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Batteries on the Battlefield: Developing a Methodology to Estimate the Fully Burdened Cost of Batteries in the Department of Defense

8 May 2010

by

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ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
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Abstract

According to Department of Defense (DoD) and Secretary of the Navy (SecNav) instructions, acquisition decisions should be based on analysis that considers both the costs and benefits of different courses of action. A recent change to *DoD Instruction (DODI) 5000.02*, the DoD's regulations on the acquisition of new systems, specifically calls for its agencies to consider the fully burdened energy costs in all trade-offs involving costs and benefits. Defense ground, air, and maritime platforms, as well as communications and network systems, all use a variety of renewable and disposable energy sources. Past analyses conducted by the Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA–CE) and the Office of the Undersecretary of Defense for Acquisition Technology and Logistics (OUSD(AT&L)) have developed methodologies to calculate the fully burdened cost of fuel as delivered energy in defense systems. Whereas these previous studies did not consider other energy sources such as batteries, this thesis contributes to the DoD area of knowledge in estimating lifecycle costs of systems by developing a methodology to estimate the fully burdened cost of batteries.

Keywords: Lifecycle cost estimating, battery acquisition, delivered energy, fully burdened costs, fully burdened cost of fuel, fully burdened cost of water, fully burdened cost of batteries, analysis of alternatives, tradespace, capability development document, battery

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Acknowledgments

From Troy: In memory of Capt. Jesse Melton, 1st Lt Nicholas Madrazo, and HM3 Eichmann Strickland. May your sacrifice for our country and the nation of Afghanistan not have been in vain.

From Anthony: Thanks to my wife, Jamelle, for her patience and support.

From Mark: I would like to thank my wife, Grace, for her unwavering support and confidence while I attended school and completed this thesis. Without her love and support, my time here would not have been a success.

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List of Acronyms and Abbreviations

AAS	Armed Aerial Scout
ADP	Assured Delivery Price
AMDF	Army Master Data File
AoA	Analysis of Alternative
BRAC	Base Realignment and Closure
C-E	Communications and Electronics
CAR	Contract Action Report
CDD	Complete Discharge Device
CE	Cost Element
CECOM	US Army Communications-Electronics Command
CMC	Commandant of the Marine Corps
CAN	Chief of Naval Operations
CONUS	Continental United States
DAG	*Defense Acquisition Guidebook*
DAU	Defense Acquisition University
DESC	Defense Energy Support Center
DLA	Defense Logistics Agency
DoD	Department of Defense
DODCAS	DoD Cost Analysis Seminar
DODI	Department of Defense Instruction
DSB	Defense Science Board
EPA	Environmental Protection Agency
FAR	*Federal Acquisition Regulation*
FBCB	Fully Burdened Cost of Batteries
FBCF	Fully Burdened Cost of Fuel
FBCW	Fully Burdened Cost of Water
FDC	First Destination Costs
FISC	Fleet & Industrial Supply Center
FMTV	Family of Medium Tactical Vehicles, also the acronym for single truck from that family.

FOB	Forward Operating Base
FPDS–NG	Federal Procurement Data System–Next Generation
FSC	Federal Supply Classification
FY	Fiscal Year
GAO	Government Accountability Office
GCV	Ground Combat Vehicle
GOS	General Officer Offsite
GSA	General Services Administration
HAZMAT	Hazardous Materials
HQDA G-4	Headquarters, Department of the Army G-4
ISO	International Organization for Standardization
JLTV	Joint Light Tactical Vehicle
JRTC	Joint Readiness Training Center
LCC	Lifecycle Costs
LMTV	Light Medium Tactical Vehicle-FMTV Variant
LOGSA	US Army's Logistical Support Activity
LVS	Logistics Vehicle System
MARCORSYSCOM	Marine Corps Systems Command
MDA	Milestone Decision Authorities
MDAPS	Major Defense Acquisition Programs
MEAT	Marine Corps Energy Assessment Team
MNF–W	Multi-national Forces–West
MORS	Military Operations Research Society
MRAP	Mine Resistant Ambush Protection Vehicle
MTOE	US Army Modified Table of Organization and Equipment
Mtons	Measurement tons
MTVR	Medium Tactical Vehicle Replacement
NAVSEA	Naval Sea Systems Command
NSN	National Stock Number
OCONUS	Outside the Continental United States
ODASA–CE	Office of the Deputy Assistant Secretary of the Army for Cost and Economics

OEF	Operation Enduring Freedom
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
OPTEMPO	Military Operational Tempo
OSD	Office of the Secretary of Defense
OUSD(AT&L)	Office of the Undersecretary of Defense (Acquisition Technology and Logistics)
P&R (PA&E)	USMC HQMC Programs and Resources, Program Assessment and Evaluation Division
PEOs	Program Executive Officers
PM	Program Managers
POWER	Power Optimizer For the Warfighter's Energy Requirements
PPBES	DoD Planning, Programming, Budgeting, and Execution System
PPBS	Programming, Planning, Budgeting System
RAND	Research and Development
RCRA	*Resource Conservation and Recovery Act*
SAP	Simplified Acquisition Procedures
SARSS	Standard Army Retail Supply System
SATCOM	Satellite Communications
SBCT	Stryker Brigade Combat Team
SDC	Second Destination Costs
SDDC	Surface Deployment and Distribution Command
SecNav	Secretary of the Navy
SINCGARS	Single Channel Ground and Airborne Radio System
SMP	Sustain the Mission Project
SOCI	Status of Charge Indicator
TACOM	US Army Tank-Automotive and Armaments Command
TDC	Tactical Destination Costs
TRANSCOM	Department of Defense Transportation Command
UNS	Universal Needs Statement
US	United States
USA	United States Army

USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
WEBFLIS	DLA's Web-based Logistics Information System

Executive Summary

This study built upon USD AT&L metrics to develop a methodology and tool for acquisition planners to use in the Analysis of Alternatives process when fully burdened energy costs are an issue. The BA-5590, a high demand, DoD-specific, lithium sulfur dioxide battery was studied in order to develop a methodology to understand the burdens that affect battery costs. Burden elements developed for this study differ from the metric developed from the fully burdened cost of fuel methodologies and reflect the variable nature of battery types, the lack of dedicated transport vehicles for batteries, the more complicated acquisition process for batteries, and the variable nature of battery usage. The six burden elements are as follows: Acquisition, Transportation, Depreciation, Storage, Disposal, and Usage. A major outcome of this analysis is that the methodology developed the fully burdened cost of batteries based on two scenarios.

Under a Continental US training scenario, the base-case fully burdened costs of the BA-5590 are an additional 9.3% of the contract price of the batteries. Under an operational scenario, the BA-5590's fully burdened costs are an additional 12.85% of the contract price of the batteries. Under both base-case scenarios, disposal represents the greatest portion of the fully burdened costs. If the military seeks immediate cost savings in the use of non-rechargeable lithium batteries, the reduction of the waste stream associated with their use would most readily result in cost improvements.

Usage scenarios affect the assured delivery price greatly. Transportation planning is important for battery costs. The use of aviation assets as part of a scenario increased the cost of batteries significantly, and our analysis confirms the work of Peltz et al. (2008), as well as our observed shipments to theater via the air channel using total asset visibility tools.

This methodology lends itself to the study of other forms of delivered energy on the battlefield—i.e., wind, solar, and biofuels. The endstate of future studies undertaken to advance this methodology would be to develop a simulation model or tool that a planner could use to determine the fully burdened cost of different forms of delivered energy with a minimum number of inputs required from the user of that tool.

I.   DoD Energy Awareness

The Department of Defense (DoD) has not always taken into account the full cost of the energy that powers its systems. In the past, warfighters assumed their planes, tanks, and ships would always have sufficient fuel, and that the only cost involved was the standard commodity price of fuel. Only recently has energy security taken a front-and-center role in the DoD's planning and discussion. Lengyel (2007) discusses the issue in terms of national security, stating that the United States should begin to improve national security by decreasing its dependence on foreign oil, ensuring access to critical energy requirements, and promoting research for future energy security. The Center for Naval Analyses (CNA) (2009) finds that "inefficient use and overreliance on oil burdens the military, undermines combat effectiveness, and exacts a huge price tag—in dollars and lives" (p. 7). Eggers (2008) claims that "the seemingly intractable problem of US dependence on foreign oil is a pre-eminent national security threat" (p. 12). The true costs of energy can be much higher than the flat per-gallon or per-barrel cost that fuel military planners typically consider.

A.   Emerging Importance of DoD Fuel Cost Accountability

The earliest efforts to recognize the true cost of delivered energy for US forces came in 2001. The Defense Science Board (DSB) Task Force on Improving Fuel Efficiency of Weapons Platforms published *More Capable Warfighting through Reduced Fuel Burden: Improving Fuel Efficiency of Weapons Platforms* (2001), which contains several findings and recommendations that are detailed in the Appendix to this thesis. One particularly relevant finding was that almost 70% of the weight US Forces bring to theater is fuel that powers warfighting equipment (Defense Science Board Task Force on Improving Fuel Efficiency of Weapons Platforms [DSB], 2001).

The DSB found that although improvements have been made, the DoD still had far to go in reducing energy demand by the warfighting forces (DSB, 2008). In regard to its previous 2001 report, the DSB stated:

> The key finding was that warfighting, logistics and monetary benefits occur when weapons systems are made more fuel-efficient, but those benefits are not valued or emphasized in the requirements and acquisition processes. This is because DoD's business processes do not explicitly, routinely, or systematically consider either the energy problem or opportunities to address it. The [2001] report found that the requirements process does not require energy efficiency in deployed systems, the acquisition process does not value it, the procurement process does not recognize it, and the Planning, Programming, Budgeting, and Execution System (PPBES) process does not provide it visibility when considering investment decisions. (DSB, 2008, p. 23)

Many claim that the heavy energy burden of our systems will result in a greater number of instances of irregular warfare, wherein our enemies will find choice targets in the large logistics train, or "tail," rather than face the "tooth" of our combat forces (CNA, 2009; DSB, 2001; Eggers, 2008; Lengyel, 2007).

Warnings about securing our logistics trains, and the energy they provide to our combat systems, proved prescient when, in 2006, the commander of Multi-National Forces-West (MNF-W), MajGen Zilmer (Commanding General, Multi-National Force-West (MNF-W), 2006), submitted an Urgent Universal Needs Statement (UNS) for fuel-efficient vehicles, as a result of the high number of combat troops he had taken away from the fight and assigned to convoy escort duties. Recognizing the price he had to pay to protect his logistics tail, Zilmer requested equipment that freed him from the fuel tether. The thought behind his request was that more fuel-efficient equipment would decrease the amount of support convoys would need to sustain combat vehicles. Decreased support requirements would also diminish the number of combat forces that Zilmer needed to pull away to perform force-protection duties for sustainment convoys. Others have quoted this Urgent

UNS to further emphasize why the DoD needs to rethink its valuation of energy (Dipetto, 2008).

The Government Accountability Office (GAO) was asked to discuss the DoD's efforts to manage and reduce its mobility energy demand and found that "high fuel requirements on the battlefield can place a significant logistics burden on military forces, limit the range and pace of operations, and add to mission risks, including exposing supply convoys to attack" (GAO, 2008b, p. 1). The GAO determined that there was a lack of accountability in the DoD with overall responsibility for energy reduction. The GAO stated that, "In the absence of an overarching organizational framework for mobility energy, DoD cannot be assured that its current efforts will be fully implemented and will significantly reduce its reliance on petroleum-based fuel" (GAO, 2008b, p. 1). The GAO recommended that the DoD establish an executive-level Office of the Secretary of Defense (OSD) official to oversee all DoD energy-reduction efforts. Indeed, the GAO suggested that if such an office were instituted, the DoD would be better able to incorporate fuel efficiency as a consideration in both developing requirements and acquiring new weapons systems (GAO, 2008b).

B.   OUSD(AT&L) Efforts to Establish Fuel Metrics

In response to the 2001 and 2008 DSB and other calls to better address energy efficiency in warfighting systems, the OUSD(AT&L) developed metrics to assist materiel planners and warfighters to value the logistics and delivery costs of fuel in materiel and operational decisions. These efforts led to the development of a methodology to calculate the total cost of energy consumption of DoD systems and personnel on the battlefield.

C. Fully Burdened Cost of Fuel: DAG Rewrite and FBCF Directives

The *Interim Defense Acquisition Guidebook* (*DAG*) now includes language that considers the cost of providing energy to systems (DAU, 2009). Specifically, the *DAG* states that "the Analysis of Alternatives conducted during the Materiel Solution Analysis phase shall include an estimate of the fully burdened cost of delivered energy, added to the total ownership cost estimate" (DAU, 2009, part 3.1.6). Concentrating on the Fully Burdened Cost of Fuel (FBCF), the *DAG* seeks to capture all the costs of providing fuel to a tactical system as part of the Analysis of Alternatives. The *DAG* defines FBCF as "the cost of the fuel itself (typically the Defense Energy Support Center (DESC) standard price), plus the apportioned cost of all of the fuel delivery logistics and related force protection required beyond the DESC point of sale to ensure refueling of this system" (DAU, 2009 part 3.1.6). In addition to this concept, the *DAG* included a detailed guide of how to calculate the FBCF. This guidance describes a seven-step process shown in Table 1.

Table 1. Seven Steps to Estimating the Cost Elements of the Fully Burdened Cost of Delivered Energy
(DAU, 2009, part 3.1.6)

Step	Element	Burden Description
1	Commodity Cost of Fuel	DESC standard price for the appropriate type or types of fuel
2	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
3	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
4	Direct Fuel Infrastructure O&S and Recapitalization Cost	Cost of fuel infrastructure that is not operated by DESC and directly tied to energy delivery
5	Indirect Fuel Infrastructure*	Cost of base infrastructure that is shared proportionally among all base tenants
6	Environmental Cost*	Cost representing carbon trading credit prices, hazardous waste control, and related subjects
7	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)

To provide greater detail to planners and cost estimators, OUSD(AT&L) released the FBCF Calculator to compute a numerical estimate of the FBCF using the basic methodology provided in the *DAG* (DAU, 2009). The calculator is an Excel spreadsheet that computes a 1,000-iteration Monte Carlo simulation based upon user inputs to provide graphical output from the model for use in planning total lifecycle costs.

The Office of the Assistant Secretary of the Army (Acquisition, Logistics, and Technology) released a memorandum (USD(AT&L), 2007) to all US Army Program Executive Officers (PEOs) and Program Managers (PMs) mandating that all new program starts and increments that use energy, calculate the fully burdened costs of delivered energy required to operate their respective systems. Another memorandum states that fuel costs used in estimating total ownership costs shall be based on the Fully Burdened Costs of Fuel, not just the standard commodity price (DUSD (LMR), 2008). Based on these directives and policies, defense agencies have begun several projects to explore fully burdened costs of energy.

D. Service Efforts to Determine FBCF Methodologies

1. US Army Sustain the Mission Project

In 2006, the Army Sustain the Mission Project (SMP) developed a methodology for calculating the FBCF resources to sustain Army missions in theaters of operation and at the training base. (Eady, et al., 2006) In 2008, SMPII developed a user-friendly alpha-decision support tool in fiscal year (FY) 2008 for calculating the FBCF using the SMP methodology and for evaluating energy technology investments (Siegel et al., 2008). These studies give realistic numbers to what it truly costs to provide fuel to a Stryker Brigade Combat Team (SBCT) in a base case scenario in Iraq or in an undeveloped theater. SMP allows planners to see the costs and benefits of different fuel delivery methods for sustainment of forces. The beta version of SMP, when released by Headquarters, Department of

the Army G-4 (HQDA G-4), should allow planners to calculate the FBCF for a variety of army units over changing scenarios.

2.   ODASA–CE Methodology

At the 2009 DoD Cost Analysis Seminar (DODCAS), the ODASA–CE presented the first attempt to quantify the FBCF in the Analysis of Alternative (AoA) process based on the OUSD(AT&L) methodology (Hull & Roper, 2009). The ODASA–CE has taken the lead for generating a FBCF methodology and publishing factors for Army-wide use in the acquisitions process. The ODASA–CE plans to develop FBCF methodology to incorporate into the AoAs for the Ground Combat Vehicle (GCV), Joint Light Tactical Vehicle (JLTV) and Armed Aerial Scout (AAS) MDAPS.

3.   US Navy FBCF Efforts

Naval Sea Systems Command (NAVSEA) (Kearns, 2009) used the USD(AT&L) methodology for calculating FBCF and applied it to Navy ship applications. These results were also presented at the 2009 Department of Defense Cost Analysis Symposium (DODCAS). FBCF Calculator v6.2 is optimized for Navy systems. In an analysis of Department of the Navy Major Defense Acquisition Programs, Corley (2009) found that the majority of programs are potentially impacted by FBCF estimates and concluded that the use of the FBCF during AoAs and EOAs offers the potential for significant benefit. As Corley (2009, p. 42) states, "the use of FBCF estimates will provide PEOs, PMs, Milestone Decision Authorities (MDAs), and budgeting professionals a tool to better assess total Life Cycle Costs (LCC), the impacts of energy demand on the capability and its logistics tail, and its impact on the overall DoD budget."

4.   US Marine Corps FBCF Efforts

The Commandant of the Marine Corps (CMC) recently tasked USMC HQMC Programs and Resources, Program Assessment and Evaluation Division (P&R (PA&E)) to determine the FBCF and Fully Burdened Cost of Water (FBCW) for Afghanistan, Operation Enduring Freedom (OEF). The PA&E's Division's results—presented to General Officer Offsite (GOS) in October 2009—were based on a specific convoy scenario to a combat outpost of Marines operating in Southern Afghanistan (Cole & Blankenship, 2010). The PA&E Division modified the FBCF Calculator V6.2 to apply to this specific scenario. In so doing, the PA&E Division first-incorporated the concept of the Assured Delivery Price (ADP), a scenario-specific price of fuel that can be calculated per gallon or per barrel. The assured delivery price takes consuming systems out of the fully burdened price and gives only the cost of delivering under a specific scenario. Figure 1 shows the continuum described by PA&E of the Assured Delivery Price (expressed in dollars per gallon) and the FBCF, expressed in dollars per day only after factoring in the demand of a consuming system. Figure 1 also shows that changes in system demand can affect the retail price of fuel.
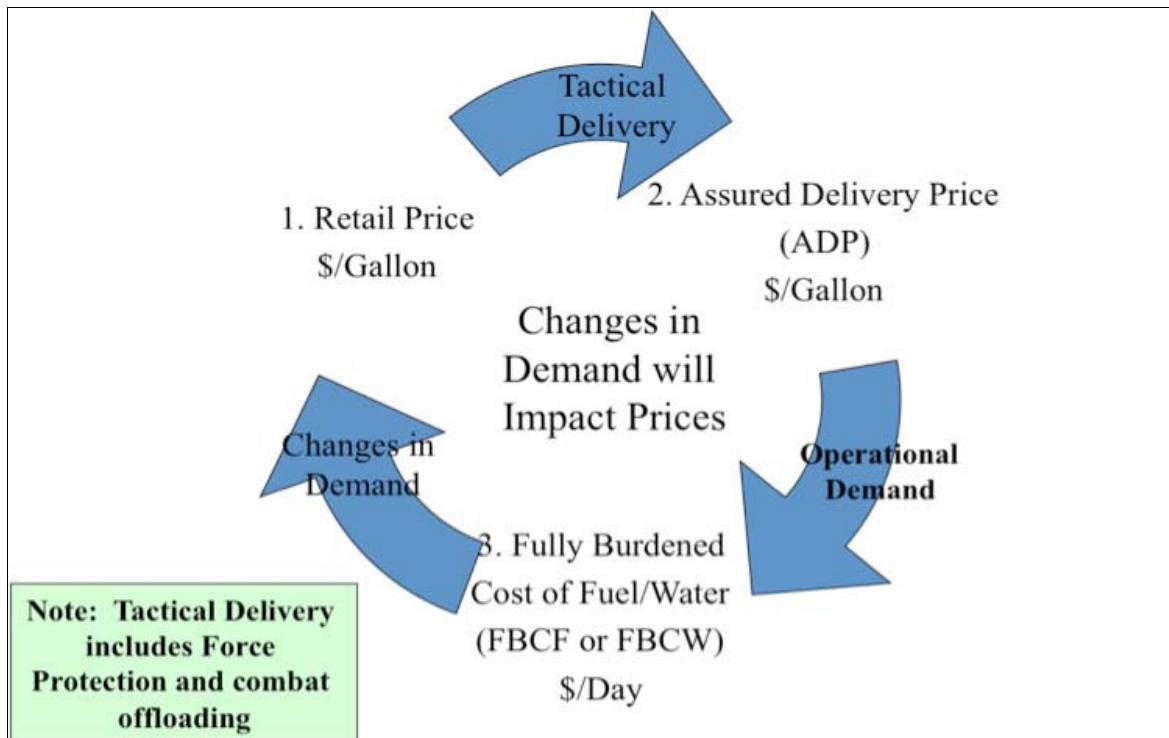
Figure 1.   Assured Delivery Price
(Cole & Blankenship, 2009, Slide 5)

5.   MORS Energy Related Efforts

The DoD's efforts to determine Fully Burdened Costs of Energy have only focused on fuel. However, the Military Operations Research Society (MORS) has found, that the fully burdened costs for energy definitions for the DoD must go beyond petroleum-based fuels. In addition to calling for standardized definitions of several energy efficiency terms, MORS insists that the definition of the FBCF must also be expanded to include energy beyond fuel (Regnier et al., 2009).

E.   Conclusion

Energy demands are placing increasing burdens on the logistical tail. Planners have begun to see this burden as a strategic issue. This chapter focused on the DoD's methods to deal with energy demand in the acquisition of new systems by applying new metrics to capability decisions. The foremost of these new metrics is the FBCF. The chapter also discussed service efforts to develop FBCF methodologies and apply the methodologies to active Major Defense Acquisition Programs (MDAPs) and current sustainment scenarios.

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II.   Delivered Energy from Batteries

A.   Introduction

Compared to the amount of money spent each year on fuel, the cost of batteries is minuscule. It stands to reason that most of the efforts spent on determining the fully burdened costs of delivered energy have focused on petroleum-based fuels. However, for a complete understanding of the fully burdened costs of delivered energy to mature, the DoD needs to develop this methodology for batteries. Additionally, as the DoD begins to use more electric-powered vehicles, delivered (e.g., petroleum-based) fuel demands will decrease while stored energy demands will increase.

During fiscal years 2000 through 2008, the Department of Defense spent over $66 billion on delivered energy (Andrews, 2009, p. 2). Less than 1% of that amount, just under $600 million in FY 2000 dollars, was used for the purchase of batteries.[1] Although comparatively small when compared to total fuel purchases, $600 million is a considerable sum—enough to fund two US Army light infantry battalions deployed to Iraq for a year in 2006 (Belasco, 2009, p. 46).

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[1]Amount of money spent by the Department of Defense on fuel and battery purchases during FY 2000 through FY2008, years in which data is available. Battery-purchase data was found based upon research conducted by authors on DoD battery-purchase contracts from FY 2000 through FY 2009. All dollar amounts are in FY 2000 values unless noted.
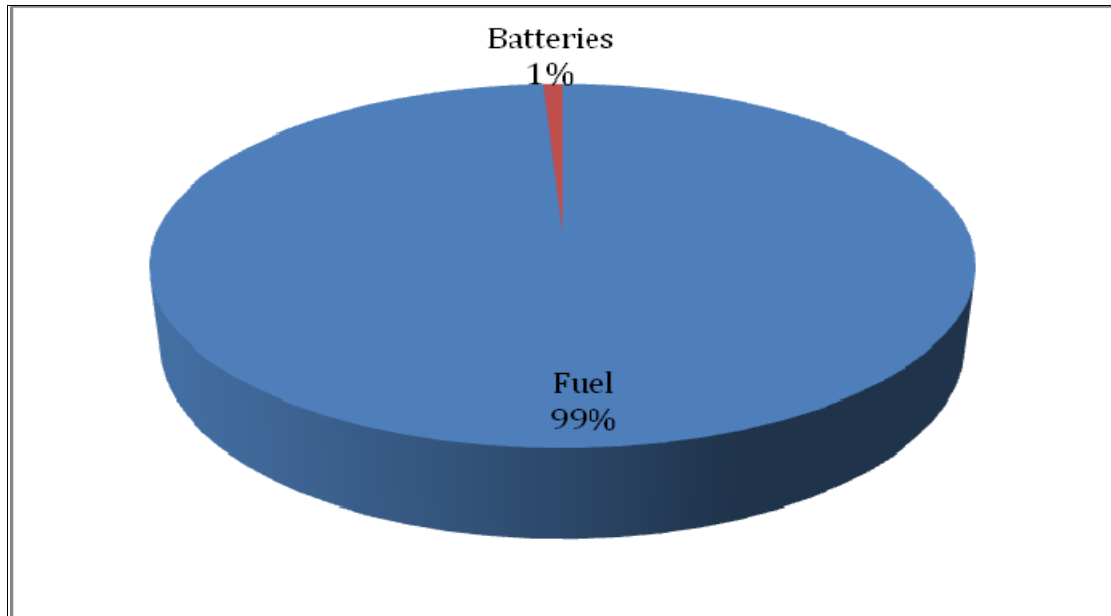
Figure 2.   Total Energy Spending (in FY00$)
(Federal Procurement, n.d.)

B.   Battery Purchases

The $600 million in battery purchases from FY 2000–2008 fell into two major divisions: rechargeable and non-rechargeable. The majority of the spending—over 350 million dollars—was for non-rechargeable batteries. Rechargeable battery contracts made up the remaining $225 million. The following table presents yearly battery purchases by category:

Table 2.   Battery Spend Data by FY and Major Category
(Federal Procurement, n.d.)

	Non-rechargeable (FSC 6135) (in FY 2000 $)	% of total FY batt purch	Rechargeable (FSC 6140) (in FY 2000 $)	% of total FY batt purch	Total batt purch for FY (in FY 2000 $)
FY00	$11,888,001	49%	$12,226,360	51%	$24,114,361
FY01	$29,944,583	60%	$20,236,862	40%	$50,181,445
FY02	$13,983,808	40%	$21,062,586	60%	$35,046,394
FY03	$154,420,532	80%	$39,417,303	20%	$193,837,835
FY04	$46,427,999	66%	$24,031,162	34%	$70,459,161
FY05	$26,480,793	47%	$30,371,799	53%	$56,852,592
FY06	$32,489,384	64%	$18,249,758	36%	$50,739,142
FY07	$25,178,831	50%	$25,131,940	50%	$50,310,771
FY08	$15,587,974	31%	$34,849,216	69%	$50,437,190
Totals	$356,401,905		$225,576,986		$581,978,891

During this period, approximately 61% of battery-purchase funds were spent on non-rechargeable batteries (Figure 3).
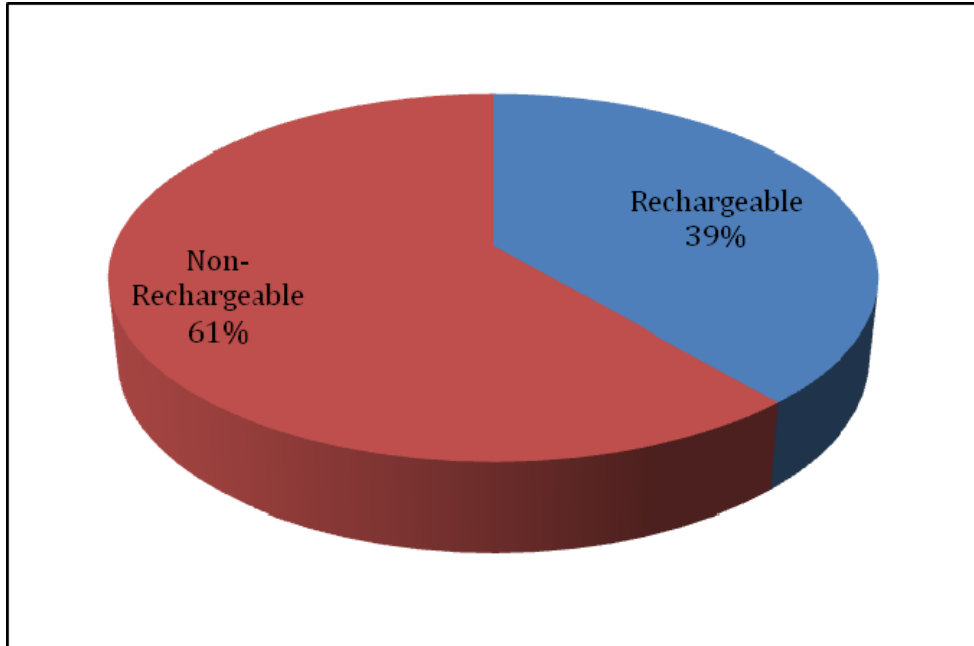
Figure 3. Battery Purchases Breakdown in $FY00
(Federal Procurement, n.d.)

C. Type 90 Battery Family

One of the more common battery types used in the Services is the Type 90 family of batteries, which includes both rechargeable and non-rechargeable batteries. Table 3 summarizes key features of both types, and Table 4 presents a short list of equipment using the Type 90.

Table 3.   Type 90 Battery Features
(Power Sources Center of Excellence)

Battery	Features
BA-5390/U	Non-Rechargeable, Lithium Manganese Dioxide
BA-5390A/U	Non-Rechargeable, Lithium Manganese Dioxide, with State of Charge Indicator (SOCI)
BA-5590A/U	Non-Rechargeable, Lithium Sulfur Dioxide, with SOCI
BA-5590B/U	Non-Rechargeable, Lithium Sulfur Dioxide
BB-2590/U	Rechargeable, Lithium Ion, with SOCI

Table 4.   Military Equipment Powered by the Type 90
(Power Sources Center of Excellence)

Nomenclature	Description
AN/PRC-119	Radio, Portable Single Channel Ground and Airborne Radio System (SINCGARS)
AN/PPN-19(V)2	Radar Transponder Set
AN/PRC-117F	Multiband Manpack Radio
EPLRS RT	Command and Control System
AN/PSC-5	Portable Satellite Communications (SATCOM) Terminal
AN/TMQ-30	Automatic Meteorological Station
AN/GSQ-187	Remotely Monitored Battlefield Sensor System
M-22 (ACADA)	Chemical Alarm
AN/PRC-150 HF/VHF	Manpack Radio
Javelin CLU	Thermal Imaging Unit

D.   Non-Rechargeable Battery Purchases

Of the $356 million spent on non-rechargeable battery purchases by the DoD during FYs 2000–2008, purchases of the Type 90 series of batteries account for approximately $140 million, or about 40% of non-rechargeable battery purchases. This amount excludes the BB-2590, which is a rechargeable Type 90 battery (See

Figure 4). The amount spent on Type 90 batteries also accounts for approximately 20% of all battery purchases during FY 2000-2008 (see Figure 4).
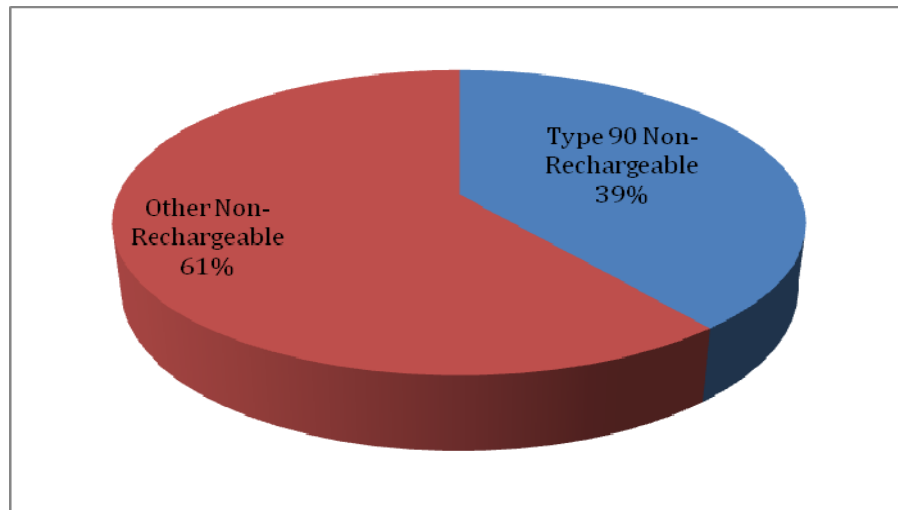

Figure 4.   Non-rechargeable Battery Purchases
(Federal Procurement, n.d.)

The amount spent on Type 90 batteries accounts for approximately 20% of all battery purchases during FY 2000-2008 (see Figure 5).
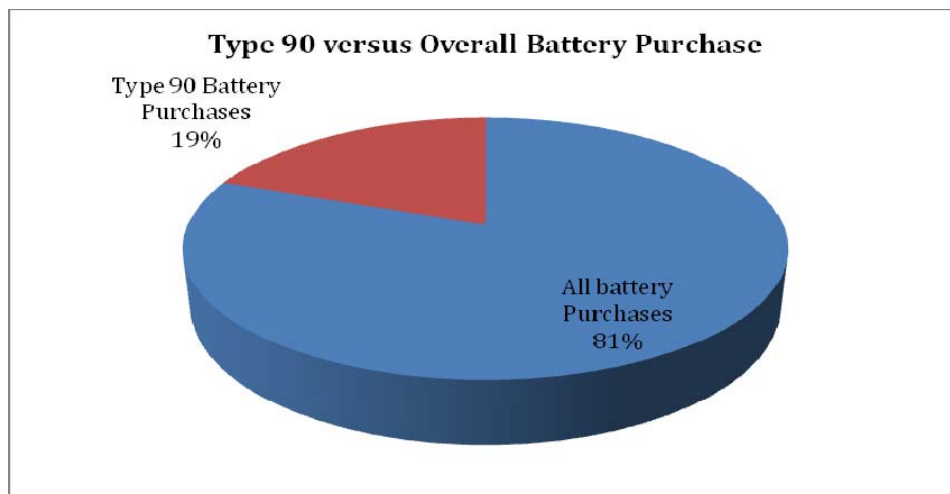

Figure 5.   Type 90 versus Overall Battery Purchases (FY2000–FY2008)
(Federal Procurement, n.d.)

E.   Conclusion

Almost 20% of the funds used to purchase batteries during FYs 2000 to 2008 were spent on the Type 90 series of batteries. This series is a widely used battery within the DoD, and its use makes a good case for which to develop and analyze a methodology to determine the FBCB. Since the authors focused on one battery type in this study, the BA-5590 battery is the most obvious choice. The BA-5590 accounts for a large number of the Type 90 series of batteries purchased by the DoD.

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III. Energy Awareness and Batteries

Much has been done to improve battery performance within the DoD and to standardize military equipment to work on a smaller set of batteries. According to the Defense Standardization Program Office (2002), "During the 1970s and 1980s, Army systems were using more than 350 different types of 1.5-volt to 30-volt military batteries. The proliferation of battery types led to high expenditures for batteries and decreasing unit readiness and interoperability" (Defense Standardization, 2002, p. 1).

Since the 1980s, the DoD has worked to reduce the number of batteries that power its 456 different communications–electronics (C-E) devices (defined as radios, laser rangefinders, telegraph terminals, global positioning systems, night-vision devices, meteorological systems, and early warning sensors) from more than 350 battery types to 35 battery types (Defense Standardization, 2002). Although costs relating to battery type have decreased since 1996, to date no studies have attempted to apply fully burdened costs to batteries.

A. Batteries as a Commodity

Batteries are similar to fuel in that they are a commodity (Rendon, 2005). However, in order to appreciate the FBCB, one must understand a critical difference between how the DoD acquires batteries and how it acquires fuel. As the sole acquirer and provider of fuel to all of the DoD, the Defense Energy Supply Center (DESC) develops and executes the DoD fuel procurement strategy. Analysts and mission planners base their calculations on, and draw their conclusions from, the transaction costs and prices that DESC establishes. The DoD battery procurement strategy is more commercialized due to the variety of commercial providers and the greater number of public and private consumers.

The economist Oliver E. Williamson stated that "if transaction costs are negligible, the organization of economic activity is irrelevant, since any advantages one mode of organization appears to hold over another will simply be eliminated by costless contracting." (Williamson, 1979, p. 233) Thus, it is important to understand and capture transaction costs in order to increase the DoD's procurement effectiveness and avoid costs. In a later article, Williamson explained transaction costs as "the comparitive costs of planning, adapting, and monitoring task completion under alternative governance structures" (Williamson, 1981, pp. 552–553).

The authors understand the complexity of capturing all applicable transaction costs accurately. Williamson even stated that beyond some general propositions, a "consensus on transaction costs is lacking" (Williamson, 1979, p. 234). Transaction costs for military battery procurement are an unrealized cost burden. However, for the purposes of this thesis, the authors captured some of this burden by limiting the study of applicable transaction costs to government agency administrative costs up to and including contract award. Even within this restricted view, costs only apply to contracting personnel actually working on a contract and not necessarily agency wide. Within this view, Elliot Yoder defined transaction costs as the quantitative value of touch time required to create, solicit, and award a contract (Yoder, 2006). Yoder went on to expand this definition as follows:

- Contract actions using large Simplified Acquisition Procedures (SAP) protocol—as outlined in *Federal Acquisition Regulation (FAR)* Part 13—use approximately 9 hours of touch time. (Yoder, 2006, pg. 24–25)

- Contract actions using large-contracting procedures—typically *FAR* Parts 14 and 15—take approximately 200 hours of touch time. (Yoder, 2006, pg. 24–25)

- Transaction costs are derived by taking the "average loaded hourly salary rate for an 1102 Contract Specialist of $50" and multiplying it by 9 hours or 200 hours, depending on the contract type. (Yoder, 2006, pg. 24–25)

In addition to the many battery-procuring agencies within the DoD, the procurement process offers numerous opportunities to add time and/or cost inefficiencies. One way to avoid or reduce the effect of transaction costs is to approach battery procurement as a strategic function. When organizations take a more strategic approach to purchasing, they can improve by 20% or more in cost, schedule, and quality (Monczka, Handfield, Giunipero & Patterson, 2009).

Strategic purchasing includes the idea of "strategic sourcing, […] however, it also emphasizes the ability of purchasing to align with and influence enterprise strategy" (Hudgens, 2008). In a 2005 memo, the Office of Management and Budget (OMB) defined strategic sourcing as "the *collaborative* and *structured* process of critically analyzing an organization's spending and using this information to make business decisions about acquiring commodities and services more effectively and efficiently" (Deputy Director for Management, 2005, p. 1). Strategic sourcing is one of the major steps in the procurement process that involves the identification and selection of the supplier whose costs, qualities, technologies, timeliness, dependability, and service best meets the organization's needs (Burt, Dobler & Starling, 2003). The success of commercial firms using strategic sourcing has been the catalyst for the increased interest by government organizations (Foust & Jenson, 2006). In order to fully understand how the DoD can purchase batteries strategically, this chapter will examine the battery industry both in terms of suppliers (using industry analysis and core competencies), and in terms of purchasing (using spend analysis (reference) and the Kraljic (1983) model).

B.   Battery Suppliers

In its 2002 case study—which analyzed how to improve the performance of portable power for C-E devices—the Defense Standardization Program noted a decrease in the industrial base for defense battery manufacturers. This study also noted how major manufacturers "such as Eveready and Duracell walked away from the military battery business because of low volume demand" (Defense Standardization, 2002). The study indicated that the military-unique battery demand is small compared to the overall commercial market; such a position can result in higher unit costs and uncertain contractual commitments. This situation created a small niche market for a few opportunistic manufacturers, which (as of 2009) consisted of five primary suppliers of Type 90 non-rechargeable batteries: Saft Batteries, Inc., EaglePicher Corp., BrenTronics, Inc., Mathews Associates, Inc., and Ultralife Batteries, Inc.

C.   Battery Purchasing

A key to managing the purchasing activity at a strategic level is to find the successes and faults in past procurement activity. Leading commercial firms discover this history by conducting "a spend analysis, or an analysis of expenditures along dimensions such as type of commodity or service and suppliers, numbers of contracts and expenditures, and other variables showing how current money is spent on goods and services" (Moore, Cook, Grammich & Lindenblatt, 2004). A spend analysis is an excellent strategic analysis tool that seeks to analyze both the purchases and the supply base in order to understand risks and opportunities involved in how, and from whom, the organization buys (2004).

An ideal starting point for conducting a spend analysis on a government agency is the Federal Procurement Data System–Next Generation (FPDS–NG). This is a digital database of every DD Form 350, the Individual Contract Action Report (CAR), which accompanies every contract or contract modification and

includes key information about that contract—such as contract number, date, agency/office, dollar amount, vendor, contract type, and socio-economic information on the contractor.

Although extremely useful in collecting data for a spend analysis, one of the limitations of the FPDS–NG is that it does not return the specific item(s) involved in the transaction. Therefore, it is impossible to determine useful information, such as unit price or quantity, without calling the office for a copy of the actual contract. The most precise detail that FPDS–NG will return for any given item is the Federal Supply Classification (FSC) Code. The Type 90 family of C-E non-rechargeable batteries falls under the FSC Code 6135, which is the classification for all non-rechargeable batteries. Therefore, the procurement data collected for this study from FPDS-NG consisted of all DoD contracts, with the FSC Code of 6135, purchased from the five aforementioned vendors.

Regarding C-E non-rechargeable battery purchases, any DoD agency can establish a new contract or make a purchase order against an existing contract from any one of these vendors. This type of activity makes purchasing extremely convenient at the individual office level but ultimately costly at the DoD enterprise level.

D.   Spend Analysis

In *Spend Analysis: The Window into Strategic Sourcing,* Pandit and Marmanis (2008) propose that a thorough spend analysis would enable an organization to answer the following types of questions:

- What was the corporate-wide spend associated with each cost center last year? Does the aggregate amount enable me to increase leverage with suppliers?

- What are the top commodities? What has the spend trend been over the last few years? Which of these commodities represent opportunities for spend reduction?

- Which suppliers are the most valuable and strategic?

- How much is spent with preferred suppliers? How much is spent with poorly performing suppliers?

- What percentage of spend is associated with contracts?

Figure 6 graphically represents all DoD purchases from January 2000 through August 2009 (with the FSC Code of 6135) from the five C-E non-rechargeable battery manufacturers.
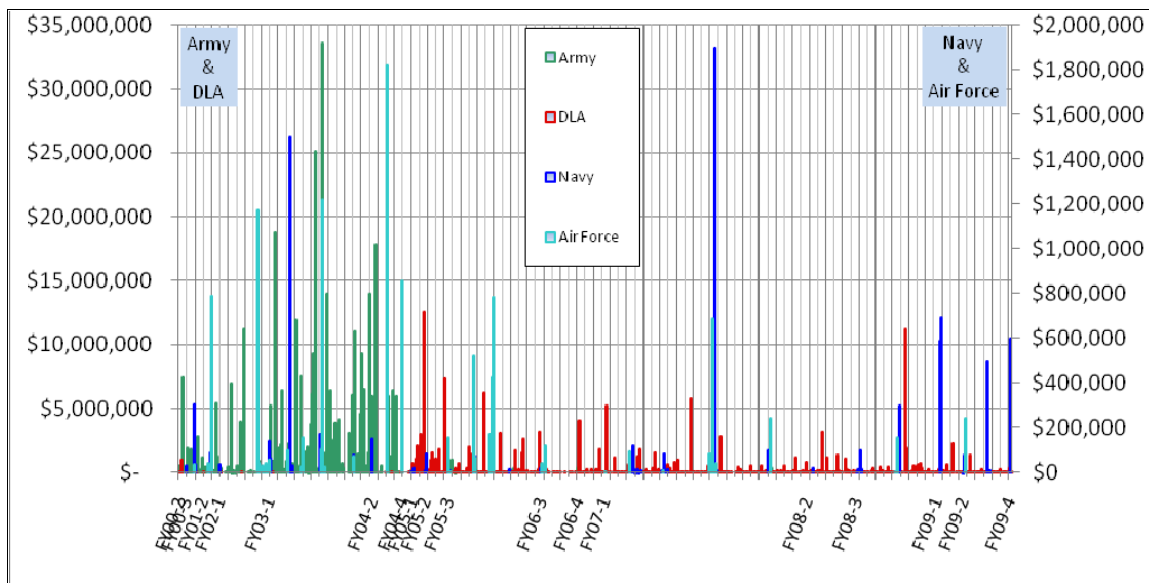

Figure 6.   FPDS-NG Data for C-E Non-rechargeable Batteries
(Federal Procurement, n.d.)

This study of FPDS-NG data yields the following results:

- The Army and Defense Logistics Agency (DLA) made the greatest number of purchases in terms of total dollar amounts and the largest purchase amounts for a single contract, and also had the highest total number of transactions.

- As expected, most of the Army activity occurred from FY 2002-FY 2004, at the beginning of Operations Enduring Freedom and Iraqi Freedom.

- Army purchasing activity tapered sharply after FY 2004. The bulk of DLA activity occurred from FY 2005 to the present.

- All DoD agencies make battery purchases with these companies, thus increasing transaction costs. There does not appear to be an overarching procurement strategy.

- A 2004 Research and Development (RAND) study that applied a spend analysis to all Air Force purchasing in order to help the Air Force in its purchasing and supply management made similar observations based on FPDS-NG data.

- Procurement offices execute more than 800 contracts per year, in more than 200 Federal Supply Classes, with more than 400 contractor codes. As a result, operational procurement personnel may have difficulty becoming expert with specific industries or contractors. (Moore, Cook, Grammich & Lindenblatt, 2004 p. ix)

- 34% of contractor ID codes have multiple contracts with the Air Force. Because many Air Force suppliers have multiple contractor ID codes, this percentage actually underestimates the number of multiple contracts with the same company. For companies with multiple contracts, the Air Force is paying (through higher prices) for the contractor's repetitive bidding and contract administration costs. (Moore et al., 2004 p. ix)

- Many purchase-office codes are associated with the same contractor. Buyers indirectly pay each contractor's administrative and marketing costs associated with selling its services to more than one unit of the buying enterprise. The decentralized Air Force purchasing structure leads to 24% of contractor ID codes selling to more than one Air Force purchase office code. (Moore et al., 2004 p. ix)

E. Purchasing Approach

In order to leverage its buying power, the DoD's battery procurement activity should resemble the Kraljic (1983) Purchasing Model. This approach "provides a systematic framework for incorporating environmental and other strategic factors into

corporate procurement strategy formulation for purchased products and material" (Rendon, 2005, p. 7). Figure 7 illustrates Kraljic's purchasing model.
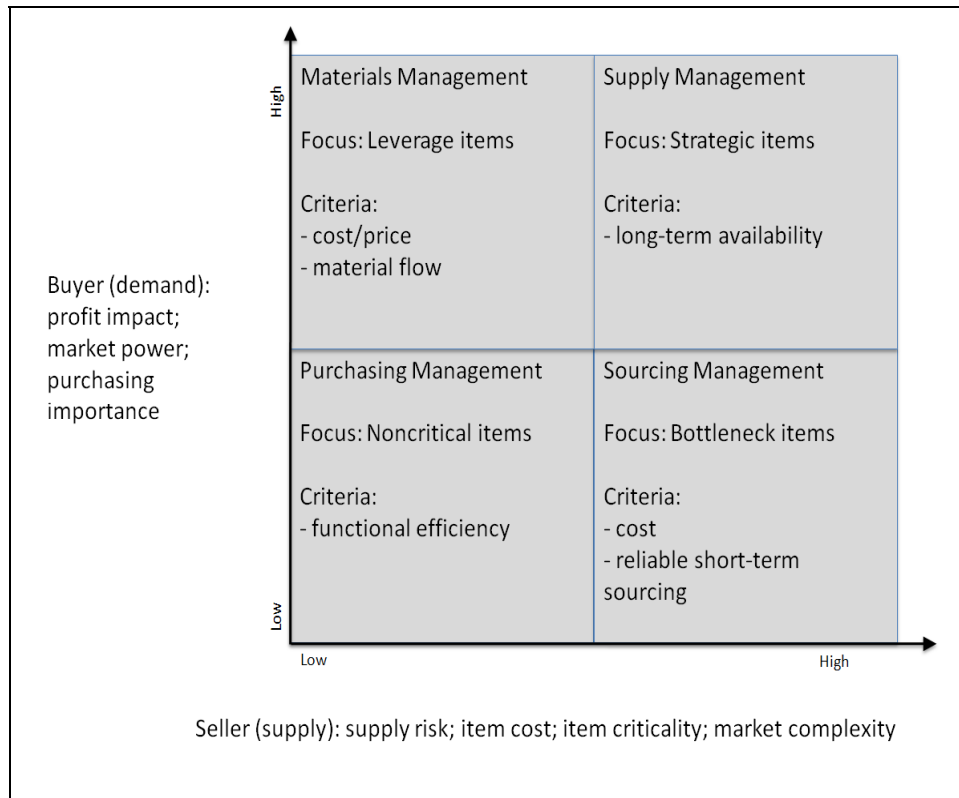

Figure 7. Kraljic Purchasing Model Approach
(Kraljic, 1983, p. 111)

A GAO report published in April 2005 detailed the market characteristics of the Type 90 family of batteries. Prior to 2002, Saft manufactured all the BA-5590 batteries for the DoD. In late 2002, the increase in operations tempo caused by Operations Enduring Freedom and Iraqi Freedom created a surge in demand that resulted in a critical shortage of the BA-5590. In response to the shortage, CECOM, the Type 90 battery manager for the DoD, contracted additional battery manufacturers: Eagle-Picher Technologies to deliver the BA-5590 and Ultralife to deliver the BA-5390, a longer lasting BA-5590 substitute. The DoD also made a $5 million investment to all three producers in 2003 and established a war-reserve

requirement of 1.5 million batteries comprised of both the BA-5590 and the BA-5390 (GAO, 2005, April). Additionally, in 2004, the Deputy Under Secretary of Defense for Logistics and Materiel Readiness transferred battery inventory management authority from CECOM to DLA (GAO, 2005, April).

The GAO report listed four related conditions as the key causes for the battery shortage: inadequate war reserve requirements, inaccurate forecasted requirements, lack of full funding, and acquisition delays due to industrial-base limitations (GAO, 2005, April). However, in March 2004, Science Applications International Corporation (SAIC), in a DoD-sponsored assessment of the logistics situation in Iraq, reported that a "limited industrial base [w]as the primary cause of the BA-5590 battery shortage."

Until stable replacement technology matures, the Type 90 battery will continue to be critical to the warfighter. The April 2005 GAO report demonstrated that the Type 90 battery family has a high purchasing importance, relatively limited supply base, and low-to-moderate market complexity. This would classify the Type 90 battery as a "strategic item" within the Kraljic purchasing model. As Dr. Rendon suggests in his 2005 report on Commodity Sourcing Strategies, "[s]trategic items require extensive market and vendor analysis, accurate product forecasting, and the establishment of long-term supplier partnerships" (Rendon, 2005, p. 300).

Failure to adequately plan for an immature combat theater scenario results in unnecessary costs for procurement transactions and additional costs for transportation. In the future, DoD purchases of Type 90 batteries should be strategically planned and coordinated to take advantage of the procurement strategies for leverage items. Using purchasing leverage now will save costs and position the DoD for future savings as battery technology develops.

F.   Recommendations

The spend data revealed a surge in battery-purchasing activity at the onset of combat operations in Iraq, as well as various uncoordinated purchases occurring over the next five years. This data also reveals a flaw in the planning and forecasting process, which results in unnecessary costs. The following recommendations will help to reduce the number of flaws in DoD's current procurement planning methods for Type 90 batteries.

First, battery purchasing should occur at a central office. This requirement would reduce the transaction costs and increase the leverage of the buyer (DoD) on the industry. As the Air Force RAND study stated:

If many purchase office codes are purchasing the same commodity, or if there are many separate contracts for the same commodity, the Air Force may be able to consolidate these purchases into fewer contracts and benefit from economies of scale with its suppliers as well as reduce its transaction costs. (Moore et al., 2004, p. 60)

Second, given the increased reliance on portable power sources, contracting strategy should be considered in the planning process prior to a) initially engaging in an immature area of operations or b) producing a new system dependent on portable power. Procurement strategy and forecasting for batteries (and for other sources of delivered energy) will not be perfect, but they should be proactive.

Third, logistics planners should incorporate a procurement strategy for the long term. This approach would mean planning for purchasing equipment and supplies in a mature theater of operations or purchasing spares over the lifecycle of a system. Proactive planning for purchasing will ultimately reduce and control transaction costs.

G.   Conclusion

This chapter discussed procurement factors that contribute to the FBCB. Though they seem unrelated to energy awareness and lifecycle modeling, the viability of the battery industry and the purchasing approach of the DoD can ultimately help or hinder the process of putting portable energy in the hands of the warfighter.

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IV.   Fully Burdened Cost of Batteries Methodology

Our analysis of the Fully Burdened Cost of Batteries (FBCB) builds upon the Fully Burdened Cost of Fuel (FBCF) methodology mandated in the *DAG*. The Fully Burdened Cost of Batteries (FBCB) is defined as the cost of batteries as delivered from the manufacturer to the Department of Defense Logistics Agency, plus the ensuing cost burdens accrued in the logistics of delivery, use, and disposal. In this thesis, we attempt to modify the FBCF methodology described by USD(AT&L) to develop a methodology that applies to the Fully Burdened Cost of Batteries within the AoA. We then apply this methodology to wartime and peacetime scenarios to determine how the fully burdened lifecycle cost of a battery impacts the total cost of a military system. Figure 8 is a pictorial representation of our methodology.
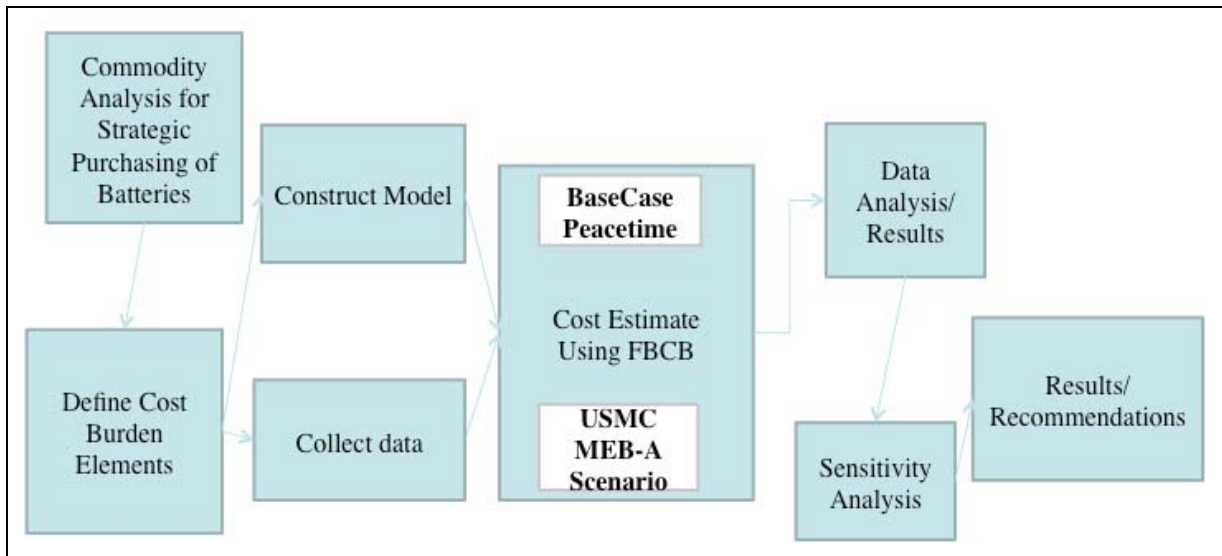

Figure 8.   Methodology of This Study

A.   Research Questions

The primary aim of this study is to determine a methodology for analyzing the FBCB for use in the Analysis of Alternatives of a DoD system acquisition.

Secondary questions this study will attempt to answer are as follows:

(1)   What cost elements can be used to determine the fully burdened cost of a battery?

(2)   What model or models can be developed to simulate the lifecycle of batteries within defense systems?

(3)   How does analysis of the battery as a commodity drive the procurement strategy?

B.   Limitations of Fully Burdened Costs

Fully burdened costs are scenario dependent. That is to say, the costs are only valid within the scenario being modeled. For example, there is no set cost for fuel to a forward operating base (FOB) in Iraq or Afghanistan. Every situation will be different based on the scenario; therefore, costs will be different.

Numbers generated from fully burdened costs should never be taken as definitive. Because a wartime scenario shows that it will cost, for example, $11.53 per fully burdened gallon of fuel to run a FOB in Operation Enduring Freedom (OEF), this number should not be used as the absolute cost of fuel in OEF. Because of the scenario-specific nature of fully burdened costs, they are most useful for trade-space analysis. The number derived from a fully burdened cost analysis is useful for comparing costs and benefits of different systems and battery types within the scenario being modeled.

Scenarios need to be standardized for AoAs in order to demonstrate the true benefits and costs within the tradespace. Currently, no standardized, unclassified scenarios exist. Unless standard "plug and play" scenarios are developed, the fully

burdened costs developed for tradespace analysis will have limited applicability across different scenarios; however, our methodology is general and the calculations are computationally efficient so as to allow many specific analyses to be conducted in a relatively short period of time.

The fully burdened price is equal to the assured delivery price multiplied by the energy demand of a system. In many instances, once the assured delivery price is established, the fully burdened cost may be of little use when compared to other similar systems. The most useful measure of assured delivery price comes when you have systems with differing energy demands within the tradespace.

C.   Limitations of this Study

This study is limited to modeling the lifecycle and fully burdened costs of the BA-5590A/B batteries. Other 90-series batteries present an enticing object of study, but due to the similarity of non-rechargeable 90 types, this study focuses on the ubiquitous non-rechargeable battery.

Models are never meant to capture all the complexities of real-life situations. The researchers desired to create a methodology that can be used to analyze fully-burdened costs of batteries. The outcome of this methodology will not result in a budgetary number that can be placed in a budget for battery costs. The resulting number will be one that can be used for analysis, i.e. it will be a scenario-based amount that can only be compared to other battery systems whose fully burdened costs were determined using the same methodology and scenarios. The model, though, presents a way to implement a general methodology that can be used for further analysis in fully-burdened energy costs.

D.   Battery Burden Elements

In order to estimate the direct and indirect costs associated with batteries, we utilized the FBCF methodology as a base model to develop the direct and indirect costs associated with batteries. The cost elements we have derived to apply FBCB are detailed in Table 5.

Table 5.   Battery Lifecycle Burden Elements

Symbol	Cost Element Name	Description
CE_1	Acquisition Costs	Transaction costs for purchases made through DLA and Services
CE_2	Transportation	Apportioned costs of air, maritime, and ground modes of shipping
CE_3	Depreciation	Shipping and storage asset depreciation
CE_4	Storage	Apportioned cost of storage infrastructure. The dissipation cost is the average time a battery spends in storage times the energy dissipation rate.
CE_5	Disposal Costs	Environmental costs and asset recovery costs related to disposal (already included in 30% of the purchase price of BA-5590).
D	Demand	Cost per unit of power output. Weight cost of the battery asset on the system. Total demand of the system on the battery after the Assured Delivery Price has been calculated.

Figure 9 depicts the flow chart that models the lifecycle of a battery under study. This flow chart is the basis for the mathematical model the researchers will devise to estimate the fully burdened cost of the battery.
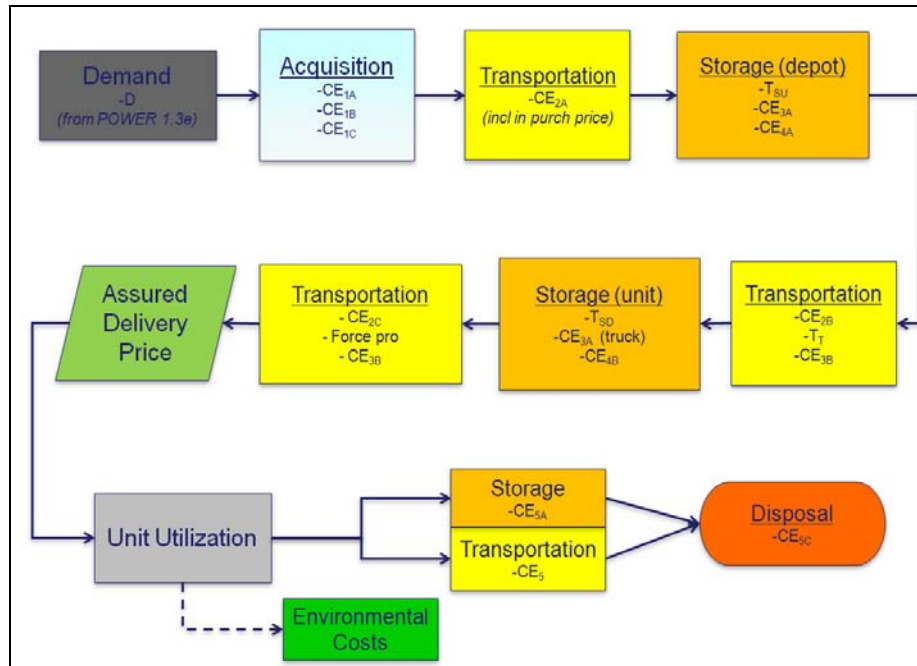
Figure 9.   Fully Burdened Lifecycle Cost Inputs

E.   FBCB Burdens

The battery's fully burdened cost elements are based on the FBCF burden elements from ODASA–CE. We have changed them to reflect the variable nature of battery types, the lack of dedicated transport vehicles for batteries, the more complicated acquisition process for batteries, and the variable nature of battery usage. The six burden elements are as follows: Acquisition, Transportation, Depreciation, Storage, Disposal, and Usage.

1.   Demand (D)

System demand feeds the model. It is used to determine how many batteries will determine an ADP and the fully burdened cost of running batteries in a particular system for an operating period. Demand, or the number of batteries required, is dependent on the situation of the user, temperature, the system being powered by the battery, and the number of times a battery is replaced in a system. For this

analysis, we developed two very specific scenarios that fine tuned the inputs to make FBCB calculations. The scenario usage data we derived is based upon demand data we received from US Army Communications-Electronics Command (CECOM) based upon their analysis of BA-5590 Battery usage. In particular, we used a spreadsheet tool developed by CECOM called the Power Optimizer For the Warfighter's Energy Requirements (POWER) version 1.3e. Appendix C describes POWER and how we used it to determine battery demand.

2. Acquisition Costs (CE_1)

We determined the acquisition costs for our battery system by analyzing purchasing data for the BA-5590 from FY 2000 to 2009. We selected this time period because of data availability. Additionally, this period coincides with the Global War on Terror, thus incorporating increased military operational tempo (OPTEMPO). Both DLA and the individual services purchased batteries during this time period. This analysis includes purchases to be to a FOB destination. This means the shipping costs were built into the unit price of the battery (Gietter, 2010). DLA's published unit price, or the price that it charges units, can be found in the Army Material Data File (AMDF). As the analysis will show, this price is significantly higher than the unit price that the manufacturer charges. DLA would not reveal its additional cost burdens nor the rationale for the additional cost burdens. In order to determine more realistic cost burdens, the researchers used the manufacturers contract price instead of the AMDF price.

In order to determine Acquisition Costs, we broke them into three sub-elements. These were Purchase Price, Transaction Costs, and Proprietary Cost Factor

a.   Purchase Price (CE1A)

The purchase price of the battery system should be the amount paid by the Department of Defense for each individual system. For many systems, though, this is difficult to determine, especially since each system's cost can fall as more systems are produced.

Saft produces the BA-5590 B/U battery, both with and without the status of charge indicator (SOCI). From FY2000 to the present, the DoD used three primary contracts to purchase the battery from Saft. Table 6 displays the details for the contracts.

Table 6.   BA-5590 (without SOCI) Contract Data
(Saft and FPDS–NG).

Contract	Period (FY)	Quantity*	Unit Price* (FY$2000)
1	2000-2002	350,000	$60
2	2003-2007	2,000,000	$55
3	2008-present	37,000	$50

*All figures are rounded estimates of actual DoD contracts. The authors have the actual data but cannot publish it because it is proprietary.

Contracts 1 and 2 were both administered by the US Army Communications and Electronics Command (CECOM) in 1999 and 2002, respectively. The Army made 11 delivery orders against Contract 2. In FY2005, the DoD transferred all of CECOM's contracting activity to DLA after closing the contracting office of Fort Monmouth, NJ through the Base Realignment and Closure (BRAC) process. DLA administers Contract 3.

Table 7 below outlines the price difference between what DLA purchased and what DLA charges to the services. Since FY2000, DLA has charged its customers

an additional 45% over the original purchase price. For the purposes of this study, the fully burdened price of batteries will begin with a unit price of $54.73. This is based on a weighted average using ten years of proprietary unit prices and contract quantities given to the researchers by Saft.

Table 7.   AMDF and Saft Unit Price Comparison
(Saft and DLA)

*All figures are rounded estimates of actual DoD/Saft contracts. The authors

FY	AMDF unit price (FY00$)	Saft unit price* (FY00$)	% difference (AMDF/Saft*)
FY00	N/A	$60	
FY01	N/A	$60	
FY02	N/A	$60	
FY03	$79.80	$55	145%
FY04	N/1A	$55	
FY05	$72.29	$55	131%
FY06	N/A	$55	
FY07	N/A	$55	
FY08	$80.83	$50	162%
FY09	$83.24	$50	166%
FY10	$58.91	$50	118%
AVG	$75.01	$54.73**	145%

have the actual data but cannot publish because it is proprietary.

**Average unit price calculated using actual proprietary data.

b. Transaction Cost (CE$_{1B}$)

The transaction costs for this report will be based on E. Cory Yoder's definition and application of transaction costs:

- Contract actions using large Simplified Acquisition Procedures (SAP) protocol—as outlined in *Federal Acquisition Regulation* (*FAR*) Part 13—use approximately 9 hours of touch time. (Yoder, 2006, pgs. 24-25)

- Contract actions using large-contracting procedures—typically *FAR* Parts 14 and 15—take approximately 200 hours of touch time. (Yoder, 2006, pgs. 24-25)

- Transaction costs are derived by taking the "average loaded hourly salary rate for an 1102 Contract Specialist of $50" and multiplying it by 9 hours or 200 hours, depending on the contract type. (Yoder, 2006, pgs. 24-25)

The following table details the transaction costs for the DoD contracts with Saft for the BA-5590. For the purposes of this study, the average transaction cost per battery will be $0.12, based on the average cost per battery for all three contracts across ten years.

Table 8. Contract Transaction Costs
(Saft and FPDS–NG)

Contract	Base Cost	Delivery Orders	Delivery Order Cost	Total Cost	Batt qty*	Cost per batt
1	$10,000	2	$900	$10,900	350,000	≈$0.03
2	$10,000	11	$4,950	$14,950	2,000,000	≈$0.01
3	$10,000	5	$2,250	$12,250	37,000	≈ $0.32

*All figures are rounded estimates of actual DoD/Saft contracts. The authors have the actual data but cannot publish because it is proprietary.

c.   Proprietary Cost (CE$_{1C}$)

We developed a proprietary cost factor so that our methodology could compare two different types of batteries in an acquisition Analysis of Alternatives (AoA) process. This cost factor enables us to compare the acquisition costs of two different battery systems by factoring in the effects of risk into the methodology based upon the contract type for the development of the system. For an acquisition of a defense system that is in the AoA stage of the acquisition process, the proprietary factor reflects the amount of risk that the government is accepting due to technology in the system. For a Fixed Price contract, in which the contractor accepts the most risk, the risk factor would be 1.

As for the BA-5590—since it is an existing contract—it also carries a risk factor of 1 (General Services Administration, 2010, part 16.1). For Cost-reimbursement Contracts, in which the government accepts a great deal of risk, the factor increases. This Proprietary Cost Factor is only to be used in the AoA process. Once a system has been produced, the purchase price and the transaction costs of the system will reflect the risk that the contractor and the government incurred (General Services Administration, 2010, part 16.301).

We multiplied the proprietarty cost factor by the purchase price, CE$_{1A}$ in order to determine the cost of CE$_{1C}$.

3.   Transportation Costs (CE$_2$)

In order to determine the transportation costs associated with movement of the BA-5590, we utilized the Marine Corps Format for Life Cycle Cost Estimates from the 1998 Marine Corp Cost Estimating Handbook for estimating transportation costs (MARCORSYSCOM, 1998, p. ANNEX C). This source gives a comprehensive and integrated analysis of the transportation costs within a lifecycle cost estimate. Additionally, it computes costs based on a per-unit basis.

The Marine Corps method breaks the transportation cost estimation into two parts: First Destination Costs (FDC) and Second Destination Costs (SDC). The handbook states that "FDC costs are for transportation from the manufacturer to the location at which acceptance occurs," while "SDC costs consist of the cost of transporting equipment between the point of acceptance and location of the using unit." The "location at which acceptance occurs," is the DoD Supply Depot (MARCORSYSCOM, 1998, p. Annex C). As we stated previously in the Acquisition Costs section, sometimes the FDC costs are included in the purchase price.

For our model, we implemented a third transportation cost factor, Tactical Destination Cost (TDC), in order to incorporate shipping to operational units at the tactical edge in our combat scenario. TDC is the transportation cost from the theater port to the unit. Thus, our use of SDC for our combat scenario referred to the transportation of the batteries from Continental United States (CONUS) to the theater port location. For our peacetime scenario, SDC refers to transportation costs from the CONUS depot to the CONUS unit. It was important to create this third transportation cost part due to the inherent complexity in the transportation of the batteries from the theater port to the unit located in a forward, combat location.

The Marine Corps Cost Estimating format estimates the costs of transport in two ways. For CONUS shipping costs, the model uses a formula based upon weight, mileage, and dollar/ton/mile rate. For our analysis, we contacted the DoD's Transportation Command (TRANSCOM) in order to determine shipping rates for batteries (which are classified as hazardous materials (HAZMAT)) within the United States. The authors noted a price of $.70 per pound for orders over 100 batteries. (TRANSCOM, 2010) For outside the continental United States (OCONUS) shipping costs, the Marine Corps method utilizes measurement tons (Mtons), US port handling charges, ocean transport rates, and destination port handling charges with a measurement ton being 40 cubic feet (MARCORSYSCOM, 1998, Annex C). This measurement was calculated by TRANSCOM's Surface Deployment and

Distribution Command (SDDC) using a hypothetical weight of HAZMAT sent from the southeastern United States to the Middle East.

The CONUS and OCONUS transportation costs (FDC and SDC) are relatively easy to determine if the weight to be transported, the distance, and the rate for distance are known. The TDC, however, is a more difficult amount to determine. The transportation that occurs during the TDC phase is usually conducted by Soldiers and Marines and not by contracted personnel. Thus, the cost associated with this transportation is fragmented between the cost of the vehicles transporting the materiel, the cost of the protection for the convoy, and the cost of the personnel who operate the vehicles. Additionally, the convoy would most likely be carrying more than just batteries, so the cost effect on the batteries is proportional based on how many batteries the convoy is carrying.

In order to estimate proportion in our scenario, we used a set number of batteries carried over a certain distance with a specific convoy make-up. We determined the make-up of the convey using an historical convoy observed by the USMC Energy Assessment Team in 2009. To determine the number of batteries in the convoy, we collected data from the Logistic Support Activities' Parts Tracker website to discover the average number of batteries in an order moving from Kuwait to Afghanistan. Additionally, we estimated the amount of other materiel that would be in the convoy. We used cost factors developed by Cole and Blankenship (2010) for force protection and other transportation costs in our determination of TDC costs.

4. Depreciation Cost (CE$_3$)

Depreciation cost is one of the seven price factors to determine the FBCF. (Regnier et al., 2009) As with the Fully Burdened Cost of Fuel, the Depreciation Cost factor for batteries will measure the decline in value of battery delivery and storage assets with finite service lives using straight-line depreciation over total service life.

Depreciation cost analysis, though, need only be done on cost elements that have not already included depreciation costs. For Transportation Costs where the DoD contracts commercial assets for use, it can be assumed that the commercial shipper has already calculated depreciation costs. In contrast, the Defense Logistics Agency, in their storage cost transfer pricing, does not include storage asset depreciation (Smith, 2009). Thus we didn't determine the depreciation for transportation assets from the depot to CONUS-based units, or from ports to overseas depots, because the contracted commercial transportation assets would price this into the amount charged to deliver the batteries. We did, however, determine the DLA storage depreciation costs per battery.

In the tactical environment, though, it is important to determine depreciation costs for the storage and transportation equipment used. For our analysis, we will utilize a specific depreciation formula to determine the depreciation costs of a transportation or storage asset. The formula for an asset is as follows:

% Space taken up by battery x % operational life battery uses x straight-line depreciation over that lifetime.

In order to determine the percent of space used for battery storage or transportation, we used an example storage amount and an example number of batteries to be transported. We based the number to be transported on the demand required to operate a radio system within the scenario. We obtained the number through the US Army's Parts Tracker website for Afghanistan requisitions (US Army Logisitics Support Activity). We based the number of batteries in storage in a location on the average number of batteries in storage at depots around the United States. We were limited in knowing the sites where batteries are stored by available storage data on WEBFLIS, the DLA's enterprise tracking systems (US Army Logistics Support Activity).

We then estimated the length of time that the batteries would spend in storage and input this information into our scenario. Our scenario also gave us the amount of operational life used for transporting the batteries based upon travel distances from forward depot to requisitioning unit.

5.   Storage Costs (CE$_4$)

In order to reduce lead-time as the batteries move from the manufacturer to the receiving unit, there will be a need to store them in preparation for future orders from the field. There are two types of storage scenarios in our methodology: Depot Storage and Unit Storage.

a.   Depot Storage (CE$_{4A}$)

The Defense Logistic Agency (DLA) charges for storage based upon the unit cubic foot of an item and on what type of environment is needed. DLA will store items in open, covered, or specialized environments. Specialized environments are required for hazardous material, flammable items, and high value and sensitive items. The BA 5590 falls under the specialized category (Smith, 2009).

The DLA FY10 annual rates for storage within these environments are as follows:

> Open -------- $4.03 per cubic foot
> Covered ------ $0.39 per cubic foot
> Specialized -- $5.59 per cubic foot

The DLA maintains a database with length, width, and height measurements for each item it stores. These measurements are used to calculate the cubic feet of each item. That number is multiplied by the quantity in storage to obtain what is called the "extended cube" of the national stock number (NSN). Then the storage cost is calculated by multiplying the appropriate storage rate ($5.59 for hazardous

materials, which includes batteries) by the "extended cube" size. This cost represents the annual cost of storing an item at the 25 Defense Distribution Depots, including Kuwait (Smith, 2009, October 20; 2010, February 1)

b. Unit Storage (CE$_{4B}$)

The numbers listed the previous section show the storage costs as the batteries move from the manufacturer to Kuwait. The last stage of storage is the unit storage cost for the battery. In order to determine this cost, we found it necessary to make certain assumptions due to the nature of unit storage costs. A warfighting unit (such as an Army brigade) does not charge or get charged for storage of materiel. The only cost factor that units have when they store items such as batteries is what they give up in order to store the batteries. In order to determine this cost factor, we analyzed a storage space that is universal to tactical units. Since buildings differ in both design and space, it is impractical to use a building as a means of calculating costs. A common storage platform, however, especially when units are on the move, is transportation space. Transportation space in the military is generally on trucks. For most Army units, truck space is in the form of the Family of Medium Tactical Vehicles (FMTV). When a unit chooses to store a battery in an FMTV, it must have determined that the battery was more deserving of that space than whatever else the unit might have stored there. Thus, we can analyze the cost of that space in order to determine the unit cost of storing a battery at the unit level. This is the basis for our assumption that the storage cost of a battery for a military unit can be determined by analyzing the fraction of space used by a battery in an FMTV.

The 2.5-ton Light Medium Tactical Vehicle (LMTV) variant of the FMTV costs $104,626, according to the Army's Master Date File (AMDF) (DLIS, 2010). Using a rough life-cycle cost estimate for Operations and Support costs of 10% of the purchase price per year, over the expected nine-year lifespan of a battery, the lifecycle cost for the vehicle would be $199,784.

The maximum payload for the LMTV is 5000 lbs, allowing the LMTV to carry 2200 of the 2.25lb batteries in its cargo area (BAE Systems, 2009). In terms of capacity, the LMTV can carry 450 ft^3 or 770,000 in^3, which, in term of batteries, is equal to more than the maximum weight battery payload (TACOM, 2005). $199,784/2,200 = $90 per battery, if the LMTV were carrying the batteries for the full nine years. That means a daily cost of $0.02 per battery and a yearly cost of approximately $10 per battery.

c. Dissipation or Loss of Battery Capacity Over Time (CE$_{4C}$)

As a battery is stored over its useful life, its full capacity charge will discharge, even at optimal temperatures. This Cost Element attempts to capture a dollar value for that loss of charge over the useful life of the battery. This Cost Element is measured in dollars per battery.

CE$_{4C}$=DPH*DR*T

Where DPH=CE$_{1A}$/Capacity

Where DR=discharge rate, which is the amount of charge in watt hours lost per month.

Where T=time in days for a scenario under study for fully burdened costs from battery purchase to use.

An example of calculating the CE$_{4C}$ is given with a notional battery (BA-XX90), which has a cost of $100 and a capacity of 1000 watt hours. The battery cost, DPH, is $.10 per watt hour (w-h). If data collected on these batteries show that over five years the batteries lose approximately 30% of their charge. At the end of five years a battery will have on average 700 watt hours of charge left, losing 60 W-h a year or five W-h a month. The operational scenario that this battery is called for

shows that it remains in the Defense Supply system for 15 months until it is used. The cost of this battery's loss of charge over time is $7.50.

6.   Disposal Costs (CE₅)

For disposal cost analysis we utilized previous studies to determine the disposal amount per battery. Ross and Hull documented two methods for disposal of a BA-5590 battery. The first method is hazardous material disposal (for batteries that have a certain amount of charge remaining). The second method is for non-hazardous disposal. Hazardous material disposal is $9.30 per battery in FY 2000 dollars (Ross & Hull, 1999). It is $1.63 per battery for non-hazardous disposal in FY 2000 dollars (Ross & Hull, 1999). One problem with this method, however, is determining if a battery is hazardous or not after a unit finishes using it.

Toxco Corporation conducts disposal of $LiSO_2$ batteries for commercial industries, and in the past it has conducted battery disposal for the DoD. Toxco quoted a price of between $2.50 and $3.50 per pound of batteries regardless of whether the batteries had a charge remaining at the time of disposal. This is a California-based cost per pound (Kinsbursky, 2010). We also contacted Fort Stewart's (Eastern United States) and Fort Lewis's (Western United States) Departments of Public Works Environmental Divisions, which quoted a price of $1.28 per pound for battery disposal (Fort Stewart) and $2.25 per pound (Fort Lewis) (Brown, 2010). Battery disposal cost will depend on the locality of the post doing the disposal (CE_{5c}). The variance between disposal costs is primarily due to the distance the post is from the disposal facility (Brown, 2010). These quoted costs include the cost of transporting the batteries (which is CE_{5b}) from the post to the disposal facility because the contractor transports the batteries for disposal. (Kane, 2010) For Cost Element CE_{5a} storage before disposal costs, we used the unit storage Cost Element amount because the storage would be with the unit until the battery is delivered to the post's environmental site.

7. Environmental Costs

In spite of the hazardous wastes inherently generated by military operations, the US Military Services constantly strive to practice environmental stewardship. This standard is consistent whether in the US or in other countries, during peacetime training or combat operations. Lithium sulfur dioxide batteries, such as the BA-5590, are quite common in military use. Once expended and removed from equipment they are "subject to the hazardous waste regulations of the *Resource Conservation and Recovery Act (RCRA)* due to the presence of un-reacted lithium" (McCarley, 2007). However, the EPA concluded in a 2006 memorandum that expended BA-5590 batteries that have been properly discharged using a Complete Discharge Device (CDD) could be treated as solid waste instead of hazardous waste (Hale, 2006).

From April 1997–April 1998, Ross and Hull studied the BA-5590 usage of US Army units in simulated combat missions at the Joint Readiness Training Center. On average, they found that 29% of the batteries that units turned in had more than 70% life remaining (Ross & Hull, 1999). While this is in no way enough data to determine the voltage or reactivity left in expended BA-5590s in current military operations, it still offers some insight. While there are proper disposal procedures for lithium batteries in Iraq and Afghanistan, it would be safe to assume that young Soldiers and Marines will improperly discard batteries as a matter of convenience, for expediency in the heat of combat, or for any number of reasons. Attempting to determine the exact ratio of improperly discarded batteries to those properly discarded would be outside the scope of this thesis. However, the Ross and Hull study established the idea that some percentage of the improperly discarded batteries carries enough voltage to classify as hazardous waste.

The starting point for environmental costs per BA-5590 would be at least in the $9.00 range. As Ross and Hull determined, this is the average cost associated

with properly disposing of the battery as hazardous waste. By taking into consideration the addition of EPA fines, remediation, and possibly personnel injury, the average environmental cost per battery would certainly increase. For the purposes of this study, the researchers did not determine these cost burdens.

F.   Scenario Development

For our model, we developed two scenarios in order to analyze battery life-cycle costs. Scenario-based modeling is necessary due to the high number of variables. This type of modeling enables us to evaluate complex systems. The Military Operations Research Society Symposium on Power and Energy stated in its out brief:

> To completely determine the impact of a specific change to an operational capability, such as a 10-percent increase in battery life, a single variable approach is not adequate. A flexible, multi-variable system model is required to allow ready definition of the impact of incremental changes to key performance parameters, key system attributes, and attributes. Many capability requirements are interrelated and cannot be adequately assessed independently. Incremental changes in one performance parameter may have significant impact on several other parameters including the logistics related costs. For example, an improvement in battery capacity may allow an item to use a smaller power source, thus providing the opportunity to increase performance or operating time. The increased operating time could impact the required cooling capacity, resulting in a larger space claim or increased power requirement. The impact of this domino effect may be no benefit realized from the improvement in battery capacity. This simple, while maybe not totally realistic, example illustrates the impact that power and energy has on equipment- from large to small, fuel burning to electric powered. (Regnier et al., 2009)

For Fully Burdened Cost of Fuel analysis, we generally used three scenarios: Peacetime, Steady State, and Undeveloped Theater Scenarios (Hull & Roper, 2009, slide 13). For simplicity's sake, but still wanting to demonstrate realism, we chose only two scenarios to demonstrate the methodology. The scenarios we developed

for analysis are a Continental United States (CONUS) peacetime scenario and an Afghanistan-based steady-state scenario.

For both of these scenarios, we made some basic assumptions. First, DLA purchased the BA-5590s from Saft. This means that FDC is included in the purchase price of the battery. Second, the BA-5590s were stored in a Depot Storage location for 365 days.
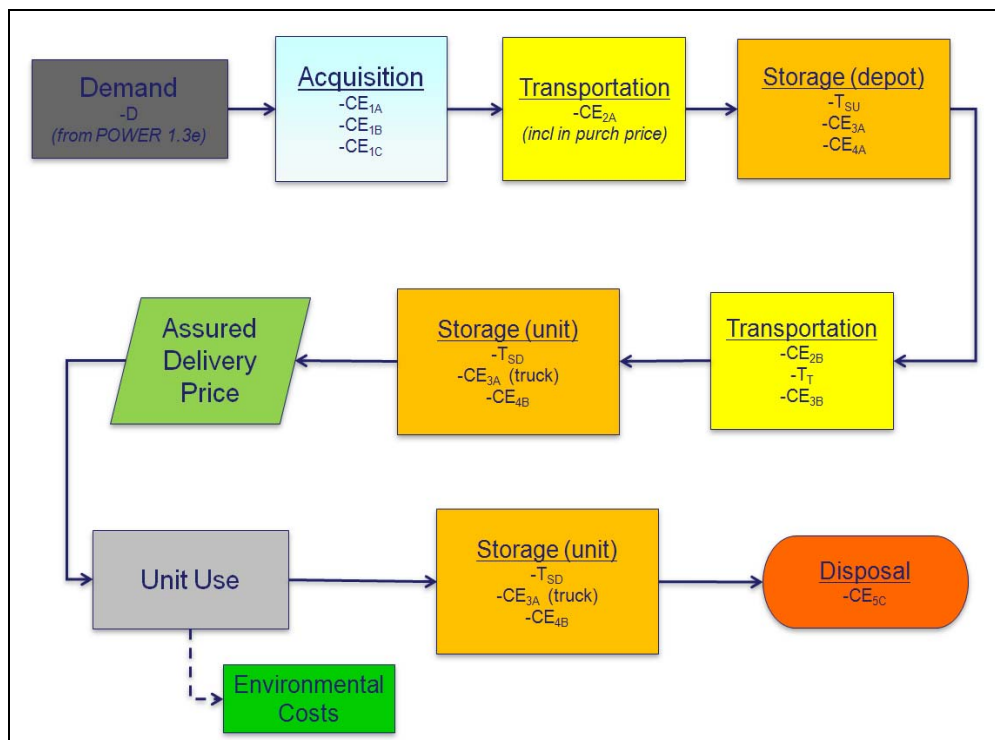
1.   Scenario 1 (Peacetime Training, CONUS)

Figure 10.   Training (CONUS) Scenario

Our CONUS scenario demonstrates the methodology for non-deployed forces conducting peacetime training operations in the United States. Our CONUS Scenario uses a US Army Light Infantry Company at Fort Stewart, Georgia conducting peacetime training operations in and around Fort Stewart for a seven-day period.

We utilized the Army's Modified Table of Organization and Equipment (MTOE) for this Infantry Company to determine the total number of radio systems that utilize the BA-5590 battery. We assumed seven days of operations and that the company was actively involved in field exercises in the Fort Stewart Training Area during this seven-day period of time. The MTOE spells out the number of radio systems that utilize the BA-5590. We used the AN/PRC-117F radio as the system for which this company used BA-5590 batteries in the seven-day mission.

Utilizing CECOM's POWER Calculator (see Appendix C) we were able to determine the number of batteries that the seven-day field-training mission would require. Table 9 provides the output from CECOM's power calculator for our CONUS Scenario. Utilization rates vary and, depending on the scenario, batteries may be used to their maximum run time in the system under observation (the PRC-117F) or for some duration under that run time. Since the authors did not study the BA-5590 with SOCI we included this high and low range of run times.

Table 9.   CONUS Scenario CECOM Power Calculator Output (POWER 1.3e)

Battery: BA-5590B/U (4 per pkg) Device: AN/PRC-117F radio (21 per mission)	# Batteries Required	# Packages to order	Battery Weight (lbs)
Minimum for 1 day mission (chg every 12 hrs)	84	21	189
Minimum for 1 day mission (chg every 18 hrs)	84	21	189
Minimum for 7 day mission (chg every 12 hrs)	588	147	1323
Minimum for 7 day mission (chg every 18 hrs)	420	105	945
Minimum for 30 day mission (chg every 12 hrs)	2520	630	5670
Minimum for 30 day mission (chg every 18 hrs)	1680	420	3780

For this scenario, we made the following assumptions:

- The Light Infantry Company had a Company-level Headquarters set up 15km from the Fort Stewart cantonment area.

- The Company transported its own supplies to the site.

- All company training operations would occur at the Company Headquarters site.

- Assured Delivery Price was determined using a requisition of 1000 Batteries through the Standard Army Retail Supply System (SARSS).

- Batteries were stored in the Unit Supply Room for one month before use.

- Used batteries were stored for another two days after use.

2. Scenario 2 (Operational, OCONUS)
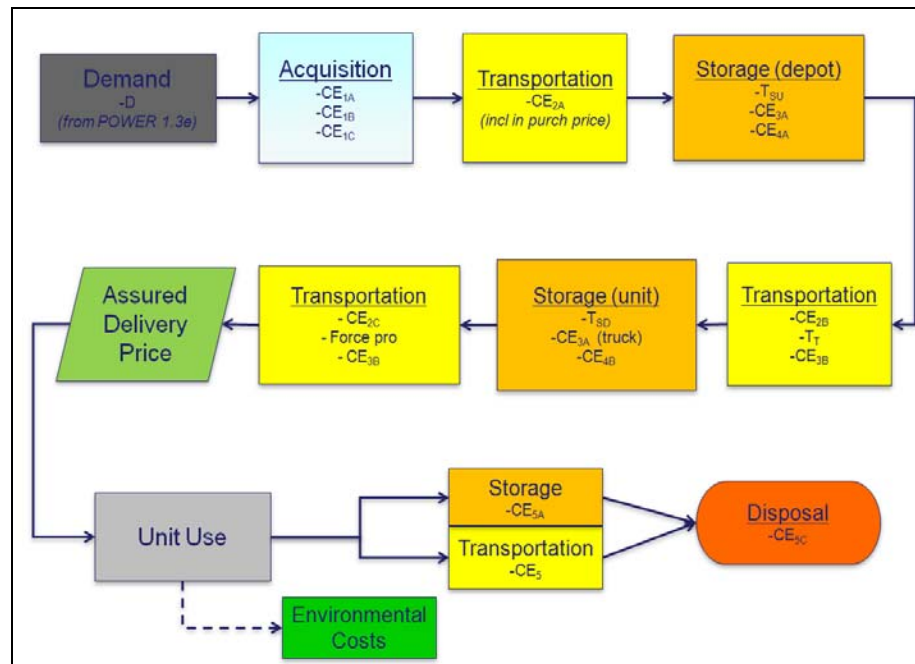
Figure 11.   Operational (OCONUS) Scenario

The operational scenario we chose to model is based on the Marine Energy Assessment Team (MEAT) visit to Afghanistan (Moore et al., 2009). The MEAT team performed an energy use for USMC forces operating in Helmand Province of Afghanistan in September 2009. We chose this scenario because it is also the base scenario that was used by Cole and Blankenship (2010) to determine the FBCF and fully burdened cost of water for OEF operations. Our methodology extends the assumptions these researchers made and the situation modeled to involve a delivery scenario that includes battery replenishment. Therefore we considered the same delivery scenario as Cole and Blankenship. The second scenario further develops burden costs for operational battery use. For this scenario we used a Battalion-sized Marine Corps unit operating in Afghanistan.

a. Scenario 2 TDC

In order to determine the assured delivery price for batteries, we included the price of batteries to the port, the transportation costs to ship the batteries from the US to the theater, the costs to move them from the theater port to a Forward Operating Base, and then the costs to handle and provide tactical delivery of the batteries from the FOB to the Battalion-sized Marine Unit. For security reasons, we will not be naming the bases or units upon which we based our scenario, but the numbers we used are based upon actual distances and basing sites. One key assumption that affects the type and speed of battery transportation into theater is the priority the requisition unit places on the battery order. For our analysis, we assumed a priority of 12 for the batteries ordered. An order priority code provides the supply system with information regarding how quickly the requisition item is needed. A priority 12 code generally allows 50 to 82 days for the unit to receive the requisitioned item (Defense Logistic Agency Training Center, 2010).

Cole and Blankenship's scenario provides a detailed amount of information for the Tactical Delivery Charge (CE_{2c}). We altered their scenario by assuming that we were using the same transportation convoys in theater but instead of analyzing the convoys to determine how their costs affect the ADP for fuel and water, we looked at how the costs affected the ADP for batteries.

Cole and Blankenship (2010) used the following convoy makeup:

- Medium Tactical Vehicle Replacement (MTVR) with mine roller (escort)

- MTVR wrecker (escort)

- Mine Resistant Ambush Protection (MRAP) 6x6 vehicles (escort)

- MRAP 4x4 vehicles (escort)

- MTVRs (for water and other supplies)

- Logistics Vehicle Systems (LVS) (for water and other supplies)

- Fuel tanker truck (M970)

For our scenario, we made the assumption that the batteries escorted from the FOB to the Battalion-sized unit would be transported on a MTVR within this convoy, replacing an MTVR that was transporting pallets of water bottles.

Cole and Blankenship's scenario included the overall cost for transporting water for 35 miles in a tactical environment. We used their scenario to determine the average cost of transporting water on an MTVR. We then transposed that cost onto a vehicle transporting batteries and determined the number of batteries an MTVR can carry. We divided the cost of the vehicle by the number of batteries to come up with the cost to transport one battery in the 35-mile convoy.

This cost was combined with the commercial cost of transporting the batteries from the port of Karachi to a logistics base in Afghanistan. The Surface Deployment and Distribution Command provided us with the cost to move one 20-foot ISO container from Karachi to the resupply point. We used this information to calculate a cost per battery to move it from Karachi to the logistics base. We came up with a cost of between $.18 and $.31 cents per battery for this movement, depending on the commercial transportation company used for the freight movement (Sitts, 2010). The cost to move the batteries from Karachi to the Battalion-sized Marine Corps unit comprises the Tactical Delivery Charge for our burden analysis.
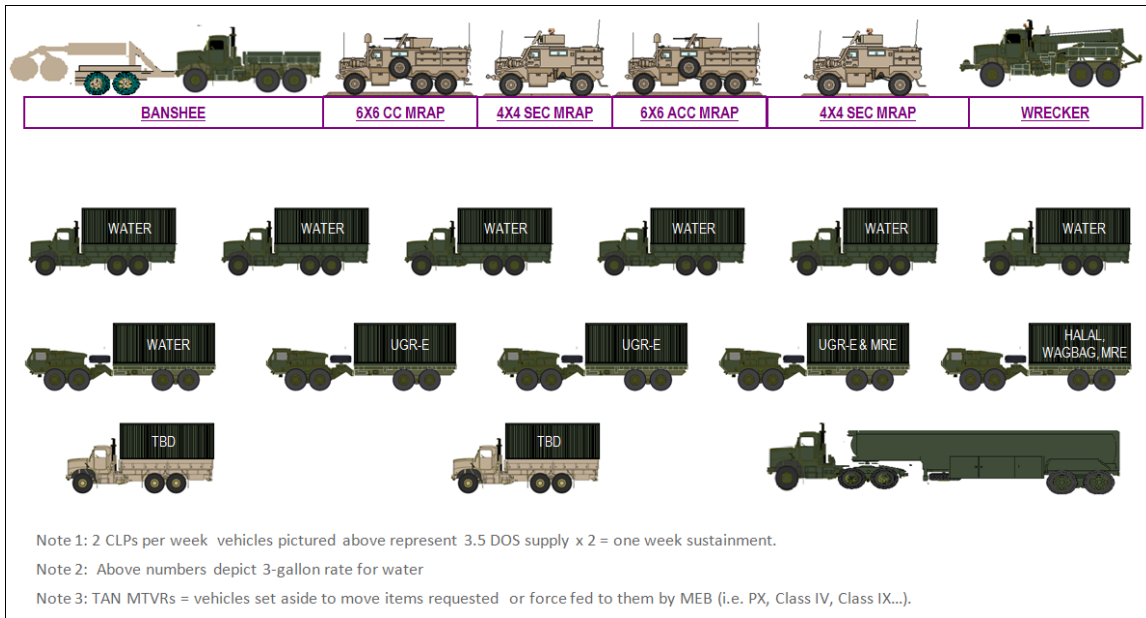
Figure 12. Tactical Convoy for Scenario 2
(Moore, Newell, Nolan, Dickson, Barnet & Alderman, 2009)

b.   Scenario 2 Demand

Utilizing CECOM's POWER Calculator (see Appendix C) we were able to determine what the seven-day Scenario 2 mission would require. Table 10 provides the output from CECOM's power calculator for Scenario 2. The table includes two rows: the top row is based upon changing out the batteries every 18 hours, while the second row is calculated based on changing out the batteries in the radios every 12 hours. Utilization rates vary and, depending on the scenario, batteries may be used to their maximum run time in the system under observation (the PRC-117F) or for some duration under that run time. Since the authors did not study the BA-5590 with SOCI we included this high and low range of run times.

c. Scenario 2 Assumptions

- The PRC-117 radio was used over a seven-day period, operating 24 hours per day.

- The unit's density of PRC-117s as the same as reported in the Mechanized Allowance List.

- Batteries sent via truck from depot to port using a commercial trucking company. Then shipped via commercial maritime cargo transport from a Southeast US port to the port of Karachi, Pakistan. From Pakistan the batteries were shipped via contracted commercial trucking to the Supply Support Activity supporting the unit we observed. TDC shipping to the final destination was via tactical convoy.

Table 10.   Scenario 2 CECOM Power Calculator Output (POWER 1.3e)

Battery: BA-5590B/U (4 per pkg) Device: AN/PRC-117F radio (46 per mission)	# Batteries Required	# Packages to order	Battery Weight (lbs)
Minimum for 1 day mission (chg every 12 hrs)	184	46	414
Minimum for 1 day mission (chg every 18 hrs)	276	69	621
Minimum for 7 day mission (chg every 12 hrs)	1288	322	2898
Minimum for 7 day mission (chg every 18 hrs)	1932	483	4347
Minimum for 30 day mission (chg every 12 hrs)	5520	1380	12,420
Minimum for 30 day mission (chg every 18 hrs)	8280	2070	18,630

G.   Analysis and Results

1.   Scenario 1 FBCB Results

a.   Base Case

The base case shows that fully burdened costs of the BA-5590 in this scenario are 9.3% of the contract price of the batteries. A summary of the fully burdened costs can be found in Table 11. An assured delivery price of $59.83 in the

POWER calculator multiplied by a low- and high-limit use for batteries in the scenario yields the fully burdened price. Total battery cost in this scenario ranges from $25,127 to $35,172. The range in this scenario is determined solely by the runtime of the system. The lower price range assumes that all batteries are used to 100% of their capacity by the users—the full 18-hour run time available. The upper range assumes a user will only utilize 67% of battery capacity before changing out the battery in the system.

Table 11.   Scenario 1 Base Case Fully Burdened Cost Summary (FY00$)

			Lower Use Limit	Upper Use Limit
CE_1	CE_{1A}	Purchase Price	54.73	54.73
	CE_{1B}	Transaction Costs	0.12	0.12
	CE_{1C}	Proprietary Costs*	0.00	0.00
CE_2	CE_{2A}	FDT Transportation	#	#
	CE_{2B}	SDC Transportation	1.31	1.31
	CE_{2C}	TDC Transportation	##	##
CE_3	CE_{3A}	Storage Asset Depreciation	0.24	0.24
	CE_{3B}	Trans Asset Depreciation	0.02	0.02
CE_4	CE_{4A}	Depot Storage	0.14	0.14
	CE_{4B}	Unit Storage	0.88	0.88
	CE_{4C}	Dissipation	0	0
CE_5	CE_{5A}	Storage before Disposal	###	###
	CE_{5B}	Transportation to Disposal	####	####
	CE_{5C}	Commercial Disposal	2.39	2.39
		Total Burden costs (CE_{1B} to CE_{5C})	5.10	5.10
	ADP	**Assured Delivery Price**	**59.83**	**59.83**
	DEMAND	Batteries demanded	420	588
	FBCB	**Fully Burdened Battery Costs**	**25,127.01**	**35,177.81**
	1.00	*Proprietary factor		
	#	Covered in FOB contract, part of CE_{1A}		
	##	No tactical delivery in CONUS scenario		
	###	Incorporated into Unit Storage, CE_{4B}		
	####	Incorporated into Commercial Disposal, CE_{5C}		

Disposal costs make up the largest percentage of the assured delivery price, with commercial disposal accounting for 47% of the $5.10 of additional burdens on the purchase price of the battery. Figure 13 shows the largest burden elements and the percentage of total cost burdens they make up.
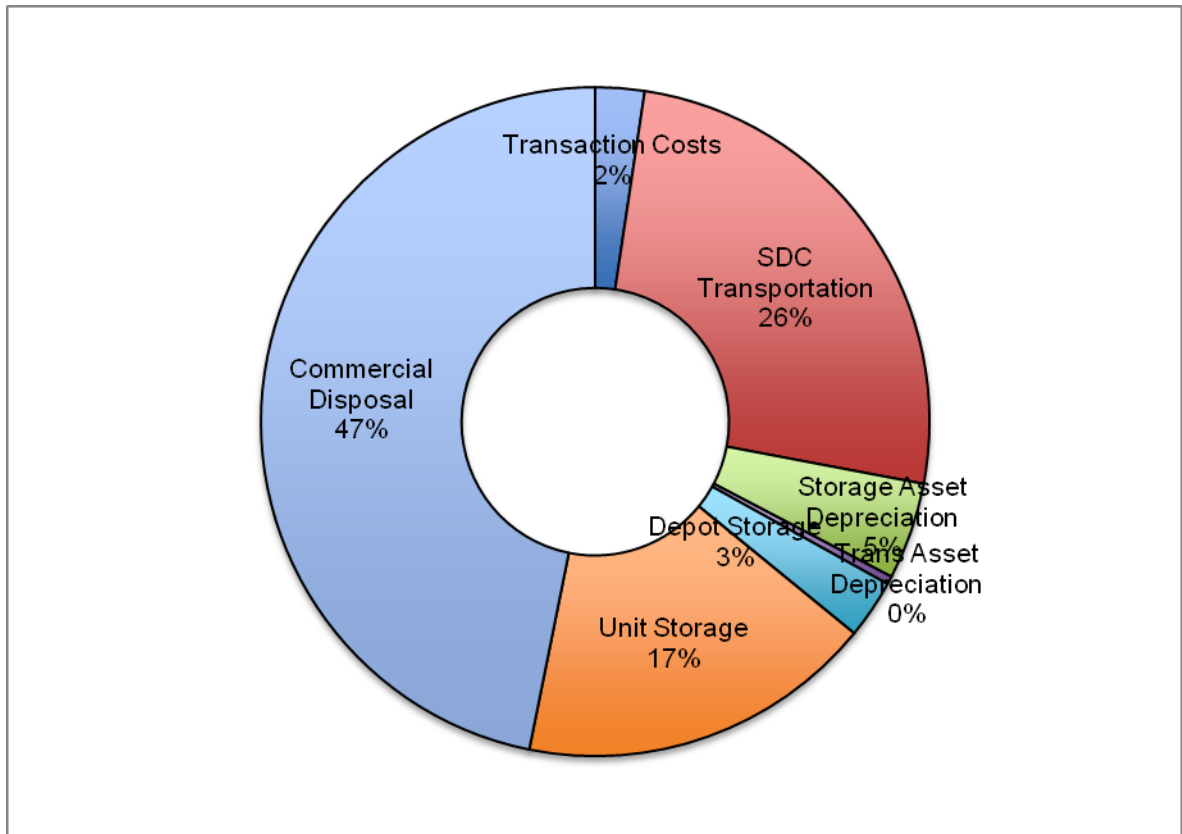

Figure 13. Scenario 1 - Cost Elements as Percent of Total Burdens,(FY00$)
(Note: non-zero burdens only)

b. Sensitivity Analysis

Mod 1 uses the higher disposal costs associated with recycling lithium batteries in CONUS. The battery disposal contract we observed at the scenario location had a lower disposal price than others (Kane, 2010). A modification to this scenario was to input the average quoted disposal price from one of the major

lithium battery recyclers in CONUS (Kinsbursky, 2010, March 25; Brown, 2010, March 30). This increases the cost of CE_{5C} to \$5.59 from \$2.39 (Table 12). The percentage of disposal costs on the full burdens jumps to 67% of the assured delivery price (Figure 14).

Table 12.   Scenario 1 Fully Burdened Cost Mod 1 (FY00\$)

			Lower Use Limit	Upper Use Limit
	CE_{5A}	Storage before Disposal	###	###
CE_5	CE_{5B}	Transportation to Disposal	####	####
	CE_{5C}	Commercial Disposal	5.59	5.59
		Total Burden costs (CE_{1B} to CE_{5C})	8.30	8.30
	ADP	**Assured Delivery Price**	**63.03**	**63.03**
	DEMAND	Batteries demanded	420	588
	FBCB	**Fully Burdened Battery Costs**	**26,473.99**	**37,063.58**
	###	Incorporated into Unit Storage, CE_{4B}		
	####	Incorporated into Commercial Disposal, CE_{5C}		
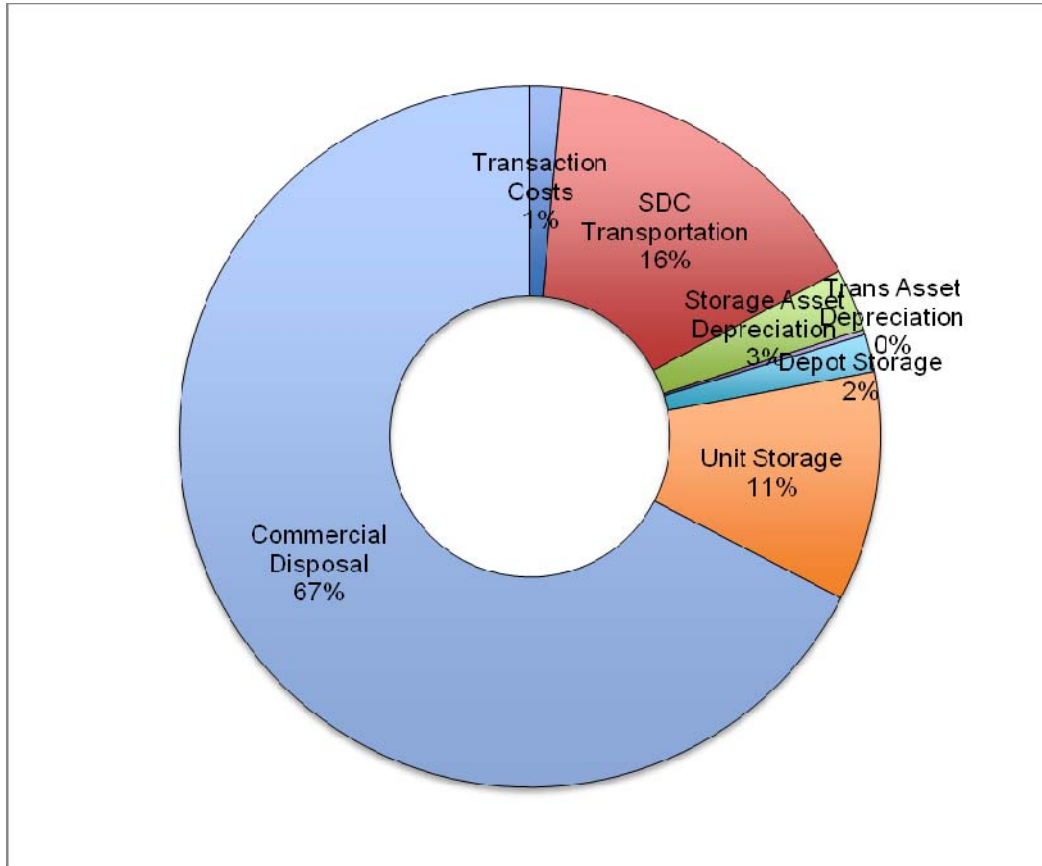
Figure 14. Scenario 1 Mod 1 Cost Elements as Percent of Total Burdens (FY00$)
(Note: non-zero burdens only)

Mod 2 replaces all disposal costs with environmental costs. Reductions in the numbers of batteries disposed of through contracted and proper means would also lessen the cost burdens. However additional environmental impacts would arise from improper disposal. Again, this thesis does not quantify those issues. Mod 2 looked at replacing all disposal costs in the scenario. Table 13 shows the changes in the ADP from this Mod.

Table 13. Scenario 1 Fully Burdened Cost Mod 2 (FY00$)

			Lower Use Limit	Upper Use Limit
CE$_5$	CE$_{5A}$	Storage before Disposal	###	###
	CE$_{5B}$	Transportation to Disposal	####	####
	CE$_{5C}$	Commercial Disposal	0.00	0.00
		Total Burden Costs (CE$_{1B}$ to CE$_{5C}$)	2.71	2.71
	ADP	**Assured Delivery Price**	**57.44**	**57.44**
	DEMAND	Batteries Demanded	420	588
	FBCB	**Fully Burdened Battery Costs**	**24,124.61**	**33,774.45**
	1.00	*Proprietary Factor		
	###	Incorporated into Unit Storage, CE$_{4B}$		
	####	Incorporated into Commercial Disposal, CE$_{5C}$		

Figure 15 shows that when disposal costs are eliminated, the largest elements contributing to the ADP are unit storage costs (33% total cost burdens) and SDC transportation costs (48% of total cost burdens). The burdens that make up the ADP total only 4.95% of the purchase price in this scenario.
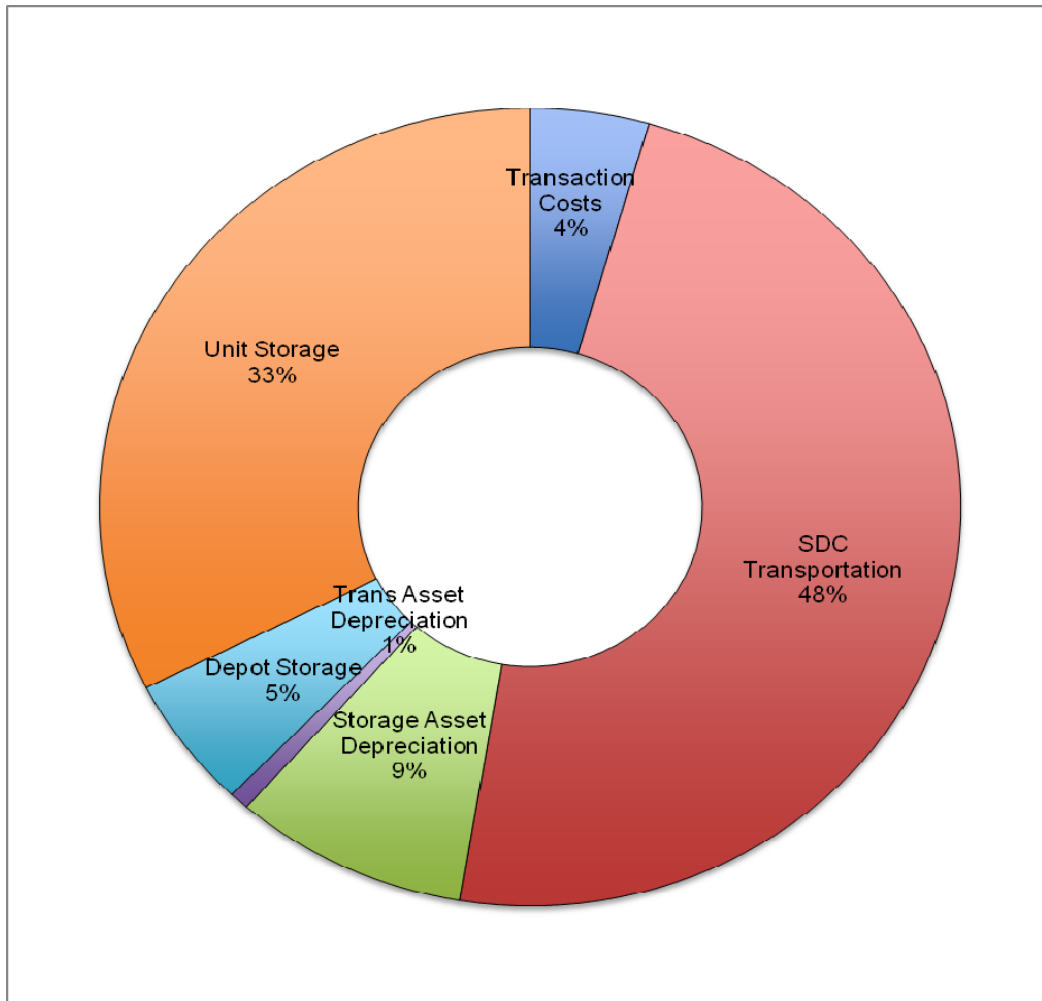
Figure 15. Scenario 1 Mod 2 Cost Elements as Percent of Total Burdens
(Note: non-zero burdens only)

For Mod 3, we attempted to analyze changes in shipping and storage methods. However, none of these methods changed the fully burdened base case by more than 1%. Adjusting the purchase price of the batteries displays a lower percentage of the overall burden.

Figure 16 shows the percentage of the burdens on the purchase price with two price points highlighted—the contract price derived by the authors and the AMDF or FEDLOG price charged by DLA averaged over 10 fiscal years. As CE_{1A}

(the purchase price) increases in the base case, the percentage of the additional cost burdens on that price decreases. At the AMDF price, burdens decrease to 6.8% from 9.83% of the purchase. The AMDF price is intended to capture some of the costs developed for this study. But the discrepancy between contract price, plus additional cost burdens and the straight AMDF price, warrants further study.
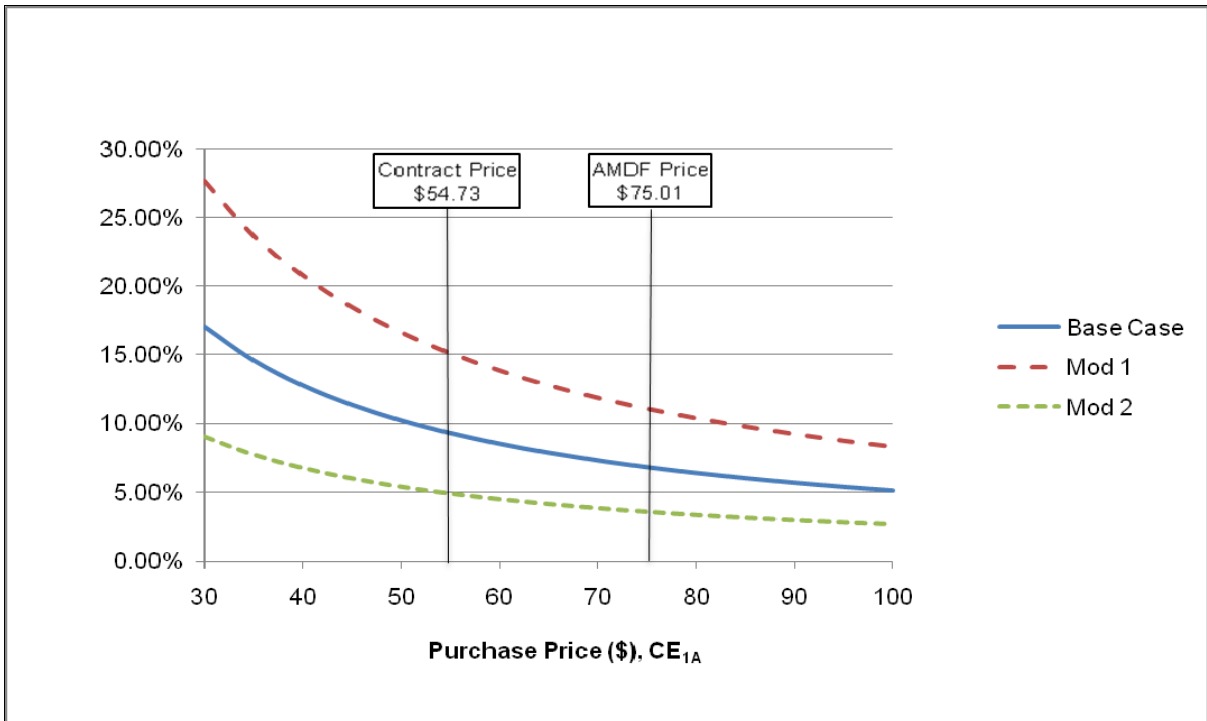
Figure 16.   Scenario 1 Total Burden as a Percentage of Purchase Price (FY00$)

2. Scenario 2 FBCB Results

a. Base Case

The base case shows that fully burdened costs of the BA-5590 in this scenario are 12.85% of the contract price of the batteries. Table 14 shows a summary of the fully burdened costs. An assured delivery price of $61.76 in the POWER calculator multiplied by a low- and high-limit use for batteries in the scenario yields the fully burdened price. Fully burdened battery cost in this scenario ranges from $79,550 to $119,325.99. Again, the range in this scenario is determined solely by the runtime of the system. The lower price range assumes that all batteries are used to 100% of their capacity—the full 18-hour run time available. The upper range assumes a user will only utilize 67% of battery capacity before changing out the battery in the system, a more likely use of batteries in combat for a battery without a SOCI.

Table 14. Scenario 2 Base Case Fully Burdened Cost Summary (FY00$)

			Lower Use Limit	Upper Use Limit
CE_1	CE_{1A}	Purchase Price	54.73	54.73
	CE_{1B}	Transaction Costs	0.12	0.12
	CE_{1C}	Proprietary Costs*	0.00	0.00
CE_2	CE_{2A}	FDT Transportation	#	#
	CE_{2B}	SDC Transportation	1.31	1.31
	CE_{2C}	TDC Transportation	0.94	0.94
CE_3	CE_{3A}	Storage Asset Depreciation	0.24	0.24
	CE_{3B}	Trans Asset Depreciation	0.04	0.04
CE_4	CE_{4A}	Depot Storage	0.14	0.14
	CE_{4B}	Unit Storage	0.81	0.81
	CE_{4C}	Dissipation	0.00	0.00
CE_5	CE_{5A}	Storage before Disposal	##	##
	CE_{5B}	Transportation to Disposal	0.94	0.94
	CE_{5C}	Commercial Disposal	2.50	2.50

		Total Burden Costs (CE$_{1B}$ to CE$_{5C}$)	7.03	7.03
	ADP	**Assured Delivery Price**	**61.76**	**61.76**
	DEMAND	Batteries Demanded	1288	1932
	FBCB	**Fully Burdened Battery Costs**	**79,550.66**	**119,325.99**
	1.00	*Proprietary Factor		
	#	Covered in FOB Contract, part of CE$_{1A}$		
	##	Incorporated into Unit Storage, CE$_{4B}$		

Again, disposal costs make up the largest percentage of the assured delivery price, with commercial disposal accounting for 35% of the $7.03 of additional burdens on the purchase price of the battery. Transportation cost increases can reduce the cost effect of disposal costs, though. Figure 17 shows the largest burden elements and the percentage of total cost burdens they make up.
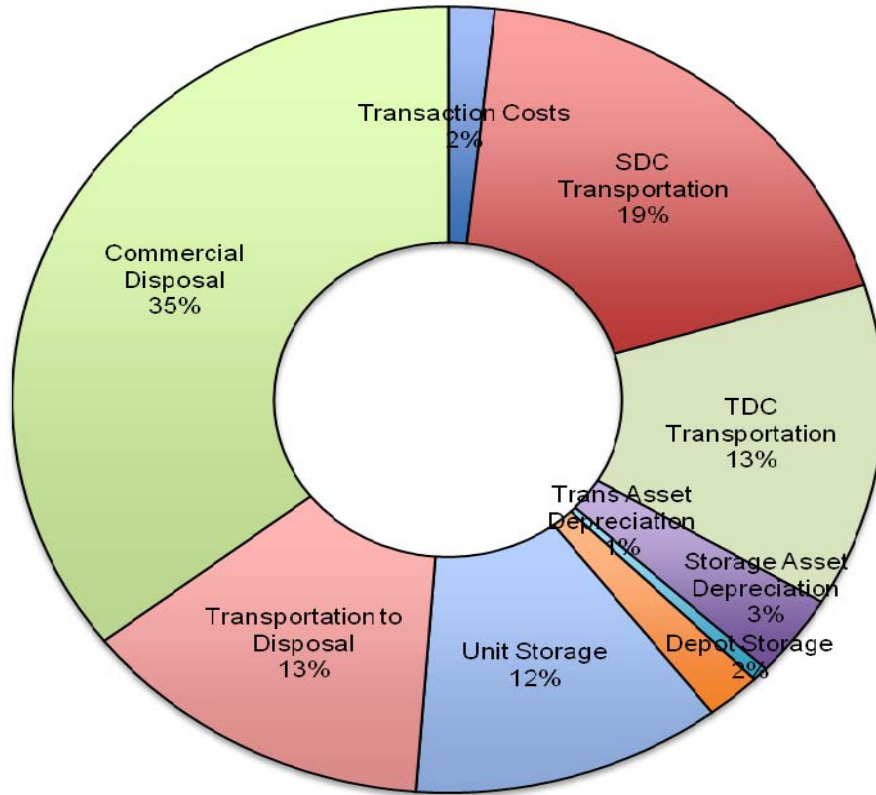
Figure 17. Scenario 2 Base Case Cost Elements as Percent of Total Burdens
(Note: non-zero burdens only)

b. Sensitivity Analysis

Mod 1 to Scenario 2 assumes that deployed battery users undertake no directed effort to dispose of the batteries. While not the best solution, we felt that it needed to be modeled in the burdens on the battery. Obviously, not properly disposing of batteries reduces the cost burdens. However, this does not take into account the environmental impacts of disposing of the batteries in local landfills in deployed areas. In this Mod, total cost burden on the battery is $3.58 which represents 6.5% of the contract price of the battery.

Table 15. Scenario 2 Mod 1 Fully Burdened Cost Summary (FY00$)

			Lower Use Limit	Upper Use Limit
CE$_4$	CE$_{4A}$	Depot Storage	0.14	0.14
	CE$_{4B}$	Unit Storage	0.81	0.81
	CE$_{4C}$	Dissipation	0.00	0.00
CE$_5$	CE$_{5A}$	Storage before Disposal	##	##
	CE$_{5B}$	Transportation to Disposal	0.00	0.00
	CE$_{5C}$	Commercial Disposal	0.00	0.00
		Total Burden costs (CE$_{1B}$ to CE$_{5C}$)	3.58	3.58
	ADP	**Assured Delivery Price**	**58.31**	**58.31**
	DEMAND	Batteries Demanded	1288	1932
	FBCB	**Fully Burdened Battery Costs**	**75,100.29**	**112,650.44**
	1.00	*Proprietary Factor		
	#	Covered in FOB Contract, part of CE$_{1A}$		
	##	Incorporated into Unit Storage, CE$_{4B}$		
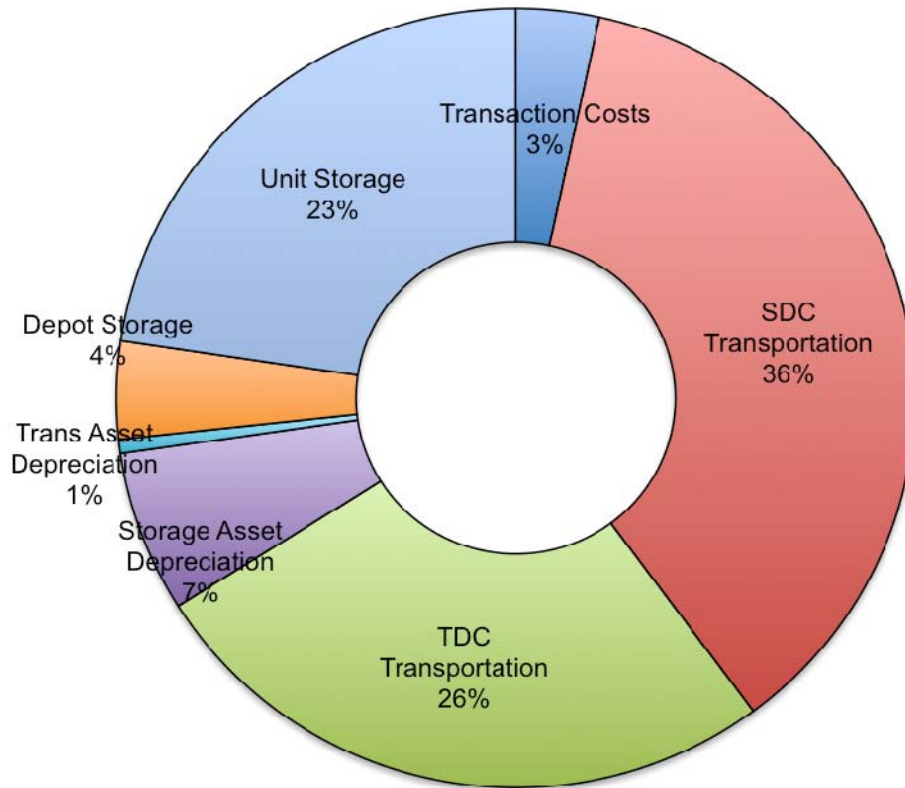
Figure 18. Scenario 2 Mod 1 Cost Elements as Percent of Total Burdens
(Note: non-zero burdens only)

For Mod 2 to Scenario 2, we used higher tactical shipping costs. We based this increase on the addition of Attack Aviation escorting to a convoy. Cole and Blankenship used two different tactical delivery charges based upon inclusion of attack aircraft. This Mod demonstrates how attack aviation escort increases our cost burdens for Scenario 2. It increases the TDC burden from $0.94 to $1.34 and increases TDC percentage of burden costs from 13% to 17% as shown in Figure 19. Total burdens become 14.28% of the purchase price in this scenario.

Table 16.   Scenario 2 Mod 2 Fully Burdened Cost Summary (FY00$)

			Lower Use Limit	Upper Use Limit
CE_1	CE_{1A}	Purchase Price	54.73	54.73
	CE_{1B}	Transaction Costs	0.12	0.12
	CE_{1C}	Proprietary Costs*	0.00	0.00
CE_2	CE_{2A}	FDT Transportation	#	#
	CE_{2B}	SDC Transportation	1.31	1.31
	CE_{2C}	TDC Transportation	1.34	1.34
CE_3	CE_{3A}	Storage Asset Depreciation	0.24	0.24
	CE_{3B}	Trans Asset Depreciation	0.02	0.02
CE_4	CE_{4A}	Depot Storage	0.14	0.14
	CE_{4B}	Unit Storage	0.81	0.81
	CE_{4C}	Dissipation	0.00	0.00
CE_5	CE_{5A}	Storage before Disposal	##	##
	CE_{5B}	Transportation to Disposal	1.34	1.34
	CE_{5C}	Commercial Disposal	2.50	2.50
		Total Burden Costs (CE_{1B} to CE_{5C})	7.82	7.82
	ADP	**Assured Delivery Price**	**62.55**	**62.55**
	DEMAND	Batteries Demanded	1288	1932
	FBCB	**Fully Burdened Battery Costs**	**80,561.79**	**120,842.68**
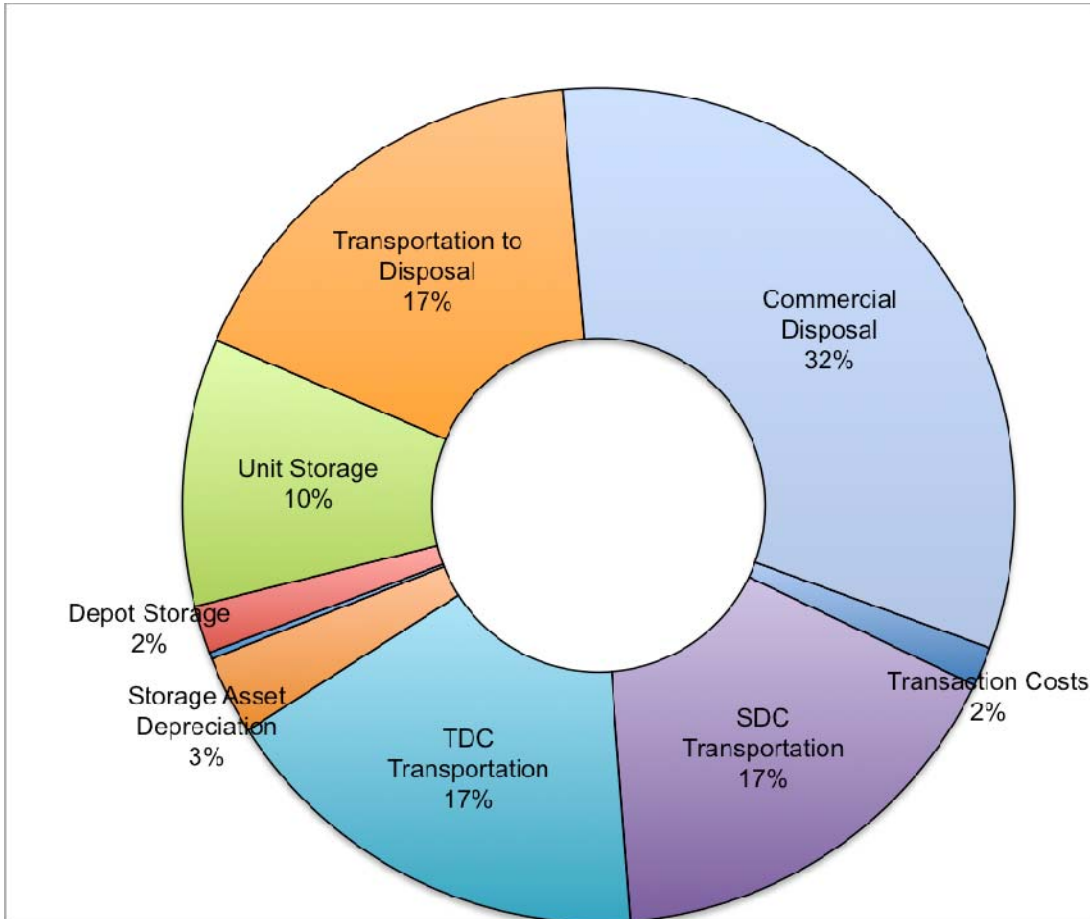
Figure 19. Scenario 2 Mod 2 Cost Elements as Percent of Total Burdens
(Note: non-zero burdens only)

For Mod 3 of Scenario 2, we looked at how flying batteries from the United States into Afghanistan affects their cost burdens. For our base scenario, we assumed the batteries were ordered at a lower priority, which uses a more economical shipping method. For this Mod, we assumed that batteries were ordered at a higher shipping priority. Transportation Command provided cost data for a shipment of two tons of batteries via channel flight from Dover, DE, to Afghanistan. Based on this scenario, we were able to calculate a per-battery shipping cost. As shown in Table 14 and Table 17, SDC charge would increase from $1.31 to $11.22 in this scenario, an increase in cost by a factor of more than 8. As shown in Figure

20, the SDC cost burden would dwarf all other burdens, and the overall cost burden would increase to $16.93, which is over 30% of the contract price for a battery. Additionally, this would increase the fully burdened cost of operating a Marine Battalion's PRC-117s for a week by over $20,000.

Table 17.   Scenario 2 Mod 3 Fully Burdened Cost Summary (FY00$)

			Lower Use Limit	Upper Use Limit
	CE_{2A}	FDT Transportation	#	#
CE_2	CE_{2B}	SDC Transportation	11.22	11.22
	CE_{2C}	TDC Transportation	0.94	0.94
		Total Burden Costs (CE_{1B} to CE_{5C})	16.93	16.93
	ADP	**Assured Delivery Price**	**71.66**	**71.66**
	DEMAND	Batteries Demanded	1288	1932
	FBCB	**Fully Burdened Battery Costs**	**92,297.14**	**138,445.71**
	1.00	*Proprietary Factor		
	#	Covered in FOB Contract, part of CE_{1A}		
	##	Incorporated into Unit Storage, CE_{4B}		
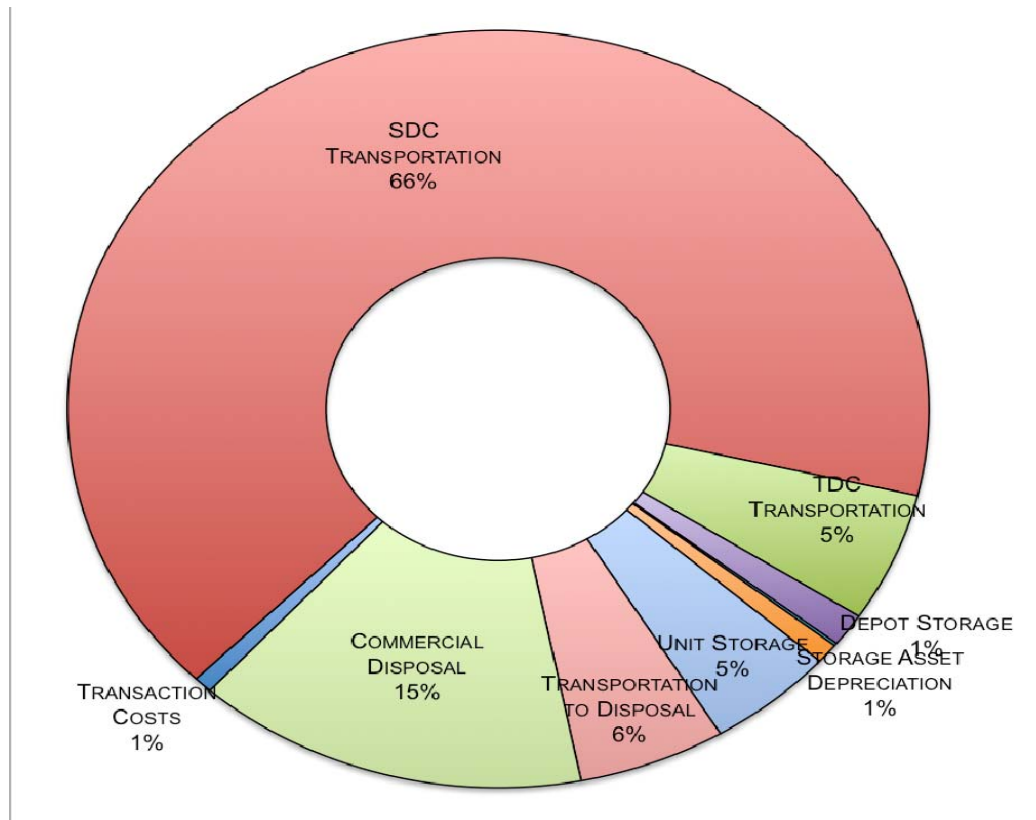
Figure 20. Scenario 2 Mod 3 Cost Elements as Percent of Total Burdens
(Note: non-zero burdens only)

Figure 23 shows the rate-of-change of the percentage of the burdens on the purchase price. We highlighted two purchase price points—the contract price we derived and the AMDF or FEDLOG price charged by DLA averaged over 10 fiscal years. As CE_{1A} (the purchase price) increases in the base case, the percentage of the additional cost burdens on that price decreases. At the AMDF price, burdens decrease to 9.37% from 12.85% of the purchase.
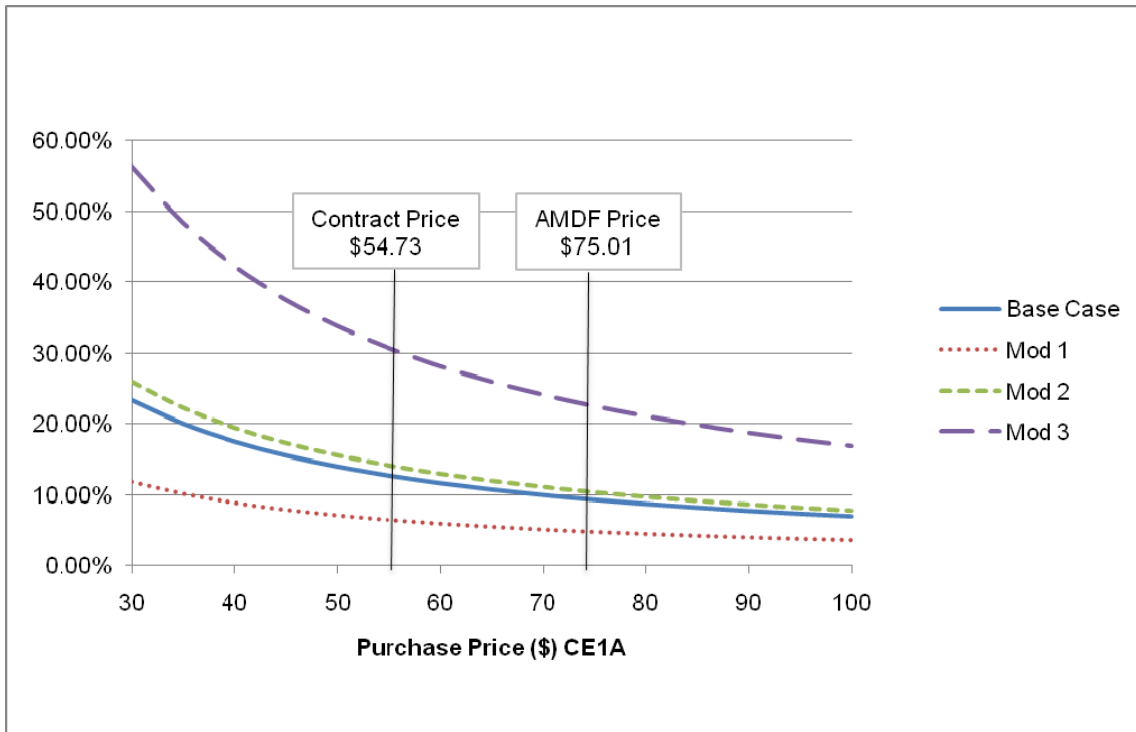
Figure 21.   Scenario 2 Total Burden as a Percentage of Purchase Price (FY00$)

V.   Conclusions and Recommendations

A.   Conclusions

This study develops a methodology and tool for acquisition planners to use in the AoA process when fully burdened energy costs are an issue. A high-demand battery was studied in order to develop a methodology to understand the cost burdens that affect battery costs. Different types of batteries and different energy systems will affect the type of models to be used. A major outcome of this analysis is that the methodology developed the FBCB.

Usage scenarios greatly affect the assured delivery price. The use of aviation assets as part of a scenario increased the cost of batteries significantly, and our analysis confirms the work of Peltz, et al (2008) as did our observed shipments to theater via the air channel using total asset visibility tools. Transportation planning is important for battery costs. Air transport adds approximately $20,000 to the fully burdened costs—about $11.22 per battery. Services should use high-priority shipping less frequently and instead forward stock batteries when it is anticipated that large quantities will be needed (see Pelt, et al 2008 for a full discussion). Additionally, by proactively coordinating purchasing at the strategic level, the DoD will optimize transportation assets and decrease overall costs.

Danger can come in adjusting scenarios to make the numbers look more attractive. We suggest using standardized scenarios or scenarios taken directly from operational plans (which may be classified) in future AoA planning.

Disposal is the largest piece of the fully burdened cost in our peacetime scenario. Other factors are minuscule compared to a battery's demand upon resources to carry it. If immediate cost savings are sought in the use of non-

rechargeable lithium batteries, the reduction of the waste stream associated with their use would most readily result in cost improvements.

Even though the authors came up with a method for calculating dissipation, or loss of a battery's initial charge based on its shelf life, after our discussions with the manufacturer we chose not to model dissipation or loss of charge due to storage. As a result, the researchers have not validated the portion of the model for calculating dissipation, and our estimates will tend to underestimate the fully-burdened cost of delivered energy in the form of a battery.

Are the services really saving money by having DLA buy batteries? This study used the manufacturer's contract price instead of the DLA published price in order to determine the most realistic cost burdens. The factors, or actual cost burdens, which make up DLA's higher price may add an unnecessary burden to the cost of batteries. One area of future study would be to see whether or not the DoD is actually saving money by having DLA perform contracting functions, given the overhead rates and the possibility that those overhead rates may be reduced through process re-engineering or other efficiency gains within DLA.

Researchers attempting to model the fully burdened cost of rechargeable batteries could readily apply this report's methodology for non-rechargeable batteries. However, additional considerations would certainly include the cost of electricity at bases/stations, cost of rechargers, depreciation of rechargers, generators, and the FBCF. This methodology lends itself to the study of other forms of delivered energy on the battlefield (e.g,, wind, solar, and biofuels). The endstate would be to develop a simulation model or tool that a planner could use that would give the fully burdened cost of different forms of delivered energy with a minimum number of inputs required from the user of that tool.

The next step would be to put this methodology into a format for presentation during AoAs, something that senior leaders can look at and make decisions with. Ideally, the briefer would create a slide to show tradeoffs/gains between the use of a BA-5590 and other battery types in future systems.

B.   Recommendations

Developing this methodology was just a first step. This methodology built upon the efforts of a number of different organizations and people in the FBCF community. Based upon our analysis, we have come up with recommendations for this methodology's growth and use:

1.   Extend methodology to other high-value batteries such as the Hawker vehicle battery.

2.   Extend methodology to other systems, such as generators, ensuring to include the cost inefficiencies inherent in wet-stacking (a power-generation problem in combat theaters) (Lovins, 2010, p. 37).

3.   Develop a simulation model or tool that a planner could use that gives the fully burdened cost of different forms of delivered energy, such as wind turbine or fuel cells, with a minimum number of inputs required from the user of that tool.

4.   When developing prototype batteries, take into account weight and available charge-life as important factors affecting the FBCB. Reducing the weight will reduce the cost of shipping and transport. Increasing the charge life will reduce the number of batteries that need to be transported.

5.   Continue to tie the FBCB with the FBCF. Expand methodology to cover more tradespace factors. An example would be the cost of a battery's weight and its effect on troops. One way to measure this cost could be by using the per-calorie cost of Meals, Ready-to-Eat to determine the tradespace between a heavy battery and a light battery over a single day's worth of activities. The reason for extending this analysis to include more factors is evident in Amory Lovin's statement regarding FBCF: "FBCF should count all assets and activities—at their end-to-end, lifecycle, fully burdened total cost of ownership—that will no

longer be needed, or can be realigned, if a given gallon need no longer be delivered" (Lovins, 2010, pp. 35-36).

6.   Extend the analysis of transaction costs to include post-award management costs.

VI. Appendices

A. Findings and Recommendations from the 2001 Defense Science Board Task Force on Energy

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.

The DoD currently prices fuel based on the wholesale refinery price and does not include the cost of delivery to its customers. This method 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.

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

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

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

B.   Manufacturer's Data on the BA-5590

Li-SO₂ primary battery system
BA 5590 B/U

One battery for various
military applications

10 LO 26 SX cells connected in
2 groups of 5 cells in series
providing 2 nominal 12 V sections
at connector. These sections can
be connected in series (for 24 V)
in parallel (for 12 V) or used as
two separate 12 V units.

Key features

• A non-replaceable fuse is
incorporated in the negative leg
of each series group of cells.

• A normally closed high
temperature switch or thermal
fuse is incorporated into each
series group of cells to protect
against overheating.

• A diode is incorporated into the
positive leg of each series group
of cells to prevent charging or
flow of current into the battery.

• A device consisting of a manually
activated pull tab and resistors
designed to discharge the battery
to 0 V is built into the battery.

Typical applications

• AN/PRC-104 Radio
• AN/PRC-113 Radio
• AN/PRC-117 Radio
• AN/PRC-119 Singcars Radio
• KY-57, KY-65 Encryption Set
• REMBASS Remotely Monitored
Battlefield Surveillance System
• PLRS Position Locator and
Reporting System
• RT-991 Buoy Radio
• RT-1175 Buoy Radio
• AN/TAS-4A TOW Night Sight

Electrical characteristics

Typical OCV (V)		15.0 or 30.0
Nominal voltage (at 500 mA) (V)		13.5 or 27.0
Cut-off (V)		10.0 or 20.0
Typical capacity +21°C/+70°F		15 Ah at 12 V
(at 250 mA discharge current)		7.5 Ah at 24 V
Operating temperature		−40°C to +71°C
		−40°F to +160°F
Storage	Recommended max	+35°C / +95°F
	Possible	−40°C to +71°C / −40°F to +160°F

Physical characteristics

Typical Weight (g/oz)	1000 / 35.3
Weight of Li metal content (g/oz)	24 / 0.85
Width (mm/in)	62.2 / 2.45
Height (mm/in)	111.8 / 4.40
Depth (mm/in)	127.0 / 5.00
Battery Case	Plastic

References

Mating connector	ITT Cannon CA 110821- 6
Reference specifications	MIL PRF 49471B or Saft Standard Specification
Nato Stock Number	6135−01−036−3495
	6135−01−438−9450

GA 2020 S/U dimensions

Capacity vs rate at various temperatures
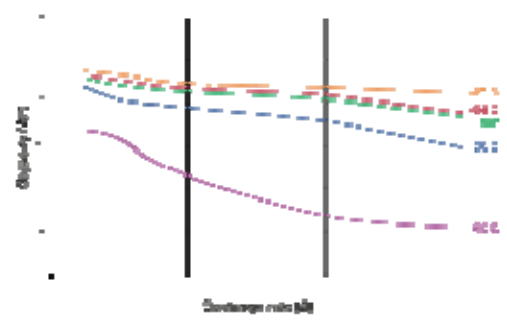
3 A discharge typical curves at various temperatures [24 V model]

Retinal schematic
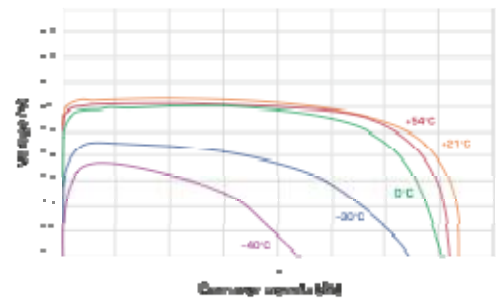
Typical discharge curves at various rates at +21°C/+70F
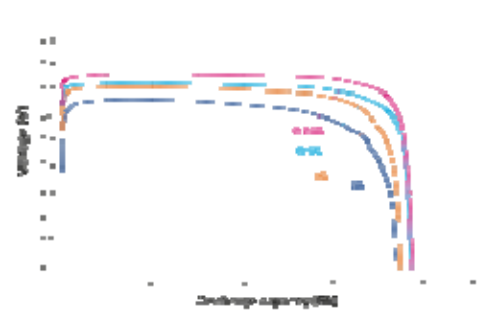
Saft
Specialty Battery Group

1P ne Sail Carrer
83170 Rigasot - France
Tel +33 (0) 4 92 89 19 15
Fax +33 (0) 4 92 89 19 60

3 DL Dressen Shoar
elease NC PG68C - USA
Tel +1 1898 894 4111
Fax +1 1898 894 9451

www.saltbatteries.com

C. POWER Version 1.3e

Power Optimizer for the Warfighter's Energy Requirements (POWER) is a Microsoft Excel-based application created by US ARMY CECOM Life Cycle Management Center Power Sources Team. It allows for end-user estimation of battery needs. POWER Version 1.3e was used to determine the demand and the FBCB in development of the methodology. POWER's two basic outputs are the number of batteries comm-elec or weapons systems will require over a user-defined runtime and the cost of those batteries based on user-input prices. Figure 21 is a flowchart that describes the process POWER uses to calculate battery requirements.
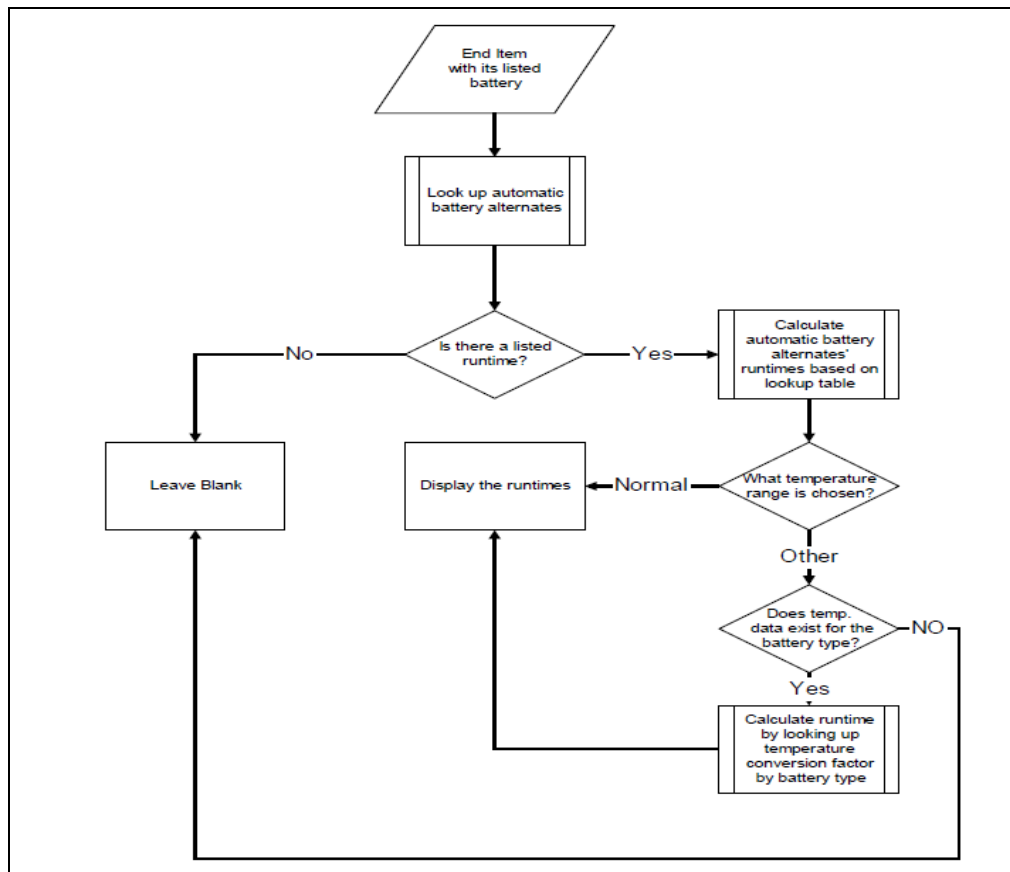
Figure 22.   POWER 1.3e Flowchart (POWER 1.3e)

1. Calculating System Demand with POWER

Use of POWER begins with selecting the system to be powered in a worksheet designed to have a few user-entered values (Figure 22). The user inputs information about the number of systems, operating temperature, and required battery type on a tab in the spreadsheet labeled *calculations*. For our study we chose to use the AN/PRC-117F in both scenarios, the BA-5590 without SOCI, and standard operating temperatures.

Figure 23. POWER Requirements Spreadsheet (POWER 1.3e)

Once the user inputs this information, he/she can search in a database for the runtimes of a system using a "parent" (i.e., BA-5590) battery. Runtime calculations are done in pure hours. The design, which is user-centric, tells how long the battery is estimated to last in their system. The values in the database generally come from Tech Manuals or the OEM's literature. The user is then presented a table of estimated runtimes. For example, for one day of operation, the AN/PRC 119F will operate on a single BA-5590 for 33 hours. Once presented with standard runtimes,

the user can then enter how often he/she wishes to swap out the battery (Figure 23). Local-unit standard operating procedures may dictate that users swap a battery after 24 hours rather than after 31. Also, runtimes are often dependent on usage: a radio in *transmit* mode uses a lot more juice than one in *standby*, therefore op-tempo has a great bearing on runtimes. For scenario calculations, the researchers used a low and high range for run times. In Scenario 1, we determined the low range to be an 18-hour swap time. We determined the high range to be 24 hours. The final calculation of how many batteries are required is based purely on the user swap time and not the runtime estimate. Figure 24 shows the format that batteries required are presented in. The researchers took these battery requirements, both low and high, and used them as demand in Scenarios 1 and 2.

Figure 24. Battery Requirement (POWER 1.3e)

Table 18.   POWER Summary of Minimum Battery Requirements (POWER 1.3e)

Summary of Minimum Battery Requirements											
Notes: Summary does not include auxiliary batteries. Fractions of packages cannot be ordered and must be rounded; prices and weight are calculated using fractions of packages. Prices are rounded to the nearest dollar.											
	Minimum for 1 day mission				Minimum for 3 day mission				Minimum for 30 day mission			
Battery	Batts (day)	Pkgs to order (day)	Weight (day)	Cost (day)	Batts (3dy)	Pkgs to order (3dy)	Weight (3dy)	Cost (3dy)	Batts (mo)	Pkgs to order (mo)	Weight (mo)	Cost (mo)
BA-5590B/U	63	15.8	141.8	$3,592	147	36.8	330.75	$8,367	1302	325.5	2929.5	$74,006

2.   Calculating Fully Burdened Costs of Batteries

POWER gives the user the capability to download current pricing from DLA for all battery NSNs in its database, or to manually enter pricing information. Both options are time stamped so the user can be sure the pricing is current. To manually enter pricing, one simply types the price in the *UI Cost* column. The entry will be time stamped and marked "User Defined." Figure 24 shows the battery-pricing information tab. To determine FBCB, the researches input the dollar amount calculated for the ADP in the *UI Cost* column. All subsequent costs of batteries for a certain number of systems at the user-input ranges gave the fully burdened costs within that scenario.

Figure 25.   Battery Pricing Information (POWER 1.3e)

D.   Getting the Most from Acquisition Reforms: *FAR 13.5* Test Provisions for Simplified Acquisition Procedures, Commercial-item Acquisition by CDR E. Cory Yoder, SC, USN, (Ret.), Lecturer

1.   Background, Review, and Applicability of the *FAR 13.5* Commercial-item Test Procedures

a.   *FAR 13.5* Transaction "Touch Time" and Transaction Cost Reductions

Managing purchase actions with *FAR 13.5* streamlined protocols and processes to conduct the construction, solicitation, and award of the purchase results in **dramatically less "touch time" and with an associated reduction in transaction costs**. According to CAPT Steve Shapro, NAVSUP Code 02, the reduction in actual touch time required to process a SAP buy versus buys using

traditional large-contract methods is significant. CAPT Shapro indicates that a recent review of protocols revealed over a ***90% reduction*** in processing touch time when SAP protocol was used. Specifically, contract actions using SAP protocol have approximately **nine hours** total touch time, while those just using large-contracting procedures have approximately **200 hours** of touch time.[19] By converting this time savings into monetary savings, the researchers discovered that for each transaction that utilizes the *FAR 13.5* provisions instead of traditional "large" protocol, there's an **average cost reduction of over $9,500 per transaction!**[20] In addition, approximately 90% of Fleet Industrial Supply Center's (FISC) 65,000 annual contract-action transactions are below the *FAR 13.5* Test Procedure's $5.5 million threshold! The potential impact of full utilization of the *FAR 13.5* protocol is obvious, given the virtual universal applicability to actions less than $5.5 million.

19 CAPT Steve Shapro, NAVSUP Code 02. Cited with permission from discussion with the author conducted at NPS on 2 November 2006.

20 Note: This information is derived by applying an average loaded hourly-salary rate for an 1102 Contract Specialist of $50, multiplied by the number of hours for large contract protocol touch time (200 hours) and subtracting the average loaded hourly salary rate multiplied by the number of touch-time hours for an 1102 Contract Specialist conducting a purchase using SAP protocols.

E. Table of FBCB Burden Elements

Table 19. FBCB Burden Elements and Results

Symbols	Parameter Name	Units	Scenario 1 Base Case Value	Scenario 2 Base Case Value
CE_{1A}	Purchase Price	FY00$	54.73	54.73
$AMDF$	FEDLOG Price	FY00$	75.01	75
CE_{1B}	Transaction Cost	FY00$	0.12	0.12
CE_{1C}	Proprietary Cost	NA	0	0
CE_{2A}	First Destination Transportation Charge (Mfg to depot)	FY00$	#	#
CE_{2B}	Secondary Destination Transportation Charge (Depot to Supply Support Activity)	FY00$	1.31	1.31
CE_{2C}	Tactical Destination Charge (SSA to using unit)	FY00$	0	0.94
CE_{2C1}	Force Protection	FY00$	0	##
CE_{2C2}	Convoy Escort Charges	FY00$	0	##
CE_{3A}	Storage Asset Depreciation	FY00$	0.24	0.24
CE_{3B}	Delivery Asset Depreciation	FY00$	0.02	0.04
CE_{4A}	Depot Level Storage Costs	FY00$	0.14	0.14
CE_{4B}	Unit Level Storage Costs	FY00$	0.88	0.81
CE_{4C}	Dissipation Costs	FY00$	0	0
CE_{5a}	Storage before Disposal Costs	FY00$	###	###
CE_{5b}	Transportation to Disposal Cost	FY00$	####	0.94
CE_{5c}	Commercial Disposal Costs	FY00$	2.39	2.50
D	System Demand	ea	420-588	1288-1932
DPH	Battery cost in Dollars per hour	FY00$/hr	0.08	0.08
DR	Discharge Rate	watt hours per day	*	*
Cap	Battery Capacity	watt hours	720	720
T	Total Scenario Length ($Tsd+Tsu+Tu+Tt$)	day	436	451

T_{sd}	Total time in depot-level storage	day	365	365
T_{su}	Time in SSA/unit level storage	day	30	5
T_u	Time batteries are in operation	day	1	1
T_t	Time Batteries are in transportation	day	10	40
T_d	Time batteries spent batteries are stored awaiting disposal	day	30	40
W	Battery Weight	pounds	2.25	2.25

\# For the BA-5590 contracts observed charge was captured in CE_{1A}

\#\# Incorporated into CE_{2C} for Scenario 2

\#\#\# Incorporated into unit storage, CE_{4A} for the scenarios studied

\#\#\#\# Incorporated into Commercial Disposal, CE_{5C}

* Model for discharge available from Saft; not used in calculations

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- Tuition Assistance

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- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
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