Universal Service Contract-9 Economic Price Adjustment Factor Update

Bunker, Currency, and Fuel Adjustment Factor Refresh

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	Inches	25.4	millimeters	mm
ft	Feet	0.305	meters	m
yd	Yards	0.914	meters	m
mi	Miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
oz	ounces	28.35	grams	g
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
mL	milliliters	0.034	fluid ounces	fl oz
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
g	grams	0.035	ounces	oz
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	Kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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List of Abbreviations

Abbreviation	Term
BAF	Bunker Adjustment Factor
CAF	Currency Adjustment Factor
CONUS	Contiguous United States
DeCA	Defense Commissary Agency
DFARS	Defense Federal Acquisition Regulation Supplement
DOE	United States Department of Energy
DOT	United States Department of Transportation
ECA	Emissions Control Areas
EIA	Energy Information Administration
EPA	Economic Price Adjustment
FAF	Inland Intermodal Fuel Adjustment Factor
FAR	Federal Acquisition Regulation
FEU	Forty-foot Equivalent Unit
FMCSA	Federal Motor Carrier Safety Administration
GT	Gross Tonnage
IFO	Intermediate Fuel Oil
IMO	International Maritime Organization
m/m	Mass/Mass
MGO	Marine Gasoil
MPG	Miles per Gallon
MSP	Maritime Security Program
MTON	Measurement Ton
NOx	Nitrogen Oxides
NRT	Net Registered Tonnage
OCEMA	Ocean Carrier Equipment Management Association
OCONUS	Outside Contiguous United States
OD	Origin-Destination
OLS	Ordinary Least Squares
PM	Particulate Matter
RFP	Request for Proposal
RORO	Roll on / Roll off
SDDC	Surface Deployment and Distribution Command
SOx	Sulfur Oxides
TEU	Twenty-foot Equivalent Unit
ULSMGO	Ultra Low Sulfur Marine Gasoil
USC	Universal Service Contract
USTRANSCOM	United States Transportation Command

Executive Summary

This report describes the refreshing of the United States Transportation Command (USTRANSCOM) Economic Price Adjustment (EPA) factors for use in the Universal Service Contract 09 (USC-09). The three EPA factors, the Bunker Fuel Adjustment Factor (BAF), the Currency Adjustment Factor (CAF), and the Inland Intermodal Fuel Adjustment Factor (FAF), developed by Volpe in the 2009 study and updated in 2013,[1] are the starting point for this update.

Concurrent with the USC contracting process, international regulations regarding the sulfur content of marine fuel used by commercial shipping vessels will change and impact carriers moving USTRANSCOM cargo. In open waters, the International Maritime Organization (IMO) regulations require that commercial shipping vessels use fuels that meet various emissions requirements, such as the sulfur content. Beginning January 1, 2020, the IMO will require vessels to use fuel with a sulfur content of no more than 0.5% m/m, a reduction from the current 3.5% m/m fuel. While this change will impact the relative prices of fuels worldwide, it will not impact overall fuel price volatility or prompt a change in the calculation of USC-9 EPAs.

Economic Price Adjustment Factors

USTRANSCOM uses EPAs with a firm-fixed price contract to address inherent instability in marine shipping input prices. Volatile input prices (marine/diesel fuels and currency exchange rates) reduce contract stability by introducing price risk and uncertainty, exacerbated by the length of the contracting period. In cases where a volatile input can be identified and tracked, an EPA allows for an adjustment to the net price paid when the input price shifts in accordance with negotiated terms. Firm-fixed price contracts with EPAs have the benefit of establishing a stable, fixed base freight rate while allowing the contract to be moderately responsive to excess input price volatility beyond the control of either the carrier or shipper.

Each EPA's methodological foundation was reexamined based on a review of industry practice, conversations with USTRANSCOM, and expressed industry concerns. While the underlying structure of each EPA remains the same, changes in the marine fuel market and a desire to reevaluate the buffer methodology (for the BAF and CAF) necessitated some methodological changes. A review of the data-driven elements led to several changes for the BAF; however, many other data-driven elements remain the same as in previous studies. No changes were made to the underlying FAF calculations.

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[1] Calculation of Bunker Fuel, Currency, and Inland Freight Fuel Price Adjustment Factors for USTRANSCOM Commercial Shipping Contracts, July 2009. Calculation of Fuel, Currency and Inland Freight Price Adjustment Factors for Military Marine Shipping, November 2013.

Bunker Adjustment Factor (BAF)

The general structure of the BAF was reviewed and determined to meet its mission requirements. At its core, the BAF has four critical elements:

1. A fuel price differential representing the change in the unit price of fuel outside the buffer zone from the baseline to the current period;
2. A fuel consumption amount for the transit of the vessel from load port to discharge port, allocated to units of cargo;
3. An input substitution multiplier accounting for a carrier's ability to adjust operations in response to fuel prices whose value can range from zero to one; and
4. A risk sharing multiplier whose value can range from zero to one.

Each of the four BAF critical elements were reviewed, including their underlying rationale, data sources, and continued applicability for USC-9. Using USTRANSCOM and commercially available vessel data, an average vessel for each lane was created to model fuel burn for a journey. While the underlying structure and methodology of the BAF remain unchanged, greater data availability allowed calculation of underlying inputs to the average vessel estimation to be refined, improving the extent to which they reflect USTRANSCOM's current shipping patterns and broader global maritime trends. The four primary recommended changes to the BAF are:

- **IMO 2020 Compliant-fuel Types.** The nomenclature for fuels that are included in the model has been adjusted to match fuels as required by the January 1, 2020 IMO requirement such that the name reflects the area of use (Over Ocean, ECA, or Port) as opposed to a specific type of fuel (e.g., ULSMGO or IFO380). The USC-9 BAF includes fuels compliant with the new IMO 2020 regulation for a worldwide cap on fuel sulfur content of 0.5% m/m. This new low sulfur "Over Ocean" fuel will be used for a vessel's non-ECA and non-port portion of a lane's distance.
- **Calculated Buffer.** Previous versions of the USC BAF set the buffer at 20 percent. The updated methodology aims to be more reflective of normal volatility, lessening the possibility that the size of the buffer is biased by inclusion of atypical periods of excess volatility. Consistent with previous recommendations, the updated calculation maintains a symmetrical buffer zone.
- **New Process for Estimating Distance.** The previous version of the USC BAF (2013) modeled the average distance for each lane using the top three ports by cargo volume from both origin and destination sides of lane. For the USC-9 BAF, distance estimates now include the top three ports for each side of a lane along with any additional port that accounts for greater than 10 percent of that lane's cargo, allowing less concentrated lanes to be more representative of the actual distance traveled by a unit of cargo. Additionally, the distance incorporates a weighted average of distance by vessel type (containership or RORO) for a single average distance by lane.
- **Estimating Vessel Characteristics for Missing Data Values.** The average vessels used to form the USC-9 Technical Factors incorporate estimated values where data were missing from the vessel characteristics database.

Using the updated methods for data analysis, an average vessel for each USTRANSCOM lane was created and fuel burn was estimated per unit of cargo for a typical voyage. From these average vessels and typical distances along with the Input Substitution and Risk Distribution Factors, the BAF Technical Factors were updated. See Section 2 for the BAF update.

Currency Adjustment Factor (CAF)

Volpe determined that the underlying CAF structure and methodology developed in previous EPA studies, and used through USC-8, remained applicable and did not require any fundamental adjustments. Therefore, the primary focus of this update is to incorporate additional historical information on USC shipping patterns, exchange rates and shipping costs into the CAF structure. Updating the underlying data ensures that the USC-9 CAF is representative of recent USTRANSCOM shipping patterns, overseas port costs relative to total shipping costs, and currency volatility.

While the calculation of many of the data driven elements of the CAF remains the same as previous studies—superlanes, currencies, trade weights, and technical factor—an important factor in this update is the new buffer calculation methodology. The updated buffer calculation method is more reflective of normal volatility, the typical currency price fluctuations over a given period. These fluctuations are the expected volatility that carriers are in a more advantageous position to manage. This allows the new buffer to be set at a level more reflective of the unanticipated excess volatility, sharing this risk among the carriers and USTRANSCOM.

The CAF EPA continues to be broken into three superlanes, which represent more than 90 percent of USTRANSCOM's CONUS/OCONUS shipments. Aggregating the CAF into these three superlanes minimizes the administrative burden of the CAF while still capturing close to all of USTRANSCOM cargo flows.

The CAF uses 16 currencies from which the superlane volatility measures are derived. These currencies were selected based on their importance in terms of USTRANSCOM shipping patterns; each must capture at least one percent of trade within their respective superlanes. This one percent decision rule limits the number of currencies, reducing the complexity of the final model, while still capturing the geographic diversity (and thus currency payment diversity) of the majority of USTRANSCOM's cargo movements. See Section 3 for the CAF update.

Inland Intermodal Fuel Adjustment Factor (FAF)

The focus of the current effort was on updating the data inputs used in calculating the FAF and not on developing a different approach to calculating a FAF. As such, Volpe recommends no changes to the FAF methodology in this refresh; there are still 24 unique FAF calculations, which are based on four shipment types, and six categories of regional movements within CONUS. Volpe does provide multiple recommendations on new values for the inputs to the FAF.

A literature review was conducted to determine if there were any significant changes in reported fuel economy for trucks and intermodal rail since the last Volpe study. In addition, recent literature was reviewed in order to determine if there were any documented changes in the distance at which intermodal rail would be considered the preferred alternative to truck. The FAF calculations continue to assume that only dry containers would ever be transported by rail.

The average intra and inter zonal haul distances used in computing the FAF for the various shipment types were recomputed using recent USTRANCOM-provided data on inland destination/origin to/from CONUS ports from 2017 and 2018. The average dray distance for the inland leg of rail intermodal trips was also recomputed based on the latest IBS data. The distance values were also used to determine if there should be any changes in the amount of off duty time required for truck drivers in reefer shipments. There were significant changes in many of these inputs to the FAF calculator. See Section 4 for the FAF update.

1. Introduction

This report describes the refreshing of the United States Transportation Command (USTRANSCOM) Economic Price Adjustment (EPA) factors for use in the Universal Service Contract 09 (USC-09). The three EPA factors, the Bunker Adjustment Factor (BAF), the Currency Adjustment Factor (CAF), and the Inland Intermodal Fuel Adjustment Factor (FAF), developed by Volpe in the 2009 study and updated in 2013, are the starting point for this update.

1.1 The Universal Service Contract

The USC is a firm-fixed price contract for international cargo transportation and distribution services. Ocean common or contract carriers, defined in the Shipping Act of 1984,[2] provide these services for requirements that may arise in any part of the world, including service areas covered by the Jones Act, as part of the carriers' regularly scheduled commercial liner service.[3] In comparison to commercial marine shipping contracts, what is unique about the USC, is the contracting length—the base shipping rates can be fixed for up to 17-months, a 5-month bidding period and a 12-month contracting period.

One challenge of the firm-fixed price contract is the inherent instability in marine shipping input prices, as these contracts are most effective when markets are stable. Volatile input prices (marine/diesel fuels and currency exchange rates) reduce contract stability by introducing price risk and uncertainty, exacerbated by the length of the contracting period. In cases where a volatile input can be identified and tracked, an EPA allows for an adjustment to the net price paid when the input price shifts in accordance with negotiated terms. Firm-fixed price contracts with EPAs have the benefit of establishing a stable, fixed base freight rate while allowing the contract to be moderately responsive to excess input price volatility beyond the control of either the carrier or shipper.

Additionally, U.S. government requires EPAs to be symmetrical with respect to increases or decreases in the exogenous commodity price. When using an EPA, the Federal Acquisition Regulations/Defense Federal Acquisition Regulation Supplement (FAR/DFARS) acquisition regulations require "mutuality" to protect both parties. The concept behind EPA mutuality is that when contract inputs are volatile enough to make cost projections and thus contracting difficult, a price range is identified outside of which either party is compensated by the other. The resulting contract assumes an input's market price and uses an index to track the price. If the price stays constant, the input price at the time of bidding is assumed to

[2] Full text of the Shipping Act of 1984 can be found here: https://www.fmc.gov/assets/1/Page/The_Shipping_Act_of_1984_Re-Codification.pdf (Federal Maritime Commission, 1984)

[3] Contract description adopted from the USC-09 Synopsis document, a component of the USC-09 RFP (United States Transportation Command, 2018)

be the full responsibility of the contractor and their bid reflects that amount.

In updating the EPAs, the Volpe team attempted to balance a desire to accurately capture and represent USTRANSCOM's evolving shipping patterns with a need to minimize the administrative burden of updating and implementing the EPAs.

1.2 Economic Price Adjustment Factors

USTRANSCOM EPA factors used in the USC-9 and its predecessors (specifically the BAF and CAF) are constructed to compensate for large and unanticipated variation, and the associated risk, in input prices of marine bunker fuel and currency risk, respectively. EPAs are not intended to account, or compensate, for normal market fluctuations that carriers are in a more advantageous position to manage. Below is a more detailed discussion of risk and uncertainty each factor tries to mitigate.

1.2.1 Bunker Adjustment Factor (BAF)

Marine carriers and shippers use a BAF as a mechanism for acknowledging the risk and uncertainty resulting from marine fuel price volatility. If fuel prices were constant or if rates were negotiated on an ad hoc basis for each piece of cargo moved, there would be no need for a BAF as the spot price would reflect the cost of transportation, including the current price of fuel. However, over the length of the USC the price of fuel may vary significantly from the fixed price of the cargo rate quoted at the start of the contract, presenting a risk to both parties. The fundamental purpose of the BAF is to share the risk posed by fuel price volatility and compensate the party made worse off by this uncertainty.

1.2.2 Currency Adjustment Factor (CAF)

Businesses and organizations engaged in international trade use a currency adjustment factor as a mechanism for acknowledging the risk and uncertainty from exchange rate volatility. This uncertainty results from when the price of a good or service, associated with moving shipments internationally is presented in one currency and subsequently invoiced, or sold, at a later date in another currency. For example, expenses incurred by a carrier moving USC cargo to a port in Europe may be priced in Euros, but USTRANSCOM contracts' are invoiced in U.S. dollars. Fluctuations in the euro/dollar exchange rate between the point at which a base contract rate is set and a shipping service is provided creates financial uncertainty for both ocean carriers and shippers. The CAF is constructed to share the risk posed by exchange rate fluctuations.

1.2.3 Inland Intermodal Fuel Adjustment Factor (FAF)

Similar to the BAF, the FAF is a mechanism to adjust for the risk and uncertainty resulting from inland fuel (diesel) price volatility. These fluctuations create uncertainty over the "true" cost of inland container moves. Between the time the base inland freight rate is negotiated/set and the time when the cargo is moved, diesel price fluctuations may expose a carrier to financial uncertainty. The FAF shares the risk posed by diesel fuel price volatility amongst the carrier and the shipper, and compensates the party made worse off.

1.3 Methodological Updates

Based on a review of industry practice, industry concerns, and through conversations with USTRANSCOM, the methodological foundation of each EPA was reexamined. While the calculation of many of the data-driven elements remain the same as in previous studies some data processes were updated in the BAF to incorporate more information on vessels and shipments. Additionally, changes in the marine fuel market and a desire to reevaluate the buffer methodology (for the BAF and CAF) necessitated some methodological changes. No changes were made to the underlying FAF calculations.

1.3.1 Refined Data Processes

Some processes from the previous BAF were updated to incorporate more vessel and shipment data into the creation of a lane's average vessel and representative voyage distance. Where vessel characteristics were missing for fuel consumption and Roll-on/Roll-off (RORO) capacity, estimates were created using other available data. When building the typical distance of each lane's voyage, more ports were included in the mapping to better represent more cargo shipments and the final distance is a weighted average of container and RORO vessels.

1.3.2 Marine Fuel Regulations

The International Maritime Organization (IMO) has implemented a reduction in the sulfur content allowable in marine fuel, effective January 1, 2020. The sulfur cap reduction, from 3.5% mass by mass (m/m) to 0.5% m/m will impact the type of over ocean fuel used by marine shippers; however, the effects of the IMO 2020 regulation will not have any structural impacts on the BAF. The fundamental methodology will remain unchanged—it will continue to trace the price of multiple fuels against a set baseline, it will continue to estimate fuel burn in the technical factors, and continue to incorporate the Input Substitution and Risk Distribution Factors.

1.3.3 Buffer Zone

Based on conversations with USTRANSCOM and after review of carrier concerns, the Volpe team undertook a review of the BAF and CAF buffer calculations. The updated methodology is more reflective of normal volatility, lessening the possibility that the size of the buffer is biased by inclusion of atypical periods of excess volatility. As with the previous methodology, the updated calculation maintains a symmetrical buffer zone.

1.4 Report Overview

This study examines in detail the development of methodologies for construction a BAF, CAF, and FAF for USC-09. Each section focuses on one EPA, providing more detail about the source of price volatility risk it mitigates as well as an in depth discussion of its calculation methodology, and new results of the EPA factor refresh, which includes: changes to the static and technical factors, additions to (or removals from) the currency basket, and updated buffer sizes. The final section concludes by summarizing the refresh findings and offering a proposed implementation plan for USTRANSCOM.

2. Bunker Adjustment Factor (BAF)

This section describes the update of the USTRANSCOM BAF for use in USC-9. For the purpose of this refresh, USTRANSCOM tasked Volpe with reviewing and updating the BAF formula to reflect current market conditions. Volpe determined that much of the underlying BAF structure and methodology developed in previous EPA studies, and used through USC-8, remained applicable and did not require any fundamental adjustments.

The primary components of the BAF, meaning the fuel price differential, the fuel consumption amount, the input substitution multiplier, the risk sharing multiplier, and the buffer, are functionally the same, although with updated values. Any improvements made to input data estimation methodology or other calculations reflect greater data availability and improved the accuracy of model inputs and estimation. This update also incorporates additional historical information on USC shipping patterns, fuel prices, and vessel characteristics into the BAF. Updating the underlying data ensures that the USC-9 BAF is representative of recent USTRANSCOM shipping patterns, new global fuel standards, and marine fuel price volatility.

2.1 General Principles of a BAF

A BAF is a mechanism utilized in shipping contracts to minimize exposure to unanticipated large swings in bunker fuel prices. Historically, carriers built the cost of bunker fuel into the basic freight rate charged to shippers. These rates were fixed for a period of time, usually not more than six months. As bunker fuel costs were both stable and a relatively small share of carriers' costs, the subsequent round of carrier freight rates reflected price increases. When fuel price volatility increased within the term of a contract, carriers sought to minimize their exposure to unanticipated large fuel price increases, and to pass those costs on to their customers.

The first BAF appeared in 1974 after the early 1970s oil shocks caused a significant rise in bunker prices. Initial versions of BAFs were percent increases on the freight rate when the rise in fuel prices met the conditions set forth in the agreement. These evolved into a flat fee per unit of cargo, the method used in industry today.

2.1.1 Sharing of Fuel Price Volatility

The main principle behind a BAF is to share the risk of price volatility between the carrier and shipper. This is particularly important in instances where carriers have to maintain shipping contract rates for a significant length of time (as done in the USC contracts). In these circumstances a BAF is warranted due to the length of time during which the price of fuel may fluctuate away from the base rate stipulated at the start of the contract period (increasing the risk from fuel price volatility). For shippers that need to plan and budget accurately for shipping costs, fuel volatility may present a substantial cost. It is important to note that risk from price fluctuations is carried by both the carriers (from higher fuel prices) and shippers (from lower fuel prices).

When considering a risk sharing mechanism it is important to recognize which party is better positioned to mitigate this risk. In the case of the BAF, carriers have opportunities that aren't available to shippers: carriers can adjust input mixes, shift costs, or hedge on prices by advance purchases or other market instruments. Even though the carrier may not have control over spot prices in world markets, it has more levers to deal with variations than the shipper, who has little or no control over the carrier's economic choices.

2.1.2 Isolating Volatility in a BAF

The volatility component of pricing can be isolated from other cost factors by setting a base price and measuring deviations of subsequent prices from that baseline. Deviations beyond a given percentage amount (a "buffer") are then compensated by a surcharge (the BAF). The baseline price is the current price at the time of the bid or contract, and the subsequent price is the price at the time of service delivery. The base shipping rate for the service takes into account all costs, including fuel; however, it does not include the volatility component of fuel prices.

2.1.3 Time Lag Between Purchase and Delivery of Service

For fuel costs, a key factor is the time horizon over which the cost must be estimated. If the price quote and the delivery date are relatively close—less than, say, two months—then the likely changes in fuel price are smaller in magnitude and more easily estimated and managed. Price quotes that need to be valid for as much as a year in advance may be subject to substantial cost variability in fuel.

Thus the utility of a BAF is dependent upon and presumes a lag between the rate setting, agreement to ship, and service delivery of a large enough elapsed time as to make price volatility a problem. Otherwise—as with charters—the price can be estimated and quoted at the time the service is provided.

2.2 USTRANSCOM's BAF

As USTRANSCOM requires that price quotes be exercisable up to 17-months from the time of bidding and rate setting, USC contracts require a unique BAF structure. Fuel prices are both relatively volatile and make up a large share of the base rate, which subjects them to potentially large price swings over the duration of the contract. The risk of cumulative fuel price changes, either up or down, leaves initial estimates of shipping cost far from accurate. Figure 1 shows fuel prices changes to marine gasoil (MGO) and IFO380 between January 2009 and January 2018.

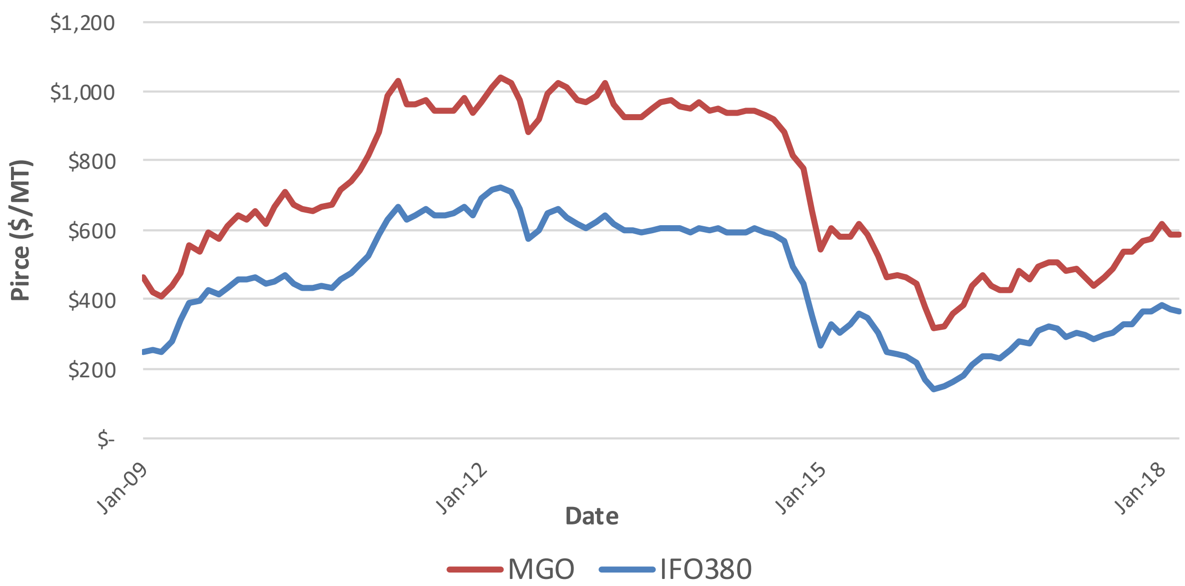

Figure 1. Monthly Average Marine Fuel Prices (2009-2018) [4]

The fundamental purpose of the BAF is to share the risk of abnormal or excess volatility in the price of marine fuel between USTRANSCOM (the shipper) and the ocean carriers that provide transportation services. If fuel prices were fixed and constant, there would be no need for a BAF as the price paid for shipping cargo would contain the entire fuel cost. Fuel prices, however, are subject to market volatility over time and the length of the USC contracts impose a risk to both parties. If USTRANSCOM purchased cargo transportation on an ad hoc basis, the total spot price would reflect the cost of transportation incorporating the current price of fuel. However, over the length of the USC contract, the price of fuel may vary significantly from the fixed price of the cargo rate quoted at the start of the contract. The BAF shares the risk of excess fuel volatility and compensates the party made worse off by that volatility.

2.2.1 General Structure of the USC BAF

USTRANSCOM's BAF methodology and implementation diverges from industry BAFs, as it must comply with the FAR and DFAR regulations, but the general goal of minimizing fuel price risk remains the same. Given potentially high volatility in fuel prices, setting a long-term, fixed price contract proves to be problematic for both shippers and carriers.

[4] The average represents a monthly average across four high activity ports including Los Angeles, Houston, Rotterdam, and Singapore. Source: Bunker Index IFO380 and MGO monthly average price

The USTRANSCOM BAF has four critical elements:

1. A fuel price differential representing the change in the unit price of fuel outside the buffer zone from the baseline to the current period;
2. A fuel consumption amount for the transit of the vessel from load port to discharge port, allocated to units of cargo;
3. An input substitution multiplier accounting for a carrier's ability to adjust operations in response to fuel prices whose value can range from zero to one; and
4. A risk sharing multiplier whose value can range from zero to one.

Their relationship is shown below in Equation 1.

$$BAF = \Delta p_f \times (Fuel_{CU} \times Input\ Substitution\ Factor) \times Risk\ Sharing\ Factor$$

Equation 1. General Structure of USTRANSCOM BAF

A brief description of each of the critical elements can be found below.

2.2.1.1 Δp_f, the Price Change Outside the Buffer Zone

The baseline fuel price establishes the expected fuel price at the time the USC contract is set. Movements in the fuel price during the USC contract period are then measured by comparing the baseline rate to the "new" rate (the average fuel price at the time of shipment) relative to the established buffer zone.

As will be discussed in Section 2.3.1.1, vessels often use multiple types of fuel (Over Ocean, Emissions Control Area (ECA), and Port) and the input mix varies by route, some routes may be primarily within an ECA zone while others will never traverse one. Because each lane is unique based on time spent in ECA zones relative to the open ocean, a unique baseline price and "new" price are calculated for each lane.

This price term includes not just the absolute change in price but the magnitude of that change relative to the buffer zone. The buffer zone establishes the range of normal volatility; a BAF payment (or rebate) is calculated only for prices outside this zone.

2.2.1.2 $Fuel_{CU}$, Fuel Consumption per Unit of Cargo

Based on the average distance of a trip, fuel consumption per unit of cargo estimates the amount of fuel used to ship one unit (twenty-foot equivalent unit (TEU), forty-foot equivalent unit (FEU), or measurement ton (MTON)) of cargo. This value helps estimate how fuel price volatility impacts the cost to move one unit of cargo between the baseline period and the shipping month. More fuel-efficient vessels will be less impacted by fluctuations in fuel prices, as they use smaller amounts of fuel.

Fuel consumption depends on a combination of vessel characteristics (type, capacity, and service speed) and operational constraints of the carrier and specific trade routes—a practical BAF can only include a limited number of these considerations.

2.2.1.3 Input Substitution Factor

In the face of fuel price volatility, carriers can adjust how they operate to reduce costs and preserve profitability. In particular, they have several inputs associated with how their vessels operate that can be adjusted, including fuel, labor, and capital. As the price of any one input rises, economic theory holds that a producer will shift their production to use less of the relatively more expensive input. When faced with rising fuel prices, carriers have numerous options to adjust their production to use less fuel including both short-term operational changes, such as slow-steaming, and longer-term capital investments such as newer, fuel-efficient engines. Absent the Input Substitution Factor, a carrier can ignore rising prices and operate in an inefficient manner, passing along the full cost of fuel volatility to the shipper through a BAF. Finally, the Input Substitution Factor accounts for the reduction in fuel consumption between the higher modeled service speed and lowered observed typical operating speed.

The Input Substitution Factor is a mechanism to account for and incentivize a carrier's ability to economize its operation. This is a negotiated value, ranging between 0 and 100 percent; at 0 percent, a carrier can adjust inputs to fully account for the fuel price change and at 100 percent a carrier has no ability to adjust operations to economize on more expensive fuel.

2.2.1.4 Risk Sharing Factor

An equitable BAF acknowledges the extent to which one party may be in a more advantageous position to manage risk due to fuel price volatility. USC carriers operate in the international market, have experience mitigating the impact of fuel price volatility, and are better positioned to manage fuel price risk. USTRANSCOM is not in the same position to manage fuel price volatility for their shipments, and should not be expected to bear the entire risk of this volatility. Nevertheless, since USTRANSCOM determines the contract length (with base rates remaining in place for up to 17-months), they should bear some of the risk.

The BAF risk sharing factor is the mechanism via which a portion of the fuel price volatility risk can be assigned to each party. This is a negotiated value, ranging between 0 and 100 percent; at 0 percent, the fuel price volatility risk is placed entirely on the carriers and at 100 percent it is placed entirely on USTRANSCOM.

2.2.2 Activating the BAF

As the BAF is only meant to mitigate risk from excess price volatility, USTRANSCOM's BAF is not always active. If the absolute price difference does not exceed a certain threshold (the buffer zone), then there is no BAF payment. The buffer represents a percentage deviation from the base fuel price. When the deviation of the current price is relatively small, no BAF is calculated and the variation is assumed to be within a normal range that the carrier is expected to accommodate within it basic ocean rate structure.

Variations outside the buffer range are assumed to be abnormal volatility, and constitute a risk that is sharable between shipper and carrier.

2.2.3 Relationship between the BAF and the Base Rate

The base freight rate and the BAF are additive, a notional representation is shown in Figure 2, and the magnitude of the BAF is not affected by the magnitude of the base freight rate. Together they make up the total net shipping cost (per unit of cargo).

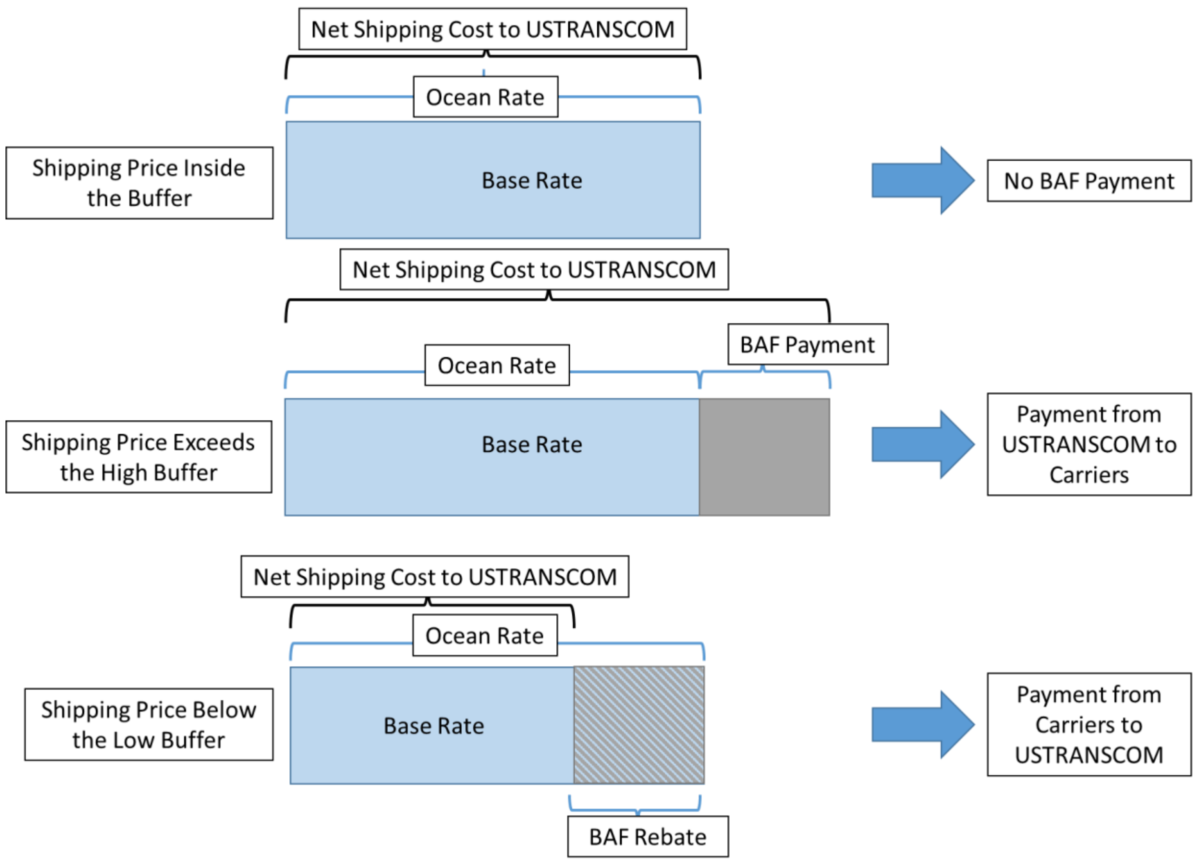

Figure 2. Notional Representation of Net Shipping Cost and BAF Payments

2.2.4 Changes from the Previous BAF

While the underlying structure and methodology of the BAF remain unchanged, greater data availability allowed calculation of underlying inputs to be refined, improving the extent to which they reflect USTRANSCOM's current shipping patterns and broader global maritime trends. Below is a brief discussion of refinements, with Section callouts for additional, more in depth, discussions.

IMO 2020 Compliant-fuel Types. Beginning January 1, 2020, ships will be required to use fuel oil on board[5] with a sulfur content of no more than 0.5% m/m. As such, the nomenclature for fuels included in the model has been adjusted so that the name reflects the area of use (Over Ocean, ECA, or Port) as opposed to a specific type of fuel (e.g., Ultra Low Sulfur Marine Gasoil (ULSMGO) or IFO380). The USC-9 BAF includes fuels compliant with the new IMO 2020 regulation for a worldwide cap on fuel sulfur content of 0.5% m/m. The new low sulfur 0.5% m/m fuel (the "Over Ocean" fuel) will be used for a vessel's non-ECA and non-port portion of a lane's distance. See Section 2.3.1.1.3 for a general discussion of the IMO fuel.

Calculated Buffer. Previous versions of the USC BAF set the buffer at 20 percent. The updated methodology aims to be more reflective of normal volatility, lessening the possibility that the size of the buffer is biased by inclusion of atypical periods of excess volatility. Consistent with previous recommendations, the updated calculation maintains a symmetrical buffer zone. See Section 2.3.4.2 for a discussion of the recommended buffer calculation and methodology.

New Process for Estimating Distance. The previous version of the USC BAF (2013) modeled the average distance for each lane using the top three ports by cargo volume from both origin and destination sides of lane. For the USC-9 BAF, distance estimates now include the top three ports for each side of a lane along with any additional port that accounts for greater than 10 percent of that lane's cargo, allowing less concentrated lanes to be more representative of the actual distance traveled by a unit of cargo. Additionally, the distance incorporates a weighted average of distance by vessel type (containership or RORO) for a single average distance by lane. See Section 2.4.4.2 for a discussion of the revised distance estimation procedure.

Estimating Vessel Characteristics for Missing Data Values. The average vessels used to form the USC-9 Technical Factors incorporate estimated values where data were missing from the vessel characteristics database. See Section 2.4.2 for a discussion of the methodology and results for this estimation.

2.2.5 BAF Section Report Structure

Moving forward, this BAF report section will isolate each critical element of the BAF, describing its role, the underlying methodology for calculation, and the process for updating it. Additionally, any improvements on previous calculations will be noted.

- Discussion of the fuel price differential and buffer zone takes place in Section 2.3: Identifying the Price Change
- Discussion of the fuel consumption amount per unit of cargo takes place in Section 2.4: Estimating Fuel Consumption
- Discussion on the input substitution multiplier takes place in Section 2.5: Input Substitution

[5] "Fuel oil on board" includes that which is used in the main and auxiliary engines and boilers.

- Discussion of the risk sharing multiplier takes place in Section 2.6: Risk Sharing

The results of these sections will be combined, generating the final BAF technical factors in Section 2.7: Combined Technical Factors.

2.3 Identifying the Price Change

A baseline fuel price provides the benchmark against which fuel price fluctuations are measured. The BAF is then designed to compensate for some of the variation from this baseline. As such, the methodology of setting a baseline and the frequency with which it is updated represent important components of the BAF methodology.

Fuel prices used in BAF calculations are taken from 3rd party sources such as Bunkerworld, Platts Bunker Wire, or Bunker Index. These prices don't necessarily incorporate the actual prices paid as carriers may purchase fuel months in advance, but rather, the prevailing market price at the time.

2.3.1 Identifying Marine Fuels to be Included in the BAF

Marine fuel choice impacts the BAF in two ways: the actual choice of the specific fuel types to model (ECA, MGO, IFO380, etc.) and the choice of which global prices to model (single port, by region, global average, etc.). These choices define the raw inputs to the fuel portion of the model and are used when setting the baseline or identifying the "new" price, and the volatility of the chosen prices will trigger a BAF payment if that volatility is outside the buffer zone.

2.3.1.1 Fuel Types

Commercial shipping vessels may use a variety of different fuel types depending on their location and operations. In and around ports, regulation requires that vessels burn MGO for environmental and operational reasons. In coastal and inland waters for many countries, environmental protection regulations require that commercial shipping vessels use fuel that has low levels of sulfur. In open waters, IMO regulations govern the sulfur content and other emissions so that commercial shipping vessels must use fuels that meet those requirements. Each of these fuels utilizes a different production process that creates variation in the relative cost of manufacturing and market price. Commercial shipping operations that depend on using these different fuels in different operations and locations will then have varying costs that depend on the mix of fuels used.

In an effort to capture the full regulatory framework, the BAF analysis considers whether all three different fuel types should be incorporated into the BAF.[6]

2.3.1.1.1 Port Compliant Fuel

MGO is a subset of bunker fuels formed from lighter distillates. While MGO is similar to diesel fuel, it does have a higher density. MGO emissions contain significantly less particulate matter/soot and have low sulfur levels, with sulfur contents ranging from as low as 0.0015% m/m (such as in the ULSMGO required in U.S. ports) to 1.5% m/m.

2.3.1.1.2 Emissions Control Areas (ECAs)

ECAs are characterized by mandatory measures governing ship emissions, which are designed to prevent, reduce, and control air pollution from Nitrogen Oxides (NOx), Sulfur Oxides (SOx), and Particulate Matter (PM) and mitigate their impact on human health and the environment.[7] To mitigate these impacts, vessels are required to use low sulfur fuel, <0.1% m/m and must comply with Tier 3 NOx emission requirements. These low sulfur fuels—MGO, LS380, and LS180—have a sulfur content below 0.1% m/m and while they can be used for the duration of the voyage, the large price differential between low sulfur and higher sulfur fuels means that carriers are likely to switch to low sulfur fuels only when the vessel is traveling within an ECA zone.

North America alone has over 300 designated ECAs, which cover the entire coastline of the United States (see Figure 3[8]). For vessels transiting to and or from U.S. ports, such as the vessels subject to the USTRANSCOM BAF, a portion of their journey will fall within at least one ECA and they must carry ECA-compliant fuel on board or risk being cited by the EPA and the U.S. Coast Guard for non-compliance.

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[6] Volpe recommended using three fuels for USC-8, one for each leg of a journey subject to different environmental regulations, open ocean, travel within an ECA zone, and within a designated port. However, as MGO satisfies environmental regulations for use in an ECA zone, it is ambiguous whether carriers actually use ECA fuel or whether they carry only two fuels and burn MGO in both ports and an ECA zone. If carriers indicate so to USTRANSCOM or if systems limitations require only two fuels be used, the ECA and port portions of the journey may be combined using only MGO fuel for that combined ECA/Port portion. Where this report references three fuels it recognizes that two fuels may be used with MGO for both the port and ECA share of a route with over-ocean fuel for the balance.

[7] U.S. Coast Guard, n.d.

[8] This figure was generated by Volpe using the NETPAS mapping software.

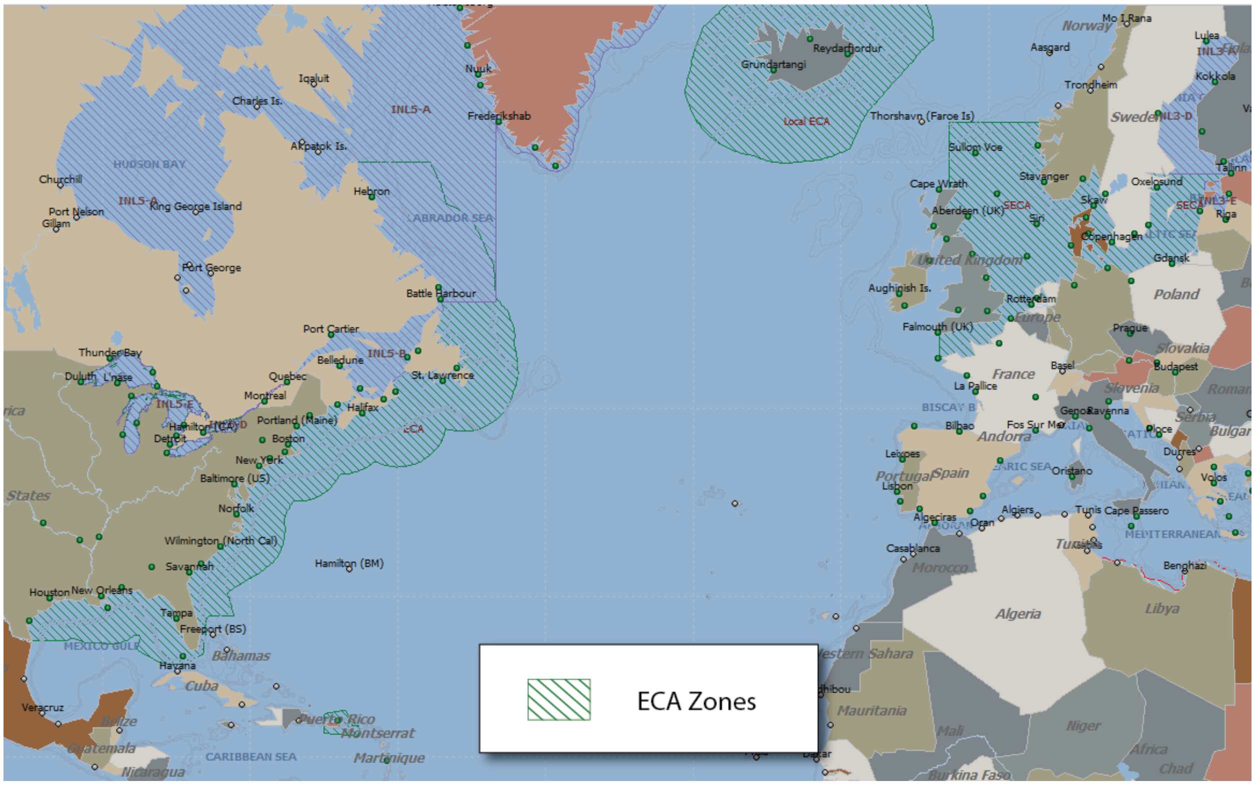

Figure 3. ECA Zones

2.3.1.1.3 Over Ocean Fuel

The USC-9 contract goes into effect September 2019, before the global sulfur cap is enacted. As such, over the course of the contract, the USTRANSCOM BAF will use two different over ocean fuel types. Before 2020, when over ocean marine fuel content can be above 0.5% m/m, USTRANSCOM will continue to use IFO380. These fuels are formed from blends of heavy residual fuels with lighter distillates in varying ratios and have higher viscosity than lower sulfur fuels. These fuels are cheaper and easier to produce as they can utilize sour crudes and residual products as inputs making them accessible to most refineries, as well as cheaper on the market.

After the January 2020 implementation date, USTRANSCOM will make the shift to IMO 2020 compliant over ocean fuel. The production of these new fuels will require more costly and complex refining processes than the heavier fuels, and will thus be expected to be sold at a premium to heavier fuels. As of now, these fuels are still in development, with some suppliers offering limited market tests.

2.3.1.2 Choosing Ports to Set Baseline Prices

The price of different fuels depends on market factors, and primarily production cost and user demand. In addition to fuel price variation by fuel grade, the fuel can also vary by the location where the fuel is sold; supply and demand factors may differ in one region relative to another.

Although fuel prices can be volatile, individual fuel prices exhibit strong correlation by type and location, shown by the clustering and consistency of price movements in Figure 4.

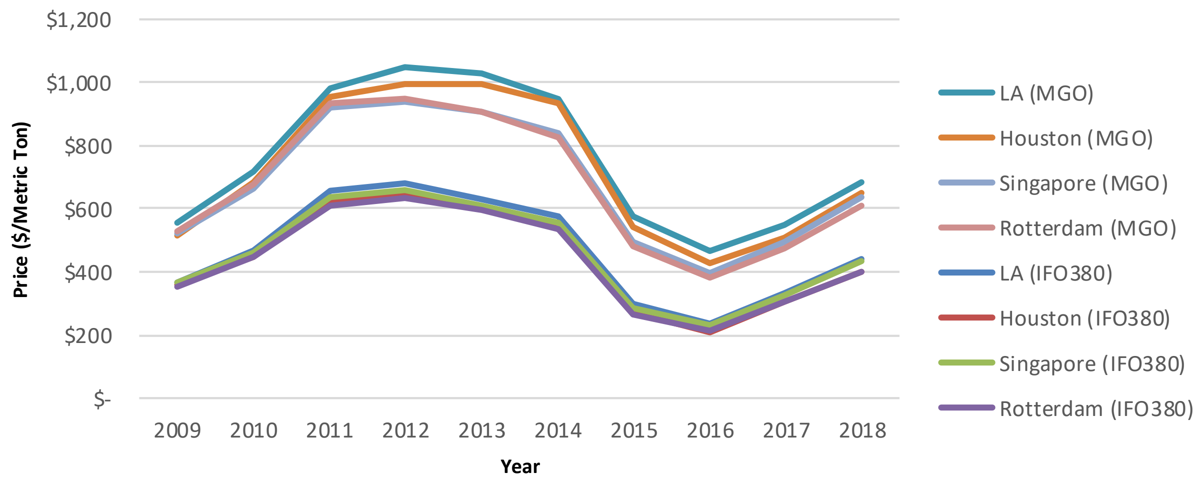

Figure 4. Average Annual Prices by Fuel Type and Port[9]

As global fuel prices are highly correlated, the global average is likely representative of the overall price level of a given fuel and could be used to calculate fuel price volatility. However, using a global average smooths some regional variation in fuel prices that does exist. For example, the price of MGO in Los Angeles is consistently higher than the price of MGO in Singapore.

2.3.1.2.1 Recommended Port Mix for Acquiring Fuel Prices

Globally, although prices are likely to move in a consistent fashion, regional variation in prices is possible. Nevertheless, it is unlikely that regional price variation will be a significant issue given the BAF's reliance on indexed prices rather than absolute price change. It is recommended that USTRANSCOM average the prices of two ports, one Contiguous United States (CONUS) port and Outside Contiguous United States (OCONUS) port. Specifically, the recommendation is to average fuel prices, by type, from Los Angeles and Gibraltar, capturing both Pacific and Atlantic trades. Averaging these two ports should help smooth regional variation in fuel prices without adding significant administrative burden.[10]

Gibraltar was selected based on knowledge of industry fueling practices. Geographically close to major shipping routes to Europe and the Mediterranean, and requiring minimum deviation from many major

[9] Average monthly fuel prices for MGO and IFO380 for Los Angeles, Houston, Rotterdam, and Singapore from 2009 to 2018. Source: Bunker Index IFO380 and MGO monthly average price

[10] If USTRANSCOM chooses to maintain regional prices, averaging multiple ports within a region will incorporate additional price data into a single index for the region. If considering more prices from additional ports, Volpe recommends using both CONUS and OCONUS high traffic ports such as Los Angeles, Tokyo/Yokohama, Bussan, Singapore, Manilla, Norfolk, Rotterdam, Gibraltar, and Fujairah.

shipping lanes, Gibraltar supplies the most marine fuel of any port in the Mediterranean and is a frequent bunkering location for many transatlantic crossing routes.[11] Moreover, the port enjoys a privileged tax regime where vessels can save on docking fees and are not charged a fuel tax.[12] Having selected an OCONUS bunkering location in the Atlantic, Los Angeles was chosen as the second port due to its location as a Pacific-touching, CONUS port.

2.3.2 Setting the Baseline Price

USC contract bidding takes place 5-months prior to contract start and the contract itself lasts for a full year. The baseline price, set at the time of bidding, is used for up to 17-months after the initial bid and is reset with each rate refresh. At the time of bidding, the baseline is set using the average prices of relevant fuels for the 3-month period immediately preceding the issue date of the solicitation.
The formula for the BAF baseline is shown below in Equation 2:

$$Price_{\,Over\,Ocean}\,(Fuel\,Mix\,Factor) + Price_{ECA}\,(Fuel\,Mix\,Factor) + Price_{Port}\,(Fuel\,Mix\,Factor)$$

Equation 2. BAF Baseline Setting Formula

Where,

- Price is the average prices of relevant fuels (Over Ocean, ECA, and Port) for the 3-month period immediately preceding the issue date of the solicitation and,
- Fuel Mix Factor describes each lanes unique fuel mix based on origin and destination, local regulations, and route.

These inputs are described further in subsequent sections.

2.3.2.1 Incorporating Fuel Prices

As discussed previously, carriers use up to three types of fuel per journey (Over Ocean, ECA, and Port). As such, the BAF baseline should incorporate these fuels. The use of these fuels is largely determined by vessel operations and the regulations that prevail where a vessel is sailing or at the ports at which the vessel is calling. Vessels burn fuel to operate while in port, coastal waters and over open ocean. In each of these environments, regulations may exist that require that vessels limit emissions such that they must burn compliant fuels or use alternative power sources. The mix of fuels that a vessel carrying USTRANSCOM goods might be required to burn in the course of operations varies depending on these regulations that in turn depend on the origin and destination of the USTRANSCOM shipment. These individual fuels enter the BAF baseline as described in Equation 2, through the price of each individual fuel ($Price_{Over\,Ocean}$, $Price_{ECA}$, and $Price_{Port}$) and, as recommended in Section 2.3.1.2.1, should be the

[11] Saul, Jonathan and Chestney, Nina. (2018, August 15).
[12] Morel, Sandrine. (2011, August 3).

monthly average spot price of Los Angeles and Gibraltar.

2.3.2.2 Calculating the Fuel Mix Factors

Each lane has a unique fuel mix required based on origin and destination, local regulations, and route taken. To obtain this mix, the average route is first modeled using the top ports within the lane,[13] which allows for calculating an average lane distance.

The distance calculations, which will be discussed in greater detail in Section 2.4.4, calculate the average distance (in nautical miles) for each lane and separate this into distance traveled in an ECA zone and distance traveled outside the ECA zone, the “over ocean” portion of the journey. The fuel mix factor for Ports is always assumed to be 5 percent, and the remaining 95 percent of the journey is split between Over Ocean and ECA fuel depending upon the fuel mix identified through the average route calculations (percentages sum to 100 percent). The percentage of the journey that vessels spend in an ECA zone is calculated by dividing the nautical miles within an ECA zone by the total nautical miles in the average route, as shown in Equation 3.

$$ECA\ Zone\ Share = \frac{nautical\ miles\ within\ ECA_{lane}}{total\ nautical\ miles_{lane}}$$

Equation 3. ECA Distance in Lane Share

Once the ECA Zone share of the average route is calculated, this is applied to the remaining 95 percent of the journey to calculate the ECA zone fuel mix share. This calculation is shown in Equation 4.

$$Fuel\ Mix\ Share_{ECA} = (1 - Port) \times ECA\ Zone\ Share$$

Equation 4. ECA Zone Fuel Mix Share Calculation

Once the fuel mix share of the voyage within an ECA Zone is known, some basic arithmetic, shown below in Equation 5, provides an estimate of the over ocean portion of the journey.

$$Fuel\ Mix\ Share_{Over\ Ocean} = 1 - Fuel\ Mix\ Share_{Port} - Fuel\ Mix\ Share_{ECA}$$

Equation 5. Over Ocean Fuel Share

As each lane has a unique set of ports and a unique distance mix, split between ports, ECA Zones, and the over ocean, this calculation is repeated for each lane. As such, each lane has its own baseline fuel mix share and price. For the full list of fuel mix factors by lane, see Appendix C: Fuel Mix Factors.

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[13] For the purpose of this section, it is not important to understand how the top ports were chosen, just to know they were chosen to be representative of the route the average piece of cargo travels on a given route. For a full discussion of the top port selection methodology, see Section 2.4.4.2.

2.3.2.3 Calculating the Baseline

Taken together, the fuel price component and the fuel mix share combine to set the lane-specific baseline.

Recalling Equation 2,

$$Price_{\ Over\ Ocean}(Fuel\ Mix\ Factor) + Price_{ECA}\ (Fuel\ Mix\ Factor) + Price_{Port}\ (Fuel\ Mix\ Factor)$$

For clarity, a numerical example of the baseline calculation for a fictional, 1,000 nautical mile route is presented below.

- The three month average price of Port fuel is \$525.50
- The three month average price of ECA Zone fuel is \$401.00
- The three month average price of Over Ocean fuel is \$363.50
- The average route distance is 1,000 nautical miles
- Based on routing, the distance software identifies that 250 miles were in the ECA zone

From Equation 3,

$$ECA\ Zone\ Share = \frac{nautical\ miles\ within\ ECA_{lane}}{total\ nautical\ miles_{lane}} = \frac{250}{1{,}000} = 0.25$$

From Equation 4,

$$Fuel\ Mix\ Share_{ECA} = (1 - Port) \times ECA_{lane} = (1 - 0.05)(0.25) = 0.2375$$

Recalling Equation 5,

$$Fuel\ Mix\ Share_{Over\ Ocean} = 1 - Fuel\ Mix\ Share_{Port} - Fuel\ Mix\ Share_{ECA}$$
$$Fuel\ Mix\ Share_{Over\ Ocean} = 1 - .05 - 0.2375 = 0.7125$$

In summary, the fuel mix factors would be 5 percent for Ports, 23.75 percent for ECA Zones, and 71.25 percent for Over Ocean.

From Equation 2,

$$Price_{\ Over\ Ocean}(Fuel\ Mix\ Factor) + Price_{ECA}\ (Fuel\ Mix\ Factor) + Price_{Port}\ (Fuel\ Mix\ Factor)$$

The individual fuel prices and the calculated fuel mix factors can be substituted into the equation, as shown below:

$$\$363.50(0.7125) + \$401.00(0.2375) + \$525.50(0.05) = \$380.50$$

For this fictional route, the baseline would be set at $380.50.

2.3.2.4 Re-Baselining

Annual re-baselining of fuel prices is a critical requirement of the BAF and USC contracting process. Under the USC contract utilizing an EPA, when base rates are submitted to USTRANSCOM, some portion of the base rate is expected to account for the carriers' fuel costs. This is intuitively shown with the usage of a buffer; if fuel prices were to remain flat for the life of a contract than no BAF would be paid per the terms of the contract. Given that fuel is a large share of operating costs, it is inconceivable that carriers would not include the current (and perhaps even the anticipated) cost of fuel in their base rates. Almost by definition then, a carrier's fuel price is already a competitive factor in bidding their own base rates.

Because the cost of fuel is built into these rates, the BAF baseline therefore needs to be set consistent with fuel prices at that time, and not at a value that is arbitrary and without relationship to current market conditions, this is shown below in Figure 5. Red circles indicate the period where the baseline is set and the buffer zone adjusts around that price for the subsequent contracting period.

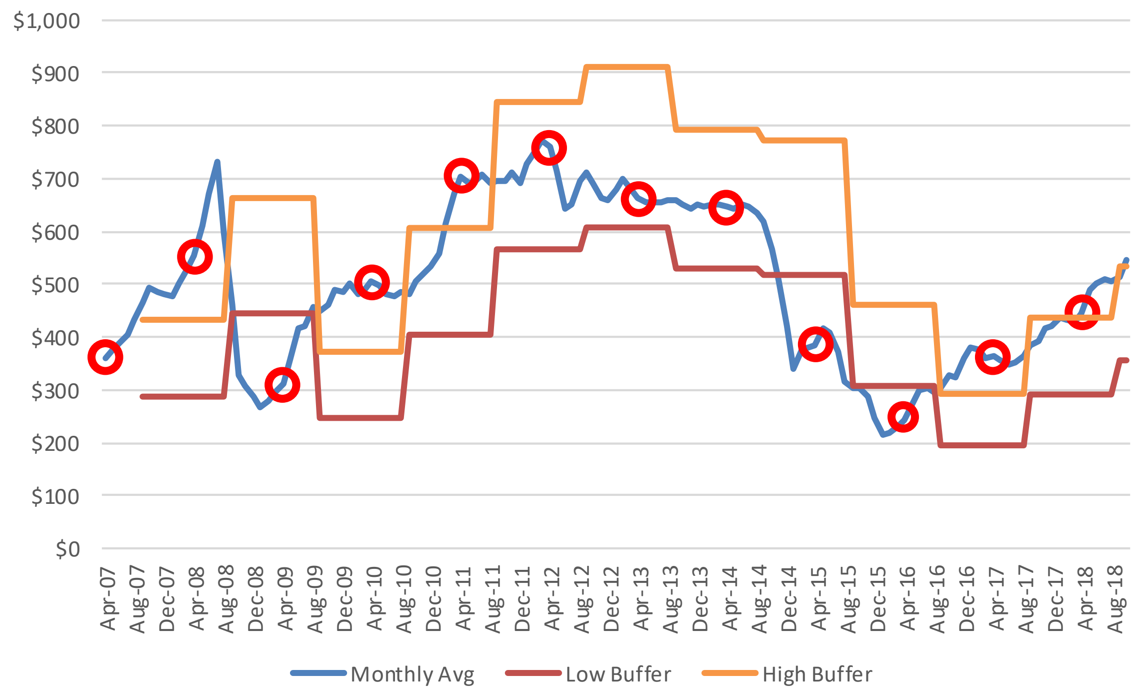

Figure 5. Notational Depiction of Annual Re-baselining[14]

The BAF is designed to share the risk of price volatility between the two parties, compensating the party made worse off by excess volatility for marine fuels. If the base rate includes current/anticipated prices, then the baseline must be set simultaneously to their submission so that the shift in marine fuel prices around the baseline adjusts the net price around the base rate.

When set independently and low enough, as is done in Figure 6, the baseline will fail to move in tandem with base ocean rates resulting in the entire burden of fuel prices shifting to the shipper.

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[14] Prices are averaged per month and across type, using the USTRANSCOM BAF fuel mix proportions. Data source: Bunker Index BIX MGO and IFO380 prices average global monthly fuel prices (2009-2018), BunkerWorld MGO and IFO380 average monthly fuel prices for Los Angeles and Norfolk (2007-2009)

Figure 6. Artificially Low Baseline, No Re-Baselining[15]

Whereas the price trend in Figure 5 is at times between the high and low buffer and no BAF is paid, Figure 6 depicts a price trend almost exclusively above the baseline price, requiring a constant BAF payment. The carrier would then be passing all price volatility to the shipper and the BAF would cease to be a risk sharing mechanism. Such a BAF would instead serve as a revenue generator as all fuel price risk is borne by the shippers, and carriers would have no incentive to economize on fuel consumption, even during periods of high volatility.

2.3.3 Establishing the "New" Price Level

USTRANSCOM publishes the BAF two months ahead—for March 2019, the BAF report is updated in January 2019 using the average fuel prices from December 2018. This ensures carriers have advance knowledge on what the BAF payment will be before agreeing to any individual shipment.

The "new" price is calculated via the same equation as the baseline price. Recalling Equation 2,

$$Price_{\,Over\,Ocean}\,(Fuel\;Mix\;Factor) + Price_{ECA}\;(Fuel\;Mix\;Factor) + Price_{Port}\;(Fuel\;Mix\;Factor)$$

Equation 6. BAF Baseline Setting Formula

[15] Source: Bunker Index BIX MGO and IFO380 prices average global monthly fuel prices (2009-2018), BunkerWorld MGO and IFO380 average monthly fuel prices for Los Angeles and Norfolk (2007-2009)

The fuel mix factors remain unchanged, the route is fixed so the individual fuel shares also remain fixed. However, the fuel prices should be updated following the same process as setting the baseline prices—monthly average of the same ports used to set the baseline price, Los Angeles and Gibraltar. The “new” price equation becomes:

$$NewPrice_{Over\ Ocean}(Fuel\ Mix\ Factor) + NewPrice_{ECA}\ (Fuel\ Mix\ Factor) + NewPrice_{Port}\ (Fuel\ Mix\ Factor)$$

Equation 7. BAF "New" Price Setting Formula

Building on the fictional route example described in Section 2.3.2.3, assuming all prices increase by 20 percent, the “new” price level would be calculated as follows:

- The “new” price for Port fuel is: $630.60
- The “new” price for ECA Zone fuel is: $481.20
- The “new” price for Over Ocean fuel is: $436.20
- The fuel mix factors are unchanged at: 5 percent for Ports, 23.75 percent for ECA Zones, and 71.25 percent for Over Ocean

The “new” price level would be calculated as follows:

$$NewPrice_{Over\ Ocean}(Fuel\ Mix\ Factor) + NewPrice_{ECA}\ (Fuel\ Mix\ Factor) + NewPrice_{Port}\ (Fuel\ Mix\ Factor)$$
$$= \$630.60(0.05) + \$481.20(0.2375) + \$436.20(0.7125) = \$456.60$$

2.3.4 Calculating the BAF Payment

Rather than being dependent on an absolute price level, BAF payments are triggered by the relative difference between the baseline price and the “new” price of fuel at the time of shipping. In order to execute the BAF, the net price change must be calculated. This value is then translated into a percent change from the baseline rate. And, if that percent change exceeds the value of the BAF buffer, a BAF payment is triggered.

2.3.4.1 Determining Net Price Change (Volatility)

The net price change is calculated as the difference between the current price and the baseline price, shown in Equation 8.

$$\Delta_{price} = "New"\ Price\ Level - Baseline\ Price$$

Equation 8. Absolute Price Change

This price difference, Δ_{price}, can then be compared to a benchmark (the BAF buffer) to determine if the net price change is within the normal bounds or is in excess. The process for establishing this buffer is described below in Section 2.3.4.2.

Building on the fictional route example described in Section 2.3.2.3 and Section 2.3.3, the net price change calculation is as follows in Equation 9,

$$\Delta_{price} = \text{"New" } Price\ Level - Baseline\ Price = \$456.60 - \$380.50 = \$76.10$$

Equation 9. Fictional Route Absolute Price Volatility Calculation

This value is then translated into a percent change from the baseline, shown in Equation 10, which will then be compared against the benchmark.

$$Percent\ Change = \frac{\text{"New" Price Level-Baseline Price}}{Baseline\ Price} = \frac{\$76.10}{\$380.50} = 0.20 = 20\%$$

Equation 10. Fictional Route Percent Change Calculation

This 20 percent is what will be compared against the buffer.

2.3.4.2 Establishing the BAF Buffer

The buffer zone is a range of percentage deviation from the baseline fuel price. If the deviation of the current price does not exceed the buffer range, no BAF is calculated and the variation is assumed to be within the normal range that the carrier is expected to accommodate within its basic freight rate structure. Variations outside the buffer range are assumed to be abnormal volatility, and constitute a risk that is potentially sharable between shipper and carrier.

With a buffer, then, the BAF functions as catastrophe insurance for both carriers and USTRANSCOM against potentially damaging price swings, a risk for which the shipper is offering to take primary but not sole responsibility.

A price buffer is built around the composite baseline fuel price to set the range of fuel price volatility over which USC parties will internalize risk. The development of an updated buffer methodology is based on several guiding principles:

- Representation of typical contract length
- Reference point against which volatility is measured
- Isolate periods of atypical volatility (outside the normal range that a buffer is supposed to represent).
- Identify price data that reflect volatility consistent with the expected price range of the new low sulfur fuel (for BAF buffer only)

The length during which USTRANSCOM's USC contracts are in place can vary. Nevertheless, a review of recent contracts shows that the average contract tended to last for around one year. Based on this, a 12-month time span was considered to be the most appropriate time frame over which to calculate volatility. In addition, to ensure the 12-month time spans were not chosen arbitrarily, and to include as much information as possible, a rolling average calculation was used. For example, average volatility would be calculated for the period from January 2010 to December 2010, then from February 2010 to

January 2011 and so on.[16]

To be consistent with USC shipping rate bidding practices, average volatility was measured against a baseline price that was set 5 months prior to the start of the 12-month period (e.g., the base rate for the 12-month period from January 2010 to December 2010 was set in August 2009). All values are calculated as a monthly average (e.g., the price of fuel for January 2010 is the average value for that month).

Fluctuations in fuel prices (or exchange rates for the CAF) are calculated in terms of the percent change in the current price relative to the baseline. To acknowledge the symmetrical nature of volatility and that positive and negative variation are equally important, percent changes are calculated in absolute terms.

Equation 11 below presents the volatility calculation:

$$Volatility_{Period\ 1} = \left(\left|\frac{Price_{Month\ 1}}{Baseline\ Price} - 1\right| + \left|\frac{Price_{Month\ 2}}{Baseline\ Price} - 1\right| + \cdots + \left|\frac{Price_{Month\ 12}}{Baseline\ Price} - 1\right|\right) \Big/ 12$$

Equation 11. Fuel Price Volatility

Where $Volatility_{Period\ t}$ is the estimate of the average volatility for a 12-month period, $Price_{Month\ t}$ is average monthly price for a specified month, and *Baseline Price* is the average monthly price during the baseline period.

For the purpose of estimating the BAF buffer, marine fuel price data from January 2009 to April 2018 is used.[17] The first period ran from June 2009 to May 2010, with the baseline set in January 2009. The last period was May 2017 to April 2018, with the baseline set as the December 2016 average.[18]

The BAF is meant to compensate for periods of excess volatility. As such, the buffer zone, which defines the limits of normal, or expected, volatility and when a BAF is paid, should not include periods of atypical variation as part of the calculation. This adjustment is made through removing estimated volatility within a 12-month period that is more than one standard deviation above the mean (Standard deviation is a common measure used in volatility calculations[19,20,21]).

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[16] In the previous study, the CAF buffer was calculated using discrete periods that were meant to represent each contract period.

[17] This time period was chosen due to data limitations.

[18] Details on the CAF buffer data and calculation can be found in Section 3.3.4

[19] Clark et al., 2004

[20] Kenen et al, 1986

[21] Schnabl, 2007

Mathematically, this adjustment is represented below in Equation 12 as:

$$\left|\frac{Price_{Month\,1}}{Baseline\ Price} - 1\right| < Mean + Standard\ Deviation$$

Equation 12. Volatility Adjustment

Values that do not meet this criterion are removed from the initial average volatility dataset. After this adjustment has been made, Equation 11 is recalculated for each 12-month period. Some of the 12-month periods retain all 12 monthly values, as all values were within one standard deviation of the global mean. Some 12-month periods now use fewer months to create an average—for example, the 12-month period from January 2010 to December 2010 may only be left with data from January 2010 to September 2010, and the final three months may have been dropped if they were outside one standard deviation from the mean. Along these same lines, some 12-month periods disappear entirely, as all monthly calculations were outside one standard deviation from the mean. These adjusted values are then averaged to provide a final estimate of typical volatility for fuel prices.

To capture possible variation in normal volatility for different fuel types (with different price points) average volatility was calculated for MGO, IFO380, and crude oil. Using these three reference fuels provides insight into whether volatility differs significantly based on whether a fuel is low or high cost (and the price of the new low sulfur fuel that will be required in 2020 is anticipated to price closer to, although still less than, MGO and ECA fuels).

2.3.4.2.1 BAF Buffer Results

Results from applying the new buffer methodology are presented in Figure 7 below. This shows both the average monthly volatility (relative to the baseline) for MGO, IFO380 and crude oil from 2009 through 2016 and the adjusted typical average volatility across the entire time frame. Points on the graph where volatility appears to be zero are 12-month periods during which average volatility was atypical, meaning this timeframe was removed. The dashed lines show the average volatility for each of the three fuel prices over the entire period of available data.

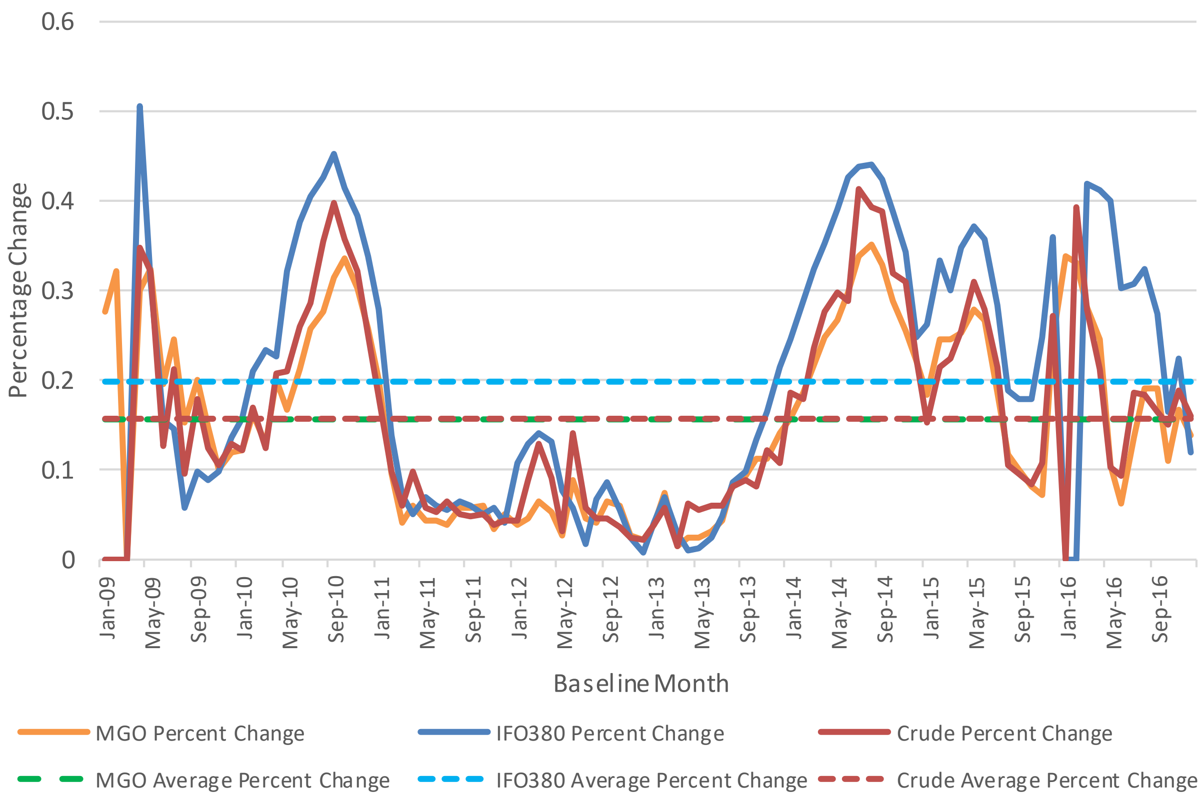

Figure 7. Graph of Average Volatilities[22]

Average typical volatility for MGO is consistent with crude oil, but lower than IFO380. This suggests that fuels with higher price points (e.g., MGO relative to IFO380) would be expected to have a smaller range of normal volatility. The data on average volatilities are shown in Table 1.

Table 1. Average Volatilities by Fuel Type

Price Data	Average Volatility
Crude Oil	15.7%
IFO380	19.9%
MGO	15.7%

Based on these results, and since MGO prices are expected to be close to the new 2020 low-sulfur fuel price, it is recommended that MGO typical volatility be used as the buffer for the BAF in USC-9. This will lower the BAF buffer from 20 to 15 percent.

[22] Source: US EIA Europe Brent Spot Price, Bunker Index MGO and IFO380 monthly average fuel price

2.3.4.3 *Calculating the Excess Volatility*

The BAF is triggered by total volatility around the baseline price but compensation is based only on the excess volatility. Excess volatility is unexpected and is difficult for either party (USTRANSCOM or carriers) to plan for. Normal volatility is captured by fuel price movements within buffer zone; excess volatility occurs when the percent change between the baseline price and the "new" price level exceed the 15 percent buffer.

$$Excess\ Volatility = Absolute\ Percent\ Change - Buffer\ Zone$$

Equation 13. Excess Volatility Calculation

Below, Figure 8 visually describes the excess volatility calculation shown above in Equation 14. The upper line with circle marks plots the actual bunker price that would be calculated for Route 1. A 15 percent buffer threshold is also plotted (highest and lowest horizontal dotted lines), indicating which months are outside the buffer, triggering a (hypothetical) BAF. The dashed line in between the dotted lines represents the baseline price. The price differential, shown as the middle solid line with diamonds, uses the right scale on the graph and generally increases over this time period.

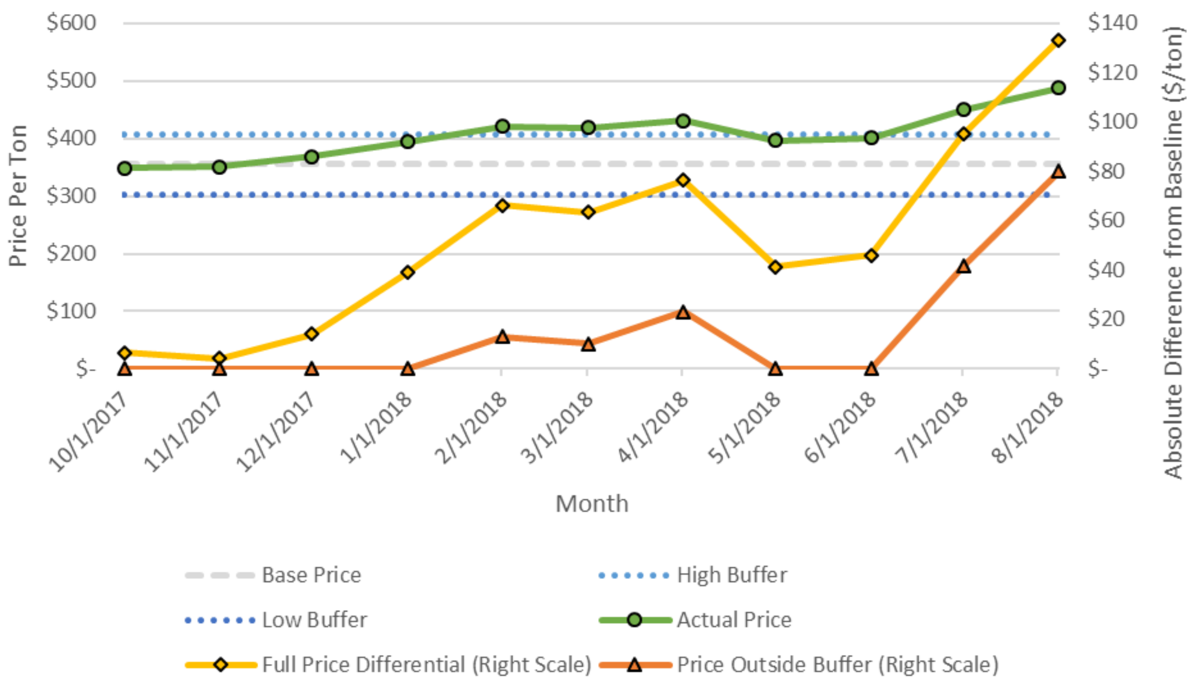

Figure 8. Fuel Price Differential, with Threshold[23]

When the actual price tops the upper buffer, a positive BAF is calculated (there is no place on this graph where the actual price fell below the bottom buffer). If the BAF is based on the difference between the

[23] Source: USTRANSCOM IBS CARE BAF Monthly Statistic Reports

base price and the actual price, the result is the full price differential line. This price can bounce around, as shown.

The excess volatility, equal to the difference between the actual price and the edge of the buffer, is shown as the lowest solid line with triangular markers (price outside buffer). The BAF should only base payments on the excess volatility as the range of price within the buffer band is intended to be included in the base container rate.

Building on the fictional route example described in Section 2.3.2.3 and Section 2.3.3, and recalling the absolute price volatility calculated in Section 2.3.4.1, a comparison between the percent change and the buffer can now be made.

- The percent change is 20 percent
- The calculated buffer is 15 percent

Because the calculated percent change exceeds the buffer (20 percent is greater than 15 percent), a BAF payment is triggered by the fuel price increase between the baseline and the "new" price. As a reminder, BAF payments are only made on excess volatility, volatility beyond the buffer zone. This calculation is shown below in Equation 14.

$$Excess\ Volatility = Absolute\ Percent\ Change - Buffer\ Zone = 20\% - 15\% = 5\%$$

Equation 14. Fictional Route Excess Volatility Calculation

BAF payments are made only on the excess volatility so, in this fictional example, the BAF payment is made on only 5 percent of the fuel price increase. In absolute terms, this 5 percent corresponds to \$19.03 (5 percent of the baseline price, \$380.50) upon which the BAF payment is based as shown in Equation 15.

$$\$19.03 = 5\%_{Excess\ Volatility} \times \$380.50_{Baseline\ Price}$$

Equation 15. Excess Volatility Amount for BAF Calculations

2.4 Estimating Fuel Consumption

In practical application, BAF transactions (payments to carriers or rebates to USTRANSCOM) are add-ons to the base rate for each individual unit of cargo. After determining whether a lane's price change triggers a BAF payment, the excess volatility is applied to each individual unit of cargo based on the amount of fuel needed to move it. Many factors affect the amount of fuel needed to move cargo from origin to destination, but a practical BAF can only incorporate a small number of them. In this section, the objective is to estimate total fuel consumption under realistic conditions that reflect a recent historical baseline, but will also hold true, on average, under future conditions that may be different. That total fuel consumption must then be allocated to individual units of USTRANSCOM cargo.

Actual fuel consumption depends on a variety of factors including vessel characteristics, such as: type, capacity, and service speed, as well as operational considerations of the carrier and specific trade routes over which the cargo must travel. Fuel consumption for the BAF is estimated using the distance traveled and fuel burn rate averaged for typical vessels in the lane.

The USTRANSCOM BAF uses actual shipment data from the Military Surface Deployment and Distribution Command (SDDC) and a commercially available vessel database, Clarkson Research Services' World Fleet Register, to identify those vessels that serve a given USTRANSCOM lane. From these two data sources, a lane average vessel is estimated along with the average distance that vessel will travel. From these average vessels and distances, the total fuel consumption for a voyage is estimated and allocated to each unit of cargo.

2.4.1 Determining Fuel Consumption Factor per Cargo Unit

The methodology used to calculate the fuel consumption factor per cargo unit seeks to capture the average conditions for the most relevant components of the fuel consumption per cargo unit. Thus, the fuel consumption per cargo unit is representative of the typical operations and conditions under which USTRANSCOM goods are shipped. Data on fuel consumption and shipments are available at the vessel level, so the BAF must first calculate the total consumption of fuel for a vessel operating on each lane and then apportion that consumption to each unit of cargo for which a BAF payment could be made. The calculation for estimating the fuel consumption factor includes three distinct components, shown below in Equation 16.

$$Fuel_{CU} = \frac{Fuel_{Day} \times Steaming_{Days}}{Capacity_{vessel}}$$

Equation 16. Calculating the Fuel Consumption Factor, per Cargo Unit

Each of the terms from Equation 16 are briefly described below, and their source data and methods of calculation are presented in subsequent sections.

- $Fuel_{Day}$, Fuel Consumption per Day for the Typical Vessel

Fuel consumption per day is the total fuel consumed by a vessel per steaming day, operating at its designed service speed, and is measured in tons per day. See Section 2.4.3 for a discussion of fuel consumption per day.

- $Steaming_{Days}$, Steaming Days of the Typical Vessel on the Average Journey

As fuel consumption is measured in tons per day, the typical length of a voyage is needed to determine total fuel consumption. Steaming days are the average number of days sailing for a vessel carrying USTRANSCOM cargo on a specific route. Determining steaming days for a lane requires knowing the typical distance of the lane's journey and the typical speed of the vessel serving the lane. See Section 2.4.4 for a discussion of steaming days.

- $Capacity_{vessel}$, The Typical Vessel's Cargo Capacity

Vessel capacity is the cargo capacity of a vessel, in units relevant to that particular vessel type (TEU, FEU, MTON). Vessels are distinguished and grouped for analysis by their cargo types, container or breakbulk cargo. Vessels carrying containers (TEUs or FEUs) are, for the purpose of this study, considered containers; vessels carrying MTONs are considered ROROs, regardless of their true vessel type. For various reasons, the full cargo carrying capacity of a vessel may not be usable. In particular, the typical configurations of vessel cargo spaces and of military breakbulk and RORO cargo may require broken stowage, meaning that some space is unavoidably left over as unusable. See Section 2.4.5 for a discussion of vessel capacity.

Combining these three factors as shown in Equation 16 yields the fuel consumption factor per unit of cargo for each lane and vessel type. The following subsections describe each of the terms from Equation 16 including their source data and methods of calculation.

2.4.2 Average Vessel Characteristics Data Analysis

The principal foundation of estimating the fuel consumption factor for the BAF is to use USTRANSCOM's own data to identify the vessels that serve each lane. Those vessels are then used to estimate a typical or average vessel. While the set of vessels that have served USTRANSCOM's lanes in the recent past may not precisely predict the vessels that will serve those lanes in the future, they are the best representation of a potential vessel that may serve a given lane over the next USC contract. Combining this set of vessels with a commercially available vessel database, Clarkson Research Services' World Fleet Register, allows for the estimation of a single typical, or average vessel. The characteristics of this average vessel are then used to populate the terms of Equation 16 to estimate the fuel consumption factor per cargo unit for each lane.

2.4.2.1 Average Vessel Data Sources

In creating the typical vessels that serve as the foundation for the fuel consumption component of the BAF calculation, a relational database was used to merge a database of vessel characteristics and a database of USTRANSCOM shipments. USTRANSCOM shipment data was sourced from the SDDC Ocean Freight module. The SDDC Ocean Freight module links individual cargo movements to origin and destinations as well as to the vessel(s) performing each move.

Data on individual vessel characteristics and design specifications was gathered from Clarkson's World Fleet Register, which contains all IMO-registered containership and RORO vessels. The two data sources were matched by vessel name to create the average vessel for each lane.

- SDDC Data

SDDC contains shipment data for all USTRANSCOM shipments and is used to identify ships on lanes. Data elements important to this study include: voyage identifiers, arriving and departing vessels, ports of embarkation and debarkation, carriers, and descriptive information about the cargo (weight, TEUs, container type, etc.). Once non-USC moves were filtered out, the dataset covered approximately 513,000 USC shipments between January 2013 and October 2018.[24] The dataset contains information on all USC cargo moves, which includes moves on vessel types beyond the RORO and Container vessels described in the BAF. No vessel type was ignored, based on cargo type, vessels were assigned to either the RORO or container category. The RORO category includes all vessels that carry primarily breakbulk—ROROs, vehicle carriers, and heavy-lift vessels.[25] The Container category includes all vessels that move only containers (TEUs and FEUs)—container vessels and geared containers. For approximately 20 percent of these shipments, the arriving and departing vessel were different vessels so that the total number of unique USC shipment-vessel observations in the IBS database were approximately 635,000 during the period representing a total of 3,100 unique vessels.[26]

- Clarkson's Data

Clarkson Research Services' World Fleet Register contains data on shipping vessels worldwide. For containerships, the fields used were: total TEU capacity, vessel service speed, and fuel consumption at vessel service speed. For RORO vessels, the Clarkson's fields used were: vessel service speed and fuel consumption at vessel service speed. For RORO capacity, Clarkson data from previous Volpe efforts on the USTRANSCOM BAF were incorporated into the analysis, as the current Clarkson's database does not have the measure of capacity, net registered tonnage (NRT), required to create the capacity measure used in the BAF, MTONs.

2.4.2.2 Merging USC Cargo-Carrying Vessels to Vessel Characteristics

The SDDC data does not have a unique vessel identifier, such as IMO number, instead identifying vessels by name and by carrier. As such, the SDDC data and the Clarkson's dataset were matched on vessel name. The Clarkson's database has three variables for name: name, alternative name and ex name. The SDDC vessel names were matched successively with name, alternative name and ex name. As an additional logical check the Clarkson's value for year built was compared against the shipping date. If the Clarkson year built was more recent than the shipping date, the vessel was not matched to that shipment. The matching process was successful for 95 percent of shipment-vessel observations in SDDC. The success of this matching method depended on using multiple names and correcting for differences

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[24] The analysis used USC shipment movements of the five-year period between January 2013 and October 2018 to update the BAF technical factors to reflect the current operational behaviors of the carriers and USTRANSCOM. The 2013 BAF technical factors similarly used a five-year period.

[25] For a previous study, in conversations with Maritime Security Program (MSP) RORO carriers, these carriers indicated that ROROs were capable of carrying containers, albeit less efficiently than a purpose-built container vessel. However, for the purpose of this study, vessels are assumed to carry only one type of cargo.

[26] Note that the 3,100 unique vessels include all vessels carrying USTRANSCOM goods over the five-year period for at least one shipment. This figure does not represent the number of unique vessels in the BAF analysis, just those that were in the IBS database during that period. This figure includes vessels that may have carried USTRANSCOM goods on a lane outside of USTRANSCOM BAF, or may not have been matched to a Clarkson vessel.

in punctuation and other potential matching errors.

After mechanically matching the two datasets, a manual inspection of unmatched vessels was performed. This check allowed for matching ships from the two databases that may have been missed due to differences in naming conventions. For the remaining 5 percent of shipments, the Clarkson dataset simply may have no record of some U.S.-flagged vessels used by USTRANSCOM.

Table 2 shows the results of the merging of the Clarkson's data and the IBS data in terms of the number of unique vessels. These figures represent the number of unique vessels used in the BAF analysis which includes only those vessels who were the arriving or departing vessel in a USC contract shipment on a BAF lane during the five-year period from January 2013 to October 2018 and that were matched with a Clarkson's database vessel. As a vessel can change flag from year to year, Table 2 assumes the flag of the vessel in the most recent year that it carried USTRANSCOM goods.

Table 2. BAF Unique Vessels by Flag and Type

Flag	Container	RORO	Total
U.S.	65	10	75
Non-U.S.	1,735	50	1,785
All	1,800	60	1,860

2.4.2.3 Vessel Data Challenges

The Clarkson's data is well populated for TEU capacity and service speed. However, fuel consumption data is not as well populated and NRT is not available in the latest Clarkson's dataset and only limited data exist from previous Volpe efforts. In order to estimate meaningful average vessel characteristics, the missing values for fuel consumption and NRT were estimated using ordinary least squares (OLS) regression based on service speed, capacity and other vessel characteristics as captured by Clarkson's. As discussed below in the fuel consumption and vessel capacity sections, the robust regression results allow the estimated fuel consumption (Section 2.4.3.1) and NRT (Section 2.4.5.2) measures to be included with the available actual values of TEU capacity, vessel service speed, and fuel consumption at service speed. The final dataset yields a comprehensive set of all vessels and characteristics from which a representative single, average vessel for each lane can be created.

2.4.2.4 Calculating the Average Vessel

The relational database allowed for the creation a typical vessel average for each lane by averaging the vessel specifications from Clarkson for all vessels identified in IBS with a particular lane. This typical vessel represents the average vessel that is available for service on a particular lane. Where there were sufficient observations to calculate a meaningful average, it represents only those vessels that actually did carry USTRANSCOM shipments. For each lane, both an average container and RORO vessel were created in order to capture differences in the characteristics of the vessels that carry both containerized and breakbulk cargo.

Each typical vessel is weighted by the frequency those vessels were booked. Frequency of vessel bookings was determined by the number of times a vessel carried USTRANSCOM cargo, regardless of the size of a shipment. A vessel booked more frequently on a lane will have a greater impact on the lane's final average vessel than a vessel only booked a single time.

To ensure data quality and accuracy for the vessel averages, a series of decision rules regarding data quality and availability was used to calculate the vessel average on each lane. The rules determine which subset of vessels to use to create the average vessel by lane. The following list of vessel data sources by lane reflect USTRANSCOM's priorities for carriers.

1. Lane-Specific Average of U.S.-flagged Vessels: the average characteristics of all U.S. vessels that ply a given lane
2. Lane-Specific Average of U.S. and Non-U.S.-flagged Vessels the average characteristics of all U.S. and non-U.S. flagged vessels that ply a given lane.
3. Average of All U.S.-flagged Vessels: the average characteristics of all U.S. vessels that ply any lane.
4. Average of All U.S.-flagged Vessels: if the US or World Average Values for a lane exceed two standard deviations outside of US average mean, the general U.S.-flagged vessel was used.

This ordering of priorities determined which vessels were used to calculate the average vessel characteristics if data quantity or quality were insufficient given a minimum standard of five shipment observations.[27] The data source procedure is as follows: If there were fewer than five U.S. vessel shipment observations on a given lane, then the lane-specific average of the U.S. and Non-U.S.-flagged vessels was used. If there were fewer than five shipment observations using the lane-specific average of U.S. and Non-U.S.-flagged vessels, then the average of all U.S.-flagged vessels was used. This represents a conceivable U.S.-flagged vessel available to USTRANSCOM for a given lane.

Finally, a statistical analysis of the lane average vessels was performed to identify and investigate outlier cases. In a small number of lanes, the resultant fuel consumption factor (vessel fuel consumption divided by vessel capacity) was statistically significantly different from the Average of All U.S.-flagged Vessels. Where a lane's vessel fuel consumption factor was outside two standard deviations from the median, the U.S.-flagged average vessel was used.

Table 3 shows the count of lanes by the data source and cargo type. For container cargo, most lanes use data sources 1 and 2, and for RORO cargo the majority of lanes use data source 3. This difference in data source by lanes and cargo reflects the scope and frequency differences in USTRANSCOM operations between container and breakbulk cargo.

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[27] This minimum standard is consistent with the BAF 2013 minimum standard and is used to ensure that the lane specific data source is robust.

Table 3. Count of Lanes by Data Source and Vessel Type

Data Source	Container	RORO
Lane-Specific Average of U.S.-flagged Vessels	39	22
Lane-Specific Average of U.S. and Non-U.S.-flagged Vessels	25	12
Average of All U.S.-flagged Vessels[28]	37	67

Table 4 gives an excerpt of the average vessel characteristics for Lanes 1-5, for both container and RORO vessels. The average vessel matching has been described in full as the matching process sets the foundation for many subsequent calculations shown below. As such, the results will be introduced in subsequent sections where they are most relevant to an underlying fuel consumption calculation. See Appendix A: The "Average" Vessel by Lane for a full listing of each lane's average vessel characteristics.

Table 4. Average Vessel Characteristics for Lanes 1-5.

Lane	Container Capacity (TEU)	Container Service Speed (Knots)	Container Fuel Con. (tons /day)	Container Obs.	Container Data Source	RORO Capacity (MTONs)	RORO Service Speed (Knots)	RORO Fuel Con. (tons/day)	RORO Obs.	RORO Data Source
01	4,853	24	175	113,940	1	43,148	19	54	5,107	1
02	5,710	24	184	8	1	46,930	20	53	27,987	3
03	2,510	23	110	7,183	1	46,930	20	53	27,987	3
04	2,358	20	80	1,342	1	45,803	19	54	216	1
05	3,856	23	130	91,315	1	51,224	20	46	2,842	1

2.4.3 Fuel Consumption per Day

Generally, fuel consumption varies by the type, size, and speed of a vessel. While the BAF needs fuel consumption per cargo unit for its full journey, Clarkson's dataset provides fuel consumption rates in tons of fuel burned per day. Using the average vessel calculation procedure described in Section 2.4.2.4, a fuel consumption measure is estimated for each lane and vessel type.

2.4.3.1 Estimating Fuel Consumption

Where fuel consumption data was not populated for vessels in the Clarkson's dataset, it was estimated by ordinary least squares (OLS) regression using other known vessel characteristics. Fuel consumption was estimated as a function of the vessel type, size of the vessel in gross tonnage (GT) or dead weight tonnage, and the service speed listed for the vessel. Figure 9 demonstrates the success of the fuel consumption regressions. The actual fuel consumption of each vessel is plotted against the regression estimated fuel consumption values. A perfect estimate would yield an estimate of fuel consumption equal to the given value of fuel consumption and would result in a single 45-degree angled line. Figure 9 shows a tight alignment along the 45-degree angle line, indicating that the estimated values closely

[28] Includes all lanes that use the U.S.-flagged vessels whether selected for data availability (data source note #3) or due to the statistical analysis of outliers (#4).

approximate actual fuel consumption.

A separate model of fuel consumption was developed for each vessel type in the Clarkson's dataset. The model that was developed for each vessel type best captured the relationship the dependent variable, fuel consumption, and the independent variables, service speed and a measure of capacity and size. Speed was captured in the model as speed and the square of speed to account for the non-linear relationship between speed and fuel consumption. The capacity measures used were GT, the square of GT, and in the case of "Ro-Ro", deadweight ton. In some models, GT was interacted with speed.

The estimation results were statistically significant for all models. For all but two models the R-square values were above 0.83; the p-value for all independent variables for all models were significant at the 5 percent level, and the F-tests for joint significance showed that the independent values for all models were jointly statistically significant.

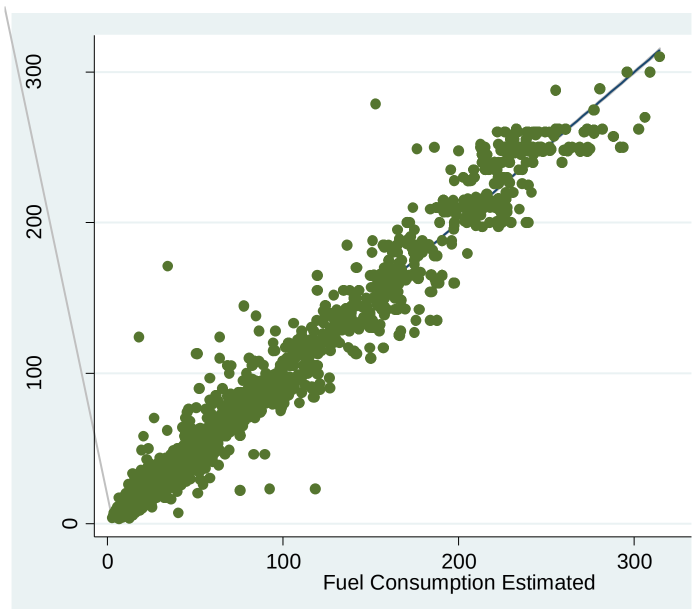

Figure 9. Estimated Fuel Consumption by Actual Fuel Consumption, All Vessel Types

2.4.4 Steaming Days

The typical fuel consumption estimate is provided in tons of fuel per steaming day. Steaming days are the number of days a ship takes to travel the full length of a lane, between an origin and destination region. In order to utilize the average vessel's typical fuel consumption factor for a given lane, the figure needs to be adjusted from a daily rate to the total consumption of fuel for a vessel's journey on a lane. As steaming days is a function of both the total distance of the journey and the speed of a vessel (as shown in Equation 17), both must be determined in order to estimate the total fuel consumption for a vessel's journey. Finally, as speed is in nautical miles per hour (knots), dividing by 24 converts the result from hours to days.

$$Steaming\ Days = \frac{Distance}{Speed} \div 24\ hours$$

Equation 17. Calculating Steaming Days

2.4.4.1 Distance Calculations

Given that lanes comprise multiple origin-destination combinations, the distance travelled for each lane used for the BAF must necessarily be some generalized representation. This is consistent with the goal of a generalized distance factor for a lane (and broadly, each USTRANSCOM BAF tech factor), and is achieved by constructing representative conditions under which carriers make USC shipments.

In the previous iteration of the BAF, the representative distance (in nautical miles) incorporated the distance between the top three ports on each side of a lane, as determined by their share of USTRANSCOM traffic. Nautical miles were then converted to steaming days using average ship speed data by lane. The representative distance was divided into distance within an ECA and non-ECA distance. See Section 2.3.1.1.2 for a discussion of how ECA and non-ECA distances factor into the price baseline for a lane.

The BAF average distances by lane are intended to represent the average distances traveled by USTRANSCOM goods on those lanes and are not intended to represent actual distances or all carrier business or operational decisions. Carrier networks can sometimes include a dominant port where cargos are delivered and then split onto vessels serving different lanes in a general hub-and-spoke fashion, known as a transshipment. For operational efficiency carriers may choose to transship cargo to intermediate ports between the port of embarkation and debarkation. While USTRANSCOM recognizes that carriers generally make transshipments for USC shipments, these are internal business decisions made by carriers to efficiently manage their traffic and are considered to be beyond the scope of what is the USTRANSCOM representative distance.

2.4.4.2 Updated Distance Calculation Methodology

This iteration of the BAF expands upon the distance calculation methodology in four ways:

- First, the final distance for a lane represents the average of distances for each vessel type, weighted by share of USTRANSCOM shipment volume. USTRANSCOM container and RORO cargo may use an alternate set of ports for operational reasons or to account for differences in port infrastructure needed for RORO or container cargo handling.
- Secondly, each side of a lane will consider, at minimum, the top three ports (as determined by volume of USTRANSCOM shipments), but will subsequently add ports that represent at least 10 percent of volume for that side.
- Thirdly, some lanes are divided into its composite regions as defined in the USC-9 Request for Proposal (RFP) Attachment 12 in order to better reflect actual vessel operations for the lane.

- Finally, in mapping and categorizing ports, separate ports in close geographic proximity such as Portsmouth and Norfolk, Virginia are combined into a single port. The port groups were created consistent with USC-9 RFP Attachment 3.[29]

The addition of ports beyond the top three is to account for ports that carry a significant share of that lane's traffic. For example, if, for a given lane, recent USC shipment data show that only one port represents 12 percent of volume and the remaining ports all represent less than 5 percent each, the top three highest volume ports will be considered. However, if, for one side of a separate lane, there are four ports with 15 percent of shipment volume each, and the remaining observed ports represent less than 5 percent, all four high volume ports will be included in the distance calculation.

Once a set of ports for a lane are determined, they are arranged in a logical order and the distance between the full set of ports is measured for each lane. The actual calculation of distance is completed through the NETPAS Distance software package, which calculates the nautical miles between each of a sequence of ports that are served by a particular lane. NETPAS provides the total distance travelled as well as the share of the trip that is within an ECA zone.

An example calculation of the distance in NETPAS can be seen in Figure 10. In this example, the distance for Lane 1, United States West Coast—Far East is calculated between the representative ports for Lane 1 RORO shipments. As determined by traffic, the ports to be mapped include:

- For the United States West Coast region of the lane:
  - Los Angeles, U.S. port group (including Los Angeles, Long Beach, San Pedro, Wilmington, and Terminal Island)
  - Hueneme, U.S.
  - San Francisco Bay Area, U.S. port group (Including San Francisco, Oakland, Richmond, Mare Island, and Alameda)
- For the Far East region of the lane:
  - Yokohama, Japan
  - Pusan, South Korea
  - Naha, Japan

The final total distance for the mapped RORO journey is 6,114 nautical miles and the distance travelled in an ECA zone is 717 nautical miles.

[29] United States Transportation Command, 2018

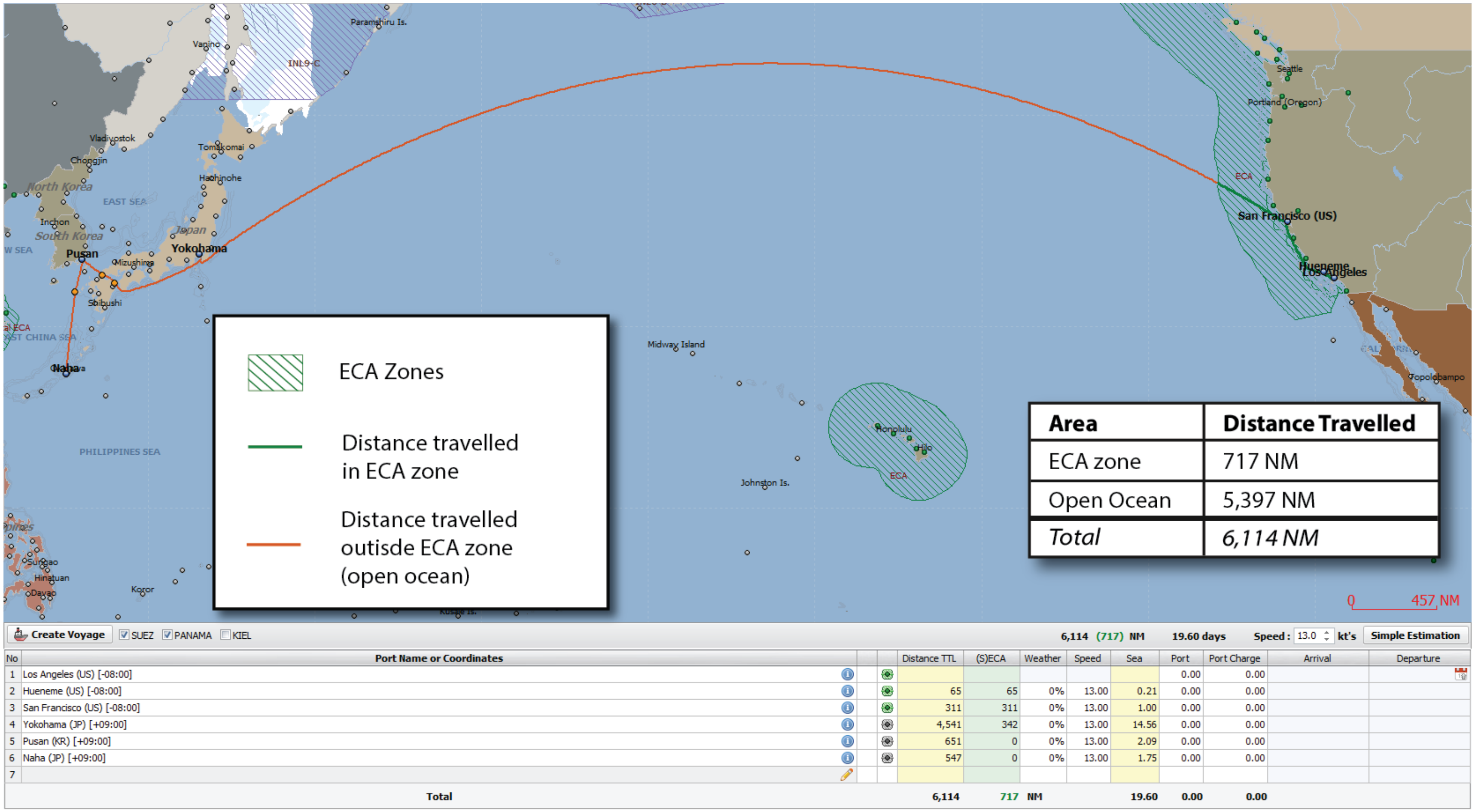

Figure 10. Calculation of Distance for Lane 1 using NETPAS Software

2.4.4.3 Single Average Lane Distance Weighted by Vessel Type

The Lane 1 distance, however, does not account only for RORO traffic. After calculating the RORO distance, a second Lane 1 distance is developed to capture the distance of container ports and the representative journey a container vessel will make. The two distances are then averaged to produce a single distance for the lane, weighted by the share of cargo type within that lane. The single distance represents the distance a unit of cargo may travel within the lane, regardless of cargo or vessel type. The distances for Lane 1 can be seen in Table 5.

Table 5. Distance Results in Nautical Miles by Vessel for Lane 1

Vessel Type	ECA distance	Non-ECA Distance	Total
RORO	717	5,397	6,114
Container	1,761	4,828	6,589
Weighted Average	1,645	4,892	6,537

The distance measurement process was carried out for each of the USTRANSCOM lanes.

2.4.4.4 Using Sub-Regional Data in a Lane

While some USTRANSCOM lanes use small or separately defined regions (such as Lane 1's U.S. West Coast), other lanes use a much broader geographic region whose overall size and geography can have a large impact on distances depending on what ports are identified. For example, when considering lanes that travel to or originate from South America, a vessel is likely to serve either the Atlantic or Pacific coasts on its journey, but not both, as this would require multiple trips through the Panama Canal. In these situations, the region was disaggregated into sub-regions within a lane with distances calculated separately. In the case of South America for example, the full continent was divided into Pacific and Atlantic coastal regions, with the Panama Canal serving as the mid-point. These disaggregated distances were then averaged and weighted by the sub-region's share of the region's shipment volume.

Sub-regional data was used in lanes that originate or terminate in the following three regions: [30]

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[30] The sub-regions were created using the trade zones in USC-9 RFP Attachment 12 as guidance and in consultation with USTRANSCOM. They are as follows:

- Africa: Five regions were used for Africa. (1) North Africa trade, (2) East Africa trade, (3) Combination of Southern Africa and Madagascar trade zones, (4) Combination of West Africa, Central Africa, and Cape Verde trade zones, and (5) Ascension trade zone.
- South America: Two regions were used for South America. (1) East Coast of South America, (2) West Coast of South America
- Central America/Mexico: Four regions were used for Central America / Mexico. (1) Central America/Mexico West Coast trade zone, (2) Central America/Mexico East Coast trade, (3) Nicaragua/Honduras East Coast trade zone, and (4) Panama/Costa Rica trade zone.

- Africa
- South America
- Central America/Mexico

2.4.4.5 *Vessel Service Speed*

Speed is the rated service speed for vessels typically, measured in nautical miles per hour (knots). A well populated data element in the Clarkson's database, a lane's average vessel speed is determined in the average vessel calculation as described above in Section 2.4.2.4. Results for the speed of average vessels for Lanes 1-5 are shown in Table 6

Table 6. Average Speed by Vessel Type for Lanes 1-5

Lane	Speed (Container)	Speed (RORO)
01	24.4	19.2
02	24.4	19.5
03	22.5	19.5
04	19.9	19.4
05	22.9	19.6

2.4.4.6 *Distance, Speed, and Steaming Days Results*

As discussed in Section 2.4.4, steaming days are computed from the average voyage distance on the lane and the average speed of the vessels on the lane. Using the weighted average distance for Lane 1 from Table 6, and the container vessel speed from Table 6, Lane 1 is determined to have 11.2 steaming days.

Recalling Equation 17,

$$Steaming\ Days = \frac{Distance}{Speed} \div 24\ hours = \frac{6{,}536\ nautical\ miles}{24.4\ knots} \div 24\ hours = 11.2_{\ Steaming\ Days}$$

Table 7 shows the average distance, speed, and calculated steaming days for both container and RORO vessels. While a lane's container and RORO vessels share a single distance (weighted by traffic type as discussed above in Section 2.4.4.3), each average vessel type has its own speed and therefore steaming days. See Appendix B: Speed, Distance, and Steaming Days by Vessel Type for the complete table.

Table 7. Distance, Speed, and Steaming Days for Lanes 1-5

Lane	Total Distance	Speed (Container)	Speed (RORO)	Steaming Days (Container)	Steaming Days (RORO)
01	6,536	24.4	19.2	11.2	14.2
02	7,732	24.4	19.5	13.2	16.5

Lane	Total Distance	Speed (Container)	Speed (RORO)	Steaming Days (Container)	Steaming Days (RORO)
03	3,525	22.5	19.5	6.5	7.5
04	2,702	19.9	19.4	5.6	5.8
05	4,446	22.9	19.6	8.1	9.5

2.4.5 Vessel Capacity

Vessel capacity is used to allocate the fuel consumption per day to individual cargo units. Container vessels are assumed to exclusively carry a mix of 20 and 40-foot containers. ROROs move breakbulk cargo and are assumed to exclusively move breakbulk, even though some are capable of moving containers as well.

World trade occurs in many directions, but not necessarily equally. The U.S. imports more than it exports and thus cargo carried to the U.S. is typically considered head-haul whereas cargo carried from the U.S. is considered back-haul. This is particularly true for U.S. trade with the Far East. Most of this effect is reflected in base shipping rates, but there will still be some directional tendency in traffic, leaving fewer cargo units across which to spread fuel costs. However, trade imbalance is a business factor that carriers adapt to in their pricing and marketing, and is reflected in their base freight rates. It is not included in the recommended BAF.

2.4.5.1 Capacity Data

Containership TEU capacity is well-populated in Clarkson's and the BAF uses the rated TEU capacity for container calculations. For RORO vessels, USTRANSCOM prefers to measure capacity using MTONs, a volumetric measure of the cargo space available on the vessel. MTONs are not a measure of weight but rather volume, equaling 40 cubic feet. MTON is not a generally used current industry standard measure of capacity but it is functionally related to a measure that has been previously used in the industry, Net Registered Tonnage (NRT). NRT is the total volume of the enclosed or covered spaces on the vessel that are available for cargo containment and is expressed in tons equaling 100 cubic feet. Thus, multiplying a vessel's NRT by 2.5 converts to estimated MTON capacity.

NRT is not available in the latest Clarkson's dataset and only limited data exist from previous Volpe efforts. In order to estimate meaningful average vessel characteristics, the missing values for NRT were estimated using OLS regression based on service speed, capacity and other vessel characteristics as captured by Clarkson's.

As discussed below, the strong regression results allow the estimated NRT measures to be included with the available actual values of TEU capacity, vessel service speed, and fuel consumption at service speed. The final dataset yields a comprehensive set of all vessels and characteristics from which a representative single, average vessel for each lane can be created.

2.4.5.2 Estimating RORO Vessel Capacity

The Clarkson's database does not currently have NRT. To supplement the current Clarkson's RORO capacity data, Clarkson's data was used from a previous pull of the Clarkson's database (2009), which had NRT. The older Clarkson's vessel data was matched with the current Clarkson's data so that the values for NRT from the older data pull were matched to the same vessels in the new data pull. In this matching process, not all of the vessels from the current Clarkson's data pull were matched with data from the older data pull, and so the capacity of unmatched vessels from the current Clarkson's pull was estimated based on the associated GT and vessel type.

As NRT is a measure of the volume of all enclosed spaces on the vessel that can contain cargo, NRT is necessarily a share of the GT, which is the total volume of all spaces. Other operational and vessel configuration factors play a limited role, and in practice, the industry targets a minimum of 70 percent of GT of a vessel to be capable of holding cargo and therefore NRT.

Figure 11 demonstrates the outcome of the NRT estimation model. The actual NRT of each vessel is plotted against the regression estimated NRT values. The graph shows a tight alignment of these values along the 45-degree angle line which means that the estimated values closely approximate the actual NRT values.

A single model was developed for estimating NRT gross tonnage as an independent variable along with regression dummies for vessel type. The estimation results were statistically significant and highly explanatory of the variation in NRT with an R-square value of 0.92. The p-value for GT was significant at the 1 percent level, while the p-value for all independent variables for all models were significant at the 10 percent level except for one subset of vessel types labeled in Clarkson as "Ro-Ro Freight/Passenger" vessels. Crucially, the F-tests for joint significance showed that the independent variables for all models were jointly statistically significant.

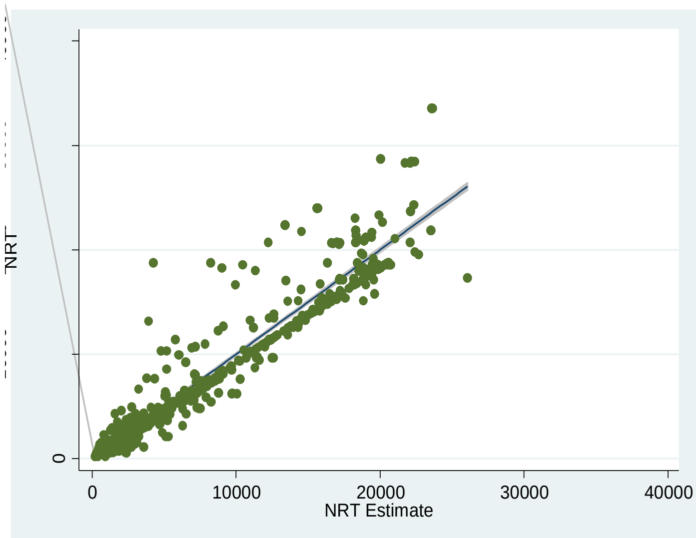

Figure 11. Estimate Net Registered Tonnage (NRT) Compared to Actual Net Registered Tonnage (NRT)

2.4.5.3 Capacity Limitations

Vessel capacity measures represent the total cargo capacity of the vessel, however, real-world factors can limit the effective cargo carrying capacity of the vessel. RORO vessels carry irregular shaped cargo and containership capacity can be limited by the volume and weight of cargo within individual containers.

2.4.5.3.1 Broken Stowage

For breakbulk cargo, the average cargo capacity of a typical RORO was adjusted downward to reflect "broken stowage," the wasted space between trucks, tanks, or other cargo that cannot be utilized as the cargo is irregularly shaped. USTRANSCOM assumes a 28 percent loss of cargo capacity due to broken stowage. In calculating the daily fuel consumption per cargo unit, the vessel cargo capacity was multiplied by 0.72 to adjust for this loss.

2.4.5.3.2 TEU to FEU Conversion

Containerized cargo can be shipped using different container sizes that can impact the cost of shipment for the parties involved. In the BAF, the container cargo calculation is done on a TEU basis. This a standard measure for containerized ocean liner freight with one TEU referring to a 20-foot long shipping container, generally measuring 20 feet by 8 feet by 8 feet 6 inches. Along with 20-foot containers, 40-foot containers are also commonly used in moving cargo. This container measures 40 feet by 8 feet by 8 feet 6 inches, which is twice the size of a 20-foot container. The volume of one 40-foot container, or one FEU, is the equivalent of two TEU's.

Since USTRANSCOM utilizes both sizes of containers for shipments—although one of their largest shippers, the Defense Commissary Agency (DeCA) tends to use predominately 40-foot containers—it is necessary to be able to convert between an FEU and a TEU for purposes of consistency when calculating a BAF.

2.4.5.3.2.1 Cargo Constraint, Weight versus Volume

Converting between an FEU and TEU can be done using either container weight or volume. Containers will "cube out," when reaching their maximum capacity by volume. In this case a 40-foot container would then hold exactly twice as much cargo as a 20-foot container, and the appropriate conversion factor would be 2-1 (or, as a multiplier, 2.0). This relationship, however, does not hold when cargo reaches the maximum container payload weight. For example, if the approximate payload weight of a 20-foot container and a 40-foot container is 48,000 lbs. and 59,000 lbs., respectively, then when "weighing-out," the 40-foot container will hold approximately 23 percent more cargo than a 20-foot container. This would imply a weighing-out conversion factor of 1.23-1 (or a 1.23 multiplier) based on maximum payload weight. If the maximum gross weight of the container is used (payload plus tare), then the conversion factor is 1.27.

Restrictions on the weight of cargo carried by trucks moving cargo to and from ports, however, add another aspect to the analysis. Ocean Carrier Equipment Management Association (OCEMA) guidelines recommend a 44,000 lbs. maximum weight on both 20-foot and 40-foot containers to "promote safe and lawful transport practices," indicating that a realistic ratio for "weighing-out" containers can be as low as 1.0.[31]

Theoretically, these two ratios establish the bounds for the conversion factor for an FEU. For example, if USTRANSCOM is shipping all relatively light goods, such as pillows, in forty-foot containers, then the cargo would cube out and the applicable network wide factor would be 2.0. In contrast, if they are shipping small, but heavy items, such as steel ball bearings, then the cargo would weigh out prior to filling all available space in the forty-foot container. In this case, the conversion factor would be 1.0. Since USTRANSCOM ships a combination of light and heavy goods, a conversion factor that blends cubing out and weighing out values is most appropriate.

2.4.5.3.2.2 Vessel Constraint, Cargo Carrying Capacity

A vessel is constrained by its space capacity, measured in TEUs. Because a 40-foot container takes up twice as much space, the FEU container is twice the opportunity cost of the smaller TEU container. Weight, however, is also an important cost factor. Every kilo of weight, whether payload or container weight, sinks the hull of the vessel deeper in the water and requires more fuel to push the vessel forward. If the payload weight limit is binding on a 40-footer, then a 20-footer could have carried all or most of the cargo, and the additional cost of the larger size is less than twice the weight of the smaller unit.

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[31] OCEMA, n.d

2.4.5.3.2.3 Developing a USTRANSCOM Conversion Factor

A central element of the FEU conversion factor is determining the relationship between the percent of cargo in forty-foot containers that is expected to weigh out compared with cube out. When cargo cubes out before weighing out, the relationship between a TEU and FEU is related to volume. When weighing out, the cargo has reached the weight capacity of the container before its volume has been reached.

This relationship will depend upon the type of goods being shipped and any restrictions placed upon the use of space and maximum payload weight. One of USTRANSCOMS largest shippers, DeCA, indicated for previous versions of the BAF that when using forty-foot dry containers they encounter cubing out when moving light snacks and weighing out with canned or bottled products. More specifically, they noted that when using dry containers their cargo tends to weigh out on somewhere around 92 percent of shipments. In contrast, DeCA cargo cubes out around 100 percent of the time when using refrigerated containers, which is in large part due to the requirement to leave space around refrigerated cargo. Furthermore, the need to ensure cargo is unharmed during shipment requires limiting the number of layers of product. As a result, only around 55 percent of the actual volume is utilized for cargo in refrigerated containers. In a similar way, at the request of distributors, and to protect cargo from being damaged, only around 65 percent of the actual volume is utilized for dry containers. Finally, to meet the weight restrictions placed on trucks traveling on the U.S. highway system, DeCA places a maximum payload weight of 40,000 lbs. on both 20-foot and 40-foot containers.

A review of 2017 USC shipping data contained in SDDC database also provided some insight into the relationship between the use of 20-foot and 40-foot dry and refrigerated containers. The majority, or 83 percent out of the 82,000 total USC container shipments in 2017 were made using 40-foot containers (this translates into 67,895 40-foot containers compared with 14,177 20-foot containers); of the 40-foot containers 100 percent weigh 40,000 lbs. or less; and in the case of 20-foot containers, 99 percent weigh less than 20,000 lbs. Cargo in 20-foot containers tends not to weight out above 40,000 lbs.

The rules used to infer a conversion factor for an individual container are outlined in Table 8. These rules were applied to the 513,000 USC shipments that occurred during January 2013 to October 2018 from the SDDC database. The 40,000 lbs. weight limit for both container sizes, which is consistent with DeCA practice and the guidelines suggested by OCEMA for when moving cargo on U.S highways, serves as a threshold weight.

Table 8. Assumed Conversion Factors for Container Types by Actual Weight

Van Type	Actual Weight Under 20K lbs.	Actual Weight Over 20K But Less Than 40K lbs.	Actual Weight Over 40K lbs.
refrigerated containers	2	2	2
20-foot dry container	2	1+(40K-actual weight)/20K	1
40-foot dry container	2	2	1.5

Based on the air space requirements for refrigerated cargo and DeCA experience, all refrigerated containers are assumed to cube out before weighing out. A 40-foot container therefore contains twice the weight for this type of cargo as a 20-foot container.

If the actual payload for a 20-foot dry container is under 20,000 lbs., then it is assumed that the cargo has cubed out. A 40-foot container holding the same contents would weigh twice as much, or the contents of two 20-foot containers carrying the same cargo would fit into a 40-foot container. Hence the conversion is 2.0.

Cargo in a 20-foot container weighing 40,000 lbs. or more is assumed to have weighed out. These same goods carried in a 40-foot container would also weigh out that container as well, making the weights the same and yielding a multiplier of 1.0.

Between 20,000 lbs. and 40,000 lbs. the multiplier would be expected to move in a linear fashion from 2.0 to 1.0 as the conversion factor moves from cubing out to weighing out. A linear interpolation is shown in the table and in the diagram in Figure 12.

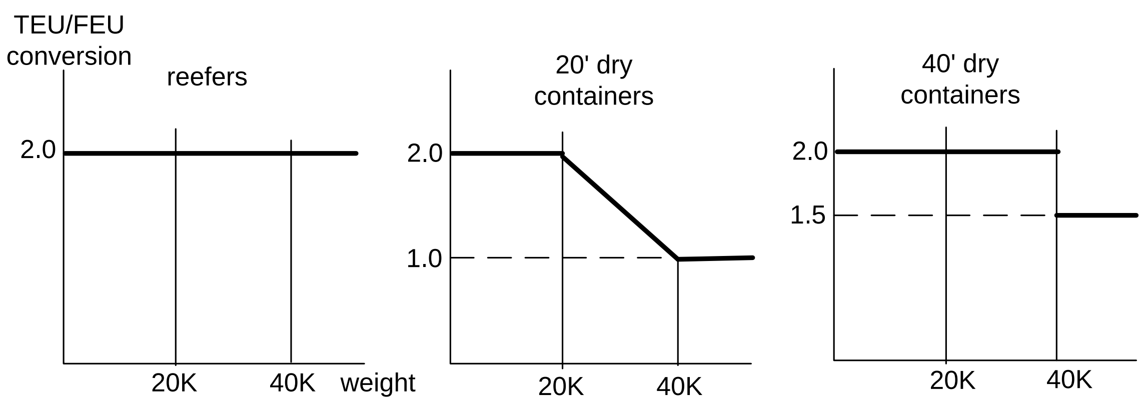

Figure 12. Notional Representation of TEU/FEU Conversion Function.

If a 40-foot container is holding less than 40,000 lbs., it is assumed to have cubed-out before weighing out. These goods would require two twenty-foot containers to move them, and the multiplier would be 2.0.

A 40-foot container with 40,000 lbs. or more of cargo may have cubed out or weighed out; without further information, either case would be equally likely, implying an average multiplier of 1.5.
The results of applying these rules to the IBS data are summarized in Table 9, which shows the average conversion factors for each container type. Although developed separately, the single combined average network-wide conversion factor for all containers used by USTRANSCOM in the BAF is of 1.94 FEUs for each TEU.

Table 9. TEU/FEU Conversion Factor[32]

[32] Estimated from SDDC data

Description	Factor
20-foot Container Average Conversion Factor	1.95
40-foot Container Average Conversion Factor	1.94
20-foot as percent of all containers	32%
40-foot as percent of all containers	68%
Combined Weighted Conversion Factor in BAF	1.94

The 20-foot container average conversation factor is the conversion for 20-foot-containers to forty-foot-containers meaning that 1.95 20-foot-containers are on average filled such that they equal one 40-foot-container. Conversely, 40-foot containers are filled such that they are equivalent to 1.94 20-foot containers. The closeness of these values demonstrates that the industry has been successful in filling 20-foot and 40-foot containers to near equivalence. In the IBS database during the January 2013 to October 2018 period, the share of 20-foot dry container was 32 percent and the share of 40-foot dry container was 68 percent. The combined value is the weighted average of the conversions, which were already very close. The combined weighted conversion factor is higher than the 2013 value of 1.86, which suggests that shippers are more careful to balance the weight and size of shipments and choose the container size that is most cost and operationally efficient.

2.4.6 Calculating Fuel Consumption Factor per Cargo Unit

Recalling Equation 16, from Section 2.4.1,

$$Fuel_{CU} = \frac{Fuel_{Day} \times Steaming_{Days}}{Capacity_{vessel}}$$

The available daily fuel consumption rates are multiplied by the voyage length to determine the total fuel consumption factor for a vessel type in a given trade. *Fuel*$_{Day}$ is the fuel consumption in tons per day for each lane's average vessel. *Steaming Days* is the number of days it takes a lane's average vessel to travel between the origin and destination regions. *Capacity*$_{vessel}$ is the cargo carrying capacity of the vessel, as adjusted by load factors and capacity constraints.

Combining the example data from Lane 1 for containerships as used throughout the section, the final calculation is:

$$Fuel_{CU} = \frac{Fuel_{Day} \times Steaming_{Days}}{Capacity_{vessel}} = \frac{175_{\frac{tons}{day}} \times 11.2_{Days}}{4{,}853\ TEU\ Capacity_{vessel}} = 0.404$$

Equation 18. Fuel Consumption Factor for Lane 1-Containership

This figure represents the total fuel consumed by a lane's average vessel to move one TEU on its journey for an average length trip for Lane 1. A fuel consumption factor is developed for each lane by vessel type. The fuel consumption factor is a critical component of the BAF, and when combined with the Input Substitution and Risk Distribution Factors discussed in the next sections, results in the final Technical Factor for each lane and vessel type.

2.5 Input Substitution

This section describes the third term from the general structure of the BAF, the *Input Substitution Factor*. When faced with rising fuel prices, carriers have numerous options to adjust the inputs to their production to use less fuel, including both short-term operational changes, such as slow-steaming, and longer-term capital investments such as newer, fuel-efficient engines. The Input Substitution Factor is a mechanism to account for and incentivize a carrier's ability to economize its operation.

2.5.1 Theoretical Background

In theory, the mix of inputs into a given production function is selected according to their relative prices. The price of labor, the opportunity cost of a vessel, and the price of fuel usually have some effect on the amounts and proportions of those inputs that produce a vessel voyage. As the prices of each input change, the mix of inputs changes. The extent to which the proportions of inputs change in response to price changes depends upon the ability to substitute among inputs within the production function, which, in turn, depends on the technology of the industry and the firm.

While labor, capital and fuel costs are required for vessel freight services, fuel appears to be the only component singled out for surcharge treatment. Fuel costs have higher variability than do labor or capital costs which are usually fixed over long periods. As the price of fuel rises, the vessel operator tries to produce the same output at the least cost by substituting other inputs for the more-expensive fuel. The primary means for saving on fuel on ocean vessels is to reduce speed, but other strategies such as hull cleaning, propeller design, vessel trim, and energy efficiency monitoring can yield fuel savings. The higher the price of fuel, the more worthwhile these activities become.

The result is that the mix of inputs (fuel, vessels, labor) is not independent of the price of fuel. As the price of one input goes up, the total cost (or unit cost) goes up, but by less than would be the case if the ratios of inputs were fixed. The amount of substitution that will efficiently take place in response to a change in the price of one input depends upon technology, the importance of the input in the production function, and the relative variation in price.

In economic terms, this is represented by a substitution elasticity. A high elasticity would maintain a constant *ratio* of input costs (to each other) while quantities of inputs varied in relation to price. A high elasticity results in a substitution factor of approximately 0.75, meaning that for every dollar increase in the price of fuel, total costs would increase by $0.75. In contrast, completely inelastic inputs (called fixed factors, e.g., one vessel and one master) result in a substitution factor of 1.0: every dollar of fuel price yields a $1.00 increase in cost.

Table 10. Numerical Example of Input Substitution

Variable Factors	Initial Condition-Price	Initial Condition-Quantity	Fixed Proportion-Price	Fixed Proportion-Quantity	Efficient Input-Price	Efficient Input-Quantity
Fuel	$2.00	6.2	$4.50	6.2	$4.50	3.6
Labor (and other inputs)	$4.00	6.2	$4.00	6.2	$4.00	8.2
Total Cost	-	$37.20	-	$52.70	-	$49.00
Percent Change in Total Cost	-	-	-	42%	-	32%
Efficient cost % of fixed Input Cost	-	-	-	-	-	93%
Fuel Share of Total Cost	-	33%	-	53%	-	33%

A simple, representational numerical example of input substitution is constructed in Table 10. Initial equilibrium prices and quantities are shown, with quantities optimized for given input prices and a fixed output and a total cost of $37.20. The price of fuel is then assumed to increase by 125 percent. Given the initial input quantities and fixed proportions in production (i.e., only the given mix of inputs is capable of producing the given output, or the firm is otherwise unable or unwilling to change its input mix), the increased fuel price causes total costs to increase by 42 percent to $52.70. However, a firm that can adjust the mix of their inputs to production can better respond to a price change in any one input. The efficient firm's decisions, shown in the right-hand columns can use more labor (and other inputs) and less fuel for a total cost of $49.00. While it is still a higher total cost than the initial scenario, the efficient firm's total cost is 93 percent of the fixed proportion's total.

2.5.2 Input Substitution in Ocean Shipping

Ocean freight service firms are in a position to adjust input mixes in a way that minimizes its costs. Table 11 identifies several methods that carriers can employ to adjust their operation both in the short or long term to reduce fuel costs. If the price of fuel goes up relative to other inputs, the producer should shift its input mix so as to use less of the relatively scarce input. This might be done by slowing down (using less fuel per vessel mile but requiring more vessels to provide the same overall cargo-movement capacity), by increasing the load factor (altering schedules or offering incentives to reduce spare capacity on each vessel), by shifting routes and steaming times to minimize conflict with weather conditions, etc.

Table 11. Short and Long Term Methods for Reducing Fuel Consumption

Input Factor	Estimated Savings	Citation
Speed adjustment/Slow Steaming	17-22%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Replacing older, smaller vessels with larger, newer vessels	25%	American Bureau of Shipping, 2013
Trim/Draft Optimization	1-2%	American Bureau of Shipping, 2013
Autopilot Improvements	1%	American Bureau of Shipping, 2013
Engine monitoring, air-fuel mix	3-10%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Air Lubrication	0-10%	American Bureau of Shipping, 2013
Wake Equalizing and Flow Separation Alleviating Devices	0-5%	American Bureau of Shipping, 2013
Main Engine Performance Monitoring and Control	1-2%	American Bureau of Shipping, 2013
Rudder Control Technology	1-3%	American Bureau of Shipping, 2013
Hull Maintenance	3-30%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Hull Coating	5-12%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Propeller Roughness Management	0-6%	American Bureau of Shipping, 2013
Bow design modifications	1-3%	American Bureau of Shipping, 2013
Higher Strength Steel	10%	American Bureau of Shipping, 2013
SEEMP	20%	American Bureau of Shipping, 2013
Bow optimization	10%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
High Efficiency Propellers	3-10%	American Bureau of Shipping, 2013
Wind power	20-30%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Ducted propeller	10%	Winkel, van den Bos, & Weddige, 2015
Contra-rotating propellers	13%	Winkel, van den Bos, & Weddige, 2015
Wheels	10%	Winkel, van den Bos, & Weddige, 2015
Waste heat recovery	8-11%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige,

Input Factor	Estimated Savings	Citation
		2015
Rudder bulb	4%	Winkel, van den Bos, & Weddige, 2015
Post swirl fins/ Pre-swirl Devices	2-6%	American Bureau of Shipping, 2013 Winkel, van den Bos, & Weddige, 2015
Twisted rudder	3%	Winkel, van den Bos, & Weddige, 2015
Main engine de-rating	3%	Winkel, van den Bos, & Weddige, 2015

Conceptually, the Substitution Factor is equal to one minus the percentage cost savings from re-optimizing the input mix after a change in the price of fuel. It depends on the elasticity of substitution between fuel and all other inputs, and the share of fuel in total cost. If the elasticity of substitution is zero, then the substitution factor is equal to 1.0, because no savings are possible. For ocean shipping, substitution elasticity is moderately high and is likely to lie in the range of 0.80–0.85. Carriers can instantaneously respond to higher prices by slow steaming and also employ a series of longer term capital strategies to efficiently deploy capital resources to minimize the impact of increased fuel costs.

2.5.3 Service Speeds and Fuel Consumption

Finally, the Input Substitution Factor serves as a real-world adjustment to the fuel consumption estimates in the BAF model. Clarkson's data includes fuel consumption at "service speed" and so the BAF model assumes that vessels operate at that speed at all times. However, service speed is at the high end of an engine's capability and not typically used in normal operations. As a vessel moves faster, fuel consumption increases at a growing rate; conversely, slowing down from higher speeds will produce a more than proportionate reduction in fuel consumption.

As the BAF model uses service speed and fuel consumption at service speed, it overestimates fuel consumed by carriers. This assumption is known to be unrealistic as carriers have indicated to USTRANSCOM they typically operate vessels at a speed slower than service speed. The Input Substitution Factor incorporates this reduction in speed from service to typical speed and reduces fuel consumption accordingly. See Appendix E for a discussion of fuel consumption estimates under alternate speed scenarios.

2.5.4 Input Substitution Factor

In order to maintain the incentive for efficient adjustment of inputs in response to changes in input prices, the BAF should not compensate carriers for the full increase in fuel cost while holding the input mix constant. Although the actual production function for vessel shipping has not been fully modeled, it clearly is not one in which the proportions between fuel and other inputs is fixed which is inconsistent with actual shipping behavior. However, compensation based on an (implicit) assumption of fixed input proportionality removes the incentive to optimize fuel consumption within the input mix, and potentially overcompensates carriers. Finally, the Input Substitution Factor adjusts the modeled service speeds available in Clarkson's to the typical operating speeds and lower fuel consumption indicated by carriers.

The Input Substitution Factor thus incorporates the real world operational decisions of carriers while incentivizing them to make optimal decisions about their input mix in the face of rising fuel costs. Accordingly, the value for the substitution factor is set at 0.80, consistent with recent versions of the USTRANSCOM BAF. The 0.8 recommendation is likely a conservative estimate, supported by both the underlying economic theory of input substitution as well as an analysis of the fuel consumption savings of vessels under alternate speed scenarios.

2.6 Risk Sharing

This section describes the logic for the final term of the BAF Equation 1, the *Risk Factor*. The BAF is a mechanism for risk distribution, and the distribution of that risk is subject to negotiation and USTRANSCOM policy. For a BAF to function in the way it is intended, the risk of fuel price change must be fairly distributed so that parties share an equal amount of risk commensurate with the parties' abilities to mitigate that risk.

2.6.1 Principles of Risk Sharing

As the BAF is a mechanism for shifting the distribution of risk of fuel price volatility, the decision should be explicitly made as to how much of the risk each party should bear. That allocation will then be reflected in the bid or offered basic freight rates. If carriers are in the best position to forecast risk and take appropriate actions to minimize the impacts, then they should bear the risk directly; they will pass on the costs in their base freight rates. Alternatively, if the risk is largely out of anyone's control (or any of the relevant parties), and shippers (USTRANSCOM) can absorb the uncertainty of not knowing actual costs until the time of delivery, then shippers can bear the risk. The Risk Distribution Factor assigns some proportion of the risk to each party.

The length of the USC contract is a source of fuel price risk and USTRANSCOM should bear some of that risk as the responsible party. At the same time, it is not desirable for USTRANSCOM to bear all of the risk. In addition to erring on the side of avoiding overcompensation to carriers (carriers make money on higher fuel prices), the risk of cost increases should be shared between shipper and carrier. This preserves the incentives for each party to be efficient and to seek ways to minimize the cost of price volatility. A price increase is an adverse event whose burden can be assigned to one party, or shared.

The BAF should not be based on actual costs or operational decisions, but constitutes a partially compensating adjustment for unanticipated unit input price changes. Hence the technical factors should be based on a representative set of conditions, not actual conditions. Carriers that use fuel-efficient vessels will profit from the BAF adjustment when prices rise; inefficient ships will benefit more when prices drop (fuel efficiency then has less value).

2.6.2 Carrier Risk Mitigation

While USTRANSCOM faces little flexibility in meeting its mission to ship cargo worldwide in order to reduce its exposure to risk, carriers are experienced actors in the world shipping and fuel markets. In addition to the carrier operational and capital strategies to increase fuel efficiency as noted in Section 2.5.2, carriers can act in the fuel production and financial markets to minimize their exposure to the risk of increased fuel price volatility.

2.6.2.1 Hedging

A strategy for reducing the impacts of uncertainty and volatility is generically referred to as hedging. Essentially, buyers take a position in the fuel market such that they protected to some degree from significant price swings. This allows a buyer to suppress the volatility of future price changes, both up and down. The fundamental concept of hedging is that in giving away some of the upside potential, the downside is also limited. Fuel price hedging can be accomplished by purchasing futures or options contracts on the commodities market. [33]

Although the inclusion of a BAF in purchasing transportation services is a form of hedging, the one does not obviate the other, nor are they exact substitutes. Inclusion of a BAF does, however, reduce the need for hedging. Without a BAF, carriers are likely to hedge or pre-purchase a larger share of their fuel than with the BAF.

2.6.2.2 Fuel Sourcing

Beyond purely financial instruments such as hedging, in the face of fuel price increases, carriers can act directly in the fuel production and sourcing markets. Carriers can partner directly with refineries, fuel delivery, and storage facilities to produce and store fuel at favorable rates. Maersk for instance has partnered with fuel producers on the U.S.[34] and Europe[35] on agreements that include investments to retool refineries and expand bunkering facilities. These agreements will ensure Maersk access to 0.5% m/m IMO compliant fuels on both sides of its transatlantic trades. Although not all carriers may

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[33] USC Carriers with annual reports identifying fuel hedging practices include, but are not limited to: CMA CGM (2017 Annual Report, Page 46), Hapag-Lloyd (2017 Annual Report, Page 65), Maersk (2017 Annual Report, Page 65), NYK (2017 Annual Report, Page 66), and Wallenius Wilhelmsen (2017 Annual Report, Page 118).

[34] gCaptain, 2019.

[35] World Maritime News, 2019.

participate in such agreements to this extent, they represent potential avenues for carriers to mitigate fuel price risk, options unavailable to USTRANSCOM as a shipper.

2.6.2.3 Increased Base Rates

In addition to these market mechanisms the carriers can adjust the bid or offered basic freight rates as a hedging mechanism. Carries can offer higher bids to offset the potential for fuel price increases. However, if a carrier pursues a high bid for freight rate to offset potential risk of an increase in fuel price over the life of the contract this strategy carries risk of losing the contract to carriers offering a lower bid. Carriers may vary in their exposure to fuel price risk but all carriers face fuel price risk and therefore face similar tradeoffs for bid strategies. Assuming rates are set in competitive markets, the more that the risk is borne by carriers, the lower will be the BAF and quoted base freight rates will be higher in order to absorb the risk.

2.6.3 Risk Distribution Factor

The Risk Distribution Factor sets the upper bound on what constitutes full compensation for a fuel price change, but, as a matter of policy, it is not necessary to provide full or 100 percent compensation. The Risk Distribution Factor can vary between zero (no BAF, all risk of price volatility borne by carriers) and 1 (USTRANSCOM bears the cost of price volatility, up to the efficient re-optimization of fuel consumption).

It is recommended that the Risk Distribution Factor be set at 0.75, meaning that 75 percent of the estimated cost of price volatility is absorbed by the shipper with the remaining 25 percent borne by the carriers. This recommended value is consistent with the most recent USTRANSCOM BAF. It is important to recognize that the Risk Sharing Factor is a policy choice on the part of the shipper rather than an empirical technical factor.

2.6.4 Buffer Threshold and Risk Distribution

The BAF contains two components that allocate price volatility risk between the shipper and the carrier: the explicit Risk Distribution Factor, and the threshold value used to determine whether a BAF is paid or not. The higher the risk distribution factor, the larger the share of risk that is borne by USTRANSCOM, the shipper. The higher is the threshold for the buffer zone, the more of the price risk that is borne by the carrier. These two concepts can be combined as shown in Table 12.

Table 12. Interaction of Buffer Threshold and Risk Distribution Factor

Threshold Level	Low Risk Distribution Factor	High Risk Distribution Factor
Low Buffer Threshold	BAF is more frequently invoked, but carrier compensation is smaller in magnitude; all risk is borne proportionately but mostly by the carrier	BAF is frequently invoked and shipper bears most of the cost of risk
High Buffer Threshold	Carrier bears a large amount of basic risk, and receives only a small compensation for large price fluctuations	BAF is rarely invoked, but compensation is high when large price fluctuations occur.

The extremes are on the reverse diagonal, for which the combinations of the two factors align in the same direction. A high buffer threshold and low risk allocation factor, for example, place most of the risk on the carrier; deviations from the base fuel rate must be large before any compensation is paid, and even then the share borne by USTRANSCOM is limited. A large buffer zone combined with high share of risk assigned to the shipper places an emphasis on distinguishing what is “normal” (everyday risk typically borne by carriers, and readily mitigated) from what is “unusual” (deemed outside what carriers can reasonably be expected to absorb).

The suggested values for BAF purposes, 15 percent for the buffer trigger and 75 percent for the USTRANSCOM share of risk, fall on the inner edge of the high-high box in the table. This is roughly akin to catastrophe insurance, in which most of the risk is borne by the insured, but for rare extreme events the compensation is sufficient to avoid ruin.

2.7 Combined Technical Factors

Once the average fuel consumption (Section 2.4), the Input Substitution Factor (Section 2.5), and the Risk Distribution Factors (Section 2.6) are determined, they combine to form the Technical Factor for each lane. The final technical factor is calculated by multiplying the fuel consumption factor per cargo unit by the Input Substitution Factor and the Risk Distribution Factor to adjust for efficient carrier production decisions and the sharing of risk between USTRANSCOM and carriers, as shown in Equation 19 below:

$$Technical\ Factor = \ Fuel_{CU} \times Subfac \times Risk\ Sharing\ Factor$$

Equation 19. Composite Technical Factor

where the $Fuel_{CU}$ is the fuel consumption factor estimate for the lane (0.404 as shown in Equation 18), *Subfac* is the Input Substitution Factor from Section 2.5.4, recommended earlier to be 0.8, and the *Risk Sharing Factor* from Section 2.6.3 is 0.75. The resulting Technical Factor for Lane 1 can be calculated as:

$$0.242 = 0.404 \times 0.80 \times 0.75$$

Equation 20. Technical Factor for Lane 1, per TEU

Technical Factors are presented below in Section 2.7.2 for container and RORO vessels by lane for each type of cargo unit, TEUs, FEUs, and MTONs. Although the motivations for each component are entirely different, both the Input Substitution Factor and the Risk Distribution Factor can be set for at least a year or the life of the contract. These factors both scale the fuel consumption factor and the relevant change in fuel price downward by some amount.

2.7.1 Details for 2018 USTRANSCOM BAF

While there have been some changes in the methods and calculation of the components of the BAF as described above, the fundamental logic of the 2018 BAF Technical Factor methodology has not changed relative to the 2013 methodology. The principle difference between the 2013 and the 2018 BAF Technical Factors is not methodological, but is due to the fact that the factors are empirically developed. The BAF Technical Factors are constructed using actual shipment data from USTRANSCOM shipments that occurred from 2013 to 2018. USTRANSCOM operations and shipments from 2013 to 2018 have changed relative to 2009 and 2013, which would impact the origin and destinations of goods, the amount of shipments between regions and on lanes, and the vessels used.

Methodological changes to underlying estimates have improved the accuracy of the BAF fuel consumption estimates, and have had limited impact on the Technical Factors as a result of the data changes overall. First, the vessel characteristics include more vessels because the vessel matching method between the IBS and Clarkson's database has been adjusted to produce more accurate matches and critical vessel characteristics that were missing have been estimated using regression. And second, the average distance of shipments on a lane has been improved through empirical methods to better represent the average shipment distance by lane. These changes provide greater accuracy in reflecting USTRANSCOM and carrier operation decisions and provide a more accurate BAF adjustment which more fairly compensates each party when a BAF payment is activated.

2.7.2 BAF Technical Factors Results

Table 13 displays the final technical factors for each lane (for a comparison between this and the previous BAF, see Appendix C: Fuel Mix Factors

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
01	U.S. West Coast - Far East	71%	29%	71%	24%	5%
02	Continental Europe, United Kingdom, Ireland - Middle East, South Asia, Indian Ocean	85%	15%	85%	10%	5%
03	U.S. West Coast - Hawaii	44%	56%	44%	51%	5%
04	Middle East, South Asia, Indian Ocean Interport	95%	5%	95%	0%	5%
05	U.S. East Coast - Continental Europe, United Kingdom, Ireland	36%	64%	36%	59%	5%
06	U.S. East Coast - Mediterranean	71%	29%	71%	24%	5%
07	U.S. East Coast - Middle East, South Asia, Indian Ocean	81%	19%	81%	14%	5%
08	U.S. East Coast - Far East	87%	13%	87%	8%	5%
10	U.S. Gulf Coast - Scandinavia, Baltic Sea	39%	61%	39%	56%	5%
11	U.S. Gulf Coast - Continental Europe, United Kingdom, Ireland	63%	37%	63%	32%	5%
12	U.S. Gulf Coast - Mediterranean	81%	19%	81%	14%	5%
13	U.S. Gulf Coast - Middle East, South Asia, Indian Ocean	85%	15%	85%	10%	5%
14	U.S. Gulf Coast - Far East	90%	10%	90%	5%	5%
15	U.S. Gulf Coast - Hawaii	84%	16%	84%	11%	5%
16	Hawaii - Far East	89%	11%	89%	6%	5%
18	Caribbean Interport	0%	100%	0%	95%	5%
19	Far East Interport	95%	5%	95%	0%	5%
20	Mediterranean Interport	95%	5%	95%	0%	5%
23	U.S. West Coast - Continental Europe, United Kingdom, Ireland	95%	5%	95%	0%	5%
24	SCANDINAVIA, BALTIC SEA - CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND	6%	94%	6%	89%	5%
25	U.S. West Coast - Mediterranean	89%	11%	89%	6%	5%
26	U.S. West Coast - Alaska	41%	59%	41%	54%	5%
27	Hawaii - Continental Europe, United Kingdom, Ireland	84%	16%	84%	11%	5%
28	U.S. West Coast - Central America/Mexico	63%	37%	63%	32%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
29	Alaska Interport	87%	13%	87%	8%	5%
31	U.S. East Coast - Iceland	27%	73%	27%	68%	5%
32	U.S. East Coast - Scandinavia, Baltic Sea	32%	68%	32%	63%	5%
33	U.S. EAST COAST - AZORES	70%	30%	70%	25%	5%
34	Continental Europe, United Kingdom, Ireland - Mediterranean	78%	22%	78%	17%	5%
35	U.S. WEST COAST - CARIBBEAN	74%	26%	74%	21%	5%
36	Mediterranean - Hawaii	91%	9%	91%	4%	5%
37	U.S. East Coast - Caribbean	57%	43%	57%	38%	5%
39	U.S. East Coast - Central America/Mexico	41%	59%	41%	54%	5%
40	AFRICA INTERPORT	95%	5%	95%	0%	5%
41	HAWAII INTERPORT	0%	100%	0%	95%	5%
42	U.S. Gulf Coast - Caribbean	59%	41%	59%	36%	5%
43	U.S. Gulf Coast - Central America/Mexico	55%	45%	55%	40%	5%
44	ALASKA - HAWAII	78%	22%	78%	17%	5%
47	U.S. West Coast - Middle East, South Asia, Indian Ocean	82%	18%	82%	13%	5%
48	CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND INTERPORT	40%	60%	40%	55%	5%
49	Far East - Continental Europe, United Kingdom, Ireland	89%	11%	89%	6%	5%
50	Far East - Mediterranean	95%	5%	95%	0%	5%
51	Far East - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
52	U.S. East Coast - Black Sea	75%	25%	75%	20%	5%
53	U.S. West Coast - South America	92%	8%	92%	3%	5%
54	U.S. West Coast - Oceania	80%	20%	80%	15%	5%
55	U.S. East Coast - South America	82%	18%	82%	13%	5%
56	U.S. Gulf Coast - South America	81%	19%	81%	14%	5%
57	Mediterranean - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
58	Far East - South America	95%	5%	95%	0%	5%
59	U.S. GULF COAST - BLACK SEA	80%	20%	80%	15%	5%
60	U.S. East Coast - Africa	79%	21%	79%	16%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
61	Far East - Oceania	95%	5%	95%	0%	5%
64	CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND - AZORES	68%	32%	68%	27%	5%
65	Central America/Mexico - Continental Europe, United Kingdom, Ireland	82%	18%	82%	13%	5%
67	U.S. West Coast - Africa	85%	15%	85%	10%	5%
68	Central America/Mexico - South America	95%	5%	95%	0%	5%
70	Azores - Mediterranean	95%	5%	95%	0%	5%
71	Continental Europe, United Kingdom, Ireland - Africa	81%	19%	81%	14%	5%
72	Continental Europe, United Kingdom, Ireland - Oceania	90%	10%	90%	5%	5%
73	U.S. Gulf Coast - Africa	85%	15%	85%	10%	5%
74	Mediterranean - Africa	95%	5%	95%	0%	5%
75	Africa - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
76	Central America/Mexico Interport	95%	5%	95%	0%	5%
77	U.S. East Coast - Oceania	89%	11%	89%	6%	5%
78	U.S. Gulf Coast - Oceania	92%	8%	92%	3%	5%
79	Hawaii - Oceania	87%	13%	87%	8%	5%
80	Oceania - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
81	Oceania Interport	95%	5%	95%	0%	5%
82	Alaska - Far East	91%	9%	91%	4%	5%
83	Alaska - Oceania	91%	9%	91%	4%	5%
84	Caribbean - Central America, Mexico	86%	14%	86%	9%	5%
85	Hawaii - Middle East, South Asia, Indian Ocean	92%	8%	92%	3%	5%
86	MEDITERRANEAN - SCANDINAVIA, BALTIC SEA	74%	26%	74%	21%	5%
87	FAR EAST - SCANDINAVIA, BALTIC SEA	84%	16%	84%	11%	5%
88	Continental Europe, United Kingdom, Ireland - Caribbean	80%	20%	80%	15%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
89	MEDITERRANEAN - OCEANIA	95%	5%	95%	0%	5%
90	Far East - Africa	95%	5%	95%	0%	5%
91	Alaska - Middle East, South Asia, Indian Ocean	93%	7%	93%	2%	5%
92	Caribbean - Middle East, South Asia, Indian Ocean	94%	6%	94%	1%	5%
93	Far East - Central America/Mexico	95%	5%	95%	0%	5%
94	Mediterranean-Black Sea	95%	5%	95%	0%	5%
95	Black Sea - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
96	BLACK SEA INTERPORT	95%	5%	95%	0%	5%
97	Continental Europe, United Kingdom, Ireland - Black Sea	78%	22%	78%	17%	5%
98	SCANDINAVIA, BALTIC SEA INTERPORT	0%	100%	0%	95%	5%
99	Caribbean - Africa	92%	8%	92%	3%	5%
CA	Caspian Sea Interport	95%	5%	95%	0%	5%

Appendix D: Comparison of 2013 & 2019 BAF Technical Factors). The technical factors are reported for TEUs, FEUs, and MTONS commensurate with the vessel and cargo types that are used for USTRANSCOM shipments. The technical factors represent the amount of fuel required to move a cargo unit within a trade adjusted by the Input Substitution and Risk Distribution Factors. In practice, this technical factor, expressed in tons, is multiplied by the price of fuel outside of the buffer resulting in a BAF surcharge in dollars per cargo unit.

Table 13. 2019 BAF Technical Factors, by Lane

Lane	TEU	FEU	MT
01	0.242	0.472	0.015
02	0.256	0.498	0.015
03	0.171	0.334	0.007
04	0.115	0.224	0.006
05	0.163	0.319	0.007
06	0.219	0.426	0.013
07	0.348	0.679	0.020
08	0.405	0.790	0.030
10	0.249	0.486	0.011
11	0.207	0.403	0.009
12	0.254	0.496	0.013
13	0.398	0.776	0.023
14	0.373	0.728	0.027
15	0.235	0.458	0.012
16	0.218	0.425	0.013
18	0.058	0.113	0.002
19	0.103	0.202	0.006
20	0.079	0.155	0.005
23	0.341	0.665	0.018
24	0.066	0.128	0.003
25	0.348	0.678	0.018
26	0.088	0.172	0.003
27	0.355	0.693	0.020
28	0.126	0.245	0.007
29	0.088	0.171	0.005
31	0.115	0.225	0.006
32	0.208	0.405	0.010
33	0.143	0.279	0.007
34	0.133	0.259	0.009
35	0.209	0.407	0.011
36	0.483	0.943	0.021
37	0.091	0.177	0.004
39	0.067	0.130	0.004
40	0.226	0.440	0.012
41	0.016	0.032	0.001
42	0.082	0.160	0.004
43	0.066	0.128	0.003
44	0.118	0.230	0.005
47	0.509	0.993	0.029
48	0.028	0.055	0.002
49	0.381	0.743	0.026
50	0.422	0.822	0.021
51	0.292	0.569	0.015
52	0.247	0.482	0.010
53	0.157	0.305	0.011
54	0.390	0.760	0.020
55	0.186	0.362	0.012
56	0.104	0.203	0.006
57	0.251	0.490	0.014
58	0.453	0.883	0.024
59	0.280	0.545	0.015
60	0.278	0.542	0.014
61	0.332	0.648	0.017
64	0.136	0.266	0.006
65	0.211	0.412	0.012
67	0.502	0.979	0.027
68	0.073	0.143	0.004
69	0.157	0.305	0.006
70	0.245	0.478	0.013
71	0.509	0.993	0.030
72	0.322	0.628	0.020
73	0.193	0.377	0.009
74	0.202	0.394	0.012
75	0.066	0.128	0.003
76	0.350	0.682	0.023
77	0.356	0.694	0.019
78	0.258	0.503	0.014
79	0.399	0.778	0.021
80	0.078	0.153	0.004
81	0.175	0.342	0.010
82	0.195	0.380	0.010
83	0.070	0.136	0.003
84	0.471	0.919	0.021
85	0.161	0.315	0.011
86	0.395	0.770	0.025
87	0.164	0.320	0.007
88	0.508	0.991	0.023
89	0.256	0.499	0.017
90	0.371	0.723	0.021
91	0.339	0.661	0.017
92	0.269	0.525	0.020
93	0.152	0.296	0.007
94	0.192	0.374	0.011
95	0.027	0.053	0.001
96	0.124	0.242	0.009
97	0.018	0.036	0.001
98	0.295	0.575	0.016
99	0.018	0.035	0.001

2.7.3 Applying the Technical Factors

The combined final Technical Factors by lane incorporate the vessel and cargo fuel consumption estimates along with the Input Substitution and Risk Distribution Factors. In order to calculate the relevant BAF payment, the Technical Factors must be combined with the relevant price information from Section 2.3.

When the shipping price for a lane exceeds the buffer zone, a BAF payment is warranted. The excess volatility portion of the price difference, the portion of the price beyond the buffer, is then multiplied by the Technical Factor, resulting in a payment amount per unit of relevant cargo (TEU, FEU, or MTON). Recalling the Technical Factor from Equation 20 and the Excess Volatility Amount from Equation 15, the final BAF payment using Lane 1 vessel data and fictional prices is calculated as:

$$\$4.61_{per\ TEU} = 0.242_{Lane\ 1\ TEU\ Tech\ Factor} \times \$19.03_{Excess\ Volatility}$$

Equation 21. Example BAF Payment Calculation

Section 2.8 describes the accompanying workbook that can be used to calculate BAF payments.

2.8 Implementing the BAF

Implementation of the BAF is timed so as to match the appropriate phase of procurement of shipping services:

- Calculate the base price immediately concurrent with base rate submission.
- Calculate the current price each month after the contract begins.
- Revise base price whenever new prices are posted.
- Extract the relevant data from Bunker World or similar service and insert into the appropriate calculations.
- Use the model results to determine whether a BAF is warranted, and if so, which party is compensated.

2.8.1 BAF Calculator

As part of this study, Volpe provided USTRANSCOM with an Excel workbook titled "2018 BAF Calculation" that can be used to calculate the USTRANSCOM BAF for each lane. The workbook contains tabs of input data and secondary calculations used in the final calculation of the BAF technical factors. Each of the tabs and their purpose are described below:

- Fuel Price & Buffer Assumptions: this tab contains the fuel price and buffer assumptions used for the BAF
- BAF Results: this tab calculates the BAF payment for lanes by cargo type

- Trade Technical Factors: this tab contains the final BAF technical factors using the variables and factors from subsequent tabs. The following tabs contain the underlying vessel and fuel data used in the calculation, steaming days, and other factors. Using the sample fuel price data in the workbook, BAF charges may be simulated over a specified baseline period or changing factor values in the model.
- Fuel Consumption: this tab calculates the fuel consumption factor using the average vessel service speed, fuel consumption and capacity by lane and vessel type.
- Days: this tab calculates the total steaming days using the average vessel speed and fuel consumption and the average total distance by lane and vessel type.
- Distances: this tab reports the average distances calculated by the methodology described in Section 2.4.4.2.
- Fuel Mix: this tab calculates the fuel mix shares by lane based on the share of average total distance within an ECA zone.
- Vessel Data: this tab contains the average speed, capacity, fuel consumption and shipment count by vessel type and lane for all USTRANSCOM lanes.
- Vessel Capacity: this tab contains the assumptions of the capacity utilization described in Section 2.4.5.
- FEU Adjustment Factor: this tab contains the values for the FEU adjustment factor described in Section 2.4.5.3.2.
- Volpe Factors: this tab contains the values for the Input Substitution Factor for container and RORO vessels, the Risk Distribution Factor.

2.9 Conclusion

The updated and refreshed BAF described in this section aims to create a risk sharing mechanism that can function within the constraints of the firm fixed-price USC-9 contract. The USTRANSCOM BAF meets the standard BAF requirements, which are that it includes a fuel price differential representing the change in the unit price of fuel from the baseline to the current period; a fuel consumption amount for the transit of the vessel from load port to discharge port, allocated to units of cargo; an Input Substitution Factor multiplier that recognizes carrier flexibility in promoting fuel economy; and a Risk Distribution Factor multiplier whose value can range from zero to 1.0.

The current BAF outlined in this report is consistent with the USTRANSCOM BAF implemented in 2013 for previous USC contracts but some elements of the BAF and data inputs to the BAF elements have changed:

IMO 2020 Compliant-fuel Types. The recommended BAF for USC-9 includes fuels compliant with the new IMO 2020 regulation for a worldwide cap on fuel sulfur content of 0.5% m/m. The new low sulfur 0.5% m/m fuel will be used for a vessel's non-ECA portion of a lane's distance.

Calculated Buffer. Previous versions of the USC BAF have used a buffer of 20 percent. The recommended USC-9 BAF includes a calculated buffer of +/- 15 percent.

New Process for Estimating Distance. The last version of the USC BAF modeled the average distance for each lane using the top three ports by cargo volume from both origin and destination sides of lane. The recommended distances for USC-9 includes the top three ports for each side of a lane along with any additional port which accounts for greater than 10 percent of that lane's cargo. Additionally, the distance incorporates a weighted average of distance by vessel type (containership or RORO) for a single average distance by lane.

Estimating Vessel Characteristics for Missing Data Values. The average vessels used to form the USC-9 Technical Factors incorporate estimated values where data were missing from the vessel characteristics database.

3. Currency Adjustment Factor (CAF)

3.1 Introduction

This section describes the update of the USTRANSCOM CAF for use in USC-9. For the purposes of this refresh, Volpe determined that the underlying CAF structure and methodology developed in previous EPA studies, and used through USC-8, remained applicable and didn't require any fundamental adjustments.[36] Therefore, the primary focus of this update is to incorporate additional historical information on USC shipping patterns, exchange rates and shipping costs into the CAF structure. Updating the underlying data ensures that the USC-9 CAF is representative of recent USTRANSCOM shipping patterns, overseas port costs relative to total shipping costs and currency volatility.

3.1.1 Exchange Rate Volatility

Businesses and organizations engaged in international trade use a currency adjustment factor as a mechanism for acknowledging the risk and uncertainty from exchange rate volatility. This uncertainty results from when the price of a good or service, associated with moving shipments internationally, is presented in one currency and subsequently invoiced, or sold, at a later date in another currency. For example, expenses incurred by a carrier moving USC cargo to a port in Europe may be priced in Euros, but USTRANSCOM contracts' are invoiced in U.S. dollars. Fluctuations in the euro/dollar exchange rate between the point at which a base contract rate is set and a shipping service is provided creates financial uncertainty for ocean carriers.

How exchange rate volatility affects ocean carriers is dependent upon the direction the base currency in which the service or good is invoiced moves (for USC contracts this is the U.S. dollar). As carriers go through the process of bidding their base shipping rates for a USC contract, the expectation is that the exchange rate at this point in time will be incorporated into the base rate and will, therefore, remain constant throughout the contract period. If the U.S. dollar depreciates, relative to the currency in which the good or service is consumed (e.g., Euro), then the service becomes more expensive (in dollar terms).

For example, if at the time the base contract rate is set the exchange rate is $1.20 per euro and the carrier expects to pay €100 euros for a USC related service at a foreign port, then the expected invoice cost would be $120. If this service is provided some time after the base contract rate is set, and the exchange rate has depreciated to $1.32 per euro, the cost (in dollar terms) will have increased by 10 percent leaving the carrier worse off. Conversely, if the U.S. dollar appreciates to $1.08 per euro, then

[36] Calculation of Bunker Fuel, Currency, and Inland Freight Fuel Price Adjustment Factors for USTRANSCOM Commercial Shipping Contracts, July 2009. Calculation of Fuel, Currency and Inland Freight Price Adjustment Factors for Military Marine Shipping, November 2013.

the dollar cost of the service will 10 percent lower than the invoice cost leaving the shipper better off.[37] This uncertainty imposes a cost on firms trading internationally, and as a result of this risk (more specifically, this transaction risk[38]) carriers may determine they need to hold large reserves of foreign currency, diverting these funds from other more productive purposes.

The bidirectional nature of exchange rate uncertainty is accounted for in the structure of the CAF. Specifically, this is done through capturing either currency depreciation or appreciation relative to a base rate.

3.1.2 Managing Exchange Rate Risk

Firms engaged in international trade have several options for managing, or hedging, exchange rate risk. Techniques include using the forward exchange market, which allows for pre-ordering foreign currency for future delivery at a pre-determined exchange rate. Another approach is a currency option, which provides a firm with the opportunity to purchase a foreign currency at a future date; when the purchase decision is made, if the spot exchange rate is above the option rate, then the firm will exercise the option, otherwise the foreign currency will be bought on the spot market. Other techniques include currency swaps or the futures market. Firms can also manage exchange rate uncertainty through either accelerating payments (if the base currency is expected to depreciate) or delaying payments (if the base currency is expected to appreciate). Invoicing directly in the foreign currency or adding a surcharge are also mechanisms through which exchange rate uncertainty can be managed.

3.2 Components of a CAF

The key components of the CAF, which remain unchanged from previous iterations, are:

- Currencies to be included in the CAF

[37] The bidirectional nature of exchange rate risk is accounted for in the USTRANSCOM CAF. Specifically, the CAF will compensate ocean carriers when the U.S. dollar depreciates, and provide rebates to USTRANSCOM when it appreciates.

[38] Transaction Exposure arises from uncertainty around the dollar cost of foreign goods or services. For example, a company may establish a contract for future delivery of foreign goods at a set price in a foreign currency. Between the points in time when the contract is signed and the goods are received and invoiced, the price of the goods in dollars, and hence the cost to the business, may have changed due to exchange rate volatility. The other forms of risk include translation exposure and economic exposure. Translation exposure risk stems from changes in assets and liabilities denominated in a foreign currency. As currencies fluctuate, the dollar value of a company's overseas assets will change due to currency volatility, rather than from changes in the company's market position. Economic exposure risk arises from the uncertainty of the future value of revenues from foreign operations and how this may affect the valuation of the business.

- Baseline exchange rate for all relevant currencies, against which volatility can be measured
- A buffer zone (and risk sharing factor) representing the relative ability of carriers to manage normal market volatility
- Technical factor that allows for isolating the amount of shipping costs invoiced in a foreign currency

A discussion of these elements and the process by which they were updated is presented below.

3.2.1 Eligible Currencies

Theoretically the CAF could include currencies for all of the possible locations where USTRANSCOM shipments may possibly go. Being this comprehensive, however, would impose a significant burden in terms of managing the CAF and the benefit from this would not justify the additional cost. For example, there are trade lanes (and currencies) that have little or no USTRANSCOM shipments and the additional cost associated with including these in the CAF is likely higher than the potential costs associated with exchange rate risk.

3.2.2 Exchange Rate Elements

The baseline exchange rate establishes the expected conversion rate at the time the USC contract is set, in U.S. dollars, for shipping services invoiced in a foreign currency (specifically, all currencies used in the CAF are in terms of foreign currency per U.S dollar). Movements in the exchange rate during the USC contract period are then measured by comparing the baseline rate to the “new” rate (the monthly average exchange rate at the time of shipment).

3.2.3 Risk Sharing

An equitable CAF acknowledges the extent to which one party may be in a more advantageous position to manage exchange rate risk. USC carriers operate in the international market; have experience in purchasing goods and services in foreign currencies, and invoicing for them in U.S. dollars; and are better positioned to manage exchange rate risk. In addition, carriers also have the ability to influence operational practices (e.g., timing/details of contracts, location of suppliers and adjusting transshipment ports). USTRANSCOM is not in the same position to manage exchange rate risk for their shipments, and logically should not be expected to bear the entire risk of currency volatility. Nevertheless, since USTRANSCOM sets the contract length (with fixed prices remaining in place for up to 17 months), they should reasonably bear some of this risk.

The CAF risk sharing factor is the mechanism via which a portion of the currency risk can be assigned to each party. This is a negotiated value ranging between 0 percent and 100 percent; at 0 percent the currency risk is placed entirely onto the carriers and at 100 percent it is placed entirely onto USTRANSCOM.

3.2.4 Technical Factor

The technical factor ensures that the CAF is applied only to those costs in a foreign currency as opposed to the entire base freight rate. It is developed by estimating the portion of shipping costs incurred in a foreign currency (e.g., port handling charges) and assuming that this ratio is reflected in the base rate.

3.3 Updating the CAF

Since the underlying CAF structure and methodology developed in previous EPA studies, and used through USC-8 required no fundamental adjustments, this section focuses on the methods of updating the values of the various CAF components. Value changes are primarily the result of incorporating additional, more recent information on USC shipping patterns, exchange rates, and shipping costs into the CAF structure

3.3.1 Choosing Eligible Currencies

Consistent with the previous EPA studies, the number of currencies included in the CAF is determined to provide maximum coverage of USTRANSCOM's shipments while at the same time minimizing the administrative burden. This results in tracking a basket of currencies that has been optimized to be representative of USTRANSCOM shipping patterns.

The currency optimization process starts by assembling USC shipping information from iSDDC's Ocean Cargo module. Five years of data were selected, for the period spanning January 1, 2013 through November 13, 2018[39], and contained 513,831 observations.

Using these data, origin/destination (O-D) pairs that begin or end in the United States were isolated; no OCONUS to OCONUS shipments are included in the CAF.[40] iSDDC identifies O-D pairs by port code, one for the port of embarkation and one for the port of debarkation. To isolate O-D pairs with a U.S. component, each port code was assigned to a country and region.

The next step involved assigning ports to superlanes, geographically-based groupings of individual ports, which allows for identifying and grouping international regions to the majority of USTRANSCOM shipments. Superlane definitions, the countries assigned to individual superlanes, remained unchanged from the previous CAF iterations, but names of some superlanes were updated to better align with

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[39] While additional data was available pre-2013, in consultation with USTRANSCOM, it was decided that DOD shipping patters had evolved sufficiently such that additional years of data would fail to accurately reflect current cargo movement trends.

[40] Although previously excluded from CAF analysis, improved data quality meant that shipments embarking/debarking in Alaska or Hawaii could be included.

USTRANSCOM nomenclature.[41] As per previous study guidance, despite sometimes originating for the U.S., moves to/from Guantanamo Bay, Cuba are excluded from the analysis. Removing these data, along with cargo moves with no U.S. component, lowered the count of observations to 448,109.

Table 14. Superlane Volume

Superlane	Cargo Moves	% volume
Africa	2,153	0%
Black Sea	4,806	1%
Caribbean	6,297	1%
Central America & Mexico	2,369	1%
Europe & the Med	144,652	32%
Far East	149,287	33%
Middle East & South Asia	107,151	24%
Oceania	31,038	7%
South America	356	0%

Table 14 presents the distribution of international cargo movements by superlane. Implementation of the CAF is simplified by using only those superlanes that represent more than 10 percent of USTRANSCOM's CONUS/OCONUS trade.[42] The three largest superlanes are: Europe and the Med., Far East, and Middle East & South Asia; these are the same superlanes recommended in the previous study. Together, the superlanes account for 90 percent of CONUS/OCONUS and 78 percent of total USC cargo movements.[43]

The next step involves identifying the relative importance of each of the currencies within the three CAF superlanes. To accomplish this, currencies are first grouped by superlane and trade weighted by recent (1/1/2013-11/13/2018) USTRANSCOM shipping patterns. To maintain a manageable set of CAF currencies, only those weighted at 1 percent or higher of trade within the superlane are retained. The selected currencies and their respective weights are shown below in Table 15.

Table 15. Superlane Currencies and Weights

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[41] The naming updates include renaming the Eastern Asia superlane the Far East; renaming the Western Indian Ocean (inc Persian Gulf) superlane the Middle East and South Asia; and renaming Europe/Mediterranean/Iceland/Greenland, Europe & the Med.

[42] Previously a 5 percent cutoff had been used for superlane inclusion, which would have brought in the Oceania superlane. In this superlane, however, 97 percent of cargo moved through overseas ports in countries that use the U.S. dollar, which means the vast majority of trade in this superlane would not be subject to currency volatility and there would little programmatic benefit from including Oceania in the CAF structure. Additionally, the cargo concentration of the top 3 Superlanes was much more evenly dispersed than previous years and there was a clear separation between the top 3 lanes and all others. As a result, the cutoff point was set above Oceana at 10 percent.

[43] The previous study accounted for only 75 percent of USC traffic.

Superlane Name	Percent of Trade	Currency	Currency Name	Currency Weight
Europe & the Med	32%	MAD	Moroccan dirham	1.32%
Europe & the Med	32%	PLN	Polish zloty	2.73%
Europe & the Med	32%	GBP	Pound sterling	6.22%
Europe & the Med	32%	TRY	Turkish lira	15.28%
Europe & the Med	32%	EUR	European euro	74.45%
Far East	33%	SGD	Singapore dollar	1.94%
Far East	33%	KRW	South Korean won	32.43%
Far East	33%	JPY	Japanese yen	65.62%
Middle East & South Asia	24%	JOD	Jordanian dinar	1.58%
Middle East & South Asia	24%	DJF	Djiboutian franc	3.64%
Middle East & South Asia	24%	OMR	Omani rial	6.57%
Middle East & South Asia	24%	BHD	Bahraini dinar	7.31%
Middle East & South Asia	24%	QAR	Qatari riyal	8.20%
Middle East & South Asia	24%	PKR	Pakistani rupee	8.76%
Middle East & South Asia	24%	AED	UAE dirham	11.65%
Middle East & South Asia	24%	KWD	Kuwaiti dinar	52.28%

Collectively, these 16 currencies account for 94 percent of trade within these superlanes.[44]
Changes in USTRANSCOM shipping patterns since 2013 have resulted in some currency changes. Since 2013, Latvia and Lithuania joined the euro necessitating the removal of their respective currencies (the Lats and Litas) from the Europe and Mediterranean superlane. Additionally, the Philippine Peso, Iraqi Dinar, Israeli New Shequel, and Norwegian Krone have fallen below the 1 percent threshold. The Djibouti Franc, Polish Zloty, and Moroccan Dirham have been added to the currency basket.

3.3.2 Establishing the Currency Baseline

A baseline exchange rate provides the benchmark against which currency fluctuations are measured. The CAF is then designed to compensate for some or all of the variation from this base rate. As such, the methodology of setting a baseline and the frequency with which it is updated represent important parts of the CAF methodology that cascade through subsequent calculations.

As carriers go through the process of bidding their base shipping rates for a USC contract, the expectation is that the exchange rate at this point in time will be incorporated into the base rate and will, therefore, remain constant throughout the contract period.

[44] Within each superlane, the chosen currencies account for at least 90 percent of total superlane-specific cargo volumes: currencies account for 91 percent of cargo moved within Europe & the Med.; currencies account for 99 percent of cargo moved within the Far East; currencies account for 98 percent of cargo moved within the Middle East & South Asia.

Consistent with previous iterations of the CAF, the baseline, therefore, should be set as the average exchange rate from the month prior to the start of bidding. For example, if bidding takes place in April 2018, the baseline should be set using the monthly average exchange rate from March 2018. Additionally, to ensure the baseline remains responsive to market conditions when carriers are setting their base contract rates, re-baselining of the exchange rate should occur at the start of every contract period (base and option years).

3.3.3 Risk Sharing

The CAF operates as a mechanism for risk distribution and as such needs to account for this in its construction. In particular, it needs to incorporate a component that allows for allocating risk according to the relative position of the carriers or USTRANSCOM to manage exchange rate volatility during the contract period.

Since carriers operate in the global market, they are better positioned to manage exchange rate volatility. For example, a risk-averse carrier could essentially purchase currency at the baseline price to cover the expected future foreign currency expense, eliminating all currency risk. Conversely, a less risk-averse carrier would determine the expected or normal deviation of the exchange rate during the contracting period and hedge accordingly. The risk sharing component will therefore need to describe the transaction risk associated with the contracting period and acknowledge how carriers are better positioned to observe the foreign exchange market and manage volatility.

Risk sharing within the CAF is handled using two methods: a buffer zone around the baseline price, and a risk sharing factor.

3.3.4 Setting the Buffer

The buffer zone reflects historically observed normal deviations in an exchange rate around a baseline. It is expected that carriers engaging in normal business operations can identify and hedge (at their discretion) against the risk from typical currency fluctuations. As such, a CAF should not apply inside the buffer zone. Outside this zone, where currency volatility and risk becomes more atypical and harder to effectively hedge against, the burden of risk should be apportioned across both carrier and shipper through the application of a CAF with a risk-sharing factor.

Recognizing that currency risk is symmetrical, the buffer zone has an upper and lower bound around the baseline. The inclusion of a symmetrical buffer zone is consistent with FAR and DFARS regulations for the application of EPAs.[45]

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[45] Federal Acquisition Regulations and Defense Federal Acquisition Regulations

3.3.4.1 Measuring Currency Volatility, Updated Buffer Zone Methodology

This CAF approach to measuring currency volatility was constructed to take into account the nature of the USTRANSCOM contracting process. It reflects the fact that a baseline currency rate is set prior to the implementation of the actual carrier base rates. This baseline currency rate can remain in place for up to 17 months at the start of each the contract or extension. As part of this EPA update, the buffer zone calculation was reevaluated so that it more accurately captures normal currency market volatility while excluding significant shocks (such as speculation driven volatility) that would represent unforeseen events out of the range of normal historical variation.

While the previous methodology measured volatility using the coefficient of variation, updated methodology uses a 12-month moving absolute average percent change to identify normal volatility. This approach was developed based on an examination of recent USC contract lengths; the average contract tended to span approximately one year thus the decision was made to calculate the average volatility over 12-month periods. To mirror the typical duration of the USC contract period, from bidding to contract completion, the base value for the exchange rate was set 5 months prior to the start of the 12 month period during which volatility is measured. To ensure the 12-month periods were not chosen arbitrarily, a rolling average mechanism was used. The formula for calculating the base moving average percent change is shown in Equation 22. Section 2.3.4.2 has a full discussion of the updated USC buffer methodologies.[46]

$$Volatility_{Period\ 1,C1} = \frac{\left(ABS\left|\frac{Price_{Month\ 1,C1}}{Baseline\ Price} - 1\right| + ABS\left|\frac{Price_{Month\ 2,C1}}{Baseline\ Price} - 1\right| + \cdots + ABS\left|\frac{Price_{Month\ 12,C1}}{Baseline\ Price} - 1\right|\right)}{12}$$

Equation 22. Period 1 Moving Average Percent Change Calculation

Where:

- Price is the currency exchange rate ("new price") for a given month (1,2,3, etc.) and a given currency (C1,C2,C3, etc.)
- Baseline Price is the currency-specific baseline exchange rate, the average exchange rate 1 month before bidding

Data on exchange rate volatility was collected for the period spanning November 2006 to December 2018. Period 1's baseline was set November 2006 for the period April 2007 to March 2008. The final period was from January 2018 to December 2018 with the baseline set August 2017.

Once the base volatility was calculated for each period of analysis, periods of extreme volatility were removed. The CAF buffer is meant to reflect typical currency volatility, therefore periods of high, atypical volatility should not be used in its estimation. Values more than one standard deviation above the mean

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[46] The CAF and the BAF use the same updated methodology to calculate their respective buffer zones.

were deemed to be atypical volatility and were removed.[47] In removing outliers above the mean, low volatility-high stability periods are retained in the buffer calculation while periods of atypical volatility cannot bias the size of the buffer zone upwards; the decision rule for removing outliers is shown in Equation 23.

$$ABS\left|\frac{Price_{Month\ i}}{Baseline}-1\right| < Mean + Standard\ Deviation$$

Equation 23. Decision Rule for Removing Outliers

Volatility values that did not meet the criteria shown in Equation 23 were removed. Once all the individual monthly volatility outliers were removed, the average volatility for each 12-month period was recalculated. Those values were then averaged to estimate the typical volatility for each currency, which is then used to calculate the CAF buffer zones.

Notably, the CAF buffer deviates from BAF buffer calculations in one aspect. Currency movements are fundamentally different than crude oil volatility; some currencies are pegged to the U.S. dollar or a basket of currencies and experience essentially zero volatility. The buffer is designed to capture normal volatility amongst currencies of countries USTRANSCOM does the majority of its trade and, as such, volatility requires a floating exchange rate. Thus, currencies pegged to the U.S. Dollar or to a basket of currencies were omitted from global mean buffer calculations.[48]

Finally, the CAF buffer also includes a global mean value. This value is calculated by taking the average of currency buffers for currencies not pegged to the U.S. Dollar or a basket of currencies. For this analysis, the global mean is an average of the following currencies: Great British Pound, European Euro, Japanese Yen, Moroccan Dirham, Pakistani Rupee, Polish Zloty, Singapore Dollar, Kuwaiti Dinar, and Turkish Lira.

3.3.4.2 Addressing Dominant Exchange Rates

The CAF buffer zone is calculated on a trade-weight basis. And, while this methodology is responsive to USTRANSCOM's trade patterns and currency volatility, it does not capture instances whereby a single, or a small group of currencies can skew the size of a superlane buffer zone. This could happen in instances where the majority of cargo moves to a country with a comparatively stable exchange rate (note: pegged currencies are already omitted from this analysis). In this case, the buffer zone would be overly narrow and not reflect the higher variation in other currencies.

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[47] Note, values below the mean were not removed. This adjustment was made as the volatility calculated by Equation 23 is an absolute percent deviation from the baseline (which represents the symmetric nature of currency volatility), so the focus is on removing those outliers that are above the mean that represent the periods of high atypical volatility.

[48] Currencies pegged to the U.S. Dollar are: the Jordanian Dinar, the Djiboutian Franc, the Omani Rial, the Bahraini Dinar, the Qatari Riyal, and the UAE Dirham. The Kuwaiti Dinar is pegged to a basket of currencies. Not subject to normal currency volatility, all of these currencies were omitted from the global mean calculation.

To avoid rendering the CAF irrelevant in these circumstances, a second constraint to the buffer size is applied, requiring that the buffer for the superlane must also be greater than the global mean buffer size. Thus, the rule for choosing the buffer size is the greater of either the weighted buffer by superlane or the global mean value across all non-pegged currencies. In the case of the updated superlane buffers, the global mean is applied to the Middle East & South Asia superlane; the same adjustment was made in both the 2013 and 2009 CAF buffer recommendations.

3.3.4.3 Currency Buffer Zone Analysis

Using the methodology described above, volatility measures and buffer zones were calculated for each of the selected currencies. Table 16, shown below, shows the currency fluctuations between November 1, 2006 and August 1, 2017.[49]

Table 16. Expected Currency Volatility

Currency	Estimated Volatility
Moroccan dirham	5%
Polish zloty	4%
Pound sterling	5%
Turkish lira	10%
European euro	6%
Singapore dollar	4%
South Korean won	6%
Japanese yen	6%
Jordanian dinar	0%
Djiboutian franc	0%
Omani rial	0%
Bahraini dinar	0%
Qatari riyal	0%
Pakistani rupee	4%
UAE dirham	0%
Kuwaiti dinar	2%
Global Mean	5%

In general, with the exception of the Turkish Lira, the extent of currency volatility is less than 10

[49] Currency data is truncated as August 1, 2017 is the final month for which the full 17-month analysis could be conducted (5-month baseline plus twelve month moving average of currency data). The 10 years of data used for this analysis cover an economic cycle measured roughly from the peak of the last expansion to an ongoing period of growth.

percent.[50] The global mean volatility is 5.44 percent, which is marginally higher than the 5.32 percent median value calculated in the previous study.

To calculate a superlane buffer, the recommended CAF currencies above are weighted by the superlane weights presented in Table 15. The results of the weighted buffer calculation are presented below, in Table 17.

Table 17. Currency Weights and Weighted Buffers

Superlane Name	Currency	Currency Name	Weight	Buffer	Weighted Buffer
Europe & the Med	MAD	Moroccan dirham	1.32%	5.41%	0.0715%
Europe & the Med	PLN	Polish zloty	2.73%	8.19%	0.2238%
Europe & the Med	GBP	Pound sterling	6.22%	5.35%	0.3330%
Europe & the Med	TRY	Turkish lira	15.28%	7.29%	1.1132%
Europe & the Med	EUR	European euro	74.45%	6.56%	4.8809%
Far East	SGD	Singapore dollar	1.94%	3.32%	0.0645%
Far East	KRW	South Korean won	32.43%	2.91%	0.9434%
Far East	JPY	Japanese yen	65.62%	6.90%	4.5276%
Middle East & South Asia	JOD	Jordanian dinar	1.58%	0.10%	0.0016%
Middle East & South Asia	DJF	Djiboutian franc	3.64%	0.00%	0.0000%
Middle East & South Asia	OMR	Omani rial	6.57%	0.00%	0.0000%
Middle East & South Asia	BHD	Bahraini dinar	7.31%	0.12%	0.0088%
Middle East & South Asia	QAR	Qatari riyal	8.20%	0.00%	0.0000%
Middle East & South Asia	PKR	Pakistani rupee	8.76%	3.65%	0.3196%
Middle East & South Asia	AED	UAE dirham	11.65%	0.06%	0.0067%
Middle East & South Asia	KWD	Kuwaiti dinar	52.28%	2.42%	1.2657%

From these values, the buffer by superlane is calculated. The weighted currency buffers by trade lane are summed and compared to the global mean value, for this study, 5.44 percent. For weighted superlane buffers exceeding the global mean value, the calculated superlane weighted buffer is applied. For superlanes with calculated weighted buffers below the value of the global mean, the global mean value is applied. The single trade-weighted buffer for each superlane is presented in Table 18.

Table 18. Superlane Buffers

[50] The Turkish Lira experienced significant volatility early on in the analysis period, September 2008, as well as again in August of 2018. However, the in between period saw monthly percent change averaging around one percent.

Superlane Name	2018	2013
Europe & the Med	6.39%	7.16%
Far East	6.03%	5.95%
Middle East & South Asia	5.44%	5.32%

While the Europe and the Med Superlane buffer has decreased, the buffers for the Far East and Middle East & South Asia Superlanes have remained relatively consistent, increasing only slightly from previous the previous CAF iteration.

3.3.5 Risk Sharing Factor

As noted earlier, the CAF is a mechanism for risk distribution and as such should reflect the relative market position of USTRANSCOM and the ocean carriers and the ability they have to manage this risk. Relative to USTRANSCOM, carriers are in a stronger position from which to manage exchange rate risk through the use of currency hedging tools. Should these tools allow carriers to manage some of the exchange rate risk, even outside the CAF buffer zone, carriers should bear a larger proportion of the risk. Alternatively, if the risk is deemed to be largely outside the control of any one party, then USTRANSCOM should bear more of the risk.

The risk sharing factor assigns some portion of the risk to each party. The factor can vary from 0 to 100 percent. Where, at 0 percent, the entire currency risk from fluctuations outside the buffer zone is placed on the carriers and at 100 percent, the entire risk is placed on USTRANSCOM. How this risk is distributed is subject to negotiation and USTRANSCOM policy.

3.3.6 Technical Factor

The final component of the CAF is a technical factor, which makes an allocation for costs in the base freight rate requiring payment in foreign currency. Typically, this includes services paid for at the foreign ports where cargo is loaded or unloaded. Specific and detailed industry information on this topic is difficult to obtain. Anecdotal evidence from previous studies suggested that around 5 percent of shipping costs are in a foreign currency (Hapag-Lloyd) or around 10-15 percent of costs (Maersk) are for port or short inland movements of goods invoiced in a foreign currency.

Maersk's 2017 Appendix to their Annual Report Presentation indicates that approximately 32 percent of total costs are spent on terminal services across the globe in 2017, although how much of this was non-dollar denominated was not disclosed.[51] Since this figure includes U.S. activities as well as those in foreign ports, it is not directly a useful measure of exposure to foreign currency costs. Regardless, it does provide insight into the total magnitude of port costs relative to carrier costs. Moreover, the base freight rates provided by carriers are "all in," and include services that require payment in foreign

[51] A.P. Møller-Mærsk A/S, 2018

currency. The nature of these "all in" rates does not allow for isolation of the portion of the base rate that would be for foreign services requiring payment in foreign currency.

Given these data considerations, the tech factor is calculated first by estimating the composition of shipping costs being borne by carriers—direct voyage costs (e.g. bunker fuel and port handling charges), capital expenses (e.g. vessels), and allocation for profit. It is assumed that these costs, and their relative ratios, will be reflected in the base freight rate offers made by carriers to USTRANSCOM.[52] The relative shares of these values were determined through shipping company 2017 financial reports and presentations.[53, 54] From these data, a percentage cost for foreign currency expenses was then estimated.

An average shipping cost structure was calculated with profits set as 0 percent, 3 percent, and 7 percent, Scenarios 1-3, respectively. Previous analyses used 0 percent, 5 percent, and 10 percent; however, since the maritime shipping industry is historically a low profit industry, the decision was made to lower the upper limit profit assumption. The updated cost structure is presented below in Table 19.

Table 19. Technical Factor Cost Structure

Carrier Cost Structure	Scenario 1	Scenario 2	Scenario 3	2018 Average	2013 Average
Direct Voyage Cost	70%	67%	65%	67%	64%
Capital Expenses	22%	21%	21%	21%	23%
Administrative Costs	8%	8%	8%	8%	8%
Profit	0%	3%	7%	3%	5%

Terminal costs are estimated to be around 23 percent of total costs. Applying this value to direct voyage costs provides an indication of the percent of costs incurred at ports. From this calculation, a port cost factor of 14 percent is obtained, which is unchanged from previous values. Under the assumption that carriers moving USTRANSCOM cargo incur approximately equal costs at both CONUS and OCONUS ports, the port cost factor is divided in two, giving a final CAF technical factor of 7 percent.

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[52] The technical factor relates to only those costs invoiced in a foreign currency, which are assumed to relate to the loading/unloading of cargo in foreign ports. These costs do not include the price of inland freight movements to/from the foreign port.

[53] Financial data was gathered from the following annual reports: Maersk, COSCO, NYK, and OOIL. NYK's terminal costs, however, which were significantly lower than all other carriers (7 percent as opposed to 21-32 percent), were deemed to be an outlier and omitted the tech factor calculations. Full citations are located in Section 0

[54] While past studies utilized data from academic literature, a search of recent academic literature, post-2009, yielded no additional information. The studies used by previous analyses were dated 2008 and 1983. Since the commercial shipping industry has evolved since the last recession, these studies were deemed not relevant enough to be included in this analysis.

3.4 Conclusions and Recommendations

This report presents the details of the updated USTRANSCOM CAF Economic Price Adjustment. While the calculation of many of the data driven elements of the CAF remains the same as previous studies—superlanes, currencies, trade weights, and technical factor—an important factor in this update is the new buffer calculation methodology. The updated buffer calculation method is more reflective of normal volatility and removing values one standard deviation above the rolling average absolute value percent change mean lessens the possibility that size of the buffer is biased by inclusion of atypical excess volatility.

Despite the updated methodology, a symmetrical buffer zone remains in place. This is an important component of the CAF as it is an acknowledgement that the CAF is designed to compensate for unexpected exchange rates changes equally likely to favor either USTRANSCOM or the ocean carriers. The buffer zone accounts for typical exchange rate volatility, which carriers, who conduct transactions in foreign currencies, are better positioned to manage through various hedging techniques. Notably, this characteristic of the CAF is consistent with FAR and DFAR regulations.

Within the buffer zone, there is no CAF payable by either party. Outside the buffer zone, the CAF is activated and a payment is due to one of the parties based on the direction of the exchange rate movement. Payment is only due on the excess currency volatility, the amount outside the buffer zone. The CAF EPA is broken into three superlanes, which represent more than 90 percent of USTRANSCOM's CONUS/OCONUS shipments. Aggregating the CAF into these three superlanes minimizes the administrative burden of the CAF while still managing to capture close to all of USTRANSCOM cargo flows.

There are 16 currencies from which the superlane volatility measures are derived. These currencies were selected based on their importance in terms of USTRANSCOM shipping patterns; each must capture at least one percent of trade within their respective superlanes. This one percent decision rule limits the number of currencies, reducing the complexity of the final model, while still capturing the geographic diversity (and thus currency payment diversity) of the majority of USTRANSCOM's cargo movement.

3.4.1 Recommendations

3.4.1.1 CAF Calculation

There is no change to the recommended CAF payment calculation formula.

$$CAF\ Payment = Excess\ Volatility \times Technical\ Factor \times Risk\ Sharing\ Factor$$

3.4.1.2 Baseline

There is no change to the recommended baseline setting or rebaselining procedures.

- The baseline should be set as the average exchange rate (foreign currency/U.S. dollar) from the month prior to the start of bidding. For example: if bidding takes place in April 2018, the baseline should be set using the monthly average exchange rate from March 2018.
- Rebaselining should occur at the start of every contract period.

3.4.1.3 "New" Price

There is no change to the recommended "new" exchange rate setting procedure (this is the exchange rate that is compared to the base exchange rate for estimating currency volatility).

- The "new" exchange rate should be the monthly average rate from two months earlier. For example: for March 2019, the CAF report is updated January 2019 using the average monthly exchange rate from December 2018.

3.4.1.4 Superlanes

There have been a few changes to the superlanes mostly in terms of naming convention.

- Western Indian Ocean became the Middle East and South Asia, Eastern Asia became the Far East. Changes were made to be consistent with language taken from USTRANSCOM and industry documents.

Additionally, the decision rule for superlane inclusion was changed from 5 percent to 10 percent.

- The concentration of cargo between the three included superlanes (Europe and the Med, the Far East, and the Middle East & South Asia) is far more even than in previous years, 32 percent, 33 percent, and 24 percent, respectively. And subsequently, moving the cutoff from 5 percent to 10 percent was deemed appropriate.

There was no change to the recommendation of the superlanes to be included in the CAF.

- The superlanes recommended remain: Europe and the Med, the Far East, and the Middle East & South Asia.

3.4.1.5 Recommended Currencies

There are some changes to the recommended currencies.

- Recommend the removal of: Philippine Peso, Iraqi Dinar, Israeli New Shequel, Lithuanian Litas, Latvian Lats, and Norwegian Krone

- Recommend the inclusion of: Djibouti Franc, Polish Zloty, and Moroccan Dirham

These changes are based on evolving shipping patterns of USTRANSCOM.

3.4.1.6 Applying the Buffer

There has been no change in recommending how the buffer should be applied, but the values have been updated to reflect the new buffer methodology. As in previous studies, for superlanes with buffers below the global median, the global median buffer should be applied.

- The recommended buffers by superlane are:
  - Europe & the Med—6.39 percent
  - Far East—6.03 percent
  - Middle East & South Asia—5.44 percent

3.4.1.7 Tech Factor

The tech factor calculation was updated to reflect new, lower profit assumptions as the maritime shipping industry is considered a low-profit industry.

- The new profit assumptions are: 0 percent, 3 percent, and 7 percent (down from 0, 5, and 10 percent in previous studies)

There is no change to the base tech factor calculation.

$$Tech\ Factor = Direct\ Voyage\ Cost \times Terminal\ Cost \times Percentage\ OCONUS$$

There is no change to the recommended technical factor.

- The recommended technical factor remains at 7 percent.

4. Inland Intermodal Fuel Adjustment Factor (FAF)

4.1 Introduction

This section of the EPA study considers the development and use of inland transportation fuel surcharges, or an inland intermodal fuel adjustment factor (FAF), for the movement of USTRANSCOM freight. The FAF is similar in concept to the BAF in that its purpose is to protect ocean carriers from the risk of fluctuating fuel prices, but is focused on the inland portion of container movements. It was initially developed by overland common carriers (specifically U.S. trucking companies) to pass fuel price volatility along to shippers. USTRANSCOM did not have a FAF provision in place until USC-06.

It should be noted that the term "FAF" or "fuel adjustment factor" is not widely used in the carrier industry. The term "fuel surcharge" is more commonly used in the trucking and rail industries, while the term "inland fuel charge" is used in the ocean carrier industry. The ocean carrier industry uses the terms "BAF" and "FAF" interchangeably in reference to fuel charges associated with the ship itself. "FAF" and "fuel adjustment factor" are commonly used by electric utilities. For the purposes of this study, the term FAF will be used to refer to an economic price adjustment factor applied to the inland portion of USTRANSCOM shipments.

The objective of Volpe's 2009 study was to determine if a FAF is necessary and feasible for inland transportation services (rail and truck) associated with ocean liner services supplied to USTRANSCOM. Once deemed necessary and feasible, then the focus was on developing CONUS FAFs together with supporting technical factors to manage the consequences of significant and unexpected fluctuations in fuel prices applicable to inland transportation. The resulting FAFs were to comply with the EPA provisions of the FAR and DFAR regulations. In addition, the methodology employed to calculate the FAFs and technical factors were to be consistent with standard commercial practices and not present significant barriers to the efficient administration of USC-06.

Recommendations for the FAF methodology were presented in the 2009 study, and were subsequently adopted by USTRANSCOM. In 2013, Volpe refreshed the FAF input values, but made no changes to the general FAF methodology.

This current report presents the results of an update of the FAF methodology, similar to the 2013 report. The focus of the current effort was on updating the data inputs used in calculating the FAF and not on developing a different approach to calculating a FAF. As such, Volpe recommends no new changes to the FAF methodology in this refresh, but does provide multiple recommendations on new values for the inputs to the FAF.

A literature review was conducted in an attempt to determine if there were any significant changes in reported fuel economy for trucks and intermodal rail since the date of the last Volpe study, i.e. 2013. In addition, the recent literature was reviewed in order to determine if there were any documented changes in the distance at which intermodal rail would be considered the preferred alternative to truck. The average intra and inter zonal haul distances used in computing the FAF for the various shipment types were recomputed using recent USTRANCOM-provided data on inland destination/origin to/from CONUS ports from 2017 and 2018. The average dray distance for the inland leg of rail intermodal trips was also recomputed based on the latest dataset. There were significant changes in many of these inputs to the FAF calculator.

The remainder of this chapter presents a review of when to apply a FAF (Section 4.2), the key components of USTRANSCOM's FAF (Section 4.3), how the FAF is generally applied (Section and the updated values based on Volpe's literature review and the analysis of recent USTRANSCOM-provided data (Section 4.5). Section 4.6 concludes this chapter and summarizes Volpe's recommendations for the FAF.

4.2 When to Apply a FAF

When considering the construction of a FAF, it is important to recognize that diesel fuel price risk is not unidirectional. An increase in fuel prices results in increased expenses for the carrier that may not be covered by the base contract rate, while a decrease in fuel prices results in USTRANSCOM overpaying the carrier. As such, a FAF is applied both when prices rise and when prices fall. If prices rise, USTRANSCOM pays a FAF to the carriers. If prices fall, the carriers pay USTRANSCOM a rebate.

USTRANSCOM's FAF is restricted to only CONUS moves. Outside of CONUS, there is a lack of both readily available up-to-date fuel price and technical (fuel consumption) data on transport operations. Due to the lack of data, among other reasons, it is not believed to be currently feasible to either develop or administer an OCONUS FAF. Additionally, past Volpe studies indicated that industry practice is to collect a FAF for the CONUS portion of the shipment but not the OCONUS portion.

For CONUS moves, a FAF is always applied. Unlike the BAF and the CAF, there is no buffer. As such, any change in fuel prices triggers a FAF, regardless of the relative size of the price change. Figure 13 shows the FAF payments that have been made for dry containers traveling between East Coast ports and East Coast cities during USC-08 Base Year, Option Year 1, and several months of Option Year 2. As the graph shows, there has been a FAF payment every month for shipments entirely within the East Coast region, where negative payments were rebates to USTRANSOM.

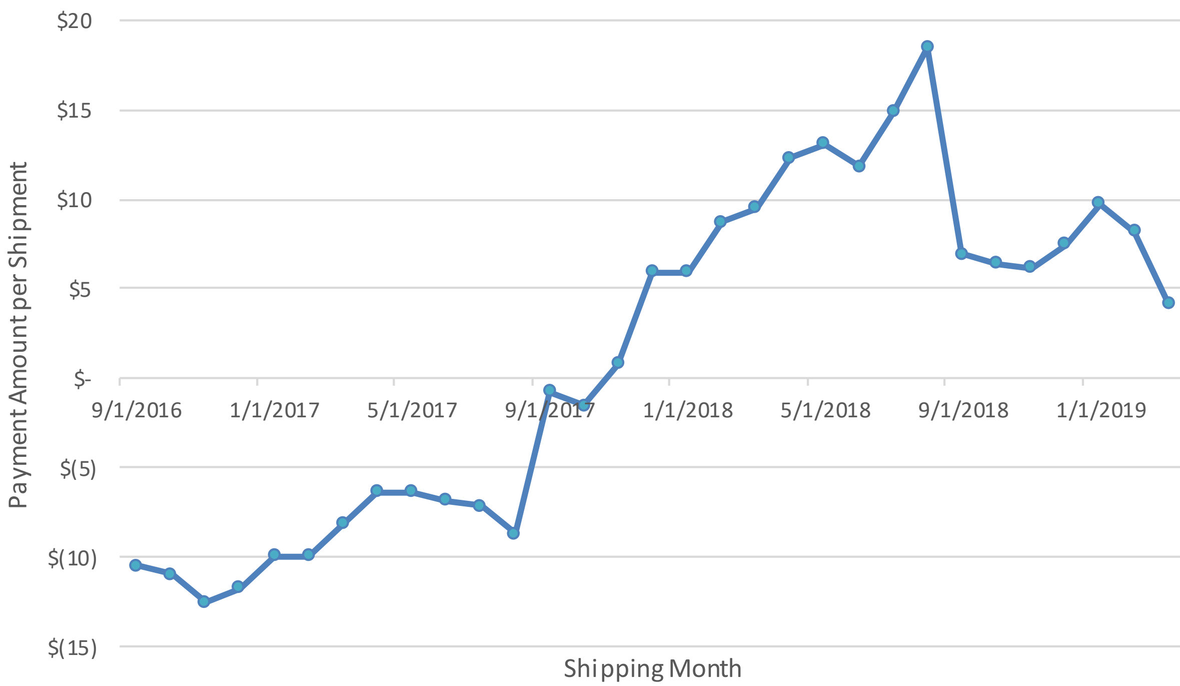

Figure 13. FAF Payments – Dry Containers – EC to EC[55]

4.3 Components of the FAF

The FAF methodology proposed in Volpe's prior studies has the advantages of transparency, credibility, and equity. Carriers will be fairly compensated for increased fuel costs, but will not be awarded windfall profits. The other methods originally considered by Volpe (a single inland fuel charge, separate surcharges for truck movements and rail movements, or a surcharge based on the actual distance moved by each individual shipment) were rejected either due to unavailable data, such as the actual inland distance for each shipment, or lack of knowledge of whether the shipment actually moved by truck or rail. The data that is required for the current FAF methodology includes values for fuel consumption, the distance traveled by a typical shipment, and fuel prices. These elements are discussed in the following subsections, and the next section, Section 4.4, discusses how these components come together to create a FAF payment.

4.3.1 Baseline Rate

The baseline rate is the value at which USTRANSCOM sets the expected fuel cost for the duration of the contract. Volatility in fuel prices during the contract period is then measured against the baseline rate. The longer the base rate remains in effect, the higher the risk that prices during the contract will be

[55] Negative payments are rebates to USTRANSCOM from the carriers.

significantly different from the base rate.

USTRANSCOM currently uses the month prior to the month the solicitation is issued to calculate the baseline fuel price.

4.3.2 Current Rate

The current rate is the value USTRANSCOM calculates for each month of the contract. This value is measured against the baseline to help determine the FAF payment. If the current rate is more expensive than the baseline, then there will be a FAF payment to the carriers. If the current rate is cheaper than the baseline, then there will be a FAF rebate to USTRANSCOM.

USTRANSCOM calculates the fuel price for a shipping month using data from three months prior.

4.3.3 Average Distances

In Volpe's past studies, it was determined, based on an examination of FAF industry practice and the availability of required data, that USTRANSCOM should utilize a FAF methodology based on a distance approach. The surcharge is then on a per container basis, in line with current ocean carrier industry practice.

This results in the FAF calculations requiring a value for the average distance traveled on a typical shipment. The average distance data is based on USTRANSCOM-provided data on recent shipments, and is weighted to ensure that more frequent routes have a larger influence on the average distance value. There are ultimately 24 average distance values used in USTRANSCOM's FAF calculations. This is because there is a unique distance for each zone and container type combination.

4.3.3.1 Zones

Instead of calculating one average distance for all inland shipments, the FAF calculations are separated by zones, resulting in multiple average distances. Shipments are matched to a zone based on the location of the port, and then by the location of the inland city. Ports are separated into West Coast states, East Coast states, and Gulf Coast states. The zones can be seen in Figure 14, which colors the three port zones. Most of the states are not in a port zone.

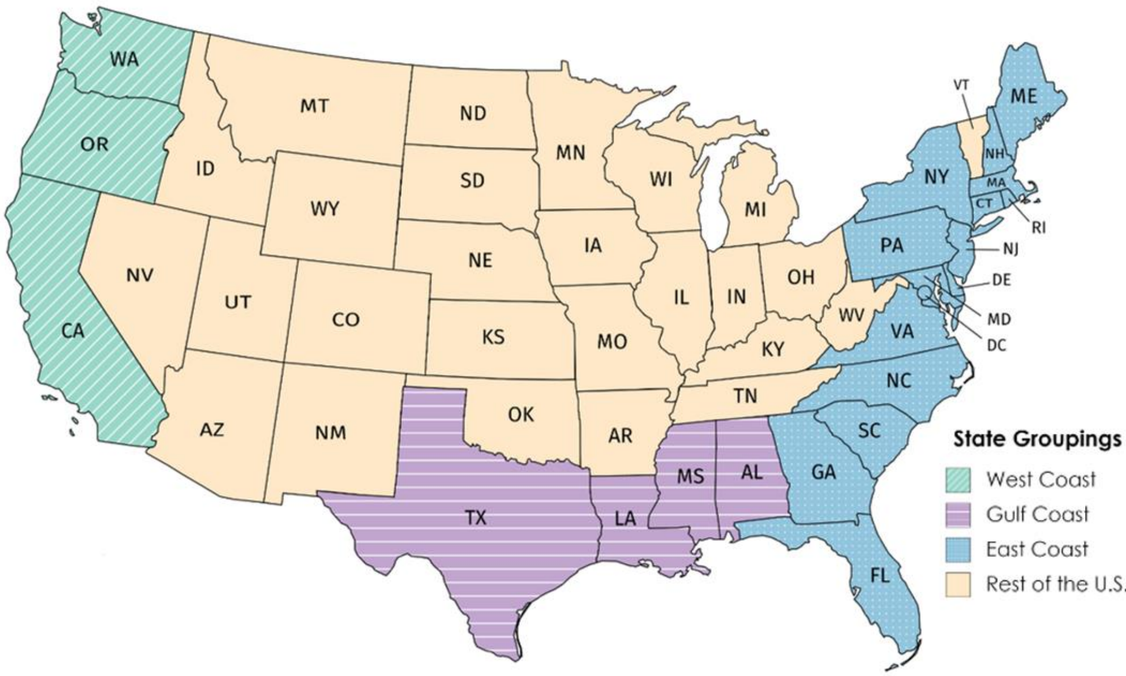

Figure 14. FAF Zones[56]

There are then three within zone calculations and three between zone calculations:

- West Coast ports to West Coast cities
- East Coast ports to East Coast cities
- Gulf Coast ports to Gulf Coast cities
- West Coast ports to the rest of the U.S.
- East Coast ports to the rest of the U.S.
- Gulf Coast ports to the rest of the U.S.

4.3.3.2 Container Type

FAF calculations are separated based on the type of cargo being shipped, as the shipment type affects the fuel consumption and the transportation mode. The four types of shipments are:

- Dry Containers
- Reefer Containers
- Breakbulk that weighs less than 50,000 lbs.
- Breakbulk that weighs more than 50,000 lbs.

Reefer containers and dry containers must be considered separately as reefer containers require more

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[56] The states can also be seen in a list in Appendix E: FAF – List of States by Zone.

fuel than dry containers. Reefer units are essentially dual mode hybrids. They are powered by small diesel generators when moving over the road. The generator provides electricity that powers the refrigeration unit, and when at dockside or aboard a ship the units are plugged in and run directly on electric power from the dock or ship. When being carried inland via truck, the generator burns more fuel than a truck without a reefer container.

Breakbulk shipments are also considered separately as carriers have noted in previous Volpe studies that breakbulk always ships via truck, while dry containers sometimes are shipped by rail. The different modes require different fuel consumption values, and therefore the calculations are separated. Breakbulk is further divided into two weight categories since break bulk that weights more than 50,000 lbs. requires specialized heavy hauler equipment, resulting in more fuel burned than lighter breakbulk.

The four container types each have an average distance calculated for the six zones, resulting in 24 average distance values and 24 unique FAF calculations.

4.3.4 Mode of Transportation

Another important element of the FAF is determining the mode of transport for shipments. USTRANSCOM does not collect data on the inland transportation mode, making it difficult to ascertain how shipments are actually moving. But for the FAF to work, there need to be estimates of fuel consumption (see Section 4.3.5), which will differ depending on if the shipment travels by truck or by rail.

Volpe used statements from the carriers where possible to determine the likely mode of transportation. In Volpe's earlier studies, the carriers indicated that reefer shipments and break bulk shipments usually moved by truck, not by rail. Volpe therefore makes the assumption that reefer and break bulk always travel by truck for the purposes of the FAF calculations.

Dry containers were more complicated, as they do sometimes move by rail. According to industry, the decision on whether to use truck or rail is often based on the distance traveled, as rail is usually thought of as only being competitive with trucks at larger distances. As part of the FAF refresh, Volpe reviewed literature to determine the appropriate distance at which rail becomes competitive with trucks. The results of this review can be found in Section 4.5.3.

4.3.5 Fuel Consumption

Fuel consumption is used to estimate, based on the average distance of a trip, how much fuel is used in a typical shipment. For the FAF, fuel consumption values are estimated for trucks, specialized heavy hauler trucks, rail, and reefer containers, based on a literature review. Each of the 24 FAF calculations includes at least one fuel consumption value. Multiplying the fuel consumption by the average distance gives an estimate of how much fuel was used in any one shipment.

The fuel consumption values for trucks, specialized heavy hauler trucks, and rail are all in gallons/container mile. As one truck carries one container (of any size), gallons/container mile for this mode are equivalent to gallons/mile for the purposes of the FAF—as rail can carry more than one container, gallons/mile would not be equivalent to gallons/container mile for rail. The rail gallons/container mile fuel consumption value is based off of the truck value, as will be explained in Section 4.5.4.3. The reefer fuel consumption is in gallons/hour, as that fuel depends on time, not distance traveled, especially given that the reefer unit consumes fuel even when the truck is not moving (i.e., when the driver must stop for a mandatory break).

4.4 Application of the FAF

The FAF calculations displayed below apportion the price differential to container shipments based on distance. Each FAF calculation takes the estimated distance and multiplies it by the typical fuel consumption to get an estimated total gallons of fuel used on the journey. The FAF then multiplies the gallons of fuel used by the price differential between the base fuel price and the current fuel price; this gives the FAF payment amount per shipment. In simple units, this looks like:

$$\left(\frac{Dollars}{Gallon_{current}} - \frac{Dollars}{Gallon_{baseline}}\right) x \frac{Gallons}{Container\ Miles} x\ Container\ Miles = Dollars$$

Equation 24. Base FAF Calculation

The majority of the FAF calculations assume that the shipment moves by truck, which means the more specific equation typically looks like:

$$\begin{aligned} FAF\ Payment = {} & (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \\ & \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance) \end{aligned}$$

Equation 25. Truck-Specific Base FAF Calculation

In calculations where the total distance suggests that the shipment moves by both truck and rail, the above equation is just calculated twice: once using typical truck distance and truck fuel consumption, and the second time using typical rail distance and rail fuel consumption. The two calculations are then summed to get the FAF payment:

$$\begin{aligned} FAF\ Payment = {} & (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \\ & \times (Intermodal\ rail\ gallons\ per\ container\ mile\ \times Average\ Rail\ Distance) \\ & + (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \\ & \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Truck\ Distance) \end{aligned}$$

Equation 26. Multi-Modal Inland Freight Movement Base FAF Calculation

Reefer shipments add in the fuel consumption of the reefer unit. The consumption of reefer fuel is calculated slightly differently than the typical fuel consumption of the truck or train, as reefer fuel consumption is in gallons per hour instead of gallons per mile. As such, the FAF payment uses the average distance as well as the typical speed of trucks to estimate the gallons of reefer fuel burned. Reefer calculations also account for the time the truck driver spends off duty—even if the truck driver is taking a mandatory break, the reefer unit must still be running to ensure the shipment remains cool. This adds an additional amount of fuel burned to reefer shipments. These calculations end up as:

$$FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile \times Average\ Distance + \frac{Average\ Distance}{Average\ Speed} \times Reefer\ unit\ gallons\ per\ hour + Off\ Duty\ Time \times Reefer\ unit\ gallons\ per\ hour)$$

Equation 27. Reefer-Specific Base FAF Calculation

If the distance is not long enough to require the truck driver to take a break, then the off duty time becomes zero and that aspect of the calculation is removed. The amount of off duty time required is based on the average distance calculations and FMCSA regulations. More specific information can be found in Section 4.5.5.

Overall, although there are variations between some of the FAF calculations, the basic premise is the same in each one. The gallons of fuel consumed are calculated using an estimate of distance and fuel consumption, and the gallons are then multiplied by the difference between the baseline fuel price and the current fuel price. If the current fuel is more expensive than the baseline, this results in a positive value, meaning USTRANSCOM should pay the carriers. If the current fuel is less expensive, this results in a negative value, meaning the carriers should issue a rebate to USTRANSCOM.

4.5 Updating the FAF

This section presents the results of the FAF update. The analysis suggests that the FAF should largely remain unchanged, with only minor recommendations related to updating the input values based on new information.

4.5.1 Equations

Volpe's updated analysis has not suggested that any of the base FAF calculations need to change. The principles behind each equation remain the same (Section 4.4 covers the general rationale of the equations), and there has been no known change to the industry that would warrant a change in any equation. The basic equations are as follows:

- Dry Containers Within Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance)$

Equation 28. Calculation for Dry Containers within Zones

- Dry Containers Between Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Intermodal\ rail\ gallons\ per\ container\ mile\ \times Average\ Rail\ Distance) + (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Truck\ Distance)$

Equation 29. Calculation for Dry Containers between Zones

- Reefer Containers Within Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance + \frac{Average\ Distance}{Average\ Speed} \times Reefer\ unit\ gallons\ per\ hour)$

Equation 30. Calculation for Reefer Containers within Zones

- Reefer Containers Between Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance + \frac{Average\ Distance}{Average\ Speed} \times Reefer\ unit\ gallons\ per\ hour + Off\ Duty\ Time\ \times Reefer\ unit\ gallons\ per\ hour)$

Equation 31. Calculation for Reefer Containers between Zones

- Normal Breakbulk Within Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance)$

Equation 32. Calculation for Normal Breakbulk within Zones

- Normal Breakbulk Between Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance)$

Equation 33. Calculation for Normal Breakbulk between Zones

- Overweight Breakbulk Within Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance)$

Equation 34. Calculation for Overweight Breakbulk within Zones

- Overweight Breakbulk Between Zones
  - $FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ container\ mile\ \times Average\ Distance)$

Equation 35. Calculation for Overweight Breakbulk between Zones

Volpe does not recommend any changes to the structure of these equations.

4.5.2 Average Distances

USTRANSCOM provided the Volpe team with IBS data from approximately April 2017 through October 2018. The data provided, for each shipment, an inland origin-destination (OD) pair[57], the type of shipment, the weight of the shipment, and other information that was unnecessary for Volpe's analysis (such as arrival date, TCN number, and the booked carrier). The data was filtered to ensure that all moves were CONUS, and then distances were assigned to at least the top 95 percent of OD pairs. The data was not, however, filtered out by USC moves, meaning that the distance values could be biased if USC shipments move significantly different from all moves—based on conversations with USTRANSCOM, the determination was made that USC CONUS shipments are not significantly different from other moves.

The dataset was then broken up by shipment type, and then further divided by zone. An average distance was then estimating for each of the 24 FAF calculations by weighting distances between OD pairs based on the number of shipments that traveled that route.

The new average distance values by shipment type can be found in the following four subsections.

4.5.2.1 Dry Containers

Table 20 shows the 2013 average distance values, the updated values, and the difference between the two values for only shipments of dry containers. Differences between the 2013 values and the updated values are due solely to changes in the ports and inland cities to which USTRANSCOM is sending their shipments.

The distances for the truck components were found by using the Intermodal Association of North America's Intermodal Facilities Directory[58], the same database used in previous studies. Distances were estimated between facilities and the most common inland cities in the USTRANSCOM-provided data and then averaged by number of shipments.

Table 20. Dry Containers – Average Distances in 2013 and 2018 FAF Updates

Zone	2013 Distance Value	2018 Updated Value	Difference
East Coast to East Coast	154	137	-17
Gulf Coast to Gulf Coast	194	303	+109
West Coast to West Coast	83	76	-7
East Coast to the rest of the U.S.	1043	908	-135
Truck Component	108	56	-52
Gulf Coast to the rest of the U.S.	1626	1647	+21

[57] Note that, based on recommendations from USTRANSCOM, Volpe used the shipper and the consignee as proxies for the inland cities.

[58] Intermodal Association of North America (2018)

Zone	2013 Distance Value	2018 Updated Value	Difference
Truck Component	77	93	+16
West Coast to the rest of the U.S.	2042	2064	+22
Truck Component	77	53	-24

4.5.2.2 Reefer Containers

Table 21 shows the 2013 average distance values, the updated values, and the difference between the two values for only shipments of reefer containers. Differences between the 2013 values and the updated values are due solely to changes in the ports and inland cities to which USTRANSCOM is sending their shipments.

Table 21. Reefer Containers – Average Distances in 2013 and 2018 FAF Updates

Zone	2013 Distance Value	2018 Updated Value	Difference
East Coast to East Coast	243	89	-154
Gulf Coast to Gulf Coast	216	275	+59
West Coast to West Coast	42	41	-1
East Coast to the rest of the U.S.	1103	1421	+318
Gulf Coast to the rest of the U.S.	1384	1167	-217
West Coast to the rest of the U.S.	1783	1806	+23

4.5.2.3 Normal Breakbulk

Table 22 shows the 2013 average distance values, the updated values, and the difference between the two values for only shipments of breakbulk under 50,000 lbs. Differences between the 2013 values and the updated values are due solely to changes in the ports and inland cities to which USTRANSCOM is sending their shipments.

Table 22. Normal Breakbulk – Average Distances in 2013 and 2018 FAF Updates

Zone	2013 Distance Value	2018 Updated Value	Difference
East Coast to East Coast	264	218	-46
Gulf Coast to Gulf Coast	387	429	+42
West Coast to West Coast	157	204	+47
East Coast to the rest of the U.S.	1022	1076	+54
Gulf Coast to the rest of the U.S.	1808	1071	-737
West Coast to the rest of the U.S.	2138	1789	-349

4.5.2.4 Overweight Breakbulk

Table 23 shows the 2013 average distance values, the updated values, and the difference between the two values for only shipments of breakbulk above 50,000 lbs. Differences between the 2013 values and the updated values are due solely to changes in the ports and inland cities to which USTRANSCOM is sending their shipments.

Table 23. Overweight Breakbulk – Average Distances in 2013 and 2018 FAF Updates

Zone	2013 Distance Value	2018 Updated Value	Difference
East Coast to East Coast	215	202	-13
Gulf Coast to Gulf Coast	300	456	+156
West Coast to West Coast	132	163	+31
East Coast to the rest of the U.S.	847	1253	+406
Gulf Coast to the rest of the U.S.	1632	973	-659
West Coast to the rest of the U.S.	2165	1574	-591

4.5.3 Truck/Rail Breakpoint

In order to accurately estimate the fuel consumption (and fuel cost) associated with the inland move of a container, it is necessary to know how the container actually moved, specifically whether it moved by truck or by rail intermodal. This information is not available for USTRANSCOM shipments in IBS. In the absence of historical mode data, the assumption is made that the most likely mode of transport used in moving a container inland would be based on the distance moved. This approach has been used in both of Volpe's previous FAF analyses, and each time Volpe used 700 miles as the distance at which rail becomes competitive with truck.

Based on a review of the literature, Volpe has updated its estimate of the truck/rail breakpoint to 500 miles, but this results in no functional difference in the FAF calculations.

Volpe's literature review found four new articles that gave an explicit value for the point at which rail becomes competitive at truck. The first paper, published in 2017, discussed what domestic truck traffic could switch to intermodal truck to rail shipping.[59] The second reference was from a 2017 Georgetown University presentation that looked at cooperation and competition between truck and rail.[60] The third article, published in 2014, was a final report for research funded by the Department of Transportation (DOT) that looked at barriers to intermodal rail freight.[61] The final article came from the Association of American Railroads, and offered a brief discussion about the partnership between rail and trucks.[62]

All four articles stated that 500 miles is often the breakpoint between truck and rail, while two of the articles also offered 250 miles as a distance at which rail could be competitive (in some circumstances).

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[59] Benjamin R. E. Zietlow, Ernest B. Perry, Teresa M. Adams, Thirunavukkarasu Sivappha, and Soren Walljasper, 2017

[60] Amanda Delp, 2017

[61] Yuntao Guo, Srinivas Peeta, Hong Zheng, and Bruce Cox, 2014

[62] Association of American Railroads, n.d.

Since all four new articles agreed on 500 miles, that was chosen as the new recommended value for the truck/rail breakpoint.

The way that the truck/rail breakpoint factors into FAF calculations is in determining, just for dry container movements, whether the typical movement occurred by truck or rail. This is based on the average distances found from the IBS data. If the average distance is below 500 miles, then the calculation just uses truck fuel consumption. If the average distance is above 500 miles, then the calculation includes an element for both the rail and truck portions of the trip.

In previous studies, the three within zone calculations for dry containers have fallen below the truck/rail breakpoint, and the three between zone calculations have been above the breakpoint. This is still true in this FAF update, despite the reduction in the breakpoint distance. Therefore, there are no recommended changes to the calculations.

4.5.4 Fuel Consumption

A literature review was conducted to update the four fuel consumption values found in the FAF calculations. These four fuel consumptions are for trucks, specialized trucks for overweight breakbulk, rail, and reefer units.

4.5.4.1 Trucks

In 2013, Volpe calculated the truck fuel consumption as six miles per gallon (equivalent to 0.1667 gallons/mile). A literature review was conducted to determine whether this value should be updated and, based on those results, Volpe recommends updating truck fuel consumption to seven miles per gallon (mpg) (equivalent to 0.1426 gallons/mile). This update is due to an improvement in fuel efficiency.

Data suggests that trucks are generally getting more fuel efficient over time. Although different trucks have different fuel consumption values, values from seven new sources all generally provided larger values than Volpe's old value of six mpg. Fourteen mpg figures were taken from these sources, and those values were 6 mpg and 8 mpg[63]; 7.4 mpg, 5.9 mpg, and 6.4 mpg[64]; 10 mpg[65]; 6.1 mpg, 7 mpg, 6.6 mpg, and 6.6 mpg[66]; 6.5 mpg[67]; 7 mpg[68]; and 7.23 mpg and 7.45 mpg[69]. Together, these average to

[63] U.S. Energy Information Administration, 2018
[64] Federal Highway Administration, 2018
[65] American Council for an Energy-Efficient Economy, 2017
[66] Andrew Burke and Hengbing Zhao, 2017
[67] Rentar, 2017
[68] John O'Dell, 2016
[69] U.S. Energy Information Administration, 2017

approximately 7.013 mpg, or, more simply, 7 mpg. Converting the value to gallons per container mile gives 0.1426.

Volpe's recommendation is to update the truck fuel consumption value to 0.1426 gallons per container mile.

4.5.4.2 Overweight Breakbulk

In 2013, Volpe calculated the fuel consumption value for overweight breakbulk as 0.2192 gallons per container mile. Volpe did a literature search to see if there was any new information that would warrant updating this value. It is likely that there has been an increase in fuel efficiency since the last study, however Volpe was unable to find any new quantitative data. Because no new information could be found, Volpe does not recommend updating the value.

It is recommended to keep this fuel consumption value at 0.2192 gallons per container mile, the same value recommended in 2013.

4.5.4.3 Rail

After a review of literature, the decision was made to base the rail fuel consumption value off of the truck value. Many sources discuss rail fuel consumption in relation to truck fuel consumption, without always providing a simple value for rail fuel consumption. Since there was plenty of data of truck fuel consumption, the value estimated for truck fuel consumption was divided by four to get the value for rail, with the assumption being that rail is four times more efficient than trucks

Three different articles were consulted. One suggested that rail was 3.5 times more efficient than trucks[70], one said that rail was three to four times more efficient than trucks[71], and one said that rail was four times more efficient[72]. Based on this information, Volpe decided to assume that rail is four times more efficient than trucks. Taking Volpe's recommendation for truck fuel consumption (0.1426 gallons per container mile) and dividing by four gives 0.036 gallons/container mile, which is very close to the value estimated in 2013 (0.033 gallons/container mile).

Volpe recommends updating rail fuel consumption from 0.033 gallons/container mile to 0.036 gallons/container mile.

4.5.4.4 Reefers

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[70] CSX, 2016

[71] Agforce Transport Services, 2018

[72] Benjamin R. E. Zietlow, Ernest B. Perry, Teresa M. Adams, Thirunavukkarasu Sivappha, and Soren Walljasper, 2017

Volpe found little new information on reefer fuel consumption, and the values found all suggested that reefer units had become less efficient. This is not to say that articles specifically said units were becoming less efficient, but rather the values for fuel consumption (in gallons per hour) in the literature review were larger than the values found in the past, suggesting a decrease in efficiency. It is unclear whether this is because units are actually decreasing in efficiency, or if the literature reviewed for this study provided a more comprehensive view of reefer fuel consumption.

Although recommending that the reefer fuel consumption value change to a less efficient value may be odd, it is still the recommendation Volpe is making based on the new literature reviewed. In the past, Volpe suggested a value of 0.7 gallons/hour. New literature suggests this value should be 0.8 gallons/hour.[73]

It is recommended that the reefer fuel consumption value be updated to 0.8 gallons/hour.

4.5.5 Off Duty Time

As discussed in Section 4.3.3.2, reefer containers require additional fuel to ensure the unit remains refrigerated. This is the case regardless of whether the truck is currently moving. Some trips can be completed in a day, while other trips are long enough that the driver must stop and rest, but the reefer container still burns fuel even during these times. This time therefore needs to be included in the FAF reefer calculations to account for this extra fuel burned.

Federal Motor Carrier Safety Administration (FMCSA) regulations limit a driver's hours to a maximum of 11 hours driving and a maximum of 14 continuous hours “on duty”. The duty hours must be followed by 10 hours of off duty time with no driving.[74] Assuming an average speed of 50 mph, which is consistent with Volpe’s previous studies, implies that a truck can cover 550 miles per day. Trips beyond 550 miles but less than 1,100 miles would require 2 days. Trips greater than 1,100 miles but less than 1,650 miles require 3 days and trips between 1,650 miles and 2,200 miles require 4 days. This is equivalent to no required off duty time (1 day), 13 hours required off duty time (2 days), 26 hours (3 days), and 39 hours (4 days). This has not changed since the 2013 FAF update.

Based on the new average distance values calculated as part of the FAF refresh, the off duty time should be updating accordingly for reefer shipments. All within zone reefer movements are still assumed to not require any off duty time, as the average distances all fall below 550 miles. All between zone movements do require off duty time to be included in the calculations. The values for off duty time, based on the average distances, are:

[73] IceCOLD, n.d.

[74] Federal Motor Carrier Safety Administration, 2017

- East Coast ports to the rest of the U.S.: 26 hours
- West Coast ports to the rest of the U.S.: 39 hours
- Gulf Coast ports to the rest of the U.S.: 26 hours

These are the same values as recommended in the last Volpe study, since the average distance values have not changed enough to suggest a change in the average number of days.

4.5.6 Prices

The Energy Information Administration (EIA) of the U.S. Department of Energy (DOE) publishes U.S. On-Highway Diesel Fuel Prices every Monday, excluding holidays. Both weekly and monthly averages are reported, and the data is available at https://www.eia.gov/petroleum/gasdiesel/. Volpe recommends that this data serve as the source of the fuel price data for both the baseline fuel prices as well as the "current" fuel price data needed for the monthly updates of the FAF. Additionally, Volpe recommends that the monthly averages are used as opposed to the weekly averages to ensure a better representation of current fuel prices.

This is the same data source recommended in Volpe's previous studies, meaning there is no recommended change.

Volpe originally recommended that the "current" fuel price data be collected two months in advance (i.e., fuel price data for March would come from January). Volpe now recommends that the fuel price data be collected three months prior to the shipping month, which is what USTRANSCOM is currently doing and matches the CAF recommendation (see Section 3.4.1.3). In other words, Volpe recommends, for example, that the current fuel price for shipments in March should use the average fuel prices from December, and the FAF payments can then be calculated and posted in January.

The baseline fuel price data should continue to be collected at the beginning of the solicitation period, which is what USTRANSCOM is currently doing.

4.6 Conclusion and Recommendations

Overall, the recommendation from this study is that the current methodology for USTRANSCOM's FAF should remain unchanged, with the only changes being made to the input values.

Table 24 shows the main FAF input values from 2013 and 2018. The table does not include the average distance values, but does show fuel consumption, the truck/rail breakpoint, and off duty hours.

Table 24. Summary of Changes to FAF Inputs

FAF Input	2013 Value	2018 Updated Value
Truck Fuel Consumption	0.1667 gallons/container mile	0.1426 gallons/container mile
Reefer Fuel Consumption	0.7 gallons/hour	0.8 gallons/hour
Rail Fuel Consumption	0.033 gallons/container mile	0.036 gallons/container mile
Specialized Heavy Hauler Truck Fuel Consumption	0.2192 gallons/container mile	0.2192 gallons/container mile
Truck/Rail Breakpoint	700 miles	500 miles
Off Duty Time – East Coast to rest of the U.S.	26 hours	26 hours
Off Duty Time – Gulf Coast to rest of the U.S.	26 hours	26 hours
Off Duty Time – West Coast to rest of the U.S.	39 hours	39 hours

Volpe also recommends updating the average distance values, which can be found in Section 4.5.2. These values, along with the updated values found in the previous table, can also all be found in the FAF calculator Volpe is providing to USTRANSCOM along with this report. The FAF calculator is a fully functioning excel spreadsheet that provides the appropriate FAF payment amounts after inputting the correct fuel price data. The FAF calculator also includes a tab with all the input values, so USTRANSCOM can pull the values directly from the spreadsheet.

Appendix A: The "Average" Vessel by Lane

Table 25 shows the average vessel characteristics for container and RORO service, number of observations and data source by lane. [75,76]

Table 25. Characteristics of Average Container Vessels by Lane

Lane	Container Capacity (TEU)	Container Service Speed (Knots)	Container Fuel Con.(tons /day)	Container Obs.	Container Data Source	RORO Capacity (MTONs)	RORO Service Speed (Knots)	RORO Fuel Con. (tons/day)	RORO Obs.	RORO Data Source
01	4,853	24.4	175	113,940	1	43,148	19.2	54	5,107	1
02	5,710	24.4	184	8	1	46,930	19.5	53	27,987	3
03	2,510	22.5	110	7,183	1	46,930	19.5	53	27,987	3
04	2,358	19.9	80	1,342	1	45,803	19.4	54	216	1
05	3,856	22.9	130	91,315	1	51,224	19.6	46	2,842	1
06	4,183	22.4	133	19,146	1	44,402	19.0	52	393	1
07	4,534	22.5	150	45,292	1	48,171	20.0	58	3,115	1
08	5,166	24.5	150	35	1	45,202	19.4	55	11	1
10	2,698	21.0	92	2,067	1	46,830	19.0	47	966	1
11	3,708	22.7	125	4,675	1	50,800	19.5	46	2,734	1
12	5,341	23.7	177	485	1	48,741	19.6	48	24	1
13	4,479	22.8	150	4,011	1	47,459	19.9	57	7,319	1
14	7,135	23.8	208	16	2	43,088	18.5	50	85	2
15	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
16	4,276	23.9	153	514	1	43,290	18.9	52	240	1
18	1,310	16.7	55	47	1	46,930	19.5	53	27,987	4
19	4,595	24.0	166	2,636	1	44,021	19.3	54	739	2
20	3,067	21.4	81	21	1	46,930	19.5	53	27,987	3
23	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
24	2,251	20.0	77	717	1	48,714	19.6	47	99	1
25	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
26	1,681	20.0	71	204	2	38,865	19.0	44	6	2
27	4,191	23.9	144	7	1	46,930	19.5	53	27,987	3
28	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
29	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
31	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
32	2,360	20.4	82	3,146	1	45,896	18.9	50	1,548	1
33	2,319	20.0	80	262	2	46,930	19.5	53	27,987	3
34	5,079	22.3	139	2,303	2	46,930	19.5	53	27,987	3
35	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3

[75] NOTE: Data source refers to which data source was used given USTRANSCOM's priority of data quality described in Section 2.4.2.4.

[76] Methodology for calculating TEU and MTON capacity is discussed in the Vessel Capacity Section, Section 2.4.5

Lane	Container Capacity (TEU)	Container Service Speed (Knots)	Container Fuel Con.(tons /day)	Container Obs.	Container Data Source	RORO Capacity (MTONs)	RORO Service Speed (Knots)	RORO Fuel Con. (tons/day)	RORO Obs.	RORO Data Source
36	2,286	20.2	86	9	2	46,930	19.5	53	27,987	3
38	3,619	22.7	148	305	1	46,930	19.5	53	27,987	4
39	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
40	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
41	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
42	4,162	23.3	146	331,315	4	46,930	19.5	53	27,987	3
43	2,202	19.5	75	58	2	46,930	19.5	53	27,987	3
44	2,418	22.0	101	29	2	46,930	19.5	53	27,987	3
47	3,290	21.7	117	159	1	43,538	19.4	57	311	2
48	4,576	24.0	153	15	1	46,930	19.5	53	27,987	4
49	5,983	23.1	163	438	1	46,930	19.5	53	27,987	3
50	4,125	22.9	148	46	1	46,930	19.5	53	27,987	3
51	4,087	23.0	146	120	1	41,506	19.5	47	11	2
52	4,162	23.3	146	331,315	3	52,068	19.3	43	383	1
53	5,832	23.5	160	22	2	46,930	19.5	53	27,987	3
54	2,625	22.8	110	28,784	1	31,788	18.3	40	343	1
55	5,457	23.1	159	259	2	46,930	19.5	53	27,987	3
56	4,460	23.1	134	17	2	46,930	19.5	53	27,987	3
57	5,048	22.9	172	12	1	48,838	20.0	59	10	2
58	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
59	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
60	6,013	24.0	201	1,728	1	54,739	20.3	55	211	1
61	2,735	21.8	103	1,211	1	43,126	19.0	53	701	1
64	1,411	18.7	52	572	2	46,930	19.5	53	27,987	3
65	3,340	21.9	106	5	2	46,930	19.5	53	27,987	3
67	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
68	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
70	1,617	18.9	60	20	2	46,930	19.5	53	27,987	3
71	1,849	21.3	70	238	1	34,876	19.2	46	12	2
72	4,123	22.5	128	15	2	46,930	19.5	53	27,987	3
73	5,940	24.0	199	367	1	43,088	18.5	50	23	1
74	5,462	24.2	184	20	1	57,583	20.5	54	34	2
75	5,429	23.1	182	49	1	48,838	20.0	59	31	1
76	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
77	5,759	24.4	170	6	2	46,930	19.5	53	27,987	3
78	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
79	2,671	22.4	103	619	1	39,369	19.0	52	111	1
80	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
81	1,371	20.0	55	254	1	43,175	19.3	55	58	1
82	4,126	23.5	146	13	1	38,865	19.0	44	11	2
83	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	3
84	1,383	18.2	47	20	1	46,930	19.5	53	27,987	3
85	2,777	21.3	105	21	2	46,523	19.8	53	120	2

Lane	Container Capacity (TEU)	Container Service Speed (Knots)	Container Fuel Con.(tons /day)	Container Obs.	Container Data Source	RORO Capacity (MTONs)	RORO Service Speed (Knots)	RORO Fuel Con. (tons/day)	RORO Obs.	RORO Data Source
86	3,848	21.2	93	46	2	46,930	19.5	53	27,987	3
87	5,252	21.3	141	90	2	46,930	19.5	53	27,987	3
88	3,200	21.9	110	6	1	46,875	19.4	46	7	2
89	2,177	20.5	80	6	2	46,930	19.5	53	27,987	3
90	6,337	23.9	177	16	2	46,930	19.5	53	27,987	3
91	4,293	23.4	145	35	2	46,930	19.5	53	27,987	3
92	2,903	20.6	93	6	2	46,930	19.5	53	27,987	3
93	6,736	23.2	166	7	2	46,930	19.5	53	27,987	3
94	1,915	19.9	66	174	2	46,930	19.5	53	27,987	3
95	4,129	21.8	121	176	2	46,930	19.5	53	27,987	3
96	4,162	23.3	146	331,315	3	46,930	19.5	53	27,987	4
97	5,207	21.7	128	68	2	46,930	19.5	53	27,987	3
98	4,162	23.3	146	331,315	3	52,805	19.7	48	175	2
US	4,162	23	146	331,315	3	5,385	20	53	148	1

Appendix B: Speed, Distance, and Steaming Days by Vessel Type

Table 26. Speed, Distance, and Steaming Days by Vessel Type

Lane	Total Distance	Speed (Container)	Speed (RORO)	Steaming Days (Container)	Steaming Days (RORO)
01	6,536	24.4	19.2	11.2	14.2
02	7,732	24.4	19.5	13.2	16.5
03	3,525	22.5	19.5	6.5	7.5
04	2,702	19.9	19.4	5.6	5.8
05	4,446	22.9	19.6	8.1	9.5
06	6,166	22.4	19.0	11.5	13.5
07	9,513	22.5	20.0	17.6	19.9
08	13,718	24.5	19.4	23.3	29.5
10	6,153	21.0	19.0	12.2	13.5
11	5,553	22.7	19.5	10.2	11.9
12	7,261	23.7	19.6	12.8	15.4
13	10,846	22.8	19.9	19.9	22.7
14	12,223	23.8	18.5	21.4	27.5
15	6,237	23.3	19.5	11.2	13.3
16	5,817	23.9	18.9	10.1	12.8
18	922	16.7	19.5	2.3	2.0
19	2,740	24.0	19.3	4.8	5.9
20	2,569	21.4	19.5	5.0	5.5
23	9,046	23.3	19.5	16.2	19.3
24	1,552	20.0	19.6	3.2	3.3
25	9,227	23.3	19.5	16.5	19.7
26	1,673	20.0	19.0	3.5	3.7
27	9,931	23.9	19.5	17.3	21.2
28	3,337	23.3	19.5	6.0	7.1
29	2,325	23.3	19.5	4.2	5.0
31	3,059	23.3	19.5	5.5	6.5
32	4,887	20.4	18.9	10.0	10.7
33	3,299	20.0	19.5	6.9	7.0
34	4,330	22.3	19.5	8.1	9.2
35	5,535	23.3	19.5	9.9	11.8
36	10,418	20.2	19.5	21.4	22.2
37	2,014	22.7	19.5	3.7	4.3
39	1,770	23.3	19.5	3.2	3.8
40	5,986	23.3	19.5	10.7	12.8
41	429	23.3	19.5	0.8	0.9
42	2,181	23.3	19.5	3.9	4.7
43	1,514	19.5	19.5	3.2	3.2
44	2,484	22.0	19.5	4.7	5.3
47	12,445	21.7	19.4	23.9	26.8
48	810	24.0	19.5	1.4	1.7
49	12,897	23.1	19.5	23.3	27.5
50	10,746	22.9	19.5	19.6	22.9
51	7,523	23.0	19.5	13.6	16.1
52	6,562	23.3	19.3	11.7	14.2

Lane	Total Distance	Speed (Container)	Speed (RORO)	Steaming Days (Container)	Steaming Days (RORO)
53	5,352	23.5	19.5	9.5	11.4
54	8,490	22.8	18.3	15.5	19.4
55	5,891	23.1	19.5	10.6	12.6
56	3,196	23.1	19.5	5.8	6.8
57	6,744	22.9	20.0	12.3	14.1
58	12,015	23.3	19.5	21.5	25.6
59	7,417	23.3	19.5	13.3	15.8
60	7,986	24.0	20.3	13.8	16.4
61	7,716	21.8	19.0	14.7	16.9
64	2,788	18.7	19.5	6.2	5.9
65	5,806	21.9	19.5	11.1	12.4
67	13,324	23.3	19.5	23.8	28.4
68	1,945	23.3	19.5	3.5	4.2
70	3,209	18.9	19.5	7.1	6.8
71	5,489	21.3	19.2	10.7	11.9
72	14,789	22.5	19.5	27.4	31.6
73	9,242	24.0	18.5	16.0	20.8
74	5,545	24.2	20.5	9.5	11.3
75	5,572	23.1	20.0	10.1	11.6
76	1,748	23.3	19.5	3.1	3.7
77	11,554	24.4	19.5	19.8	24.7
78	9,439	23.3	19.5	16.9	20.1
79	5,968	22.4	19.0	11.1	13.1
80	10,584	23.3	19.5	18.9	22.6
81	1,554	20.0	19.3	3.2	3.4
82	4,662	23.5	19.0	8.3	10.2
83	5,173	23.3	19.5	9.3	11.0
84	1,494	18.2	19.5	3.4	3.2
85	10,588	21.3	19.8	20.7	22.3
86	5,632	21.2	19.5	11.1	12.0
87	12,517	21.3	19.5	24.5	26.7
88	4,188	21.9	19.4	8.0	9.0
89	11,371	20.5	19.5	23.2	24.3
90	8,720	23.9	19.5	15.2	18.6
91	10,305	23.4	19.5	18.4	22.0
92	8,678	20.6	19.5	17.6	18.5
93	10,146	23.2	19.5	18.2	21.7
94	3,492	19.9	19.5	7.3	7.5
95	5,697	21.8	19.5	10.9	12.2
96	717	23.3	19.5	1.3	1.5
97	4,392	21.7	19.5	8.4	9.4
98	490	23.3	19.7	0.9	1.0
99	7,826	23.3	19.5	14.0	16.7

Appendix C: Fuel Mix Factors

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
01	U.S. West Coast - Far East	71%	29%	71%	24%	5%
02	Continental Europe, United Kingdom, Ireland - Middle East, South Asia, Indian Ocean	85%	15%	85%	10%	5%
03	U.S. West Coast - Hawaii	44%	56%	44%	51%	5%
04	Middle East, South Asia, Indian Ocean Interport	95%	5%	95%	0%	5%
05	U.S. East Coast - Continental Europe, United Kingdom, Ireland	36%	64%	36%	59%	5%
06	U.S. East Coast - Mediterranean	71%	29%	71%	24%	5%
07	U.S. East Coast - Middle East, South Asia, Indian Ocean	81%	19%	81%	14%	5%
08	U.S. East Coast - Far East	87%	13%	87%	8%	5%
10	U.S. Gulf Coast - Scandinavia, Baltic Sea	39%	61%	39%	56%	5%
11	U.S. Gulf Coast - Continental Europe, United Kingdom, Ireland	63%	37%	63%	32%	5%
12	U.S. Gulf Coast - Mediterranean	81%	19%	81%	14%	5%
13	U.S. Gulf Coast - Middle East, South Asia, Indian Ocean	85%	15%	85%	10%	5%
14	U.S. Gulf Coast - Far East	90%	10%	90%	5%	5%
15	U.S. Gulf Coast - Hawaii	84%	16%	84%	11%	5%
16	Hawaii - Far East	89%	11%	89%	6%	5%
18	Caribbean Interport	0%	100%	0%	95%	5%
19	Far East Interport	95%	5%	95%	0%	5%
20	Mediterranean Interport	95%	5%	95%	0%	5%
23	U.S. West Coast - Continental Europe, United Kingdom, Ireland	95%	5%	95%	0%	5%
24	SCANDINAVIA, BALTIC SEA - CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND	6%	94%	6%	89%	5%
25	U.S. West Coast - Mediterranean	89%	11%	89%	6%	5%
26	U.S. West Coast - Alaska	41%	59%	41%	54%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
27	Hawaii - Continental Europe, United Kingdom, Ireland	84%	16%	84%	11%	5%
28	U.S. West Coast - Central America/Mexico	63%	37%	63%	32%	5%
29	Alaska Interport	87%	13%	87%	8%	5%
31	U.S. East Coast - Iceland	27%	73%	27%	68%	5%
32	U.S. East Coast - Scandinavia, Baltic Sea	32%	68%	32%	63%	5%
33	U.S. EAST COAST - AZORES	70%	30%	70%	25%	5%
34	Continental Europe, United Kingdom, Ireland - Mediterranean	78%	22%	78%	17%	5%
35	U.S. WEST COAST - CARIBBEAN	74%	26%	74%	21%	5%
36	Mediterranean - Hawaii	91%	9%	91%	4%	5%
37	U.S. East Coast - Caribbean	57%	43%	57%	38%	5%
39	U.S. East Coast - Central America/Mexico	41%	59%	41%	54%	5%
40	AFRICA INTERPORT	95%	5%	95%	0%	5%
41	HAWAII INTERPORT	0%	100%	0%	95%	5%
42	U.S. Gulf Coast - Caribbean	59%	41%	59%	36%	5%
43	U.S. Gulf Coast - Central America/Mexico	55%	45%	55%	40%	5%
44	ALASKA - HAWAII	78%	22%	78%	17%	5%
47	U.S. West Coast - Middle East, South Asia, Indian Ocean	82%	18%	82%	13%	5%
48	CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND INTERPORT	40%	60%	40%	55%	5%
49	Far East - Continental Europe, United Kingdom, Ireland	89%	11%	89%	6%	5%
50	Far East - Mediterranean	95%	5%	95%	0%	5%
51	Far East - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
52	U.S. East Coast - Black Sea	75%	25%	75%	20%	5%
53	U.S. West Coast - South America	92%	8%	92%	3%	5%
54	U.S. West Coast - Oceania	80%	20%	80%	15%	5%
55	U.S. East Coast - South America	82%	18%	82%	13%	5%
56	U.S. Gulf Coast - South America	81%	19%	81%	14%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
57	Mediterranean - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
58	Far East - South America	95%	5%	95%	0%	5%
59	U.S. GULF COAST - BLACK SEA	80%	20%	80%	15%	5%
60	U.S. East Coast - Africa	79%	21%	79%	16%	5%
61	Far East - Oceania	95%	5%	95%	0%	5%
64	CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND - AZORES	68%	32%	68%	27%	5%
65	Central America/Mexico - Continental Europe, United Kingdom, Ireland	82%	18%	82%	13%	5%
67	U.S. West Coast - Africa	85%	15%	85%	10%	5%
68	Central America/Mexico - South America	95%	5%	95%	0%	5%
70	Azores - Mediterranean	95%	5%	95%	0%	5%
71	Continental Europe, United Kingdom, Ireland - Africa	81%	19%	81%	14%	5%
72	Continental Europe, United Kingdom, Ireland - Oceania	90%	10%	90%	5%	5%
73	U.S. Gulf Coast - Africa	85%	15%	85%	10%	5%
74	Mediterranean - Africa	95%	5%	95%	0%	5%
75	Africa - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
76	Central America/Mexico Interport	95%	5%	95%	0%	5%
77	U.S. East Coast - Oceania	89%	11%	89%	6%	5%
78	U.S. Gulf Coast - Oceania	92%	8%	92%	3%	5%
79	Hawaii - Oceania	87%	13%	87%	8%	5%
80	Oceania - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
81	Oceania Interport	95%	5%	95%	0%	5%
82	Alaska - Far East	91%	9%	91%	4%	5%
83	Alaska - Oceania	91%	9%	91%	4%	5%
84	Caribbean - Central America, Mexico	86%	14%	86%	9%	5%
85	Hawaii - Middle East, South Asia, Indian Ocean	92%	8%	92%	3%	5%

Lane	Name	Fuel Mix Factors, 2 Fuels		Fuel Mix Factors, 3 Fuels		
		Over Ocean Fuel Share	Ports/ECA	Over Ocean Fuel Share	ECA Fuel Share	MGO Share
86	MEDITERRANEAN - SCANDINAVIA, BALTIC SEA	74%	26%	74%	21%	5%
87	FAR EAST - SCANDINAVIA, BALTIC SEA	84%	16%	84%	11%	5%
88	Continental Europe, United Kingdom, Ireland - Caribbean	80%	20%	80%	15%	5%
89	MEDITERRANEAN - OCEANIA	95%	5%	95%	0%	5%
90	Far East - Africa	95%	5%	95%	0%	5%
91	Alaska - Middle East, South Asia, Indian Ocean	93%	7%	93%	2%	5%
92	Caribbean - Middle East, South Asia, Indian Ocean	94%	6%	94%	1%	5%
93	Far East - Central America/Mexico	95%	5%	95%	0%	5%
94	Mediterranean-Black Sea	95%	5%	95%	0%	5%
95	Black Sea - Middle East, South Asia, Indian Ocean	95%	5%	95%	0%	5%
96	BLACK SEA INTERPORT	95%	5%	95%	0%	5%
97	Continental Europe, United Kingdom, Ireland - Black Sea	78%	22%	78%	17%	5%
98	SCANDINAVIA, BALTIC SEA INTERPORT	0%	100%	0%	95%	5%
99	Caribbean - Africa	92%	8%	92%	3%	5%
CA	Caspian Sea Interport	95%	5%	95%	0%	5%

Appendix D: Comparison of 2013 & 2019 BAF Technical Factors

Table 27: Technical Factors for 2019 and 2013

Lane	TEU (2019)	FEU (2019)	MT (2019)	TEU (2013)	FEU (2013)	MT (2013)
01	0.242	0.472	0.0148	0.246	0.458	0.0113
02	0.256	0.498	0.0155	0.32	0.596	0.0159
03	0.171	0.334	0.0071	0.135	0.252	0.0054
04	0.115	0.224	0.0057	0.052	0.097	0.0025
05	0.163	0.319	0.0071	0.179	0.334	0.0078
06	0.219	0.426	0.0133	0.229	0.426	0.0118
07	0.348	0.679	0.0199	0.385	0.717	0.0189
08	0.405	0.790	0.0296	0.602	1.119	0.0302
10	0.249	0.486	0.0113	0.238	0.443	0.0115
11	0.207	0.403	0.0089	0.215	0.4	0.0108
12	0.254	0.496	0.0126	0.276	0.513	0.0143
13	0.398	0.776	0.0228	0.409	0.761	0.0209
14	0.373	0.728	0.0266	0.502	0.933	0.0301
15	0.235	0.458	0.0125	0.287	0.534	0.0169
16	0.218	0.425	0.0128	0.25	0.466	0.0111
18	0.058	0.113	0.0018	0.017	0.031	0.0004
19	0.103	0.202	0.0060	0.135	0.251	0.0076
20	0.079	0.155	0.0051	0.083	0.154	0.0044
23	0.341	0.665	0.0181	0.389	0.724	0.0179
24	0.066	0.128	0.0027	0.063	0.118	0.0028
25	0.348	0.678	0.0185	0.354	0.659	0.0184
26	0.088	0.172	0.0035	0.125	0.233	0.003
27	0.355	0.693	0.0199	0.412	0.767	0.0204
28	0.126	0.245	0.0067	0.167	0.31	0.0067
29	0.088	0.171	0.0047	0.113	0.209	0.0035
31	0.115	0.225	0.0061	0.123	0.23	0.0057
32	0.208	0.405	0.0098	0.192	0.358	0.0087
33	0.143	0.279	0.0066	0.096	0.178	0.006
34	0.133	0.259	0.0087	0.168	0.313	0.0081
35	0.209	0.407	0.0111	N/A	N/A	N/A
36	0.483	0.943	0.0208	0.427	0.794	0.0261
37	0.091	0.177	0.0040	0.075	0.139	0.0014
39	0.067	0.130	0.0035	0.122	0.227	0.0104
40	0.226	0.440	0.0120	0.097	0.181	0.0044
41	0.016	0.032	0.0009	N/A	N/A	N/A
42	0.082	0.160	0.0044	0.105	0.195	0.0054
43	0.066	0.128	0.0030	0.084	0.157	0.0085
44	0.118	0.230	0.0050	N/A	N/A	N/A

Lane	TEU (2019)	FEU (2019)	MT (2019)	TEU (2013)	FEU (2013)	MT (2013)
47	0.509	0.993	0.0290	0.502	0.934	0.0196
48	0.028	0.055	0.0016	0.024	0.044	0.001
49	0.381	0.743	0.0258	0.496	0.923	0.0218
50	0.422	0.822	0.0215	0.444	0.827	0.0246
51	0.292	0.569	0.0153	0.312	0.58	0.0168
52	0.247	0.482	0.0097	0.289	0.538	0.0138
53	0.157	0.305	0.0107	0.159	0.296	0.0073
54	0.390	0.760	0.0203	0.355	0.661	0.0093
55	0.186	0.362	0.0118	0.092	0.17	0.0097
56	0.104	0.203	0.0064	0.117	0.218	0.0107
57	0.251	0.490	0.0141	0.215	0.4	0.0113
58	0.453	0.883	0.0240	0.035	0.065	0.0023
59	0.280	0.545	0.0148	N/A	N/A	N/A
60	0.278	0.542	0.0136	0.305	0.566	0.0153
61	0.332	0.648	0.0174	0.37	0.689	0.0169
64	0.136	0.266	0.0056	0.076	0.142	0.0036
65	0.211	0.412	0.0116	0.221	0.411	0.0096
67	0.502	0.979	0.0267	0.679	1.262	0.0288
68	0.073	0.143	0.0039	0.067	0.125	0.0062
70	0.157	0.305	0.0064	0.118	0.219	0.0049
71	0.245	0.478	0.0130	0.295	0.549	0.0138
72	0.509	0.993	0.0296	0.566	1.053	0.0239
73	0.322	0.628	0.0201	0.309	0.575	0.0171
74	0.193	0.377	0.0087	0.277	0.514	0.0151
75	0.202	0.394	0.0117	0.384	0.714	0.0202
76	0.066	0.128	0.0035	0.096	0.178	0.006
77	0.350	0.682	0.0231	0.499	0.929	0.0193
78	0.356	0.694	0.0189	0.434	0.807	0.023
79	0.258	0.503	0.0144	0.275	0.512	0.0105
80	0.399	0.778	0.0212	0.422	0.785	0.0216
81	0.078	0.153	0.0036	0.119	0.221	0.0035
82	0.175	0.342	0.0097	0.19	0.353	0.0062
83	0.195	0.380	0.0103	0.304	0.565	0.0096
84	0.070	0.136	0.0030	0.055	0.103	0.0018
85	0.471	0.919	0.0210	0.566	1.054	0.0275
86	0.161	0.315	0.0113	0.177	0.329	0.0082
87	0.395	0.770	0.0250	0.414	0.77	0.0204
88	0.164	0.320	0.0073	0.165	0.308	0.0066
89	0.508	0.991	0.0228	0.37	0.687	0.016
90	0.256	0.499	0.0174	0.396	0.736	0.0129
91	0.371	0.723	0.0206	0.429	0.798	0.0133
92	0.339	0.661	0.0174	0.337	0.626	0.0161
93	0.269	0.525	0.0203	0.334	0.621	0.0136
94	0.152	0.296	0.0070	0.08	0.148	0.004
95	0.192	0.374	0.0114	0.188	0.351	0.0081

Lane	TEU (2019)	FEU (2019)	MT (2019)	TEU (2013)	FEU (2013)	MT (2013)
96	0.027	0.053	0.0014	0.027	0.05	0.0012
97	0.124	0.242	0.0088	0.159	0.295	0.0067
98	0.018	0.036	0.0008	0.017	0.032	0.0007
99	0.295	0.575	0.0157	0.134	0.25	0.0052
CA	0.018	0.035	0.0010	N/A	N/A	N/A

Appendix E: FAF – List of States by Zone

This appendix provides a list of the U.S. states by which port zone they're in for the purposes of the FAF analysis.

West Coast States:

- California
- Oregon
- Washington

East Coast States:

- Connecticut
- DC
- Delaware
- Florida
- Georgia
- Maine
- Maryland
- Massachusetts
- New Hampshire
- New Jersey
- New York
- North Carolina
- Pennsylvania
- Rhode Island
- South Carolina
- Virginia
- West Virginia

Gulf Coast States:

- Alabama
- Louisiana
- Mississippi
- Texas

States that are not in a Port Zone:

- Arizona
- Arkansas
- Colorado
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas

- Kentucky
- Michigan
- Minnesota
- Missouri
- Montana
- Nebraska
- Nevada
- New Mexico
- North Dakota
- Ohio
- Oklahoma
- South Dakota
- Tennessee
- Utah
- Vermont
- Wisconsin
- Wyoming

Appendix F: Input Substitution Factor Value

Input Substitution Factor

The Input Substitution Factor recognizes that in the face of shifting input costs, producers (and in this case carriers) adjust their mix of production inputs to decrease the use of relatively more costly inputs and increase the use of less costly inputs. In the context of the BAF, carriers have several levers to adjust their input mix, both immediately and in the long term, in order to shift their relative fuel use in response to changing prices.

The easiest adjustment for carriers to implement is altering the speed a vessel travels. The non-linear relationship between speed and fuel consumption means slowing a vessel down (known typically as slow steaming) results in a more than proportional savings in fuel, and a linear increase in trip duration. Conversely, if a vessel speeds up there is a more than proportional increase in fuel consumption and a linear decrease in trip duration.

The Input Substitution Factor is set at a value between 0 and 1, representing the extent to which carriers are traveling below service speed, and are also making operational decisions to reduce total fuel consumption in the face of rising, or volatile, prices. Input substitution values near one imply less fuel substitution (and higher BAF payments), while lower values align with more fuel substitution through slower steaming (and lower BAF payments).

Each lane's fuel consumption factor is multiplied by the Input Substitution Factor value, representing the adjustment in the mix of inputs and associated change in fuel use. While open for negotiation between USTRANSCOM and the USC carriers, the recommended value for the USC-9 BAF Input Substitution Factor is 0.8, compensating the affected party by 80 percent of lane specific fuel consumption. The 0.8 recommendation is likely a conservative estimate, supported by both the underlying economic theory of input substitution as well as an analysis of the fuel consumption savings of vessels under alternate speed scenarios.

Recommended Value

The recommended value of 0.8 is consistent with the economic theory of input substitution as well as practical considerations associated with data limitations for estimating this relationship. In the report documenting the recommended BAF for USC-6, a general production function with fuel and other inputs was used to describe various production scenarios with changing input prices.[77]

> In order to maintain the incentive for efficient adjustment of inputs in response to changes in input prices, the BAF should not compensate carriers for the full change in fuel cost while holding the input mix constant. Although the actual production function for vessel shipping has not been fully modeled, it clearly is not one in which the proportions between fuel and other inputs is fixed. Compensation based on an (implicit) assumption of fixed input proportionality removes the incentive to optimize fuel consumption within the input mix, and overcompensates carriers.

As described in that report and above in Section 2.5.1, when the price of one input rises (in this case fuel), a carrier will attempt to use more of the relatively cheaper input (such as labor, through increased sailing time) balancing the tradeoffs of speed, cost, and delivering on time. In this scenario, the Input Substitution Factor is estimated at around 0.75. An actual vessel production function will vary based on the prevailing price level and vessel characteristics, and is beyond the scope of this study; nonetheless, individual vessel values may be higher than 0.75.

The overarching economic logic behind input substitution is that a carrier has the ability to adjust its operation to minimize overall costs when faced with rising fuel costs. Some of these are instantaneous changes like adjusting vessel speed, while others require longer-term capital investments. Regardless of the timeframe, carriers have the ability to make operational decisions to account for changing fuel prices (that USTRANSCOM is unable to do). Input Substitution Factor values less than one reflect this asymmetry, prevent carriers from passing along the entire increase in fuel costs to USTRANSCOM, and maintain market forces that incentivize carrier efficiencies.

Service Speed & Consumption

To estimate each lane's typical ship, Volpe matched the vessels in USTRANSCOM's shipment database with Clarkson's Vessel Register containing vessel characteristics including size, service speed, and fuel consumption. Fuel consumption is defined in Clarkson's as "fuel consumption at service speed" and gives the tons per day of fuel consumed at the "service speed" of the vessel. The Clarkson's vessel data does not provide a schedule of fuel consumption by speed for each vessel and so the fuel consumption capability of the vessel is reflected in only the possible top speed. Any analysis of the trade-off between speed and fuel consumption needs to account for this relationship beyond just service speed.

While service speed is an engine's capable speed, carriers generally operate at a lower, more fuel-efficient, speed. Based on Clarkson's speed/fuel consumption data, across all BAF lanes the average

[77] *Calculation of Bunker Fuel, Currency, and Inland Freight Fuel Price Adjustment Factors for USTRANSCOM Commercial Shipping Contracts*. Biernbaum et al. Volpe National Transportation Systems Center. 2009.

containership and RORO service speeds are 22.4 knots and 19.5 knots, respectively. In their comments, a USTRANSCOM ocean carrier "recommends VOLPE reduce speed from 19 or 20 knots (max speed) to a more realistic vessel operation (i.e. 14–18 knots)" suggesting an overall reduction in speed of 2–5 knots.

As carrier-operated speeds are likely below the service speeds used, without adjustment, the BAF overestimates fuel consumption. Adjusting vessel speed downwards, however, also requires reducing the fuel consumption figure accordingly. Since the only data speed/fuel consumption data available for the BAF study from Clarkson's is at service speed, other information needs to be referenced to observe how fuel consumption changes with speed.

Research on Speed and Consumption Relationship

In a 2012 study, Yao et al. estimated the fuel consumption for a given speed in knots and vessel size in TEUs. In particular, their estimated model set fuel consumption on the cube of speed and an intercept. The model assumes a non-linear relationship between fuel consumption and speed through the cubed speed variable. A separate estimate of the model was produced for each of seven vessel size categories (in TEUs). The results of these estimates and relevant data details such as the number of vessels used in each estimation and the interval of speed values for each estimated are displayed in Table 28. Importantly, these results show that fuel consumption increases linearly with vessel size.

Table 28. Regression Results of Yao et al., 2012

Size (TEU)	Speed Cubed	Intercept	Number of Data Points[1]	Speed Interval of the data (knots)
0-1,000	0.004476	6.17	73	(10.5, 16.5)
1,001-2,000	0.004595	16.42	65	(12.2, 19.5)
2,001-,3000	0.004501	29.28	51	(13.5, 21)
3,001-4,000	0.006754	37.23	82	(14.5, 21.5)
4,001-5,000	0.006732	54.57	193	(15, 24)
5,001-6,000	0.007297	71.4	170	(14, 24)
6,000+[2]	0.006705	87.71	53	(18, 25)

1. Number of data points: each data point consists of one (ship speed, bunker fuel consumption rate) pair.
2. 6,000+: the largest ship in data is 8,110 TEU

Error! Reference source not found. shows the results of the Yao et al. (2012) estimations that relate fuel consumption on speed for a given vessel TEU for the speed intervals associated with that TEU size. For vessels of lower TEU size, the graph shows that the fuel consumption by speed relationship is more linear and that generally these vessels are not capable of sailing at speeds equivalent to the larger vessels. For vessels of larger TEU size (3000–6000+), the graph shows that the fuel consumption by speed relationship is less linear and steeper, and that these vessels are capable of traveling at higher speeds.

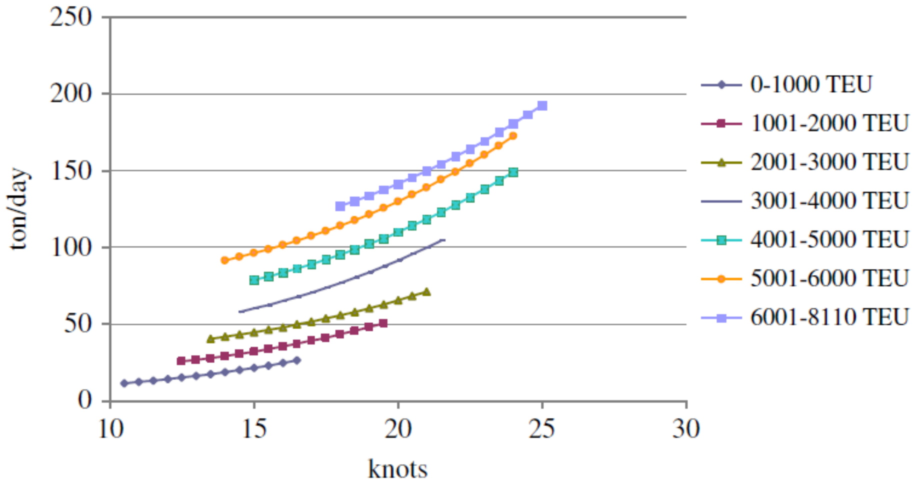

Figure 15. Graphical Results of Yao et al., 2012, Fuel Consumption (ton/day) by Speed (knots) by Vessel Size (TEU)

These relationships allow testing and comparison of various scenarios of vessel speed and size on fuel consumption including the speed parameters assumed in the BAF study and claimed by carriers.

Impact on Input Substitution Factor Value

In the BAF, the Input Substitution Factor is a reduction on the fuel consumption figure comprising the lane technical factors. At 0.8, the factor reduces the technical factor (and resultant BAF payment) by 20 percent. The 0.8 value incorporates both the underlying economic theory of input substitution by the carriers and a downward adjustment of service speed (and resulting fuel consumption) toward the carrier suggested operating speeds.

The 0.8 recommendation is likely a conservative estimate. Using the Yao et al. (2012) equations for fuel consumption from Table 28 above and adjusting speeds downward from the lane average service speeds to the speeds suggested by carriers results in a 20 to 40 percent reduction fuel consumption. Table 29 demonstrates the percent reductions in fuel consumption based on the average service speed of vessels in the BAF, 22 knots, and a 20 percent reduction in speed, for each of the TEU sizes that were estimated in the Yao et al. (2012) study. For instance, for vessels between 4,001 and 5,000 TEUs (the average U.S.-flag containership in the BAF analysis is 4,162 TEU) the fuel consumption reduction from sailing at 17.5 knots versus 22 knots is 27 percent. If these speeds and fuel consumption amounts were used in the BAF model in place of the Input Substitution Factor, resulting technical factors and BAF payments would be lower than under the current 0.8 recommendation.

Table 29. Percent Reductions in Fuel Consumption based on Yao et al. (2012)

TEU	Fuel Consumption at 22 Knots	Fuel Consumption at 17.5 Knots	Percent Reduction in Fuel Consumption from 22 Knots to 17 Knots
0-1,000	53.83	30.57	43%
1,001-2,000	65.35	41.47	37%
2,001-3,000	77.21	53.82	30%
3,001-4,000	109.24	74.14	32%
4,001-5,000	127.52	92.54	27%
5,001-6,000	149.10	111.18	25%
6,000+	159.10	124.26	22%

Volpe recommends the Input Substitution Factor value remain at 0.8. That figure is consistent with the underlying economic theory of input substitution and also the adjustment from service speed to typical operating speeds. This recommendation does not account for other input substitution capabilities of the carriers that are not available to USTRANSCOM, such as capital investments to reduce fuel consumption. Considering these other input substitution capabilities would likely further reduce the input substitution factor downwards, but as it is not possible to study these choices by the firms directly and no such systematic studies have been conducted regarding these other input substitution choices, Volpe only recommends an input substitution factor based on the carriers' capability to make speed adjustments.

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