and EXW programs and respective MDAP budgets are mostly impacted by the burdens of fuel and represent more than 90% of their total MDAP budgets. Thus, there is potentially significant impact to these programs and their respective capabilities as a function of fuel burden and the FBCF could be useful in illuminating the fuel-related burdens before major milestone decisions in the acquisition process during AOA and tradespace analysis.

C. DISTRIBUTION OF IMPACTED DON MDAPS AMONG PEOS

Of the 15 PEOs (including PEO MARCOR for Joint Marine Corps programs) responsible for the execution and management of the current 48 DON MDAPs, 9 are directly responsible for those programs most impacted by fuel burdens. Figure 4 illustrates the costs per PEO and distribution of those costs amongst the PEOs for programs impacted by fuel burdens. A summary accountability of the costs across the DASNs follows and is provided in detail in Appendix G, Table 15.

1. DASN Air's 13 of 22 impacted programs account for 96.54% of all DASN Air MDAP program costs, 62.21% of all DON MDAP program costs for programs impacted by fuel burdens and 56.29% of all DON MDAP program costs (not including MAIS programs).

2. DASN Ships 9 of 14 impacted programs account for 81.89% of all DASN Ships MDAP program costs, 32.27% of all DON MDAP program costs for programs impacted by fuel burdens and 29.19% of all DON MDAP program costs (not including MAIS programs).

3. DASN EXW's 3 impacted programs account for 100% of all DASN EXW MDAP program costs, 5.52% of all MDAP program costs for programs impacted by fuel burdens and 5.00% of all DON MDAP program costs (not including MAIS programs).

4. Neither of the two DASN C4I & SPACE MDAPs under study are considered impacted by fuel burden. These two programs account for 1.05% of the total DON MDAP program costs for MDAPs under study.

DASN Air, DASN Ships and DASN EXW MDAPs are heavily weighted with systems characterized by fuel burdens and impacted by the FBCF. They account for 90.48 percent of the total MDAP budget of $805.7 billion and thereby may potentially benefit from a more accurate assessment of fuel-related costs as described by the implementation of the FBCF in the LCC estimation of these programs.

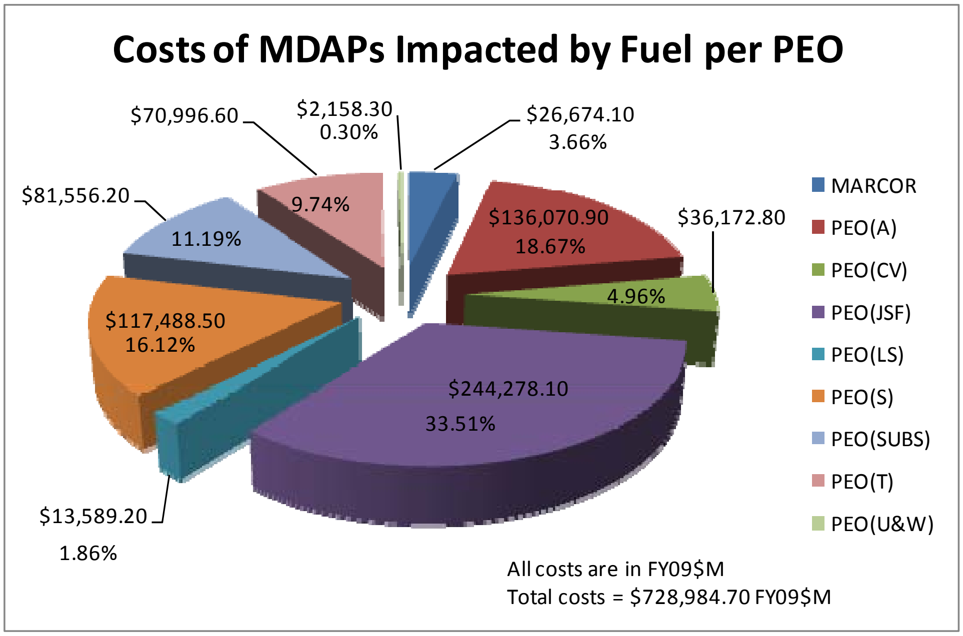

Figure 4. Distribution of Costs of MDAPs Impacted by Fuel per PEO

The distribution of costs across PEOs indicates PEO(Joint Strike Fighter (JSF)) accounts for 33.51% ($244.3 billion) of all MDAP RDT&E and Procurement costs. DASN Air, DASN Ships and DASN EXW impacted programs account for 56.29%, 29.19% and 5.00% of the total MDAP budget respectively.

IV. ANALYSIS OF AN FBCF ESTIMATE

The analytic methods for estimating the FBCF for a particular weapon system are under development within the analytic, acquisition and costing communities of OSD and the Services. At the forefront, OUSD(AT&L) has influenced recent revisions to the DAG and has provided significant guidance to the Services in order to chart a course for Service methodology development. They have designed fundamental approaches and provided analytic structure for capturing the indirect costs associated with energy demanding systems as defined in Chapter II (C). Version 2 of their developmental FBCF Calculator (the model) provides the basis for this thesis' analysis and determination of FBCF estimates (Cotman, 2009). For these reasons it is appropriate to acknowledge OUSD(AT&L) for their efforts in propagating strategic communications and the conceptual backboard that have forged the way ahead in Services' concept development and application of tools for estimating the FBCF. Documentation of the model's methodology and use are located at Appendix H.

A. BASE CASE AND ASSUMPTIONS

Using the investigational model, we developed a Base Case estimate of the FBCF for an existing capability, the DDG-51 class destroyer. Diesel fuel marine (DFM) consumption data for the DDG-51 fleet, O&S costs for their underway refueling vessels (T-AO Fleet Oilers), and infrastructure and military personnel costs for supporting naval activities were obtained from VAMOSC and used to compute an FBCF estimate for the DDG-51 fleet. This estimate was then compared to the traditionally derived life-cycle fuel costs of the DDG-51 fleet using commodity price for DFM alone. Assumptions for Base Case development are below.

- Of 250 active, commissioned DON ships, 82 do not consume DFM for underway propulsion (11 CVN, 53 SSN, 14 SSBN, 4 SSGN and USS CONSTITUTION) (Ships, 2009).
- The 52 active DDG-51 assets which reported 2008 DFM consumption data in VAMOSC constitute the DDG-51 fleet.

- DFM consumption calculations will consider only that DFM which was consumed exclusively for underway propulsion.
- The 12 active T-AO assets which reported 2008 O&S costs data in VAMOSC provide exclusive underway refueling for the DDG-51 fleet.
- Base Case only considers DFM consumption data and O&S costs reported to VAMOSC in 2008.
- Lifespan of a DDG-51 assets is 35 years (Janes, 2008).
- Lifespan of a T-AO assets is 40 years (Janes, 2008).
- All DON vessels, including the DDGs and T-AOs operate from and receive all fuel-related infrastructure support from five naval stations located at Mayport, FL, Norfolk, VA, Pearl Harbor, HI, San Diego, CA, and Everett, WA
- Apportionment of T-AO costs are proportional for all active, commissioned vessels which reported 2008 DFM underway consumption
- All costs, measurements and values are in FY2008 dollars

B. BASE CASE ESTIMATE

Initial values for each of the cost elements in the Base Case were calculated from available data before being used as inputs to the model. Though data is available for calculating cost elements, the final estimates are notional and do not necessarily reflect true costs or consumption factors associated with the destroyer and/or oiler fleets discussed. Since the developmental model employs Monte Carlo simulation, upper and lower bounds equivalent to 90 percent and 110 percent about deterministic cost element calculations were used to provide a probable range for calculation in the model. For example, the average cost of DFM is $3.12 per gallon as calculated in paragraph 1 below. Therefore, the range about $3.12 will be from $2.81 to $3.43.

1. *Commodity Cost of Fuel ($/gal):* Though the DESC standard price for DFM was $2.30 per gallon in 2008 (DESC Prices, 2008), we chose to derive the actual price per gallon per destroyer from actual consumption and expense data reported in VAMOSC for the DDG-51 class destroyer. The total DFM consumption for the 52 reporting DDG-51s was 4,478,642 barrels. Of this figure, 4,163,431 barrels (174,864,115 gallons) were consumed specifically for underway propulsion (92.9 percent). From these quantities, the

average DFM consumption for underway propulsion was calculated to be 80,066 barrels (3,362,771 gallons) per destroyer at an average annual cost of $10,484,554.00 (Appendix I, Table 16). From Equation 3.1, the resulting average cost per gallon of DFM of $3.12 per gallon was derived (Table 2).

$$CE1: CostOfFuel(\$/gal) = \frac{AverageDFMCost(\$/DDG) * NumberDDGs}{DestroyerDFMConsumed(gal)} = \frac{\$10,484,554.00(perDDG) * 52}{174,864,115(gal)} = \$3.12/gal \tag{3.1}$$

		2008 DDG-51 DFM		
		Underway	Not Underway	Auxillary
Cost Element	Total	1.2.1.1.1.1	1.2.1.1.1.2	1.2.1.1.1.3
Total Consumed (bbls)	4,478,642	4,163,431	303,937	11,274
Total Consumed (gal)	188,102,966	174,864,115	12,765,350	473,501
DDGs Reporting	52	52	52	28
Bbls / Ship	86,128	80,066	5,845	403
Gals / Ship	3,617,365	3,362,771	245,488	16,911
% of Total	100.00%	92.96%	6.79%	0.25%
DFM Cost/Ship FY2008	$ 11,277,528.00	$ 10,484,554.00	$ 763,370.00	$ 29,604.00
DFM Cost/gal FY2008	$ 3.12	$ 3.12	$ 3.11	$ 1.75

Table 2. 2008 DDG-51 DFM consumption data

Of the 54 commissioned DDG-51 assets in 2008, 52 provided DFM consumption data to VAMOSC. Within VAMOSC, a cost element structure breakdown is used to define costs for specific services. Cost element number 1.2.1.1.1.1 refers to Ship Petroleum, Oil and Lubricants (POL)—DFM Underway, the cost of interest in determining Base Case cost per gallon of DFM consumed for underway propulsion (VAMOSC Ships, 2009).

2. *Primary Fuel Delivery Asset O&S Cost ($/gal):* This is the apportioned cost of fuel per gallon across all 165 DFM consuming vessels supported by the T-AO fleet. In 2008, 10,235,362 barrels of DFM was consumed for underway propulsion by these 165 ships. Since the Base Case assumes that T-AO costs are equally apportioned across all active, commissioned vessels which reported 2008 DFM underway consumption, the amount apportioned to each vessel is calculated by dividing the sum of all T-AO reported O&S costs ($) and the total DFM consumed (in gallons) by the fleet for the purpose of underway propulsion by the fleet (Equation 3.2). Appendix I, Tables 17 and 18 contain

the VAMOSC data reports, and Table 3 provides a summary and calculation of this cost element. From the collected data, the cost per gallon of T-AO O&S costs that can be apportioned to each of the 165 DFM consuming ships was calculated to be $0.72 per gallon.

$$CE2: DeliveryAssetO\,\&\,S(\$/gal) = \frac{OilerFleetO\,\&\,SCosts(\$)}{FleetDFM(gal)} = \frac{\$309.742,188.00}{10,235,362(gals)} = \$0.72/gal \quad (3.2)$$

	2008 T-AO O&S Costs
BIG HORN	$ 25,776,493.00
GUADALUPE	$ 20,219,179.00
HENRY J KAISER	$ 23,786,437.00
JOHN ERICSSON	$ 32,324,433.00
JOHN LENTHALL	$ 26,602,481.00
KANAWHA	$ 25,522,186.00
LARAMIE	$ 24,633,387.00
LEROY GRUMMAN	$ 21,760,925.00
PATUXENT	$ 21,587,626.00
PECOS	$ 29,226,097.00
RAPPAHANNOCK	$ 27,786,957.00
TIPPECANOE	$ 30,515,987.00
Total	**$ 309,742,188.00**
Number Supported Ships	**165**
Fleet DFM Consumed (gal)	**429,885,189**
Apportioned Costs per Ship	**$ 1,877,225.38**
Apportioned Costs ($/gal)	**$ 0.72**

Table 3. Apportioned O&S costs of the T-AO fleet per DDG-51

3. *Depreciation Cost of Primary Fuel Delivery Asset ($/gal):* This is the apportioned cost of fuel per gallon due to the reduction in value of the T-AO fleet's average procurement cost over the expected lifetime of the vessels using the straight-line method of depreciation. Using a single T-AO procurement cost of $600 million (FY1998 dollars) (RAND, 1998) the procurement costs in 2008 dollars for the 12 reporting T-AOs is $8.67 billion. For straight-line depreciation, we divide the total procurement costs by the expected 40-year lifetime of a T-AO asset to calculate the annual depreciation cost for

the 12 T-AO vessels. The annual depreciation for the T-AO fleet is then $\$8.67B / 40(yrs) = \$216.77M \ / \ yr$.

The apportioned costs of T-AO depreciation per gallon is obtained by dividing the annual depreciation costs of the T-AO fleet by the number of gallons of DFM consumed for underway propulsion by all vessels (429,885,189 gallons). In this case, the additional cost per gallon of fuel due to T-AO depreciation is $0.50 (Equation 3.3 and Table 4).

$$CE3: DepreciationCost = \frac{OilerInvestmentCosts(\$)}{OilerLifespan(yrs) * FleetDFM(gal)} = \frac{\$8.67billion}{40(yrs) * 429,885189(gals)} = \$0.50 / gal \tag{3.3}$$

	(12) T-AO Assets
Procurement Cost (ea) 1998	$ 600,000,000.00
Procurement Total 1998	$ 7,200,000,000.00
Inflation Factor 1998-2008	1.2043
Procurement Total 2008	$ 8,670,960,000.00
Expected Lifetime per T-AO (yrs)	40
T-AO Fleet Annual Depreciation	$ 216,774,000.00
Fleet DFM Consumption (gal)	429,885,189
Depreciation of T-AO Fleet ($/gal)	$ 0.50

Table 4. Cost of depreciation of the 12 T-AO fleet

Total FY1998 procurement costs were converted to FY2008 dollars using the inflation factor of 1.2043 obtained from the NCCA Inflation Indices FY10 Inflation Calculator (NCCA, 2009). The per gallon depreciation of the T-AO fleet is apportioned as a “fair share” cost per gallon delivered for each of the 165 vessels which reported consumption of DFM for underway propulsion in 2008.

4. *Direct Fuel Infrastructure O&S and Recapitalization Costs ($/gal)*: These costs are estimated from port operations data for naval stations identified in the Base Case: Mayport, Norfolk, Pearl, San Diego and Everett. The combined port operations costs for the five naval stations totaled $37.72 million as reported in VAMOSC (Appendix I, Table 19). For the Base Case, it is assumed 20 percent of the total port operations costs are associated with delivery, storage and security of fuel ($7.54 million)

to those vessels consuming DFM for underway propulsion. Since the Base Case assumes all DFM consuming vessels are supported by these five ports, the apportioned direct infrastructure cost per gallon of fuel associated with port operations is $7.54 million divided by the product of the number of vessels (including T-AOs) and the number of gallons of DFM consumed for underway propulsion (sum of fleet and T-AO consumption) (Equation 3.4).

$$CE4: PortCosts(\$/gal) = \frac{PortOpsCost(\$)*20\%}{NumberShips*(FleetDFM + OilerDFM)(gal)} = \frac{\$37,717,332.14*0.20}{(165+12)*(429,885,204+174,864,102)(gals)} = \$0.08/gal \quad (3.4)$$

5. *Indirect Fuel Infrastructure Costs ($/gal)*: These costs are associated with infrastructure manpower and is also calculated as a proportion of the total gross adjusted obligated labor costs attributed to fuel delivery, storage and security operations at naval stations Mayport, Norfolk, Pearl, San Diego and Everett. As with direct infrastructure costs, 20 percent of the total labor costs for these five naval stations is assumed to represent the proportion of total labor costs associated with fuel-related functions. The total labor cost reported in 2008 for these five activities was $76.06 million (Appendix I, Table 19). Again, dividing by the product of the number of supported ships (including T-AOs) and the number of gallons of DFM consumed for underway propulsion (sum of fleet and T-AO consumption) we compute a cost of $0.16 per gallon of fuel attributable to indirect port operations costs (Equation 3.5).

$$CE5: IndirectCosts(\$/gal) = \frac{LaborCosts(\$)*20\%}{NumberShips*(FleetDFM + OilerDFM)(gal)} = \frac{\$76,061,475.63*0.20}{(165+12)*(429,885,204+174,864,102)(gal)} = \$0.16/gal \quad (3.5)$$

6. *Environmental Costs ($/gal)*: Environmental costs have been determined very difficult to quantify (DAG 2009). As such, the Base Case assumes environmental costs

associated with DoD environmental clean-up and hazardous waste control, and potentially the costs of carbon emission offsets to equal 5 percent of the commodity price for fuel. Per paragraph 1, the calculated commodity price per gallon of fuel is \$3.12. Therefore, the cost per gallon of fuel increase due to environmental costs is \$0.15 (Equation 3.6).

$$\begin{gathered} CE6: EnvironmentalCosts(\$/gal) = CommodityPrice(\$/gal) * 5\% = \\ \$3.12/gal * 0.05 = \$0.15/gal \end{gathered} \tag{3.6}$$

7. *Other Services and Platform Delivery Specific Costs (\$/gal)*: Unique to the fuel delivery operation, these costs are estimated within a range that defines the relative risks associated with the oiler fleet's fuel delivery operations as a function of the destroyer's operating environment encountered. The Base Case assumes 10 percent of the destroyer's underway time will be in hostile environments requiring additional protection to the oiler fleet performing refueling functions. During this proportion of time, corresponding to Operational scenarios, the burden associated with fuel delivery will increase within a range from 0.25 to 2.0 times the commodity price of fuel for consideration of escort vessels, force protection and security measures required to safely conduct refueling operations. During non-hostile operations, these costs are expected to be much lower, but not necessarily zero. For the proportion of time the destroyer is expected to operate in Steady-State scenarios, these costs will range from 0.01 to 0.025 times the commodity price for fuel. Therefore, the cost per gallon of fuel burdens for the destroyer operating in Operational and Steady-State environments are calculated to be \$0.78 to \$6.24 and \$0.03 to \$0.08 respectively (Equation 3.7).

$$CE7: OperationalRange: \frac{Random[0.25,2]*DestroyerDFMCosts(\$)}{DestroyerDFM\,(gal)}$$

$$OperationalLOW = \frac{0.25*\$10,484,554.00}{3,362,771(gal)} = \$0.78\,/\,gal$$

$$OperationalHIGH = \frac{2*\$10,484,554.00}{3,362,771(gal)} = \$6.24\,/\,gal$$

$$SteadyState: \frac{Random[0.01,0.025]*DestroyerDFMCosts(\$)}{DestroyerDFM\,(gal)}$$

$$SteadyStateLOW = \frac{0.01*\$10,484,554.00}{3,362,771(gal)} = \$0.03\,/\,gal$$

$$SteadyStateHIGH = \frac{0.025*\$10,484,554.00}{3,362,771(gal)} = \$0.08\,/\,gal \tag{3.7}$$

A summary of the previous cost element values are consolidated at Table 5 and used to populate the model for estimation of the FBCF for the DDG-51 class destroyer.

Cost Element	Description	Operational		Steady-State	
CE1	Commodity Cost of Fuel	$	3.12	$	3.12
CE2	Primary Fuel Delivery Asset O&S Costs	$	0.72	$	0.72
CE3	Depreciation Cost of Primary Fuel Delivery Assets	$	0.50	$	0.50
CE4	Driect Fuel Infrastructure O&S and Recapitalization Cost	$	0.08	$	0.08
CE5	Indirect Fuel Infrastructure Cost	$	0.16	$	0.16
CE6	Environmental Costs	$	0.15	$	0.15
CE7	Other Service and Platform Delivery Specific Costs				
	CE7 Lower Limit	$	0.78	$	0.03
	CE7 Upper Limit	$	6.24	$	0.08
	FBCF Lower Limit	**$**	**5.51**	**$**	**4.76**
	FBCF Upper Limit	**$**	**10.97**	**$**	**4.81**

Table 5. Base Case cost element values

Table 5 provides the calculated cost element values used as inputs to the developmental model to estimate the FBCF cost of fuel per gallon in both Steady-State and Operational environments. Deterministic lower bounds and upper bounds result from Base Case assumptions and cost element calculations specific to this scenario. Also displayed are the FBCF Lower Limits and FBCF Upper Limits for Operational and

Steady-State environments. These values are used in the developmental model to derive an overall OPTEMPO weighted FBCF for the DDG-51 class destroyer. A detail of the model inputs are provided at Appendix J. Table 6 and Figure 5 provide the quantitative values and graphical interpretation derived from the model representing aggregate fuel-related cost burdens associated with the DDG-51 destroyer as defined by the cost element inputs above and a 50 percent OPTEMPO.

	Operational		Steady-State		OPTEMPO Weighted	
	$FBCF_{SOp}$	$FBCF_{DOp}$	$FBCF_{SSS}$	$FBCF_{DSS}$	$FBCF_S$	$FBCF_D$
	$/gal	$/day	$/gal	$/day	$/gal	$/day
Mean	$ 8.13	$ 745,521.78	$ 4.87	$ 92.09	$ 5.19	$ 74,250.40
Median	$ 8.10	$ 742,354.81	$ 4.87	$ 92.14	$ 5.19	$ 73,871.71
Std Dev	$ 1.67	$ 153,440.21	$ 0.20	$ 3.87	$ 0.25	$ 15,250.59
Mean + 1.65 Std Dev	$ 10.89	$ 998,698.13	$ 5.20	$ 98.47	$ 5.60	$ 99,413.86
Mean - 1.65 Std Dev	$ 5.37	$ 492,345.43	$ 4.53	$ 85.70	$ 4.78	$ 49,086.93

Table 6. Base Case FBCF estimates for DDG-51 class

Extracted from the model's supporting documentation at Appendix H, the following legend defines and explains the operational, steady-state and OPTEMPO weighted estimates of the FBCF for the DDG-51 class destroyer.

- $FBCF_{SOp}$ = cost per gallon of fuel supplied from T-AO during operational scenario
- $FBCF_{DOp}$ = cost per day of fuel demanded from DDG-51 during operational scenario
- $FBCF_{SSS}$ = cost per gallon of fuel supplied by T-AO during steady-state scenario
- $FBCF_{DSS}$ = cost per day of fuel demanded by DDG-51 during steady-state scenario
- $FBCF_S$ = cost per gallon of fuel supplied by T-AO as a weighted average of operational and steady-state scenarios (OPTEMPO weighted)
- $FBCF_D$ = cost per day of fuel demanded by DDG-51 as a weighted average of operational and steady-state scenarios (OPTEMPO weighted)

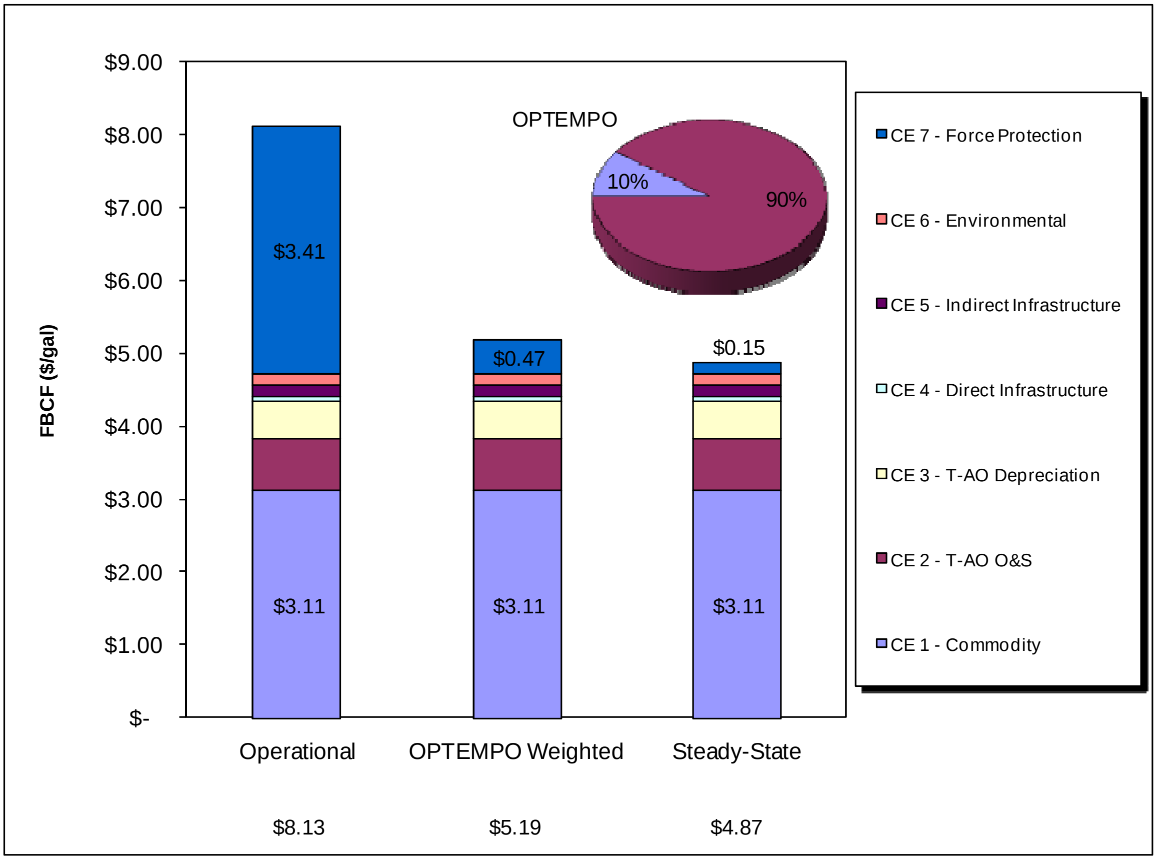

Figure 5. Base Case FBCF estimates for DDG-51 class

The values of cost elements CE1 thru CE6 are consistent for both Operational and Steady-State scenarios as they are not influenced by OPTEMPO. Conversely, CE7 exhibits the greatest variance as OPTEMPO changes as it captures T-AO force protection and security costs more prevalent during operational periods.

Per Table 6, the estimated ranges of fuel-related cost burdens vary significantly from Operational to Steady-State scenarios ($5.37 per gallon to $10.89 per gallon Operational and $4.53 per gallon to $5.20 per gallon Steady-State). These operation driven costs greatly increase the overall cost per gallon of fuel to the destroyer fleet. The OPTEMPO weighted FBCF figures ($4.78 to $5.60 per gallon from Table 6) provide the range of the weighted average of the costs required to meet the demands of the average DDG-51 destroyer DFM consumption per the Base Case's defined OPTEMPO (10 percent Operational and 90 percent Steady-State). Given these more insightful values, a LCC estimate of a destroyer's fuel-related burdens can now be derived and compared to the LCC of the fuel commodity alone.

C. IMPACT OF BASE CASE FBCF ESTIMATE ON LCC

Using data from the base case, the average annual DFM consumption of a DDG-51 is 80,066 barrels at an average annual cost per ship of $10.48 million. Given an expected lifespan of 35 years (GlobalSecurity, 2009), the total costs of fuel, based on commodity price only, for a single DDG-51 is $366.96 million and $19,081.9 million for 52 destroyers (Equation 3.8). Considering the fuel-related costs as explained by the mean OPTEMPO weighted $FBCF_S$ ($5.19 per gallon from Table 6), the cost per gallon of fuel as a weighted average of Operational and Steady-State demand given the Base Case's 10 percent OPTEMPO, the LCC of fuel-related burdens is $610.85 million per ship or $31,764.1 million over the lifespan of all 52 destroyers (Equation 3.9). This represents an increase of 166 percent over the LCC attributed to the calculated commodity price cost alone. Over the 35-year anticipated lifespan of all 52 DDG-51 ships, the total difference in total LCC is notionally $12,682.2 million—more than 20 percent of the total DDG-51 program RDT&E and procurement costs to date of $62,756.0 million (GAO, 2009).

$$\begin{gathered} DDGLifespan(yrs) * NumberDDGs * DDGAnnualDFM\,(gal) * FuelPrice(\$ / gal) = \\ 35(yrs) * 52 * 3{,}362{,}771(gal) * 3.12(\$ / gal) = \$19{,}081.9(\$M) \end{gathered} \quad (3.8)$$

$$\begin{gathered} DDGLifespan(yrs) * NumberDDGs * DDGAnnualDFM\,(gal) * FBCF_S\,(\$ / gal) = \\ 35(yrs) * 52 * 3{,}362{,}771(gal) * 5.19(\$ / gal) = \$31{,}764.1(\$M) \end{gathered} \quad (3.9)$$

The Base Case estimate shows that when fuel delivery, storage and security costs are considered, the costs for supplying fuel to an energy demanding system is much greater than the commodity price alone. Since the cost elements are assumed fixed once calculated from existing data, these costs provide a baseline from which operational-specific costs can be summed as a function of OPTEMPO and the environments of operation. By adjusting the input parameter for OPTEMPO, we can simulate ranges of fuel-related costs for the capability under assessment as a function of the percentage of time in operational environments over the capability's anticipated lifespan.

D. IMPACT OF OPTEMPO ON BASE CASE

To test the impact of OPTEMPO on the Base Case, the OPTEMPO is changed to simulate two operating scenarios. Base Case Mod 1 assumes 0 percent of the destroyer's operational life is spent in hostile environments, and Base Case Mod 2 assumes 90 percent of the destroyer's operational life is spent in hostile environments. All cost elements (CE1—CE7) remain as with the Base Case.

1. Base Case Mod 1

Keeping all cost elements as with the Base Case, OPTEMPO is changed to assume 0 percent of the destroyer's operational life is spent in hostile environments. Table 7 and Figure 6 provide the developmental model's FBCF estimates and graphical interpretation.

	Operational		Steady-State		OPTEMPO Weighted	
	$FBCF_{SOp}$	$FBCF_{DOp}$	$FBCF_{SSS}$	$FBCF_{DSS}$	$FBCF_{S}$	$FBCF_{D}$
	$/gal	$/day	$/gal	$/day	$/gal	$/day
Mean	$ 8.26	$ 7,576,530.77	$ 4.85	$ 45,029.89	$ 4.89	$ 119,972.22
Median	$ 8.28	$ 7,585,099.47	$ 4.85	$ 44,969.25	$ 4.89	$ 119,860.06
Std Dev	$ 1.60	$ 1,469,365.13	$ 0.20	$ 1,850.42	$ 0.20	$ 14,763.10
Mean + 1.65 Std Dev	$ 10.91	$ 10,000,983.23	$ 5.18	$ 48,083.08	$ 5.21	$ 144,331.34
Mean - 1.65 Std Dev	$ 5.62	$ 5,152,078.31	$ 4.52	$ 41,976.70	$ 4.56	$ 95,613.10

Table 7. Base Case Mod 1: 0% OPTEMPO

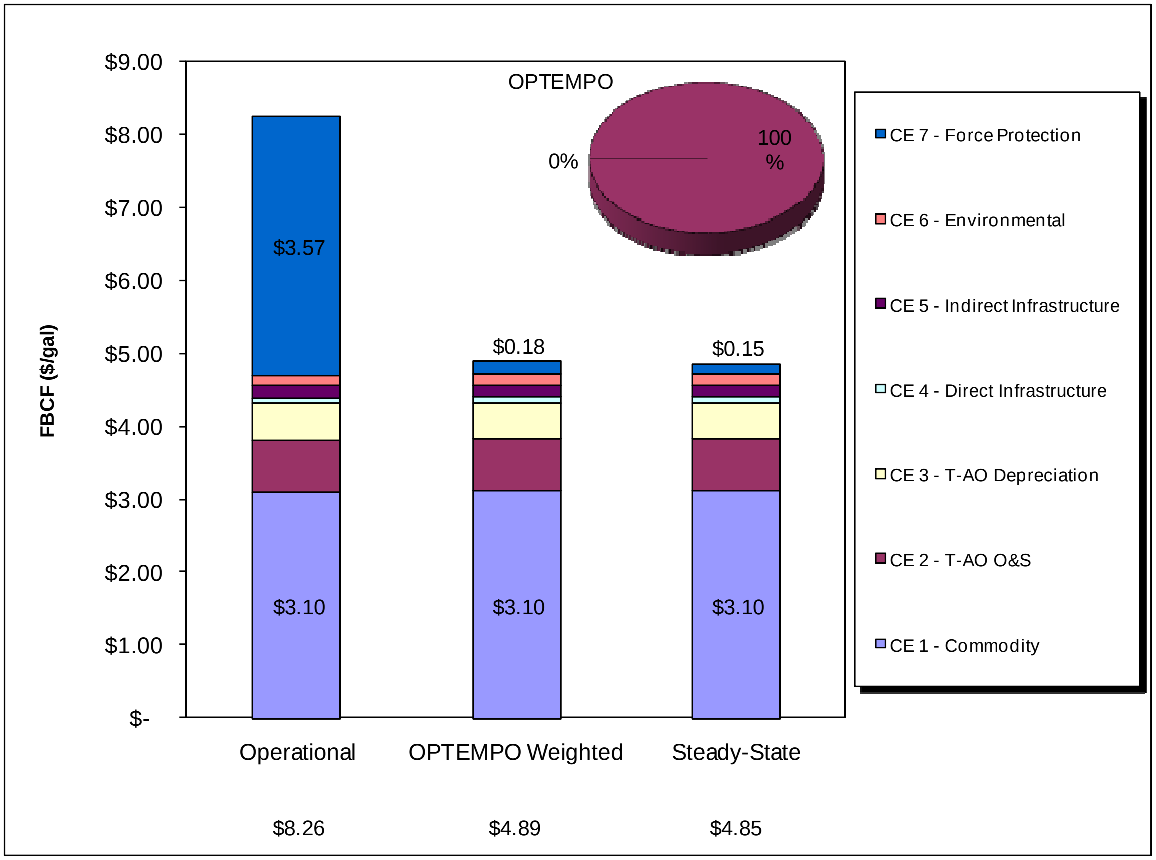

Figure 6. Base Case Mod 1: 0% OPTEMPO

The OPTEMPO weighted FBCF estimate decreased $0.30 per gallon from Base Case. This decrease was expected as the operational time in hostile environments was reduced. Note the values of Operational and Steady-State FBCF estimates remain with 1% of the Base Case.

Comparing the FBCF values estimated in Base Case Mod 1 versus the Base Case, the estimates for $FBCF_{SOp}$, $FBCF_{DOp}$, $FBCF_{SSS}$ and $FBCF_{DSS}$ are within one percent in each case. However, there is a significant decrease in $FBCF_S$ and $FBCF_D$. This decrease is expected given the reduction in operational time in potentially hostile environments and the associated reduction in force protection and security requirements (Table 8).

	Operational FBCFsop ($/gal)	Steady-State FBCFsss ($/gal)	OPTEMPO Weighted FBCFs ($/gal)
Base Case (10/90 OPTEMPO)	$8.13	$4.87	$5.19
Mod 1 (0/100 OPTEMPO)	$8.26	$4.86	$4.89
Difference from Base Case (%)	1.57%	-0.21%	-6.13%

Table 8. Comparison of Base Case and Base Case Mod 1

Comparing Base Case Mod 1 to the Base Case, it is clear that the overall FBCF estimate is driven lower by the OPTEMPO as indicated by the OPTEMPO weighted value of $4.89 per gallon versus $5.19 per gallon in the Base Case. This represents a 6.13 percent reduction in the FBCF from Base Case. Operational and Steady-State values are similar to Base Case and within one percent as expected given no change to Base Case cost elements prior to calculation.

2. Base Case Mod 2

Keeping all cost elements as with the Base Case, OPTEMPO is changed to assume 20 percent of the destroyer's operational life is spent in hostile environments. Tables 9 and 10 and Figure 7 provide the developmental model's FBCF estimates and graphical interpretation for Base Case Mod 2.

	Operational		Steady-State		OPTEMPO Weighted	
	$FBCF_{SOp}$	$FBCF_{DOp}$	$FBCF_{SSS}$	$FBCF_{DSS}$	$FBCF_{S}$	$FBCF_{D}$
	$/gal	$/day	$/gal	$/day	$/gal	$/day
Mean	$ 8.17	$ 374,348.38	$ 4.85	$ 103.32	$ 5.51	$ 74,577.67
Median	$ 8.17	$ 374,796.87	$ 4.85	$ 103.28	$ 5.52	$ 74,717.75
Std Dev	$ 1.62	$ 74,288.69	$ 0.20	$ 4.32	$ 0.36	$ 14,780.08
Mean + 1.65 Std Dev	$ 10.84	$ 496,924.72	$ 5.19	$ 110.45	$ 6.10	$ 98,964.80
Mean - 1.65 Std Dev	$ 5.49	$ 251,772.04	$ 4.52	$ 96.20	$ 4.92	$ 50,190.54

Table 9. Base Case Mod 2: 20% OPTEMPO

Note the absolute value of the increase in the OPTEMPO weighted FBCF estimate is approximately the same as the decrease in value Base Case to Base Case Mod 1 ($0.30 versus $0.32). This is understandable given the OPTEMPO ranges are set at equal values from the base case.

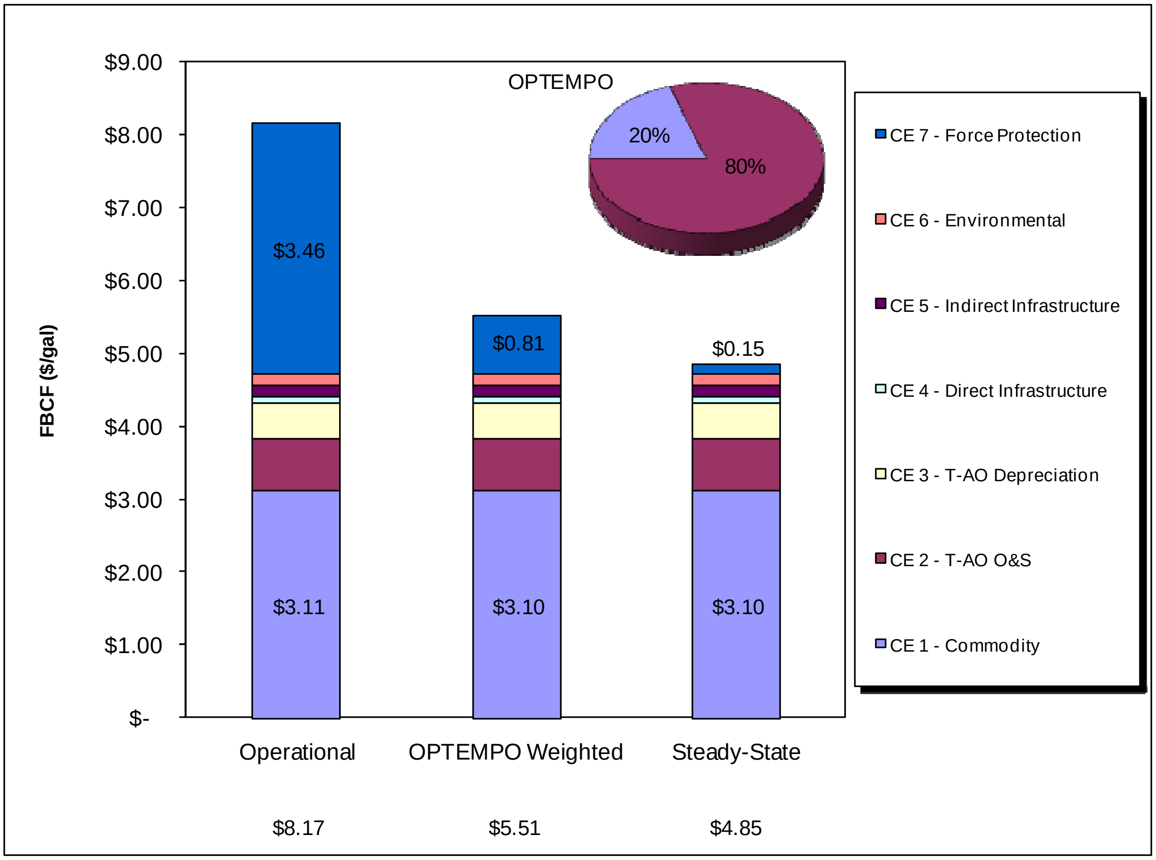

Figure 7. Base Case Mod 2: 20% OPTEMPO

Note increase in OPTEMPO weighted estimate, whereas Operational ($FBCF_{SOp}$) and Steady-State ($FBCF_{SSS}$) estimates remain consistent with Base Case estimates.

As with the previous comparison of Base Case and Base Case Mod 1, the estimates for $FBCF_{SOp}$, $FBCF_{DOp}$, $FBCF_{SSS}$ and $FBCF_{DSS}$ in Base Case Mod 2 are within one percent of the Base Case. Also similar is the percentage of increase in FBCF due to OPTEMPO change. In this case, there is an increase of $3.35 per gallon (38.8 percent) in the FBCF OPTEMPO weighted ($FBCF_S$) estimate due to the increase in operational time in hostile environments (Table 10).

	Operational	Steady-State	OPTEMPO Weighted
	FBCFsop ($/gal)	FBCFsss ($/gal)	FBCFs ($/gal)
Base Case (10/90 OPTEMPO)	$8.13	$4.87	$5.19
Mod 2 (25/75 OPTEMPO)	$8.17	$4.85	$5.51
Difference from Base Case (%)	0.49%	-0.41%	5.81%

Table 10. Comparison of Base Case and Base Case Mod 2

Note that $FBCF_{SOp}$ and $FBCF_{SSS}$ are within 1% of Base Case while $FBCF_S$ is 5.81% higher. This is in agreement with expectation since the cost of fuel for operational and steady-state environments are should not differ. However, when time in operational environments increases, so does the overall requirements for force protection and security which influence the OPTEMPO weighted average cost per gallon.

The findings comparing the Base Case to the two alternate scenarios provide rational conclusions. Since the Base Case OPTEMPO was set at 10 percent and the modified cases' OPTEMPO values were set at an equal departure from 10 percent, 0 percent and 20 percent respectively, it was expected that an approximately equal difference in OPTEMPO weighted FCBF estimate values would result above and below the Base Case value. That was the case and is shown in Table 11 and Figure 8.

	Operational	Steady-State	OPTEMPO Weighted
	FBCFsop ($/gal)	FBCFsss ($/gal)	FBCFs ($/gal)
Base Case (10/90 OPTEMPO)	$8.13	$4.87	$5.19
Mod 1 (0/100 OPTEMPO)	$8.26	$4.86	$4.89
Difference from Base Case (%)	1.60%	-0.21%	-5.78%
Mod 2 (20/80 OPTEMPO)	$8.17	$4.85	$5.51
Difference from Base Case (%)	0.49%	-0.41%	6.17%

Table 11. Comparison of Base Case to Mod 1 and Mod 2

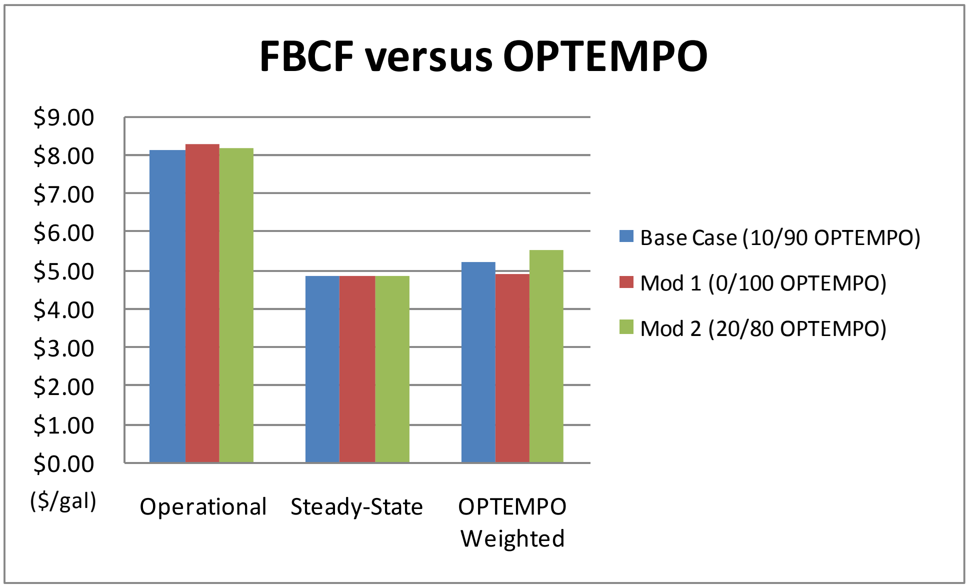

Figure 8. Comparison of Base Case to Mod 1 and Mod 2

Fluctuations in the Operational and Steady-State estimated FBCF are due to the developmental model's use of Monte Carlo simulation operating within ranges bounded as determined by the cases under study.

E. FBCF ESTIMATES VERSUS COMMODITY AND STANDARD PRICES

We next compare the mean Operational, Steady-State and OPTEMPO weighted FBCF estimates from the three previous cases against the calculated commodity price ($3.12 per gallon) and the standard price established by DESC ($2.30 per gallon) (DESC Prices, 2008). First, Table 12 and Figure 9 provide the details of the comparison between the three mean values and the calculated commodity price. The mean FBCF estimates range from 155.8 percent (Steady-State) to 262.4 percent (Operational) of the calculated commodity price. This examination exposes large amounts of fuel-related costs usually not considered during LCC estimation of MDAPs. In the three cases presented (Base Case, Base Case mod 1 and Base Case Mod 2), the LCC cost estimates when based on FBCF estimates would require an average increase in funding of 66.6 percent as computed by the mean OPTEMPO weighted FBCF estimate ($5.20 per gallon).

	Operational FBCFsop ($/gal)	Steady-State FBCFsss ($/gal)	OPTEMPO Weighted FBCFs ($/gal)
Commodity Price	$3.12	$3.12	$3.12
Mean FBCF (All Cases)	$8.19	$4.86	$5.20
% of Commodty Price	262.39%	155.77%	166.56%

Table 12. Mean FBCF estimates versus calculated commodity price

Mean FBCF (All Cases) values are the means of the FBCF estimates for the Base Case, Base Case Mod 1 and Base Case Mod 2. For example, the value of $8.19/gal defines the mean Operational $FBCF_{SOp}$ ($/gal) of all three cases per Equation 3.10.

$$MeanOperationalFBCF(\$/gal) = \frac{(\$8.13 + \$8.26 + \$8.17)(\$/gal)}{3} = \$8.19(\$/gal) \quad (3.10)$$

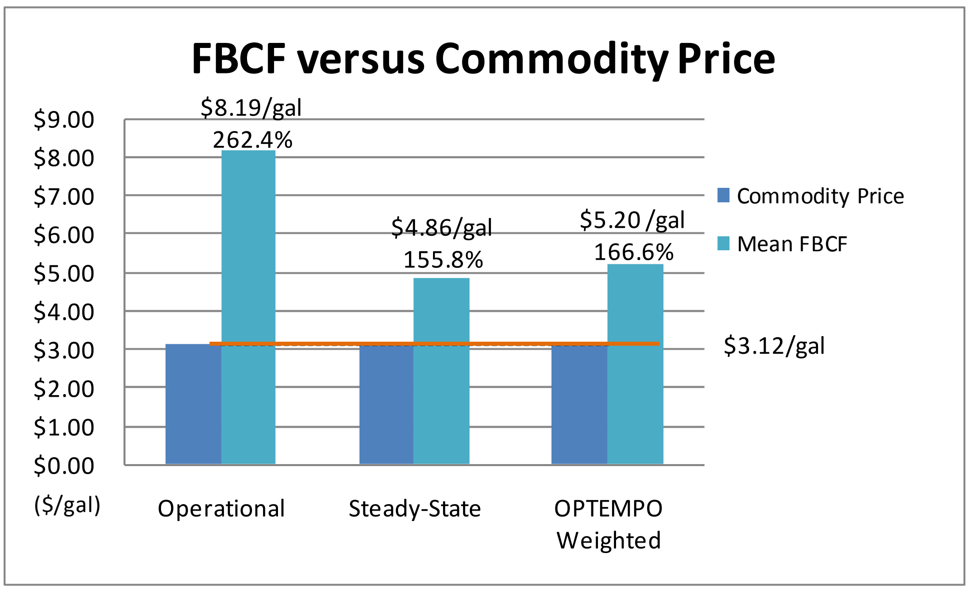

Figure 9. Comparison of mean FBCF estimates to calculated commodity price

Increases from the calculated commodity price range from 155.8% during Steady-State operations to 262.4% during Operational scenarios in hostile environments.

Figure 10 shows the comparison of the mean OPTEMPO weighted FBCF estimate with the calculated commodity price and standard price (DESC Prices, 2008). This final comparison restates that the FBCF for the DDG-51 is conservatively 166.6

percent higher than the calculated commodity price from reported consumption and expense data and 225.94 percent higher than the DESC standard price.

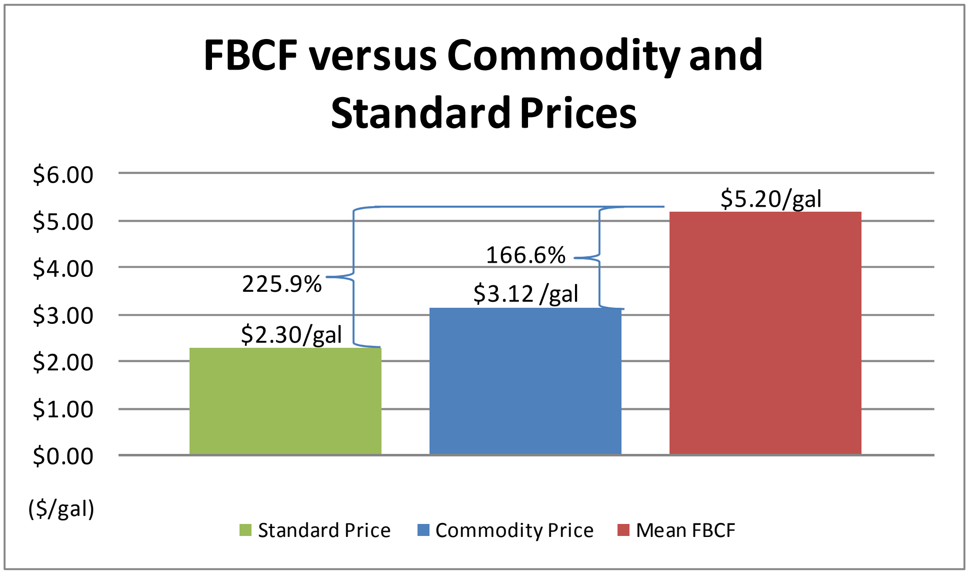

Figure 10. Comparison of mean OPTEMPO Weighted FBCF

From the previously calculated values depicted in Figure 10, the total fuel-related LCC for the DDG-51 class is computed to be $14,076.6 million, $19,081.9 million and $31,825.3 million as based on standard price, calculated commodity price and mean FBCF respectively. The differences in standard price and calculated commodity price from the computed mean FBCF range from $12.7 billion to $17.7 billion. These amounts define the notional range of actual fuel-related lifecycle cost burdens for the DDG-51 class destroyer. The significant increases in fuel-related costs over the calculated commodity price and standard price are sufficient evidence supporting the use of FBCF estimates for LCC estimation for the notional DDG-51 class destroyer under study and other energy demanding systems.

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V. CONCLUSIONS AND FOLLOW ON STUDIES

A. OBSERVATIONS

There were three major observations from this study.

- Though commodity prices fluctuate and influence the DESC in determining standard prices for fuel into the future, the burdens associated with fuel delivery assets and the supporting infrastructure, associated manpower, force protection and security will continue to contribute a significant proportion of the total fuel-related cost burdens connected with energy demanding systems.
- Our study validates previous research efforts that contend the cost to deliver, store and protect the energy and its logistics tail can be many times greater than the commodity price of fuel alone.
- Though we defined cost element CE7 (Other Services & Platform Delivery Specific Costs) and the OPTEMPO of the DDG-51 within conservative ranges, the resulting increases in fuel cost per gallon as a function of these parameters were not trivial. And, when multiplied over the lifespan of the system, amounted to many billions of dollars.

B. CONCLUSIONS

The review and analysis of DON MDAPs indicated the majority are potentially impacted by FBCF estimates. We conclude that there is potential for significant benefit in the use of the FBCF during AOAs and EOAs. Each dollar saved in fuel-related costs can be considered a dollar available for additional capability. Thus, effective LCC estimation of the FBCF can provide visibility and discrimination of capability options prior to major production and fielding. This will help ensure the most "bang for the buck" is acquired and made available to our service men and women.

OUSD(AT&L)'s developmental model proved useful in estimating the FBCF given appropriate initial conditions for the cost elements required. The greatest effort was required to establish initial cost element values as its input parameters from existing sources. Though problematic, the values that were obtained and derived following data mining of the VAMOSC user environment, proved useful for the notional case considered in this study. Furthermore, the model's use of Monte Carlo simulation to bound input parameter estimates permitted the use of statistical tools rather than a purely deterministic approach.

Use of the FBCF also answers a call for fiscal responsibility. As indicated in this study, there are potentially billions of acquisition dollars that can be more adequately addressed during the acquisition process. Without the use of FBCF estimates in forecasting fuel-related costs, the accurate predictions of an energy-demanding capability's total LCC cannot be accurately estimated. The use of FBCF estimates will provide PEOs, PMs, MDAs and budgeting professionals a tool to better assess total LCC, the impacts of energy demand on the capability and its logistics tail, and its impact on the overall DoD budget.

C. RECOMMENDATIONS

There is high uncertainty in estimating cost element CE7, yet this cost element has the potential to dominate all other costs and the FBCF estimate. In this analysis we chose conservative values, yet depending on a projected capability's employment environment and OPTEMPO, which defines its exposure time to hostilities, these cost can be much higher than we calculated. Therefore, an effective means to define these ranges is needed.

A useful means to obtain costs data for use in cost element calculation is needed. The VAMOSC environment was used for the majority of data and required a significant amount of training to become only fairly adept at its use. Though it is meant to be the repository for all DON O&S cost data, there were apparently some shortcomings, especially in the area of manpower cost retrieval. The manpower costs figures extracted for the five naval stations considered in the study were very low. Thus, the cost element value for Indirect Infrastructure O&S Costs attributable to manpower may underestimate the true value.

D. FOLLOW ON STUDIES

There is continuation work associated with this and other ongoing studies on the topic of FBCF and its implementation into the acquisition process. The following provides a primer for future studies, but is not all-inclusive:

- Perform the study using an aircraft as the notional asset
- Refine the method of calculating the cost element's initial values from VAMOSC and/or other data repositories
- Implement regression to forecast cost elements once initial estimates are determined
- Implement future studies using the later versions of the developmental FBCF Calculator under development by OUSD(AT&L)

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VI. APPENDICES

A. 2001 DSB FINDINGS AND RECOMMENDATIONS

Finding #1

Although significant warfighting, logistics and cost benefits occur when weapons systems are made more fuel-efficient, these benefits are not valued or emphasized in the DoD requirements and acquisition processes.

Recommendation #1

Base investment decisions on the true cost of delivered fuel and on warfighting and environmental benefits.

Finding #2

The DoD currently prices fuel based on the wholesale refinery price and does not include the cost of delivery to its customers. This prevents an end-to-end view of fuel utilization in decision making, does not reflect the DoD's true fuel costs, masks energy efficiency benefits, and distorts platform design choices.

Recommendation #2

Strengthen linkage between warfighting capability and fuel logistics requirements through wargaming and new analytical tools.

Finding #3

> The DoD resource allocation and accounting processes (PPBS, DoD Comptroller) do not reward fuel efficiency or penalize inefficiency.

Recommendation #3

> Provide leadership that incentivizes fuel efficiency throughout the DoD.

Finding #4

> Operational and logistics wargaming of fuel requirements is not cross-linked to the Service requirements development or acquisition program processes.

Recommendation #4

> Specifically target fuel efficiency improvements through investments in Science and Technology and systems designs.

Finding #5

> High payoff, fuel-efficient technologies are available now to improve warfighting effectiveness in current weapon systems through retrofit and in new systems acquisition.

Recommendation #5

> Explicitly include fuel efficiency in requirements and acquisition processes.

B. 2006 DSB FINDINGS AND RECOMMENDATIONS

Finding #1: The recommendations from the 2001 Defense Science Board Task Force Report "More Capable Warfighting Through Reduced Fuel Burden" have not been implemented.

Finding #2: Critical national security and Homeland defense missions are at an unacceptably high risk of extended outage from failure of the grid and other critical national infrastructure.

Finding #3: The Department lacks the strategy, policies, metrics, information or governance structure necessary to properly manage its energy risks.

Finding #4: There are technologies available now to make DoD systems more energy efficient, but they are undervalued, slowing their implementation and resulting in inadequate S&T investments.

Finding #5: There are many opportunities to reduce energy demand by changing wasteful operational practices and procedures.

Finding #6: Operational risks from fuel disruption require demand-side remedies; mission risks from electricity disruption to installations require both demand- and supply-side remedies.

Recommendation #1: Accelerate efforts to implement energy efficiency Key Performance Parameters (KPPs) and use of the Fully Burdened Cost of Fuel to inform all acquisition trades and analyses about their energy consequences, as recommended by the 2001 DSB Task Force.

Recommendation #2: Reduce the risk to critical missions at fixed installations from loss of commercial power and other critical national infrastructure.

Recommendation #3: Establish a Department-wide strategic plan that establishes measurable goals, achieves the business process changes recommended by the 2001 DSB report and establishes clear responsibility and accountability.

Recommendation #4: Invest in energy efficient and alternative energy technologies to a level commensurate with their operational and financial value.

Recommendation #5: Identify and exploit near-term opportunities to reduce energy use through policies and incentives that change operational procedures.

C. 2009 NATIONAL DEFENSE AUTHORIZATION ACT

SEC. 332. CONSIDERATION OF FUEL LOGISTICS SUPPORT REQUIREMENTS IN PLANNING, REQUIREMENTS DEVELOPMENT, AND ACQUISITION PROCESSES.

(a) PLANNING.—In the case of analyses and force planning processes that are used to establish capability requirements and inform acquisition decisions, the Secretary of Defense shall require that analyses and force planning processes consider the requirements for, and vulnerability of, fuel logistics.

(b) CAPABILITY REQUIREMENTS DEVELOPMENT PROCESS.—The Secretary of Defense shall develop and implement a methodology to enable the implementation of a fuel efficiency key performance parameter in the requirements development process for the modification of existing or development of new fuel consuming systems.

(c) ACQUISITION PROCESS.—The Secretary of Defense shall require that the life-cycle cost analysis for new capabilities include the fully burdened cost of fuel during analysis of alternatives and evaluation of alternatives and acquisition program design trades.

(d) IMPLEMENTATION PLAN.—The Secretary of Defense shall prepare a plan for implementing the requirements of this section. The plan shall be completed not later than 180 days after the date of the enactment of this Act and provide for the implementation of the requirements by not later than three years after the date of the enactment of this Act.

(e) PROGRESS REPORT.—Not later than two years after the date of the enactment of this Act, the Secretary of Defense shall submit to the congressional defense committees a report describing progress made to implement the requirements of this section, including an assessment of whether the implementation plan required by section (d) is being carried out on schedule.

(f) NOTIFICATION OF COMPLIANCE.—As soon as practicable during the three-year period beginning on the date of the enactment of this Act, the Secretary of Defense shall notify the congressional defense committees that the Secretary has complied with the requirements of this section. If the Secretary is unable to provide the notification, the Secretary shall submit to the congressional defense committees at the end of the three-year period a report containing—

(1) an explanation of the reasons why the requirements, or portions of the requirements, have not been implemented; and

(2) a revised plan under subsection (d) to complete implementation or a rationale regarding why portions of the requirements cannot or should not be implemented.

(g) FULLY BURDENED COST OF FUEL DEFINED.—In this section, the term "fully burdened cost of fuel" means the commodity price for fuel plus the total cost of all personnel and assets required to move and, when necessary, protect the fuel from the point at which the fuel is received from the commercial supplier to the point of use.

Excerpt from the Duncan Hunter National Defense Authorization Act for Fiscal Year 2009. The act requires that the FBCF be signed into law in October 2008.

D. ACAT I–III DESCRIPTIONS

Acquisition Category	Reason for ACAT Designation	Decision Authority
ACAT I	• MDAP (section 2430 of Reference (k)) o Dollar value: estimated by the USD(AT&L) to require an eventual total expenditure for research, development, test and evaluation (RDT&E) of more than $365 million in fiscal year (FY) 2000 constant dollars or, for procurement, of more than $2.190 billion in FY 2000 constant dollars o MDA designation • MDA designation as special interest	ACAT ID: USD(AT&L) ACAT IC: Head of the DoD Component or, if delegated, the CAE (not further delegable)
ACAT IA[1, 2]	• MAIS (Chapter 144A of title 10 of U.S.C. (Reference (k))): A DoD acquisition program for an Automated Information System[3] (either as a product or a service) that is either: o Designated by the MDA as a MAIS; or o Estimated to exceed: ▪ $32 million in FY 2000 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, and deployment, and incurred in any single fiscal year; or ▪ $126 million in FY 2000 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, and deployment, and incurred from the beginning of the Materiel Solution Analysis Phase through deployment at all sites; or ▪ $378 million in FY 2000 constant dollars for all expenditures, for all increments, regardless of the appropriation or fund source, directly related to the AIS definition, design, development, deployment, operations and maintenance, and incurred from the beginning of the Materiel Solution Analysis Phase through sustainment for the estimated useful life of the system. • MDA designation as special interest	ACAT IAM: USD(AT&L) or designee ACAT IAC: Head of the DoD Component or, if delegated, the CAE (not further delegable)
ACAT II	• Does not meet criteria for ACAT I • Major system o Dollar value: estimated by the DoD Component Head to require an eventual total expenditure for RDT&E of more than $140 million in FY 2000 constant dollars, or for procurement of more than $660 million in FY 2000 constant dollars (section 2302d of Reference (k)) o MDA designation[4] (paragraph (5) of section 2302 of Reference (k))	CAE or the individual designated by the CAE[4]
ACAT III	• Does not meet criteria for ACAT II or above • AIS that is not a MAIS	Designated by the CAE[4]

1. In some cases, an ACAT IA program, as defined above, also meets the definition of an MDAP. The USD(AT&L) shall be the MDA for such programs unless delegated to a DoD Component. The statutory requirements that apply to MDAPs and MAIS shall apply to such programs.
2. The MDA (either the USD(AT&L) or, if delegated, the ASD(NII)/DoD CIO or another designee) shall designate MAIS programs as ACAT IAM or ACAT IAC. MAIS programs shall not be designated as ACAT II.
3. Automated Information System: A system of computer hardware, computer software, data or telecommunications that performs functions such as collecting, processing, storing, transmitting, and displaying information. Excluded are computer resources, both hardware and software, that are:
   a. an integral part of a weapon or weapon system;
   b. used for highly sensitive classified programs (as determined by the Secretary of Defense);
   c. used for other highly sensitive information technology programs (as determined by the ASD(NII)/DoD CIO); or
   d. determined by the USD(AT&L) or designee to be better overseen as a non-AIS program (e.g., a program with a low ratio of RDT&E funding to total program acquisition costs or that requires significant hardware development).
4. As delegated by the Secretary of Defense or Secretary of the Military Department.

Figure 11. Description and Decision Authority for ACT I–III Programs

Excerpt from the DoDI 5000.02, December 2, 2008.

E. DON MDAPS

ACAT	PROGRAM NAME	DASN	PEO	FY09$M	ACAT	PROGRAM NAME	DASN	PEO	FY09$M
IAC	DJC2	C4I & Space	PEO(C4I)	$ -	IC	T-AKE	SHIPS	PEO(S)	$ 5,715.20
IAC	GCCS-M	C4I & Space	PEO(C4I)	$ -	IC	TRIDENT II MSL	SHIPS	DRPM-SSP	$ 38,343.80
IAC	NSIPS	C4I & Space	PEO(EIS)	$ -	ID	BAMS	AIR	PEO(U&W)	$ 2,976.40
IAC	NTCSS	C4I & Space	PEO(C4I)	$ -	ID	CH-53K	AIR	PEO(A)	$ 16,038.00
IAC	CAC2S	SHIPS	PEO(LS)	$ -	ID	E-2D AHE	AIR	PEO(T)	$ 15,610.60
IAM	GCSS-MC	C4I & Space	PEO(EIS)	$ -	ID	EA-18 G	AIR	PEO(T)	$ 8,784.30
IAM	NAVY ERP	C4I & Space	PEO(EIS)	$ -	ID	F-35 (JSF)	AIR	PEO(JSF)	$ 244,278.10
IC	AGM-88E AARGM	AIR	PEO(U&W)	$ 1,710.10	ID	H-1 UPGRADES	AIR	PEO(A)	$ 8,727.50
IC	AIM-9X	AIR	PEO(U&W)	$ 3,395.50	ID	JPALS	AIR	PEO(T)	$ -
IC	EA-6B ICAP III	AIR	PEO(T)	$ 256.90	ID	P-8A Poseidon	AIR	PEO(A)	$ 29,479.80
IC	F/A-18 E/F	AIR	PEO(T)	$ 46,344.80	ID	V-22 OSPREY	AIR	PEO(A)	$ 55,268.00
IC	IDECM Block 2/3	AIR	PEO(T)	$ -	ID	VH-71	AIR	PEO(A)	$ 6,575.20
IC	IDECM Block 4	AIR	PEO(T)	$ -	ID	MUOS	C4I & Space	PEO(SPACE	$ 6,346.20
IC	JSOW (DISPENSER)	AIR	PEO(U&W)	$ 1,861.60	ID	EFV	EXW	PEO(LS)	$ 13,589.20
IC	JSOW (UNITARY)	AIR	PEO(U&W)	$ 1,943.30	ID	JOINT MRAP	EXW	MARCOR	$ 26,674.10
IC	MH-60R	AIR	PEO(A)	$ 12,139.40	ID	CEC	SHIPS	PEO(IWS)	$ 4,530.50
IC	MH-60S	AIR	PEO(A)	$ 7,843.00	ID	CJR	SHIPS	PEO(IWS)	$ 1,629.50
IC	TACTICAL TOMAHA	AIR	PEO(U&W)	$ 4,375.30	ID	CVN-21	SHIPS	PEO(CV)	$ 29,914.00
IC	VTUAV	AIR	PEO(U&W)	$ 2,158.30	ID	DDG 1000	SHIPS	PEO(S)	$ 27,611.30
IC	NMT	C4I & Space	PEO(C4I)	$ 2,103.30	ID	LCS	SHIPS	PEO(S)	$ 3,921.90
IC	MTVR	EXW	PEO(LS)	$ -	ID	LHA REPLACEMENT	SHIPS	PEO(S)	$ 3,286.60
IC	CVN-68 CL	SHIPS	PEO(CV)	$ 6,258.80	ID	LPD 17	SHIPS	PEO(S)	$ 14,241.70
IC	DDG-51	SHIPS	PEO(S)	$ 62,711.80	ID	SM-6	SHIPS	PEO(IWS)	$ 5,954.40
IC	RMS	SHIPS	PEO(L&MW	$ 1,549.70	ID	SSN 774 VIRGINIA	SHIPS	PEO(SUBS)	$ 81,556.20

Table 13. DON MDAPs per 9 December 2008 ASN(RDA) ACAT Report

Major Automated Information Systems (MAIS), ACAT IAC and ACAT IAM programs, are determined least impacted by fuel burden and excluded from the study though they meet the definition of MDAP under DoDI 5000.02 statutory regulations. Other MDAPs determined not significantly impacted by fuel burden remain and form the basis for analysis with those programs most impacted.

ACAT	PROGRAM NAME	DASN	PEO	FY09$M	ACAT	PROGRAM NAME	DASN	PEO	FY09$M
IC	EA-6B ICAP III	AIR	PEO(T)	$ 256.90	ID	H-1 UPGRADES	AIR	PEO(A)	$ 8,727.50
IC	F/A-18 E/F	AIR	PEO(T)	$ 46,344.80	ID	P-8A Poseidon	AIR	PEO(A)	$ 29,479.80
IC	MH-60R	AIR	PEO(A)	$ 12,139.40	ID	V-22 OSPREY	AIR	PEO(A)	$ 55,268.00
IC	MH-60S	AIR	PEO(A)	$ 7,843.00	ID	VH-71	AIR	PEO(A)	$ 6,575.20
IC	VTUAV	AIR	PEO(U&W)	$ 2,158.30	ID	EFV	EXW	PEO(LS)	$ 13,589.20
IC	MTVR	EXW	PEO(LS)	$ -	ID	JOINT MRAP	EXW	MARCOR	$ 26,674.10
IC	CVN-68 CL	SHIPS	PEO(CV)	$ 6,258.80	ID	CVN-21	SHIPS	PEO(CV)	$ 29,914.00
IC	DDG-51	SHIPS	PEO(S)	$ 62,711.80	ID	DDG 1000	SHIPS	PEO(S)	$ 27,611.30
IC	T-AKE	SHIPS	PEO(S)	$ 5,715.20	ID	LCS	SHIPS	PEO(S)	$ 3,921.90
ID	CH-53K	AIR	PEO(A)	$ 16,038.00	ID	LHA REPLACEMENT	SHIPS	PEO(S)	$ 3,286.60
ID	E-2D AHE	AIR	PEO(T)	$ 15,610.60	ID	LPD 17	SHIPS	PEO(S)	$ 14,241.70
ID	EA-18 G	AIR	PEO(T)	$ 8,784.30	ID	SSN 774 VIRGINIA	SHIPS	PEO(SUBS)	$ 81,556.20
ID	F-35 (JSF)	AIR	PEO(JSF)	$ 244,278.10					

Table 14. MDAPs most constrained by fuel-related burdens

F. DON PEO STRUCTURE

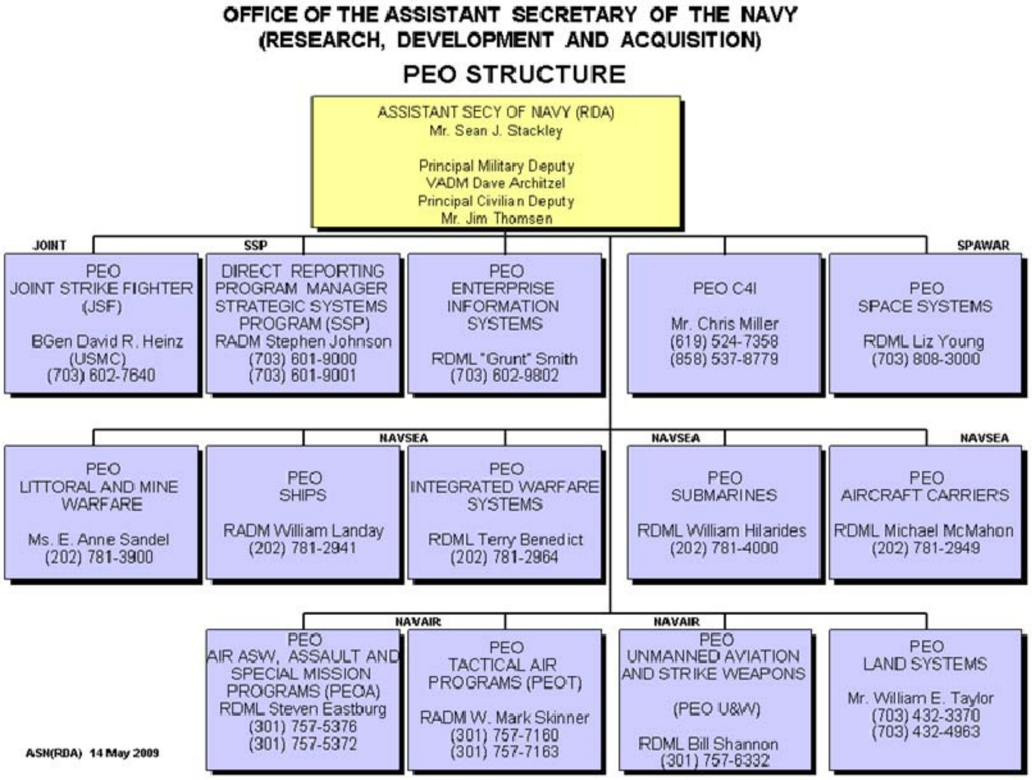

Figure 12. DON PEO Structure as of 14 May 2009

G. MDAP COSTS DETAIL PER DASN

		Impacted	Not Impacted	% Impacted DASN	% Total Impacted	% Total Costs
DASN Air	PEO(A)	$ 136,070.90	$ -	28.97%	18.67%	16.89%
	PEO(JSF)	$ 244,278.10	$ -	52.00%	33.51%	30.32%
	PEO(T)	$ 70,996.60	$ -	15.11%	9.74%	8.81%
	PEO(U&W)	$ 2,158.30	$ 16,262.20	0.46%	0.30%	0.27%
	SubTotal	**$ 453,503.90**	**$ 16,262.20**	**96.54%**	**62.21%**	**56.29%**
DASN Ships	PEO(CV)	$ 36,172.80	$ -	12.59%	4.96%	4.49%
	PEO(S)	$ 117,488.50	$ -	40.90%	16.12%	14.58%
	PEO(SUBS)	$ 81,556.20	$ -	28.39%	11.19%	10.12%
	DRPM-SSP	$ -	$ 38,343.80	0.00%	0.00%	0.00%
	PEO(IWS)	$ -	$ 12,114.40	0.00%	0.00%	0.00%
	PEO(L&MW)	$ -	$ 1,549.70	0.00%	0.00%	0.00%
	PEO(LS)	$ -	$ -	0.00%	0.00%	0.00%
	SubTotal	**$ 235,217.50**	**$ 52,007.90**	**81.89%**	**32.27%**	**29.19%**
DASN EXW	MARCOR	$ 26,674.10	$ -	66.25%	3.66%	3.31%
	PEO(LS)	$ 13,589.20	$ -	33.75%	1.86%	1.69%
	SubTotal	**$ 40,263.30**	**$ -**	**100.00%**	**5.52%**	**5.00%**
DASN C4I	PEO(C4I)	$ -	$ 2,103.30	0.00%	0.00%	0.00%
	PEO(EIS)	$ -	$ -	0.00%	0.00%	0.00%
	PEO(SPACE	$ -	$ 6,346.20	0.00%	0.00%	0.00%
	SubTotal	**$ -**	**$ 8,449.50**	0.00%	**0.00%**	**0.00%**
	Impacted	**$ 728,984.70**			**100.00%**	**90.48%**
	Not Impacted	**$ 76,719.60**				
	Total Costs	**$ 805,704.30**				

Table 15. Data table of costs for DON MDAPs impacted by fuel burden

The "% Impacted DASN" column represents the percentages of program costs per PEO divided by the costs of those programs impacted by fuel burden within their respective DASN. The "% Total Impacted" column represents the percentages of program costs per PEO divided by the sum of all impacted program costs across all DASNs. Finally, the "% Total Costs" represents the percentages of PEO impacted costs divided by the sum of all programs costs (impacted plus not impacted).

H. OUSD (AT&L) FBCF CALCULATOR DOCUMENTATION

Excerpts from the developmental FBCF Calculator:

The FBCF can only be calculated by using scenarios, because costs from other systems are factored in. The FBCF is determined for both operational (Op) scenarios and for steady-state (SS) scenarios. Each Cost Element is measured in $/gal for each of the Op and SS scenarios.

This FBCF Calculator defines two primary metrics for the FBCF, the Supplied FBCF ($FBCF_S$) measured in $/gal, and the Demanded FBCF ($FBCF_D$) measured in $/day. The $FBCF_S$ is the burdened cost to bring fuel from the DESC POS out to the location where the fuel will be consumed by the platform in question and is computed as follows:

$$FBCF_S = \underbrace{R * P_{Op} \sum_{c=1}^{7} F(c)_{Op}}_{Operational} + \underbrace{(1-R) * P_{SS} \sum_{c=1}^{7} F(c)_{SS}}_{Steady-State} \qquad \text{(eq. 1)}$$

Where:

$c =$ index of the Cost Element (DAG step) that accounts for part of fuel delivery costs

$F(c)_{OP} =$ fuel cost in operational scenarios for burdened element *c*

$F(c)_{SS} =$ fuel cost in steady-state scenarios for burdened element *c*

$R =$ ratio of time spent in operational scenarios to the time spent in steady-state scenarios

$P_{Op} =$ proportion of all fuel delivered in an operational scenario to the final location that is consumed by the platform of interest

$P_{SS} =$ proportion of all fuel delivered in a steady-state scenario to the final location that is consumed by the platform of interest

To simplify further discussion, parts of the $FBCF_S$ equation (eq. 1) are named as follows:

$$FBCF_{SOp} = P_{Op} \sum_{c=1}^{7} F(c)_{Op} \qquad \text{(eq. 1.1)}$$

$$FBCF_{SSS} = P_{SS} \sum_{c=1}^{7} F(c)_{SS} \qquad \text{(eq. 1.2)}$$

The $FBCF_D$ is the burdened cost of the fuel consumed by a single platform, per day and is computed as follows:

$$FBCF_D = \underbrace{R * D_{Op} * FBCF_{SOp}}_{Operational} + \underbrace{(1-R) * D_{SS} * FBCF_{SSS}}_{Steady-State} \qquad \text{(eq. 2)}$$

Where:

$D_{Op} =$ amount of fuel demanded (consumed) by a single platform on a daily basis while in an operational scenario

$D_{SS} =$ amount of fuel demanded (consumed) by a single platform on a daily basis while in a steady-state scenario

Once again, to simplify further discussion, parts of the $FBCF_D$ equation (eq. 2) are named as follows:

$$FBCF_{DOp} = D_{Op} * FBCF_{SOp} \qquad \text{(eq. 2.1)}$$

$$FBCF_{DSS} = D_{SS} * FBCF_{SSS} \qquad \text{(eq. 2.2)}$$

One of the primary uses of the FBCF calculation is in the Analysis of Alternates (AOA). The P_{Op} and P_{SS} terms are included as part of the $FBCF_S$ calculation in order to more clearly differentiate among the alternative platforms under consideration. Each platform will consume fuel at different rates. Thus, each one will demand a different proportion of the fuel available from the final delivery point's fuel stock. By including the proportion of fuel demanded in the calculation of the $FBCF_S$, the relative merits of each platform will become apparent in the AOA.

Conversely, if the proportion terms were removed from equations 1.1 and 1.2 and placed into equations 2.1 and 2.2, the $FBCF_S$ would only be composed of the sum of the cost elements as weighted by the ratio between the operational and steady-state scenarios. This would only capture the delivery costs and not take into account how much fuel is needed to be delivered to the consuming platforms.

Monte Carlo Simulation:

Given all of the assumptions above, one must still supply data to compute the FBCF metrics. Information is never perfect and this process in particular is fraught with many uncertainties. To capture the inherent uncertainties associated with the data, a Monte Carlo simulation is conducted, using a range of values for each variable in the model described above.

Each variable is assumed to follow a Normal distribution. The 5th and 95th percentile values are estimated and used to compute the Mean (μ) and Standard Deviation (σ) of that variable as follows:

$$\mu = (95\%ile + 5\%ile)/2 \qquad \text{(eq. 3)}$$
$$\sigma = (95\%ile - 5\%ile)/3.29 \qquad \text{(eq. 4)}$$

A simulation run of 1,000 iterations is conducted to estimate the FBCF metrics based on the ranges of the input data. Because this is a stochastic process, a random value may be generated that is less than or equal to zero. The calculator recognizes this as an un-realistic data point and automatically sets any negative or zero values to $0.1*5\%ile$ for that variable.

Once the 1,000 iterations are run, the resulting distributions of estimated values for the two FBCF metrics are analyzed to determine their respective means and standard variations. The last three tabs contain various graphical plots of the outputs. These statistical characteristics may then be used for comparison between alternatives under consideration in the AOA.

I. BASE CASE COST ELEMENT DEVELOPMENT DATA

	Element Number	Barrels of DFM Consumed		Element Number	Barrels of DFM Consumed
ARLEIGH BURKE	F.0	59,042	MAHAN	F.0	66,148
BAINBRIDGE	F.0	113,097	MASON	F.0	74,103
BARRY	F.0	75,677	MCCAMPBELL	F.0	101,130
BENFOLD	F.0	99,033	MCFAUL	F.0	72,564
BULKELEY	F.0	91,100	MILIUS	F.0	40,954
CARNEY	F.0	136,754	MITSCHER	F.0	50,488
CHAFEE	F.0	82,487	MOMSEN	F.0	146,798
CHUNG-HOON	F.0	50,316	MUSTIN	F.0	124,565
COLE	F.0	111,219	NITZE	F.0	63,440
CURTIS WILBUR	F.0	97,976	O'KANE	F.0	65,985
DECATUR	F.0	109,605	OSCAR AUSTIN	F.0	116,290
DONALD COOK	F.0	70,974	PAUL HAMILTON	F.0	43,147
FARRAGUT	F.0	91,392	PINCKNEY	F.0	46,145
FITZGERALD	F.0	124,294	PORTER	F.0	75,237
FORREST SHERMAN	F.0	103,081	PREBLE	F.0	37,042
GONZALEZ	F.0	104,911	RAMAGE	F.0	63,052
GRIDLEY	F.0	113,278	ROOSEVELT	F.0	67,011
HALSEY	F.0	83,622	ROSS	F.0	101,532
HIGGINS	F.0	81,717	RUSSELL	F.0	152,876
HOPPER	F.0	101,701	SAMPSON	F.0	34,234
HOWARD	F.0	118,949	SHOUP	F.0	140,243
JAMES E WILLIAMS	F.0	67,408	STERETT	F.0	
JOHN PAUL JONES	F.0	80,410	STETHEM	F.0	72,674
JOHN S MCCAIN	F.0	85,497	STOUT	F.0	60,636
KIDD	F.0	28,145	THE SULLIVANS	F.0	74,273
LABOON	F.0	80,405	WINSTON CHURCHILL	F.0	123,679
LASSEN	F.0	112,368			

Table 16. 2008 DDG-51 DFM consumption

The Element Number column corresponds to a specific Cost Element Description per the VAMOSC Ships User Manual version 8.0.1. Element Number F.0 defines the Total Barrels of Fuel Consumed. Within the VAMOSC environment, a drill down to sub-elements is possible to determine the contribution of sub-elements to the total. Sub-element F.1.1 data, Barrels DFM—Underway, was used for calculating the consumption estimates for Destroyer.

	1.0	2.0	3.0	4.0	5.0	6.0
BIG HORN	7,423,204	9,779,892	7,256,676	367,291	949,430	
GUADALUPE	7,405,186	6,867,432	5,276,840	266,913	402,808	
HENRY J KAISER	7,945,315	3,854,226	9,356,939	687,415	1,942,542	
JOHN ERICSSON	8,731,052	9,047,612	12,962,310	508,994	1,074,465	
JOHN LENTHALL	8,052,075	13,246,554	3,183,916	295,537	1,824,399	
KANAWHA	7,546,547	9,366,981	7,292,194	415,194	901,270	
LARAMIE	7,426,653	8,895,176	6,808,588	219,829	1,283,141	
LEROY GRUMMAN	7,213,122	9,401,587	4,200,749	400,973	544,494	
PATUXENT	7,164,888	9,383,791	4,312,145	318,316	408,486	
PECOS	9,446,473	11,683,694	7,416,691	277,891	401,348	
RAPPAHANNOCK	9,291,667	10,551,473	5,422,154	622,789	1,898,874	
TIPPECANOE	9,606,456	12,113,018	7,184,082	484,357	1,128,074	

Table 17. T-AO O&S costs for 2008 per VAMOSC

Element Numbers 1.0 thru 6.0 refer to aggregate cost elements for all major O&S costs. They are defined as follows.

- 1.0 Unit-Level Manpower
- 2.0 Unit Operations
- 3.0 Maintenance
- 4.0 Sustaining Support
- 5.0 Continuing System Improvements
- 6.0 Indirect Support

The sum of cost across cost element numbers 1.0 thru 6.0 represent the total O&S costs for the asset reported.

2008 DFM Consumption			
	ATLANTIC FLEET	PACIFIC FLEET	TOTAL
Barrels DFM Underway	4,512,879	5,722,483	10,235,362
Barrels DFM Not Underway	438,907	518,164	957,071
Barrels DFM Auxillary	9,165	16,226	25,392

Table 18. 2008 DFM Consumption–All Navy vessels

	2008 Port OPS and MILPERS Costs					
	Norfolk, VA	Pearl Harbor, HI	Everett, WA	San Diego, CA	Mayport, FL	TOTAL
Labor	$32,358,279.82	$13,991,419.66	$6,963,059.21	$11,596,972.76	$11,151,744.18	**$76,061,475.63**
Port Operations	$14,781,592.20	$964,417.38	$5,078,874.23	$10,020,273.62	$6,872,174.71	**$37,717,332.14**

Table 19. 2008 Port Operations and MILPERS Costs

J. BASE CASE FBCF CALCULATOR INPUT SCREEN

Cost Element:	C1	C2	C3	C4	C5	C6	C7
(All Cost Element units are $/gal)	Commodity Cost of Fuel (DESC)	Fuel Delivery O&S Cost	Depreciation Cost of Fuel Delivery Assets	Direct Fuel Infrastructure O&S Cost	Indirect Fuel Infrastructure O&S Cost	Environmental Cost	Other Costs (Force Prot. etc.)
Major Operational Scenarios:							
Upper Bound (95%)	$ 3.19	$ 1.98	$ 1.56	$ 0.02	$ 0.02	$ 0.04	$ 14.48
Mean	$ 2.90	$ 1.80	$ 1.42	$ 0.01	$ 0.02	$ 0.03	$ 8.69
Lower Bound (5%)	$ 2.61	$ 1.62	$ 1.28	$ -	$ 0.01	$ 0.02	$ 2.90
Steady-State Scenarios:							
Upper Bound (95%)	$ 3.09	$ 1.98	$ 1.56	$ 0.02	$ 0.02	$ 0.04	$ 0.72
Mean	$ 2.85	$ 1.80	$ 1.42	$ 0.01	$ 0.02	$ 0.03	$ 0.51
Lower Bound (5%)	$ 2.61	$ 1.62	$ 1.28	$ -	$ 0.01	$ 0.02	$ 0.29

	Ops/SS Ratio (R)	Operational Proportion (P_{Op})	Steady-State Proportion (P_{SS})	Op Demand (D_{Op}) (gal/day)	SS Demand (D_{SS}) (gal/day)
Upper Bound (95%)	51%	100%	100%	18,682	18,682
Mean	50%	100%	100%	18,589	18,589
Lower Bound (5%)	49%	99%	99%	18,495	18,495

	Major Operations		Steady-State		Duty-Cycle Weighted	
	$FBCF_{SOp}$	$FBCF_{DOp}$	$FBCF_{SSS}$	$FBCF_{DSS}$	$FBCF_S$	$FBCF_D$
	$/gal	$/day	$/gal	$/day	$/gal	$/day
Mean	$ 14.73	$ 273,816.02	$ 6.12	$ 113,793.49	$ 10.43	$ 193,817.07
Median	$ 14.73	$ 273,848.06	$ 6.12	$ 113,786.13	$ 10.41	$ 193,531.59
Std Dev	$ 3.50	$ 65,050.75	$ 0.20	$ 3,672.30	$ 1.75	$ 32,498.22
Mean + 1.65 Std Dev	$ 20.51	$ 381,149.76	$ 6.45	$ 119,852.79	$ 13.31	$ 247,439.13
Mean - 1.65 Std Dev	$ 8.95	$ 166,482.29	$ 5.80	$ 107,734.19	$ 7.54	$ 140,195.01

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