Applying the Army Fully Burdened Cost of Fuel Methodology to Analyses of Alternatives

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Abstract.

In the current conflicts in Iraq and Afghanistan, enemies are attacking United States (U.S.) military convoys that transport necessary supplies such as fuel, ammunition, food, and water in an effort to sever logistical resupply routes. Department of Defense (DoD) leadership is concerned about a having a large logistics footprint that supports U.S. forces because large convoys are attractive targets. Energy inefficiency is one of the main causes of the large logistical convoys. In an effort to eventually decrease the size of the U.S. logistics footprint, DoD leadership is putting into place procedures to better understand military fuel demands and become more fuel efficient. The Fully Burdened Cost of Fuel (FBCF) is one of the metrics DoD is using to quantify the fuel demands of acquisition systems that are being developed and fielded.

The FBCF for an acquisition system is defined as the Defense Energy Support Center (DESC) standard price for fuel plus apportioned costs of the fuel delivery and force protection assets that transport the fuel to the system. The Defense Acquisition Guidebook (DAG) requires that all future trade-off analyses for acquisition systems include Fully Burdened Cost of Energy estimates. In order to comply with this guidance, cost analysts are being tasked to develop both a wartime and peacetime FBCF estimate for acquisition systems as part of all future Analyses of Alternatives (AoAs).

Because it is a new requirement that has not been implemented to date, incorporating FBCF estimates into AoAs presents challenges. Where does an analyst start when they are required to produce a wartime FBCF estimate? How does an analyst properly apportion fuel delivery and force protection asset costs to an acquisition system? How can FBCF results be displayed so that they will be meaningful to decision makers?

This paper presents the methodology that the Army is developing to incorporate both wartime and peacetime FBCF estimates into AoAs. A description of how the Army FBCF methodology maps to the previously developed seven step Office of the Secretary of Defense Cost Analysis and Program Evaluation (OSD CAPE) FBCF methodology will be provided. Furthermore, the paper discusses some challenges that still must be overcome as FBCF estimating continues to evolve.

1. Background.

1.1. Current Wars Sparked an Interest in FBCF.

The frequent attacks on military logistics convoys in Iraq and Afghanistan over the last several years have caused DoD leadership to become extremely interested in finding a way to decrease the size of the U.S Military's logistics tail. Leadership prefers that fuel efficiency be built into new developmental acquisition systems as one solution to help reduce the logistics footprint and has been looking for quantitative metrics to measure and track this efficiency. FBCF became a particularly attractive metric because it is a way to measure fuel efficiency by looking at both cost and the effects on a logistics tail. From purely a cost perspective, FBCF calculations give insight into additional direct and indirect costs, such as Operation and Support (O&S) costs for trucks that deliver fuel to a particular system, that are not evident when looking at the DESC price of fuel by itself. To account for these additional O&S costs of fuel delivery trucks, an analyst needs to know the number of fuel trucks in a convoy and frequency of convoys over a given period of time. Using this knowledge, an analyst can tie the additional costs included in the FBCF calculations to effects on logistics footprint size. For example, if a fuel efficient system requires fewer fuel trucks per convoy and less frequent convoys in order to have the amount of fuel required to complete its mission then the FBCF for that system would be lower and the logistics tail would be smaller.

Due to DoD leadership interest, the DAG requires that Fully Burdened Cost of Energy estimates be included in all future AoAs. Fuel is the main source of energy being used by Army systems so the Army is calculating FBCF costs as part of all future AoAs to meet this DAG requirement. The DAG gives guidance on how to calculate FBCF but each military service is responsible for developing its own methodology. Methodologies between services will obviously be different because each service conducts logistics operations in a different way. Fuel resupply operations for Navy submarines are very different than fuel resupply operations of Army surface vehicles. The Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE) has been directed to be the lead Army organization for calculating FBCF estimates as part of Army AoAs.

Although the requirement to incorporate FBCF estimates into AoAs is new, the idea of calculating FBCF for certain scenarios has been around for a while. There are several models and tools that already estimate the FBCF for certain types of analyses.[1] Examples of some these analyses could be to analyze the FBCF implications on a specific unit currently in a Theater of war or to calculate FBCF costs for moving a type of military unit from one Theater to another. This paper discusses FBCF calculations as they apply to Army AoAs only. AoAs are comparative analyses for acquisition systems and the scope and assumptions required for AoA FBCF calculations are very different than what would be required for other types of analyses. The bottom line is that there is no single fully burdened cost of fuel because it truly depends on

[1] The Sustain the Mission Project (SMP) Tool currently housed by Army G-4; the Army organization whose mission is to focus on logistics and an FBCF Calculator produced by Mr. Rick Cotman; OSD Acquisition, Technology, and Logistics (AT&L); and briefed at the 2009 Military Operations Research Society (MORS) Power and Energy Workshop are two such tools that calculate FBCF.

the type of analysis being performed. The FBCF from new combat vehicle AoA is not going to be the same as the FBCF from an analysis of an Aviation Unit moving from Iraq to Afghanistan.

1.2. Seven Step OSD CAPE FBCF Methodology.

The Army FBCF methodology for AoAs builds upon previous work done on a pilot FBCF study that was conducted by the OSD Cost Analysis Improvement Group (CAIG), now known as OSD CAPE, during an AoA-like Evaluation of Alternatives for a new tactical vehicle in 2007. The goal of this study was to calculate the FBCF for the Joint Light Tactical Vehicle (JLTV), a vehicle that could potentially be a replacement for the High Mobility Multi-purpose Wheeled Vehicle (HMMWV) for the Army and the United States Marine Corps (USMC). The basic approach of this study was to use the HMMWV as an analogy to JLTV and derive a composite FBCF cost for JLTV by looking at the burden costs for HMMWVs on five different Army posts and two different USMC bases. The five posts and two bases that were used in the study were selected because, all together, they spanned the broad spectrum of the various types Army and USMC units that would be fielded the JLTV and, therefore, were assumed to be a good representation of the Army and USMC as a whole. The FBCF costs that were derived were peacetime costs. There was an excursion of this FBCF analysis conducted by OSD CAPE with help from the Institute of Defense Analysis (IDA) that took a look at wartime costs but the excursion was not tied to logistics footprint analysis in the way that OSD leadership would later require.

This pilot study resulted in the seven step FBCF costing methodology that includes the seven burden elements listed in Figure 1 below.

Step	Burden Element
1	DESC Commodity Cost of Fuel
2	Primary Fuel Delivery Asset O&S Cost
3	Depreciation Cost of Primary Fuel Delivery Assets
4	Direct Fuel Infrastructure O&S Cost
5	Indirect Fuel Infrastructure O&S Cost
6	Environmental Cost
7	Other Costs

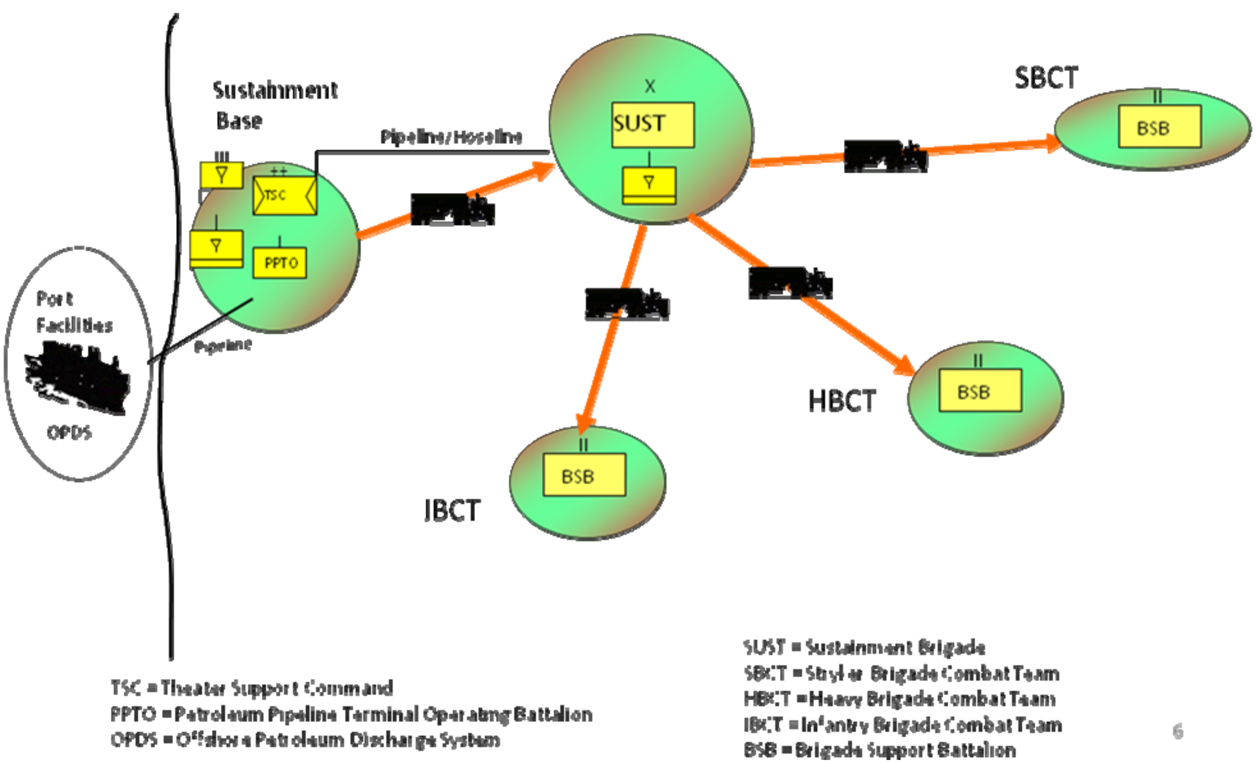
Figure 1: OSD CAPE Seven Step FBCF Methodology

All burden elements of this seven step OSD CAPE FBCF methodology is in the current DAG. The DESC Commodity Cost of Fuel is the standard price for the appropriate type or types of fuel. The Primary Fuel Delivery Asset O&S Cost is the cost of operating service-owned fuel delivery assets including the cost of military and civilian personnel dedicated to the fuel mission.

The Depreciation Cost of Primary Fuel Delivery Assets is the cost of the decline in value of fuel delivery assets with finite service lives using straight-line depreciation over total service life. The Direct Fuel Infrastructure O&S Cost is the cost of any fuel infrastructure that is not directly operated by DESC and directly tied to delivering fuel. Indirect Fuel Infrastructure O&S Cost is the cost of base infrastructure that is shared proportionally among all base tenants. Environmental Cost is the cost representing carbon trading credit prices, hazardous waste control, and related subjects. Other Costs include potential costs associated with delivering fuel such as convoy escort, force protection, regulatory compliance, contracting, and other costs as appropriate.[2] The DAG refers to these seven steps as guidance with the understanding that costs will vary by Military Service and delivery method.

2. FBCF Defined From an Army Perspective.

The Army FBCF approach to AoAs is very similar to the approach OSD CAPE took with the FBCF pilot study for the JLTV Evaluation of Alternatives because that study focused on a vehicle that would be fielded to the Army. Figure 2 was based on logistics information from logistics subject matter experts at Fort Lee, was used by OSD CAPE in its 2007 study.



[2] Descriptions of each of the steps in the OSD CAPE Seven Step Methodology came from a document titled, "Fully Burdened Cost of Delivered Energy – Methodological Guidance for Analyses of Alternatives and Acquisition Tradespace Analysis" that is referenced in the current Defense Acquisition Guidebook (DAG) that can be found online.

Figure 2: Fuel Delivery Diagram for a Wartime Theater [3]

Although the JLTV FBCF methodology was peacetime focused, it was assumed that the Army trains as it fights and fuel would be delivered from a higher unit to a lower unit in a very similar manner to which Figure 2 displays how fuel is displayed in a Theater of war. The highest level Army unit in Figure 2 is the Theater Support Command (TSC) which is the big green circle on the far left with the name, Sustainment Base, above it. Fuel trucks are the fuel delivery assets that are used by the Army. Fuel is delivered by truck convoys from the TSC down to the next lower level unit, the Sustainment Brigade, which is the big green circle depicted in the top center of Figure 2. Then fuel is delivered by truck convoys from the Sustainment Brigade down to the next lower level units, the Brigades. Three types of Army Brigades are depicted in Figure 2. They are the Infantry Brigade Combat Team (IBCT), the Heavy Brigade Combat Team (HBCT), and the Stryker Brigade Combat Team (SBCT). These units are the three smaller circles depicted at the bottom and right side of the diagram. The yellow squares inside the three Brigades depict the Brigade Support Battalions, the logistics and supply units that support each of those Brigades.

One of the main differences between the Army's FBCF methodology and the methodology OSD CAPE used for the JLTV Evaluation of Alternatives is that the Army's approach will be Brigade Combat Team (BCT)-centric as opposed to the Military Installation-centric approach taken by OSD CAPE. The main reason for moving to a BCT-centric approach is because the DAG is requiring wartime FBCF costs be included in AoAs and, because the Army fights wars with autonomous BCTs, it makes sense to develop wartime costs from a BCT perspective. This Army approach still provides the same overall representation that was provided by the OSD CAPE approach. For example, OSD CAPE's approach included various military installations to cover the broad spectrum of military units such as an Army post that is home station to Heavy Tank Units, an Army post that is home station to Light Infantry Units, and USMC bases that are home station to Marines. The Army approach covers the same broad spectrum of Army unit types but does it at the BCT level; HBCTs cover the Heavy Tank Units, SBCTs cover the Stryker Combat Vehicle Units, and IBCTs cover the Light Infantry Units. Although the Army decided to use this BCT-centric approach because of the requirement to include wartime FBCF costs in AoAs, it is also being used for the peacetime FBCF costs in order to maintain consistency.

3. Peacetime FBCF Calculations.

3.1. Where to Start.

[3] Diagram was used by OSD CAPE in their 2007 Pilot FBCF Study to provide an overview of how fuel is delivered by the Army in a wartime Theater.

Calculating peacetime FBCF costs for AoAs is fairly easy to do for two reasons. The first reason is that cost analysts have always been asked to do peacetime cost estimates so, although analysts may not be used to burdening fuel costs, it is not completely new territory. The second reason is that a almost all of the groundwork for calculating peacetime FBCF costs was laid with the peacetime FBCF methodology used for the OSD CAPE pilot study. The only difference is that the Army peacetime methodology is BCT-centric and the OSD CAPE peacetime methodology was Installation-centric. In other words, the only difference is that if an AoA for a new combat vehicle needs peacetime FBCF costs, the Army's approach analyzes the burdened fuel costs for the quantity of analogous combat vehicles in a BCT while OSD CAPE's approach analyzes the burdened fuel costs for the quantity of analogous combat vehicles that reside on a military installation. Neither approach is better than the other for peacetime FBCF costs. The Army just uses the BCT-centric approach for peacetime costs because it is using this same approach for the wartime FBCF methodology.

Before moving to the OSD CAPE seven step methodology, there are some pieces of information that will be required for the analysis. First, for an FBCF cost to be derived for a new system, an analyst needs to know what type of BCT that system is going to reside in. This is very important because, based on the way the Army structures its units, some types of systems reside in one type of BCT while others reside in two or more BCTs. For example, a new system replacing a tank would most likely only reside in an HBCT but a new system replacing a HMMWV would reside in every type of BCT in the Army. If an AoA is looking at a system that resides only in one type of BCT, fuel burden costs that apply only to that type of BCT needs to be analyzed. On the other hand, if an AoA is looking at a system that resides in multiple types of BCTs, fuel burden costs that apply to all the relevant BCTs must be analyzed in order to derive a composite FBCF cost.

Once an analyst knows what type of BCT they are dealing with, they need to look at the systems that reside in that BCT and select an analogous system to the one being analyzed in the AoA. If the AoA is analyzing a new tank that will operate in an HBCT, the analyst will most likely want to select the tank that currently resides in the HBCT as an analogy. Selecting an analogous system will be very critical to the next piece of information that is required for this analysis.

Now that the analyst knows what type of BCT and has selected an analogous system, they need to know how many gallons of fuel the BCT uses per year. Analysts regularly use databases that provide information on fuel usage per year in order to calculate peacetime estimates, so finding how much fuel a BCT uses per year is not difficult to find. The one very important thing to keep in mind, though, is that the analyst is trying to find the annual fuel usage of the BCT with the new system in it. Databases will provide analysts annual fuel usage for BCTs with current systems in the BCT but not with new systems that are being analyzed in AoAs. Using the new tank in an HBCT AoA example, databases will only be able to provide analysts annual fuel usage information on HBCTs with current tanks in them. What the analyst actually wants is annual fuel usage information on the HBCT with the new tank in it. To get what the analyst wants, some assumptions and calculations will have to be made. The new tank in an HBCT AoA example will be used to explain how to calculate the yearly amount of fuel used by an HBCT with the new tank in it. First, the analyst will need to find the number of total amount of fuel used by the current tanks that reside in the HBCT. If there are 50 current tanks in an HBCT, the total annual amount fuel used by all 50 tanks must be found. Second, the analyst will need to subtract the amount of fuel used by the current tanks from the amount of fuel used by the entire HBCT. Third, the analyst will need to use miles per gallon fuel efficiency information on both the current and new tanks to calculate the amount of fuel used by the new tank in a year. The fuel efficiency in miles per gallon for both the new tank and the current tank will need to be known to make this calculation. If the fuel efficiency of the new tank is not known, it can be assumed using a ton-miles per gallon calculation. Assuming that the Operational Tempo (OPTEMPO), in both miles per year as well as time spent idling, would be the same for both the new and the current tank, the fuel efficiency information will be directly proportional to the amount of fuel used by the new tank. The fuel price per gallon divided by the fuel efficiency in miles per gallon and then multiplied by the annual OPTEMPO in miles is the calculation that derives annual amount of fuel usage. If the new tank has double the fuel efficiency of the current tank, the amount of fuel used by the new tank in a year will be half that used by the current tank assuming both the new and current tanks have the same OPTEMPO. Another assumption that will most likely have to be made is that the new tank will be a one for one replacement for the current tank in an HBCT. This means that 50 new tanks will be replacing the 50 current tanks that reside in HBCTs. The amount of fuel used in a year by the new tank multiplied by the quantity, 50 in this example, of new tanks that will operate in the HBCT. Then, this total amount of fuel in gallons used by all 50 new tanks will then be added to the total amount of fuel for the HBCT that remained after the total amount of fuel for the 50 current tanks had been subtracted out of it. All of this work finally results in an estimated total fuel usage per year of an HBCT with the new system in it.

Since the FBCF methodology is deriving a cost per gallon in a given year, the estimated number of gallons of fuel a BCT uses in a year with the new system in it will be the denominator and all costs that burden the fuel cost for the new system estimated using the OSD CAPE seven step methodology will be the numerator. This burdened cost per gallon of fuel will then be added to the DESC price per gallon to get the final FBCF cost per gallon. If an analyst is required to find the FBCF cost per gallon of just one system in an AoA, why go through all this work to find a FBCF cost per gallon for the entire BCT that the system resides in?

There are two reasons the FBCF cost per gallon of the entire BCT is important. The first reason is that the FBCF cost per gallon of an entire BCT will be exactly the same as the FBCF cost per gallon for every system type inside that BCT. For example, the FBCF cost per gallon for an HBCT, a tank in that HBCT, and a HMMWV in that HBCT will be exactly the same. The only differences in cost will be once the FBCF cost per gallon is multiplied by the amount of fuel used by the various systems in the BCT. For example, a tank and a HMMWV that both reside in an HBCT may both have the exact same FBCF cost per gallon but the cost that results from multiplying that cost per gallon by the amount of fuel the tank uses in a year will most likely be very different than the cost that results from multiplying the FBCF cost per gallon by the amount of fuel used by the HMMWV in a year. The second reason is that all burden costs that are calculated using the OSD CAPE seven step methodology are easily calculated for a BCT and these results can then be used to find the amount of FBCF costs that get apportioned to the system in question. For example, databases already provide O&S costs for the number of fuel trucks that supply fuel to a BCT but not for the number of fuel trucks that supply fuel to a particular system. Once the annual O&S Costs for fuel resupply of an entire BCT is divided by the number of gallons of fuel used by that BCT in a year, the resulting cost is a burdened cost per gallon of fuel for an entire BCT that is the exact same burdened cost per gallon of fuel for the system in question as well as any other system that resides in that BCT. Then, once the burdened cost per gallon of fuel is multiplied by the number of gallons of fuel the system in question uses in a year, the result is the correctly apportioned amount of burdened cost that applies to that system. At this point in time, the stage has been set to actually start estimating the burden costs and the analyst is now ready to use the OSD CAPE seven step methodology to do so.

3.2. Using the OSD CAPE Seven Step Methodology.

The first step in the OSD CAPE seven step methodology is to find the DESC Commodity Cost of Fuel. The most current DESC cost per gallon of fuel can be found on the internet at the DESC website. The DESC price tends to fluctuate regularly, so finding an average DESC cost per gallon over several years is preferable. This is the unburdened cost per gallon of fuel for the BCT. All additional steps in this methodology account for the fully burdened part of the FBCF.

The second step is to calculate the primary fuel delivery asset O&S costs. For the Army, the primary fuel delivery asset is the fuel truck. The O&S costs related to the fuel truck are the annual spare and repair parts costs; annual Petroleum, Oil, and Lubricants (POL) costs, and a annual crew costs of all the fuel trucks that support a BCT. The crew of the fuel truck is defined as the driver and vehicle commander. The driver’s rank is assumed to be E-4 and the vehicle commander’s rank is assumed to be E-6. The Army has O&S databases that provide annual parts and POL costs for fuel systems and a personnel costing database that provides annual salaries for the crew based on the assumed ranks of the crew. It is assumed that all annual parts and POL costs for the fuel trucks are as a result of performing fuel resupply missions for the BCT. However, the soldiers that are the crew for the fuel trucks are not performing crew duties 365 days out of every year, only a percentage of that annual salary is assumed to be the percentage of man-years those soldiers spend actually acting as the crew. Based on standard Army unit training schedules and standard frequency of BCT-level training exercises where these soldiers would be manning the fuel trucks in support of their BCT, that percentage is assumed to be eight percent. The analyst now has O&S costs associated with the fuel trucks. What about O&S costs of the personnel and equipment that are involved in refueling the BCT that are not covered by these fuel truck O&S costs?

The Army FBCF methodology is assuming that the O&S variable costs of a standard POL Section, the type of unit that refuels systems in a BCT, would cover these additional unit personnel and equipment O&S costs. A POL Section has fixed O&S costs as well as variable O&S costs and, like the OSD methodology, the Army methodology is only worried about the variable portion. Unfortunately, force costing databases provide costs for POL Platoons and not POL Sections. However, based on how the Army structures its units, a section is roughly 1/4 of a platoon so taking 1/4 of the O&S costs of a POL Platoon can be assumed to the O&S cost of a POL Section. It should be noted that the force costing database used by this methodology to estimate the O&S cost for a POL Section does not capture what the fixed or variable portions of the cost are. In order to calculate the variable O&S cost of the section, an assumption has to be made. All of the O&S costs for the equipment in the POL Section are assumed to be allocated to the BCT but this is not the case the personnel and all other O&S costs. Since the soldiers that act as the crew for the fuel trucks only spend an assumed eight percent of a man-year actually being the crew, this methodology assumes that eight percent of the annual personnel O&S and other non-equipment O&S costs of a POL Section is the variable cost. This is a rough assumption that gets used throughout this methodology but there is currently no better way to try to get at the variable costs. This assumption will hopefully get better refined as this methodology evolves over time. The other thing to note is that counting these O&S costs of the POL Section in addition to the O&S costs of the fuel trucks is not double counting. According to Army Field Manuals on Army support units, those fuel trucks are part of a Transportation Company, which is a separate unit from the POL Section.

Due to how the Army structures its units, there is a hierarchy of headquarters O&S costs above the POL Section level that are also included in step two of this methodology. The POL Section is part of a platoon in a Distribution Company and this methodology allocates part of the Distribution Company Headquarters Platoon's O&S costs to this step. Since soldiers spend roughly eight percent of a man year performing crew duties for fuel trucks, this methodology assumes that eight percent of the Distribution Company Headquarters Platoon's O&S costs are variable. In addition, this methodology goes one step further in its allocation scheme by dividing by 12 because it is assumed that a section is 1/4 of a platoon and a platoon is roughly 1/3 of a company. The reasoning behind this allocation scheme is that the if a POL Section is roughly 1/12 of a Distribution Company, then 1/12 of the Distribution Company Headquarters Platoon's time is spent in support of the POL Section and , therefore, 1/12 of the Distribution Company Headquarters Platoon's variable O&S cost is allocated to the POL Section. This same allocation applies at the next highest level, the Brigade Support Battalion (BSB) Headquarters Company.

The allocation scheme at this level starts with the same assumption of eight percent of O&S costs of the BSB Headquarters being variable for the same reasons previously stated. However, the Army methodology goes a step further with the BSB Headquarters Company by dividing by 36 because the Army normally structures itself by having 3 companies in a BSB, three platoons within each of those 3 companies, and roughly 4 sections in each platoon. Then the final level that this allocation methodology applies to is the Sustainment Brigade Headquarters Company. Again, the same methodology for assuming eight percent of Sustainment Brigade Headquarters Company O&S costs are variable apply. However, the Army methodology goes a step further with the by dividing by 144 because the Army normally structures itself to have 4 BSBs in a Sustainment Brigade, 3 companies in each of those BSBs, 3 platoons in each of those companies, and roughly 4 sections in each platoon. For peacetime FBCF calculations, the Sustainment Brigade will be the highest level unit that will be included because that is the highest level unit that would be involved in any BCT-level peacetime training operations. Wartime calculations will include a unit that is one level higher, the TSC. The total annual O&S cost of primary fuel delivery assets divided by the total annual gallons of fuel used by the BCT with the new system in it results in the primary fuel delivery asset O&S cost per gallon burden.

The third step in the seven step methodology is to calculate the depreciation costs for primary fuel delivery assets. Army force costing models provide the acquisition costs to buy the fuel trucks and all of the equipment in the units from the POL Section all the way up to the Sustainment Brigade Headquarters Company. The method used to calculate depreciation is straight line depreciation; acquisition costs of the fuel trucks and unit equipment over an assumed service life of 20 years. All POL Section equipment is assumed to be allocated to the BCT. In the same manner and for the exact same reasons that the O&S costs of the various levels of headquarters units were allocated to the BCT, 1/12 of the depreciation costs of the Distribution Company Headquarters Platoon, 1/36 of the depreciation costs of the BSB Headquarters Company, and 1/144 of the depreciation costs of the Sustainment Brigade Headquarters Company get allocated to the BCT. The total annual depreciation cost of primary fuel delivery assets divided by the total annual gallons of fuel used by the BCT with the new system in it results in the primary fuel delivery asset depreciation cost per gallon burden.

The fourth step is to calculate the direct fuel infrastructure O&S costs. The Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD (AT&L)) / Installations and Environment (I&E) has a facilities database that provides annual direct fuel infrastructure O&S costs on various military posts. Direct fuel infrastructure O&S costs are the O&S costs of any fuel infrastructure that is not directly operated by DESC and directly tied to delivering fuel. Examples of such infrastructure are bulk fuel storage locations, and POL pipelines. The O&S costs are infrastructure sustainment costs, infrastructure recapitalization costs, other O&S costs, and straight line infrastructure depreciation cost that divides Plant Replacement Value (PRV) costs by an assumed infrastructure lifetime of 67 years. It should be noted that, since this cost is an annual cost for an installation, the cost must be divided by the total annual amount of fuel used on that installation as opposed to the total annual amount of fuel used by a BCT in the other steps of this methodology. Army O&S databases can provide the total amount of fuel used on an installation in a year. The type of installation an analyst gets infrastructure information on should depend on what type of BCT is being analyzed. For example, if an HBCT is being analyzed, infrastructure costs from installations that are home station to HBCTs should be used for this analysis. The total annual direct infrastructure O&S costs divided by the total annual amount of fuel used on that installation results in a direct fuel infrastructure O&S cost per gallon.

The fifth step is to calculate the indirect fuel infrastructure O&S costs. Indirect fuel infrastructure O&S cost are the costs of base infrastructure that is shared proportionally among all base tenants. Examples of these costs are fire station costs whose job it would be to put out POL fires at any of the direct fuel infrastructure locations. The total annual indirect infrastructure O&S costs divided by the total annual amount of fuel used on that installation results in an indirect fuel infrastructure O&S cost per gallon. This cost tends to be so low that it usually gets zeroed out. As this methodology evolves, future recommendations may be to remove this step.

The sixth step is to calculate the environmental costs. Environmental cost is the cost representing carbon trading credit prices, hazardous waste control, and related subjects. For right now there is a placeholder of ten cents per gallon from an old environmental study that is being used for this cost. As this methodology gets refined, it will be desirable to have an updated environmental methodology that will be able to estimate environmental cleanup costs for systems based on historical studies of environmental costs of other systems with similar weight and OPTEMPO.

The seventh and final step of this methodology is to calculate other costs. Other Costs include potential costs associated with delivering fuel such as convoy escort and force protection costs. For peacetime calculations, this cost will most likely be zeroed out. There will most likely not be any force protection or convoy escort costs like there would be in a wartime scenario. If there are any costs during training, they would be so small that they would be negligible.

After the costs in each step are in cost per gallon form, they can be added together to achieve a peacetime FBCF cost per gallon. Peacetime FBCF estimates are not difficult to calculate because analysts are used to doing peacetime estimates and peacetime data is plentiful. Calculating wartime FBCF costs are a little more challenging.

4. Wartime FBCF Calculations.

4.1. Where to Start.

The requirement to any type of wartime estimate into an AoA, much less a wartime FBCF estimate, is new. Cost estimates are usually peacetime estimates because the Army plans and programs its budget based on peacetime operations. Wartime is very volatile with no clear plans or schedules from which to produce a cost estimate. Analysts are used to making assumptions for peacetime estimates to fill in the blanks where little or no required information is available. However, due to wartime operations being so full of uncertainty, so many very significant assumptions would have to made in order to produce a wartime estimate that it quickly becomes very uncomfortable. Where does an analyst start when asked to produce a wartime FBCF estimate for an AoA?

The path that the Army FBCF methodology is taking is to directly tie the FBCF cost estimating to the effectiveness analysis that is being conducted for the AoA. An AoA always starts with two types of analyses on a system; an effectiveness analysis and a cost analysis. The AoA takes these two analyses and conducts a third type of analysis; the cost-effectiveness analysis. This cost-effectiveness analysis combines certain system effectiveness measures with lifecycle cost to show leadership how much capability is being bought for the price of the system. An example of a cost-effectiveness result may be a chart showing some measure of lethality versus cost or some measure or survivability versus cost.

Typically, the effectiveness analysis and cost analysis are completely separate analyses in an AoA with the exception of when the cost-effectiveness analysis is conducted. This is because the cost analysis results in a peacetime lifecycle cost of a system and the effectiveness analysis results in how well the system performs in a wartime scenario. There may some connections between the two types of analyses such as quantities per unit or system reliability information but, for the most part, they are usually separate.

The requirement to produce a wartime FBCF estimate changes this paradigm. This requirement forces cost analysts and effectiveness analysts to work together in way that has not typically been done before because, for a wartime FBCF cost estimate, the cost analyst is basically putting a cost to what is happening in the logistics portion of the effectiveness scenario. This convergence of cost and effectiveness analysis adds credibility to the any wartime cost assumptions because they have to be in alignment with the effectiveness scenario assumptions in order to make everything work.

The portion of the effectiveness analysis that most affects FBCF calculations is the logistics footprint analysis. This logistics footprint analysis looks at fuel uses fuel consumption information of certain types of systems during various types of operations over various types of terrain in order to provide input into the actual effectiveness scenarios that are being conducted for the AoA. The information from this logistics footprint analysis that most benefits FBCF calculations is the amount of fuel used by a BCT over the timeframe specified in the analysis, the

amount of fuel used by the system in question for the AoA during that same timeframe, and system OPTEMPOs. This information allows insight into fuel burn rates of systems in the AoA and, based on how much fuel Army fuel trucks can carry and how much fuel is needed by the BCT, provides the ability to calculate the number of fuel trucks resupplying the BCT and frequency of fuel resupply convoys.
There are some areas where this wartime methodology falls short. First, the logistics footprint analysis being used for current AoAs only analyzes logistics operations from the Sustainment Brigade down to the resupplied unit. Referring to Figure 2, there are logistics operations above the Sustainment Brigade, to include operations from a port in Theater to the TSC and on down to the Sustainment Brigade that are not captured. Enemy forces attacking logistics convoys and force protection vehicles being used as convoy escorts are also not captured in current analyses. The reasons for these shortfalls is because Theater level analyses are usually too big for typical AoAs and no effectiveness models exist today that capture enemy effects on logistics tail. To alleviate these issues in the short term, the Army methodology is leveraging work done by the Army G-4[4] to account for logistics operations above the Sustainment Brigade level and account for fuel convoy attrition. In the long term, the goal is for updated effectiveness scenarios to eventually build in cases where the enemy attacks logistics convoys and maybe even provide a Theater level look.

4.2. Using the OSD CAPE Seven Step Methodology.

With the exception of tying FBCF calculations to the logistics footprint analysis, there are not many differences between how the OSD seven step methodology is used for the wartime calculations and how it is used for the peacetime calculations. The first step of finding the DESC Commodity Cost of Fuel for the wartime FBCF estimate is no different than the first step of the seven step methodology for the peacetime methodology. The only difference with the second step of calculating the primary fuel delivery asset wartime O&S cost is that fuel truck quantities, fuel truck OPTEMPOs, resupply convoy frequencies, and logistics operations above the Sustainment Command level will be taken into account from the logistics footprint analysis, assumptions, or information leveraged from work done by G-4. The only difference with the third step of calculating the wartime depreciation costs of primary fuel delivery assets is that attrition of fuel trucks due to the enemy attacking the logistics tail has to be taken into account. For example, if a total of 16 fuel trucks supports a unit but 4 of those trucks get destroyed by enemy action, 4 more fuel trucks, a total of 20 trucks, need to be acquired to meet the requirements of the unit. A factor for attrition is still being developed and will either be an assumption or information leveraged from work done by G-4. The fourth step of calculating the direct fuel infrastructure wartime O&S cost is very different from the fourth step of the peacetime methodology. The concept is the same but the infrastructure will not reside on

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[4] Army G-4 currently houses the Sustain the Mission Project (SMP) Tool and has validated certain logistics assumptions that the tool uses to calculate FBCF.

peacetime military installations. For the wartime calculations, the infrastructure will be on Forward Operating Bases (FOBs) and other bases in Theater. This type of infrastructure information is difficult to find. The fifth step of calculating the indirect fuel infrastructure wartime O&S costs will most likely be zeroed out for the same reasons it was zeroed out in the peacetime FBCF calculations. As this methodology evolves in the future, this step may go away. The sixth step of calculating the wartime environmental costs will be very similar to the sixth step of the peacetime FBCF calculations with the exception that wartime OPTEMPOs will be taken into account if the Army methodology can move to an updated environmental methodology that will be able to estimate environmental cleanup costs for systems based on historical studies of environmental costs of other systems with similar weight and OPTEMPO. The seventh and final step of calculating other wartime costs is very different than the seventh step of the peacetime calculations because the peacetime methodology zeroed out the seventh step. For the wartime methodology, O&S and depreciation costs of the force protection vehicles that act as convoy escorts will be accounted for in the exact same manner fuel truck O&S and depreciation costs are accounted for. The vehicles are assumed to be Mine Resistant Ambush Protected (MRAP) vehicles. The quantity of these force protection vehicles will either be an assumption or information leveraged from work done by G-4. Fixed and rotary wing air support for convoys is also something that is desirable to take into account but currently too many assumptions would be required to include in this methodology. As this methodology evolves over time, air support for convoys may be taken into account.

5. Displaying Army AoA FBCF Results to Decision Makers.

Displaying AoA FBCF results to decision makers in way that will be meaningful for them is very important. Due to the fact that FBCF calculations for AoAs are a new requirement and leadership has not actually seen results of this nature before makes this a little challenging. For Army AoAs, it has been decided that the FBCF estimate will appear in an annex of the AoA final report as opposed to being a part of the lifecycle cost estimates. There are a few reasons for this. First, the lifecycle cost estimates will be peacetime estimates and the FBCF estimates will have wartime costs in addition to peacetime costs. If one cost element of the entire cost estimate is burdened in any way with wartime burdens, the entire estimate must account for wartime costs and this is not feasible. Second, the FBCF will make more of an impact on decision makers if separated from the entire lifecycle cost estimate. Even if only the peacetime FBCF was included in the lifecycle cost estimate, the differences in FBCF costs between AoA Courses of Action (COAs) would hardly be seen at all because the fuel costs, even heavily burdened, would be dwarfed by the Research, Development, Test, and Engineering (RDTE); Procurement, and other O&S costs. The bottom line is that any FBCF differences between the COAs would stand out more in an annex separated from the lifecycle cost estimates.

Although more thought needs to be put into how to actually display the results in the FBCF annex, one way that is being envisioned is to show two different types of displays. The first display would be the wartime and peacetime FBCF cost per gallon displayed for each system in the AoA in the manner presented in Figure 3.

Course of Action (COA)	Wartime FBCF Cost Per Gallon (BY10$)	Peacetime FBCF Cost Per Gallon (BY10$)
Base Case	$8.40/Gallon	$5.80/Gallon
COA 1	$8.65/Gallon	$6.15/Gallon
COA 2	$9.20/Gallon	$7.55/Gallon
COA 3	$7.75/Gallon	$5.35/Gallon

Figure 3: FBCF Cost Per Gallon Display (Note: Costs Are Notional)

Another way to display FBCF costs is to show the wartime and peacetime costs per year for the BCT analyzed in the AoA. Figure 4 shows FBCF costs displayed in this manner.

Course of Action (COA)	Total Wartime BCT FBCF Cost Per Year (BY10$K)	Total Peacetime BCT FBCF Cost Per Year (BY10$K)
Base Case	$280.5K	$167.9K
COA 1	$302.3K	$192.1K
COA 2	$421.7K	$265.8K
COA 3	$248.4K	$129.6K

Figure 4: FBCF Cost Per BCT Per Year Display (Note: Costs Are Notional)

One or more of these types of displays may actually be presented in the FBCF annex of the AoA final report.

6. FBCF Challenges.

There are numerous challenges to incorporating FBCF costs into Army AoAs. Most of the challenges deal with availability of data and certain assumptions that will have to be made to produce a wartime FBCF cost estimate. Some challenges will occur during AoAs that are analyzing Joint Service Systems. For example, if an AoA is looking at a system that both the Army and USMC will acquire, the FBCF methodology must be able to take into account the differences in logistics resupply operations of both Services. Future challenges will be when systems start using other types of energy besides fuel. This Army methodology will have to incorporate the Fully Burdened Cost of Energy (FBCE) to account for other types of energy that systems could use such as hybrid electric drives or wind powered energy. The Army FBCF methodology will continue to evolve over time to overcome these challenges.

7. Summary.

The purpose of this paper has been to introduce analysts who are not familiar with it to FBCF and to explain how the Army plans to incorporate FBCF estimates into its AoAs. The Army methodology outlined in this paper is in the very beginning stages and will continue to get refined in the future. Estimating FBCF is not without its difficulties but if there were not any challenges, it would not be any fun.

The best way to get some type of FBCF results is to have a deadline to work toward. The first Army AoA that requires FBCF calculations is the Ground Combat Vehicle (GCV) AoA and the FBCF results for this analysis will be required in early summer 2010. There are at least two more Army AoAs that will occur in 2011 that will require FBCF calculations as well. The Army goal is to work toward the best possible FBCF solution that can be produced for the near term GCV AoA, conduct an after action review to determine what went right and what could have been done better, and improve upon this FBCF methodology to better inform the future upcoming AoAs.

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