# Universal Service Contract-10 Economic Price Adjustment Factor Update

## Bunker, Currency, and Fuel Adjustment Factor Refresh

Jonathan Badgley, Kaitlin Coppinger, David Hyde, Mae Lewis-Workman, Kendall Mahavier, David Pace, and Joey Reed

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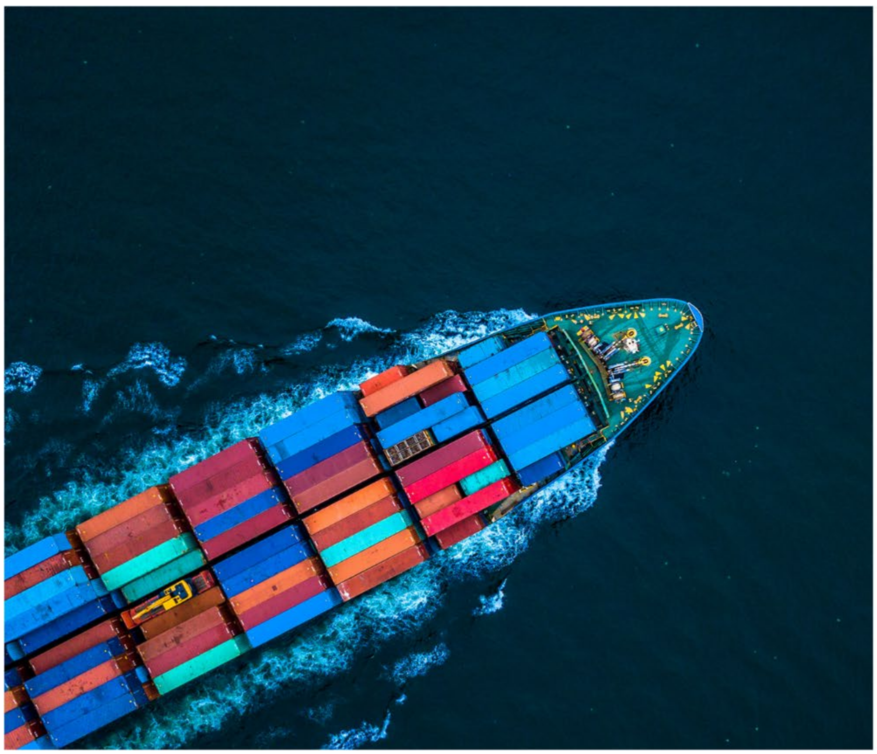

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John A Volpe National Transportation Systems Center
55 Broadway
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**14. ABSTRACT**

This report describes the refresh of the USTRANSCOM Economic Price Adjustment (EPA) factors for use in the Universal Service Contract 10 (USC-10). 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 and 2019, are the starting point for this update. Using updated shipment data from USTRANSCOM along with improved data methods, the technical factors for each EPA were updated. Several other methodological updates were made including an empirical estimation of the input substitution factor based on existing operational practices and International Maritime Organization (IMO) 2023 regulations.

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# List of Abbreviations

| Abbreviation | Term |
|---|---|
| AIS | Automatic Identification System |
| BAF | Bunker Adjustment Factor |
| BIX | Bunker Index |
| BTS | Bureau of Transportation Statistics |
| CAF | Currency Adjustment Factor |
| CARB | California Air Resources Board |
| CII | Carbon Intensity Index |
| CONRO | hybrid roll-on/roll-off container vessel |
| CONUS | Contiguous United States |
| DC | District of Columbia |
| 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 |
| EEXI | Efficiency Existing Ship Index |
| FAF | Inland Intermodal Fuel Adjustment Factor |
| FAR | Federal Acquisition Regulation |
| FEU | Forty-foot Equivalent Unit |
| FMCSA | Federal Motor Carrier Safety Administration |
| GHG | Greenhouse Gas |
| GT | Gross Tonnage |
| HSFO | High Sulfur Fuel Oil |
| IANA | Intermodal Association of North America |
| IBS | Integrated Booking System |
| IFO | Intermediate Fuel Oil |
| IMO | International Maritime Organization |
| iSDDC | Integrated Mission Support for Surface Deployment and Distribution Command |
| LNG | Liquid Natural Gas |
| LPG | Liquefied Petroleum Gas |
| LSMGO | Low Sulfur Marine Gasoil |
| m/m | Mass/Mass |
| MARAD | Maritime Administration |
| MEPC | Marine Environmental Protection Committee |
| MGO | Marine Gasoil |
| MPG | Miles per Gallon |
| MSP | Maritime Security Program |
| MTON | Measurement Ton |
| NOx | Nitrogen Oxides |

| Abbreviation | Term |
|---|---|
| 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 |
| SEEMP | Ship Energy Efficiency Management Plan |
| SDDC | Surface Deployment and Distribution Command |
| SOx | Sulfur Oxide |
| TEU | Twenty-foot Equivalent Unit |
| UAE | United Arab Emirates |
| USC | Universal Service Contract |
| USTRANSCOM | United States Transportation Command |
| VLSFO | Very Low Sulfur Fuel Oil |

# Executive Summary

This report describes the process for and outcome of updating the United States Transportation Command's (USTRANSCOM's) Economic Price Adjustment (EPA) factors for use in the Universal Service Contract 10 (USC-10). Vessel characteristics and operations continue to shift rapidly because of both regulatory changes and dynamic market forces such as International Maritime Organization (IMO) regulations, alternative fuel sources, and cost-competitiveness of inputs. These evolving market forces necessitate an EPA factor refresh ahead of new contract negotiations.

The three EPA factor methodologies, which include the Bunker Fuel Adjustment Factor (BAF), the Currency Adjustment Factor (CAF), and the Inland Intermodal Fuel Adjustment Factor (FAF), were originally developed by Volpe in 2009 for USC-7. Volpe has re-examined the EPAs for each subsequent USC including in 2013 (which included a validation of the factor methodologies) for USC-8 and again in 2018 for USC-9. [1,2]

**Economic Price Adjustment (EPA) Factors**

USTRANSCOM uses EPAs to address exposure to marine shipping input price volatility inherent to firm-fixed price contracts with long contract periods. The extended length of the USC increases exposure to market-driven input price risk (e.g., marine and diesel fuels and currency exchange rates) that have meaningful price volatility over extended periods. These price changes can compound, leading to significant differences between the contract price for a shipment and its market cost. In cases where an input experiences significant price volatility, an EPA helps to minimize the risk for both contract parties. EPAs allow for an adjustment to the net price paid by the shipper to the carrier when the input price shifts in accordance with negotiated terms. Typically, these terms involve rules for the extent of input price change and parameters for capturing how much of the input price volatility is beyond the control of either party to mitigate. EPAs allow firm-fixed price contracts to have a stable, fixed base freight rate while allowing responsiveness to excess input price volatility beyond the control of either the carrier or shipper.

For the 2023 update, Volpe reviewed the methodological foundation for the USC-9 EPAs, considering general industry practice, market trends, and feedback from the carriers and USTRANSCOM. The review concluded that the structure of the EPAs should remain the same. However, Volpe recommends changes to EPA parameter values. Recommendations are separated by implementation feasibility – those that USTRANSCOM can implement for the next contracting period and others that depend on changes in USTRANSCOM administrative capabilities (specifically migration of the Integrate Bridge

[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.

[2] Universal Service Contract-9 Economic Price Adjustment Factor Update Bunker, Currency, and Fuel Adjustment Factor Refresh, August 2019.

System (IBS)/CARE II systems to the cloud-based system and expansion of their features and capabilities) and should be considered for implementation in the future.

**Bunker Adjustment Factor (BAF)**

Volpe reviewed the underlying BAF structure and methodology developed in previous EPA studies and determined it remained applicable and did not require any fundamental updates. The following revisions were made to key input parameters:

- **Revised Representative Vessels:** The methodology for estimating representative vessels has been adjusted to consider only U.S. flagged vessels that moved cargo on a USC tariff between January 1, 2018, and March 8, 2023. For this refresh, carriers supplied Volpe with real world vessel data describing speed, capacity, and fuel consumption which was used to improve the technical factor accuracy. The method for assigning a representative vessel to a lane was adjusted to consider only either the shipment-weighted average of vessels that moved goods on a lane or the shipment-weighted average of U.S. flag vessels across all lanes. Additionally, combination container roll-on/roll-off vessel (ConRo) vessels are treated as either container and Roll-On/Roll-Off (RORO) vessels when moving containerized or breakbulk cargo. The breakbulk cargo vessel Broken Stowage Factor, which accounts for the additional cargo space required for breakbulk cargo due to size and stowage configuration inefficiencies, was revised from 28 percent to 35 percent based on USTRANSCOM input.
- **Revised Input Substitution Factor:** The recommended Input Substitution value for USC-10 has been revised upward to 0.90. In previous studies, the Input Substitution Factor was used to account for the use of service speed and fuel consumption which is higher than actual speeds. For this study, carriers provided real-world speed data so that the Input Substitution Factor does not need to account for significant difference in fuel consumption between service speed and real-world speed. The factor was also revised to reflect new IMO regulations that will require carriers to reduce vessel emissions. To achieve the new regulatory standards for emissions, carriers will need to manage fuel consumption using operational changes and capital investments that would not be possible to re-deploy in response to significant fuel price changes, and therefore the Input Substitution Factor was revised upward to account for the reduce capacity of carriers to manage fuel consumption in response to fuel price changes.
- **Revised (twenty-equivalent unit) TEU to (forty-equivalent unit) FEU Conversion Factor:** The TEU to FEU conversion factor has been updated using container shipment data between January 1, 2018 and March 8, 2023. The recommended TEU to FEU conversion factor increased to 1.96 from the 1.94 recommended in USC-9.
- **Mediterranean Emission Control Areas (ECA)**: Volpe calculated two sets of fuel mix factors for each lane to account for the Mediterranean Sea becoming an ECA zone in May 2025, which is a significant change in global shipping regulations that will impact the BAF payment amounts. The two sets of fuel mix factors are provided so that USTRANSCOM can update their BAF payment calculation in May 2025 to reflect the new Mediterranean ECA.
- **Fuel Price Sourcing:** Volpe recommends using prices for very low sulfur fuel oil (VLSFO) and

marine gasoil (MGO) to calculate the baseline and BAF payments. It recommends the following approaches for fuel price sourcing. Regardless of approach, USTRANSCOM should average the prices from whichever ports are ultimately selected and a single fuel price for each fuel type should be applied to all lanes.

  - **Status Quo Recommendation:** two contiguous United States (CONUS) ports – Los Angeles and Norfolk, averaged, with prices sourced from Bunker Index (requires USTRANSCOM to switch price provider).
  - **Low-Effort Recommendation:** one CONUS and one outside contiguous United States (OCONUS) port – Los Angeles and Antwerp, averaged, with prices sourced from either Bunker Index or Bunker World.
  - **High-Effort Recommendation:** global basket of ports – Los Angeles, Antwerp, Kuwait, and Houston, averaged, with prices sourced from Bunker World (the current source).

  Ultimately, USTRANSCOM will need to weigh the administrative burden of implementing the fuel price port sourcing recommendations when selecting the approach for USC-10.

- For the upcoming transition to a cloud-based version of the IBS and CARE II systems, Volpe recommends USTRANSCOM consider additional functionality that would be possible under the cloud-based systems but not under the legacy system to facilitate BAF implementation, including:
  - Consider including vessel IMO number in the Integrated Mission Support for Surface Deployment and Distribution Command (iSDDC) data so that it is available for future EPA refreshes.
  - Consider allowing the calculation of average fuel prices across multiple ports for each lane.
  - Consider calculating the BAF payment based on actual shipment distance between OD pairs.

For a full discussion of the BAF and any 2023 updates, see Section 2.

**Currency Adjustment Factor (CAF)**

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

The CAF is separated into three Superlanes which represent more than 90 percent of USTRANSCOM's contiguous United States (CONUS) and outside contiguous United States (OCONUS) shipments. Aggregating the CAF into these three Superlanes minimizes the administrative burden of the CAF while accurately representing shipment flows. It uses sixteen currencies from which the Superlane currency exchange volatility measures are derived. Currencies are included if at least one percent of USTRANSCOM shipments are moved within their respective Superlanes. The one percent decision rule limits the number of currencies, reducing implementation burden, while still capturing the geographic diversity of USTRANSCOM's cargo movements.

The CAF buffer 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 where a single or small group of currencies can skew the size of a Superlane buffer zone. In instances where the buffer is unusually narrow, a global mean buffer is applied. Volpe recommends applying the values that exclude the pandemic period and as such the buffer recommendations are as follows,

- **World Buffer (status quo)**, USTRANSCOM applies a single buffer to all currencies, – the buffer should be set at 4.75%
- **Superlane-Specific Buffer**, UTRANSCOM applies the larger of the Superlane or the global buffer – the Europe & the Med buffer should be set at 4.98%, the Far East Buffer should be set at 4.91%, and the Middle East & South Asia buffer should be set at 4.75%. The decision of which recommendation to apply, either the World Buffer (status quo) or the Superlane-Specific Buffer, is at the discretion of USTRANSCOM and is largely dependent upon the existing capabilities of IBS/CARE system and the future capabilities of the cloud-based systems.
- For the upcoming transition to a cloud-based version of the IBS and CARE II systems, Volpe recommends USTRANSCOM consider additional functionality that would be possible under the cloud-based system but not under the legacy system to facilitate CAF implementation, including allowing individual buffers for currencies when their volatility is higher than the global average.

For a full discussion of the CAF and any 2023 updates, see Section 4, Currency Adjustment Factor (CAF).

**Inland Intermodal Fuel Adjustment Factor (FAF)**

Volpe reviewed the underlying FAF structure and methodology developed in previous EPA studies and determined it remained applicable and did not require any fundamental updates. As part of the 2023 refresh, updates include calculating new zone distances based on recent USC shipment data and expanding the FAF to include moves in Alaska and Hawaii. With changes in USTRANSCOM's shipping patterns over the past few years, there were significant changes in some of the distance inputs to the FAF calculator and there were additional FAF calculations needed with the addition of Alaska and Hawaii zones.

Finally, a literature review was conducted to assess any changes in reported fuel economy for trucks and intermodal rail since 2018. Volpe also reviewed the distance at which intermodal rail would be considered a preferred alternative to truck, if the rail fuel consumption methodology should be revised, and if any changes were required to the truck driver off-duty time parameter for reefer shipments. There were generally only minor changes to these factors.

For the upcoming transition to a cloud-based version of the IBS and CARE II systems, Volpe recommends

USTRANSCOM consider additional functionality that would be possible under a cloud-based system but not under the legacy system to facilitate FAF implementation, including:

- Consider revising how OD pairs are collected to clearly identify ODs using new or existing fields.
- Consider requesting information from carriers about whether they will or may consider using rail during shipment.
- Consider calculating the FAF payment based on actual shipment distance between OD pairs.

For a full discussion of the FAF and any 2023 updates, see Section 5, Inland Intermodal Fuel Adjustment Factor (FAF).

# 1 Introduction

This report describes the update process of the United States Transportation Command (USTRANSCOM) Economic Price Adjustment (EPA) factors for use in the Universal Service Contract 10 (USC-10). These factors include the Bunker Adjustment Factor (BAF), the Currency Adjustment Factor (CAF), and the Inland Intermodal Fuel Adjustment Factor (FAF).

## 1.1 The Universal Service Contract (USC)

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,[3] 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.[4] 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. For example, under USC-9 the contracting periods were,

- USC-9 Base Year, September 2019 to November 2020
- USC-9 Option Year 1, December 2020 to August 2021
- USC-9 Option Year 2, September 2021 to August 2022
- USC-9 Option Year 3, September 2022 to August 2023
- USC-9 Option Year 4, September 2023 to August 2024

One challenge of this 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 separately 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 responsive to excess input price volatility beyond the control of either the carrier or shipper.

Additionally, the 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

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[3] 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)

[4] Contract description adopted from the USC-09 Synopsis document, a component of the USC-09 RFP (United States Transportation Command, 2022)

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

The revised EPAs in this report balance the need for accurate representation of USTRANSCOM’s evolving shipping patterns with the administrative burden of updating and implementing the EPAs.

## 1.2 Report Overview

This study documents the methodologies for parameter values of the BAF, CAF, and FAF calculations for USC-10. Sections 2-4 review each EPA separately and provide detail about the price volatility risk it mitigates, a complete description of the results, details about methodology and data adjustments, and recommendations for both the near-term using the current IBS/CARE II system and recommendations for the long-term cloud-based version of the IBS/CARE II systems.

# 2. The Unique Events of 2020-2022

The period between 2020 and 2022 presented the shipping industry with several significant challenges including the COVID pandemic, slowing of the global supply chain, and the Russian invasion of Ukraine. The pandemic put pressure on shipping flows and global supply chains, and then the oil market was affected by the start of the Russian invasion of Ukraine causing significant spikes in fuel prices. While the industry is starting to return to the stability that it enjoyed in the years prior, the impact of these events still lingers.

**Pandemic & Increased Supply Chain Pressures** – the pandemic exposed the high level of global interdependency that forms the backbone of local economies. Driven by declines in demand, lockdowns, key sector shortages, and industrial base shutdowns, world merchandise trade contracted 9 percent in 2020.[5] While the pandemic affected the entire globe, individual communities were responsible for deciding and directing their community's response. However, these disruptions at the local level had far reaching economic impacts. With lockdowns, volatile fuel prices, and shifting supply patterns, cargo vessel calls fell, and a series of blank sailings were introduced. Blank sailings mean fewer opportunities to move cargo and when compounded by port closures from COVID precautions and vessel backlogs at overwhelmed ports. The pandemic period there was a shift in location of port calls, away from some of the more traditional choices toward less congested, non-pandemic impacted ports. For shippers, the pandemic added friction to a usually seamless supply chain – cargo that would normally arrive *just in time* may arrive early or late and it could vary from sailing-to-sailing. Cargo owners had to hold additional stock and order early to make sure they had inventory on hand and even then, there were still shortages related to difficulties producing and moving component parts introducing slowdowns higher up in individual product supply chains.

Economic uncertainty and friction in the supply chain led to volatility in the marketplace, including the market for bunker fuel. Early in the pandemic, oil prices fell, see Figure 1, but as the pandemic lingered and the Ukraine-Russia conflict intensified, prices began to trend upward.

[5] UNCTAD, 2022

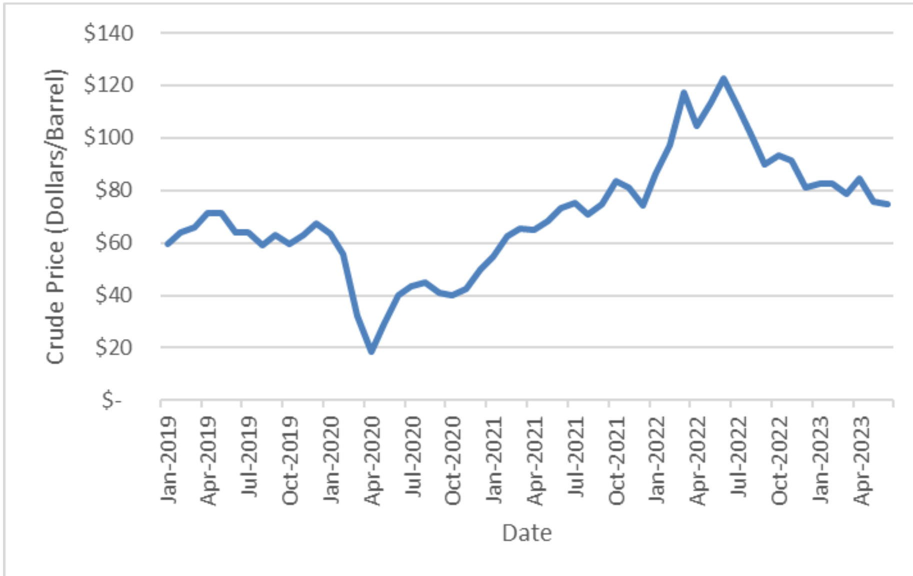


**Figure 1. Crude Price 2019-April 2023**

When prices are high, carriers will take the most efficient route, but when fuel prices drop, other routing options become equally cost-effective or relatively cost beneficial. For example, some carriers chose to reroute vessels from the Suez Canal around the Cape of Good Hope as the additional fuel consumed travelling the greater distance was lower than the costs associated with queuing and transiting the canal.[6] Carriers also shifted capacity and port calls, reflecting pandemic waves and its asynchronous spread across the world.[7] With limited excess capacity in the broader supply chain network, this shift in ocean carrier operations had cascading effects on related supply-chain systems including congestion from new traffic levels at container ports and with domestic rail and truck freight carriers.

**Russian Invasion of** Ukraine – in February 2022, Russia began their full-scale invasion of Ukraine which led to an unprecedented spike in the price of bunker fuel. Prices remained high for a significant portion of 2022 and remained high, relative to historical trends for even longer.[8]

In addition to these significant exogenous events, the bunker market was in the midst of an overhaul from the International Maritime Organization (IMO) 2020 regulations. The Marine Environmental Protection Committee (MEPC) is responsible for coordinating the IMO's environmental actions – prevention and control of environmental pollution from ships – which includes IMO's 2020 sulfur cap reduction. On January 1, 2020, a global sulfur cap reduction from 3.5% mass/mass (m/m) to 0.5% m/m went into effect, which banned carriage of all high sulfur fuel oil (HSFO) for vessels not fitted with scrubbers starting in March 2020. Relative to the HSFO, VLSFO is expensive, and the global uncertainty

[6] Ibid.
[7] Ibid.
[8] Miller, 2022.

only worsened the spread.

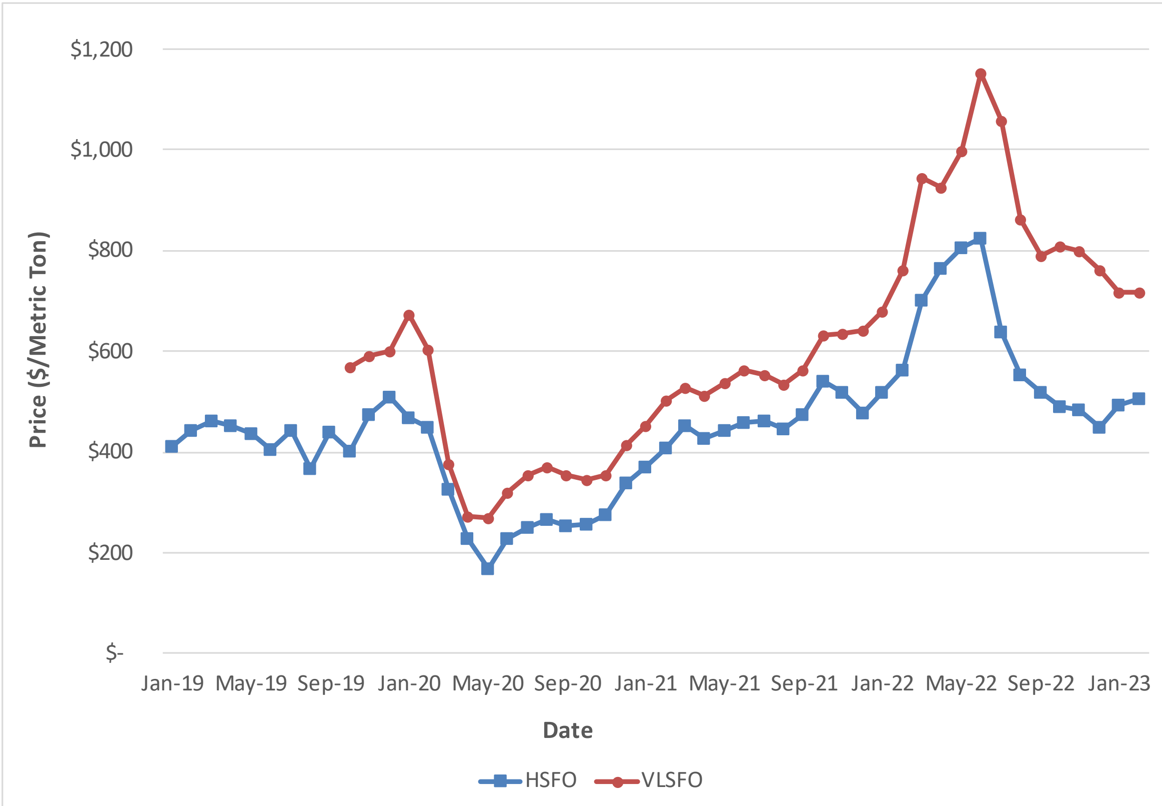


**Figure 2. Comparison of VLSFO and HSFO (Intermediate Fuel Oil (IFO) 380)**

As shown in Figure 2, VLSFO and HSFO track closely in terms of absolute prices for much of 2020 and 2021. VLSFO is consistently more expensive and while there is some variation in the price spread, it averages around $100 in both 2020 and 2021. In 2022, the spread jumped to an average of almost $300 in 2022 with the peak being over $400.

The period of 2020-2022 was anomalous with significant factors causing fuel prices to exceed the normal historical fuel price volatility – even beyond previous periods that were considered abnormal volatility. In economics, Black Swan Theory describes random, unexpected, but high-impact events of which there's no past data to point towards its occurrence in the foreseeable future. There is not a formal definition for such events, but the impact of global pandemic and supply chain crunch and supply chain meltdown coupled with an invasion would likely qualify. Given that the 2020-2022 was so anomalous, these outlier periods have been excluded from the buffer calculations for both the BAF and the CAF for USC-10.

| **Understanding Different Marine Fuel Types and their Use** |
|---|
| Commercial shipping vessels may use a variety of fuel types depending on their location and operations. For majority of the voyage, vessels use what we call "**Over Ocean Fuel**." This term describes fuel that is appropriate for use outside of ECA zones and is compliant with the IMO fuel |

sulfur limit of 0.5%.

In coastal or inland waters, environmental protection regulations may designate **ECAs**. These areas are characterized by mandatory measures governing vessel emissions. Vessels are required to use low sulfur fuel, <0.1% m/m and must comply with Tier 3 nitrogen oxide (Nox) emission requirements.[9] North America alone has over 300 designated ECAs, which cover the entire coastline of the United States (see Figure 3).[10] 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.

On May 1, 2025, the Mediterranean Sea will become an ECA zone requiring vessels sailing in the sea to use low sulfur fuel, <0.1% m/m and must comply with Tier III Nox emission requirements.[11] Due to this change occurring during the USC-10 period, Volpe has calculated the ECA distance for both the current ECA regime and the future ECA regime after May 1, 2025 (See Section 3.4.4.1 for a discussion of the lane distance methodology including ECA distances). Volpe provides two sets of fuel mix factors in this report to reflect the two different ECA distances in each of these future periods (See Appendix C: Fuel Mix Factors).

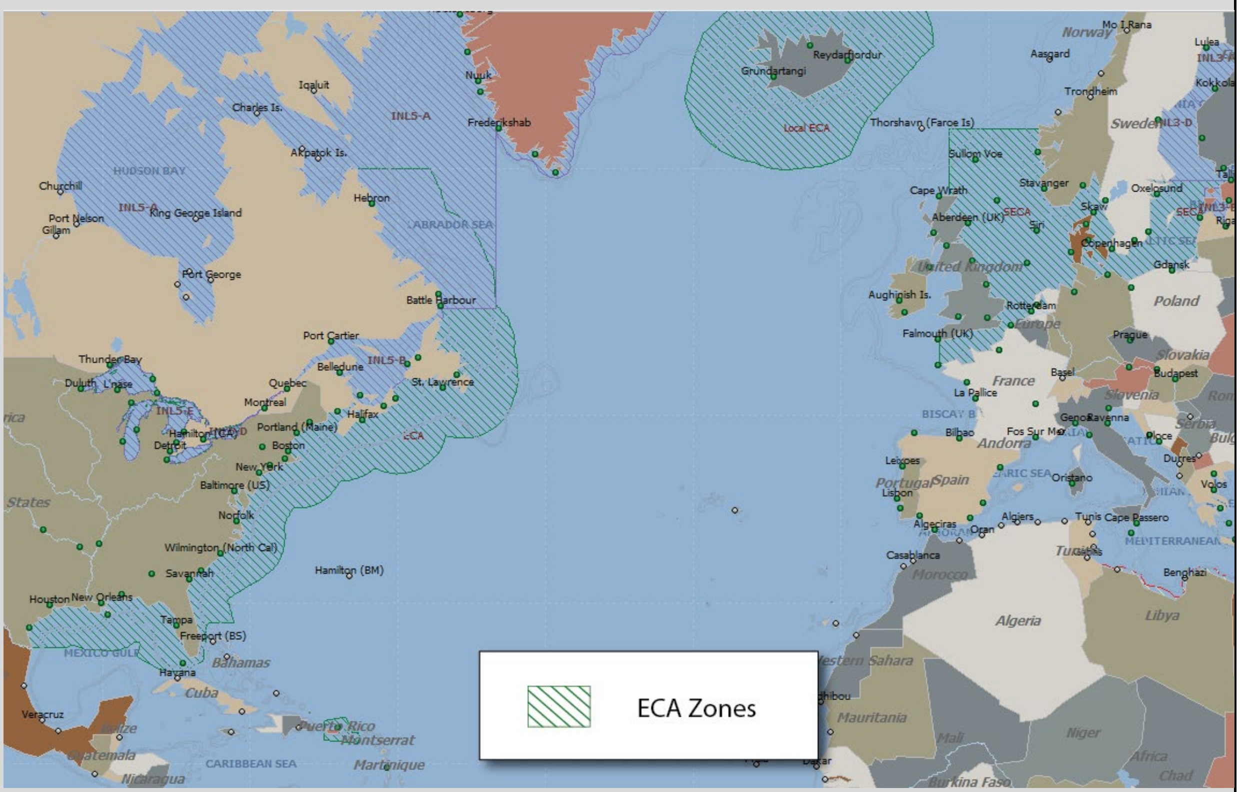


**Figure 3. ECA Zones**

Additionally, depending on the Port, local regulations may impose stricter emissions standards for

[9] Tier III requirements apply to in areas where NOx emissions are subject to more stringent regulations, Nitrogen Emission Control Areas (NECAs), and to all ships constructed after January 1, 2016.

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

[11] United Nations, 2022

vessels to follow while in port. For example, the California Air Resources Board (CARB) enforces a 0.10% m/m sulfur limit within 24 nautical miles of the California Coast, which includes California ports. For the purpose of this analysis, we assume that vessels are required to use a low sulfur fuel (such as one appropriate for an ECA Zone) in port, accounting for at minimum 5 percent of the journey. In the analysis, this share is included in the ECA Fuel Mix Share. This is consistent with all earlier EPA work conducted for USTRANSCOM.

As part of this report, we discuss the following fuel types,

- **MGO** – assumed to be compliant at the low end of the sulfur content rage, at-or-below 0.5% m/m.
- **HSFO** – pre-2020, this was the standard for over ocean fuel. With a sulfur maximum of 3.5% m/m, this fuel is no longer compliant with IMO standards unless the vessel has been fitted with an emission scrubber.
- **VLSFO** – IMO 2020 compliant fuel with a maximum sulfur content of 0.5% m/m. Post-2020, this is the standard over ocean fuel for vessels without an emission scrubber installed.

**For the purpose of this analysis, only two fuel prices are considered: low-sulfur MGO is the ECA Zone and Port fuel, and VLSFO is the Over Ocean fuel.**

Looking to the future, a variety of alternatives to high pollution marine fuels that vessel owners are beginning to explore. Vessels using these alternative fuels such as liquid natural gas (LNG), Liquefied Petroleum Gas (LPG), Ammonia, Hydrogen, and Methanol are already on the orderbook and while their market share remains small, as the IMO continues its work to decarbonize the shipping industry, it's likely that use of these fuels will be more widespread, and they'll be more widely available at ports worldwide.

# 3. Bunker Adjustment Factor (BAF)

This section describes the updates to the USTRANSCOM BAF for use in USC-10. The existing BAF structure and methodology remain fundamentally the same, but the parameter values have been updated based on USTRANSCOM shipment patterns in USC-9 and general maritime market conditions. Any improvements made to input data estimation methodology or other calculations reflect greater data availability and improved the accuracy of model inputs and estimation. Updating the underlying data ensures that the USC-10 BAF is representative of recent USTRANSCOM shipping patterns, new global fuel standards, and marine fuel price volatility.

## 3.1 USTRANSCOM's BAF

As USTRANSCOM requires that price quotes be exercisable up to 17-months from the time of bidding and rate setting, USCs 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.

In the case of USTRANSCOM's EPA factors, they are designed to be risk sharing mechanisms, an element introduced by the FAR/DFARS regulations for application of EPAs. Carriers can manage fuel consumption in ways that aren't available to shippers such as adjusting input mixes, shifting costs, or hedging prices with 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 no control over the carrier's economic choices.

Figure 4 shows average fuel prices taken from Bunker Index across high activity ports including Los Angeles, Houston, Amsterdam, and Singapore for MGO and VLSFO between January 2009 and January 2023.

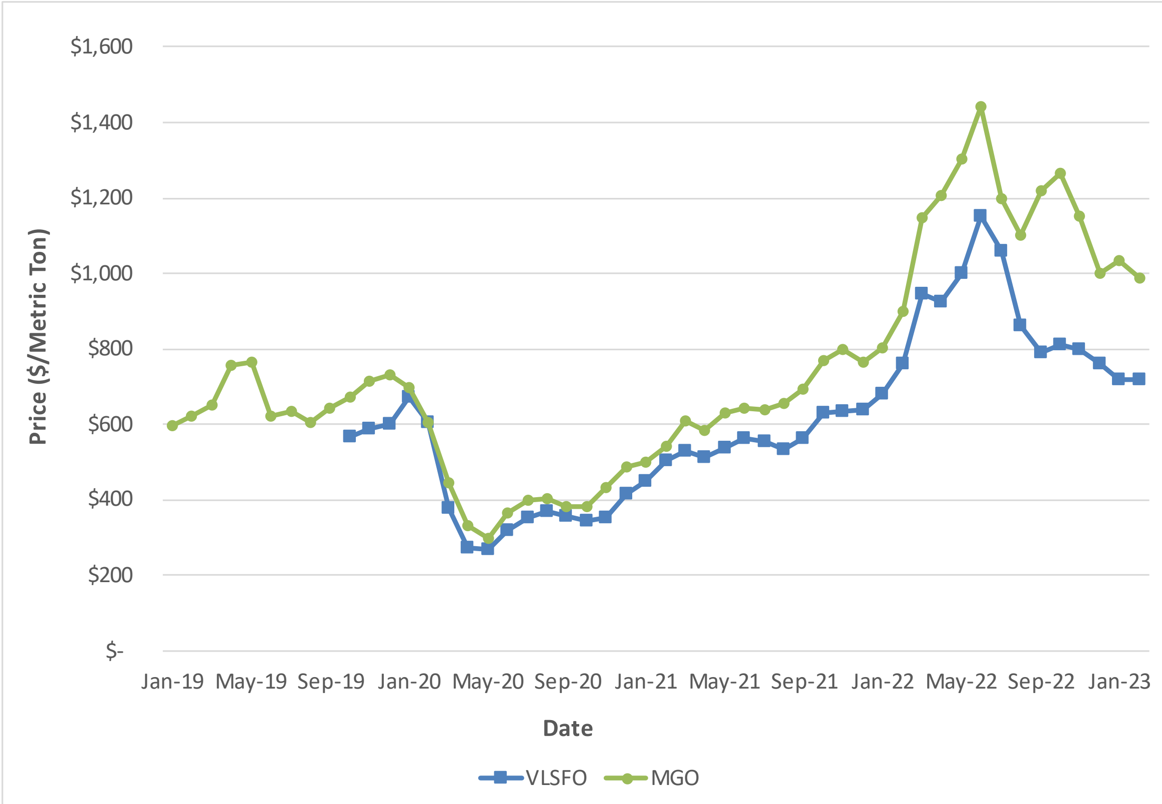


**Figure 4. Monthly Average MGO and VLSFO Fuel Prices (2009-2023)**

The fundamental purpose of the USC BAF is to share the risk of excess fuel price volatility between USTRANSCOM (the shipper) and the ocean carriers by compensating the party made worse off by that volatility. 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 imposes risk on 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, the price of fuel may vary significantly from the fixed price of the cargo rate quoted at the start of the contract.

### 3.1.1 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 that impose inclusion of a symmetrical buffer zone, 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.

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 factor 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 distribution factor whose value can range from zero to one.

Their relationship is shown below in Equation 1.

$$BAF = \Delta p_f \times Fuel_{CU} \times Input\ Substitution\ Factor \times Risk\ Distribution\ Factor$$

**Equation 1. General Structure of USTRANSCOM BAF**

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

#### 3.1.1.1 $\Delta p_f$, the Price Change Outside the Buffer Zone

The baseline fuel price establishes the expected fuel price at the time the USC is set and a buffer zone around that price. Movements in fuel price during the USC 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 noted earlier, vessels may use multiple fuel types depending on vessel positioning (middle of the ocean versus ECA) 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, "new" price, and buffer 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.

#### 3.1.1.2 $Fuel_{CU}$, 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))[12] of cargo. This value applies fuel price volatility to 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 speed) and operational constraints of the

[12] An MTON is a volumetric measure equal to 40 cubic feet (1.133 $m^3$).

carrier and specific trade routes—a practical BAF can only include a limited number of these considerations.

#### *3.1.1.3 Input Substitution Factor*

Carriers can adjust their operations to mitigate the impact of rising fuel prices while USTRANSCOM cannot. Economic theory holds that as the price of any one input rises, a producer will shift their production to use less of the relatively more expensive input. Carriers have opportunities 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, more fuel-efficient engines. Within the USC, the Input Substitution Factor incentivizes carrier behavior to make short-term adjustments within a base or option year, as long-term fuel efficiency adjustments would be incorporated into lower bid prices for future contract periods. The Input Substitution Factor is applied symmetrically to the BAF payment: With rising fuel prices, the factor adjusts the BAF payment to carriers downward, incentivizing carriers to minimize costs by operating more efficiently and not pass all the fuel cost increase to the shipper. With falling prices, the factor adjusts the BAF payments to shippers downward to incentivize carriers to return to normal operations.

The Input Substitution Factor is a negotiated value, ranging between 0 and 1. At 0, a carrier can adjust inputs to fully account for the fuel price change. At 1, a carrier has no ability to adjust operations to economize on more expensive fuel.

#### *3.1.1.4 Risk Distribution 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, whereas USTRANSCOM does not have the capability or experience to manage fuel price volatility for their shipments. Therefore, the carriers should manage most of the risk, and because USTRANSCOM determines the length of the contract, which introduces the risk of fuel price volatility, they should bear some of the risk. The Risk Distribution Factor is applied symmetrically to fuel price increases above the buffer and decreases below the buffer.

The Risk Distribution Factor assigns a portion of fuel price volatility risk to each party. It is a negotiated value, ranging between 0 and 1; at 0 no BAF would be paid, and at 1 the full BAF payment would be paid on any excess volatility.

### 3.1.2 Activating the BAF

The BAF is only intended to mitigate risk from excess price volatility. If the absolute price fuel price difference does not exceed a determined buffer zone, a percentage deviation from the baseline, then there is no BAF payment. Fuel price volatility within the buffer zone is considered normal and the carriers are expected to be able to manage it; however, fuel price volatility outside of the buffer zone is considered abnormal and constitute a risk that is shared between both parties in the contract. The buffer is calculated empirically based on historical fuel price volatility.

### 3.1.3 Relationship between the BAF and the Base Rate

The base freight rate and the BAF are additive, a notional representation is shown in Figure 5, 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).

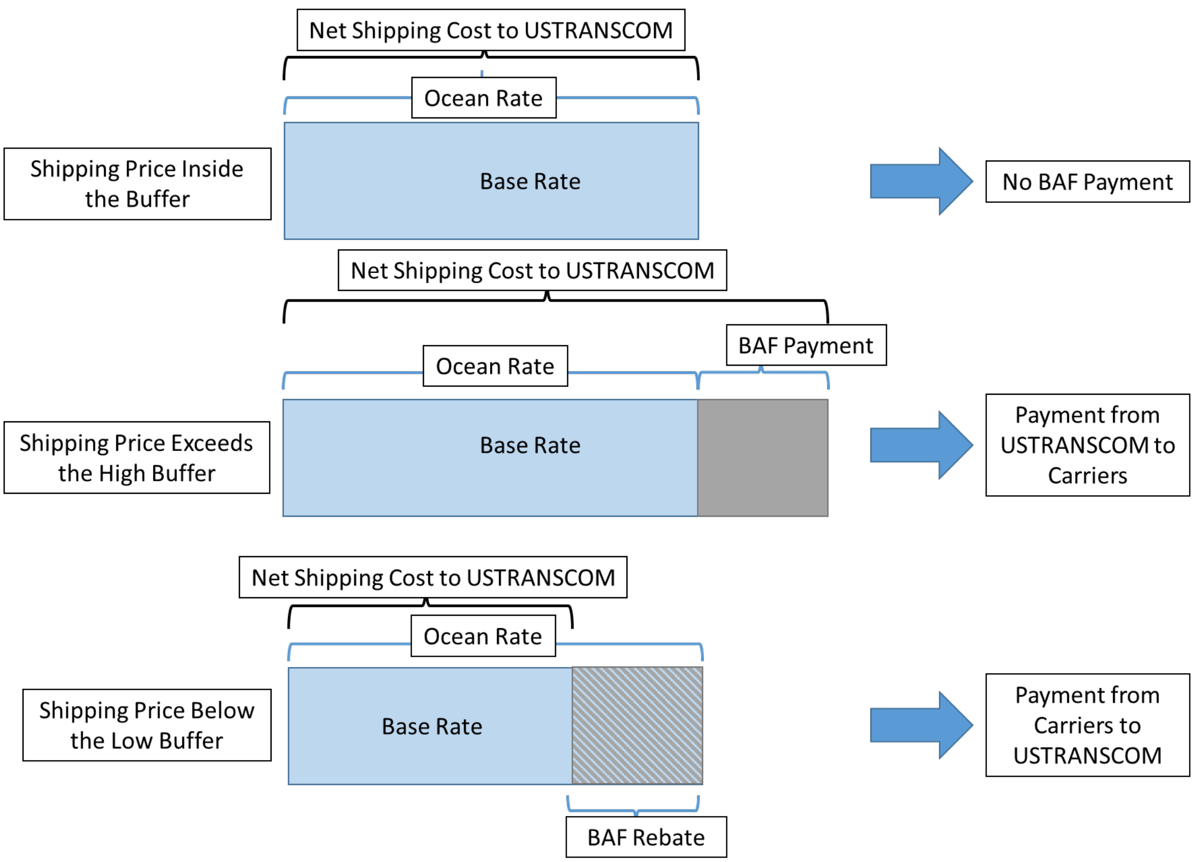


**Figure 5. Notional Representation of Net Shipping Cost and BAF Payments**

### 3.1.4 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.

- Section 3.2 covers the fuel price differential and buffer zone.
- Section 3.4 covers the fuel consumption amount per unit of cargo.
- Section 3.5 covers the Input Substitution Factor

- Section 3.6 covers the Risk Distribution Factor
- Finally, Section 3.7 covers the final BAF technical factors.

## 3.2 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 third-party sources such as Bunker World and Bunker Index.[13] 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.

### 3.2.1 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 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; the volatility of the chosen prices will trigger a BAF payment if that volatility is outside the buffer zone. For the purpose of the BAF, low sulfur MGO (<0.1%) should be considered the port fuel and VLSFO (<0.5% m/m) should be considered the over ocean fuel.

#### *3.2.1.1 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 price variation by fuel grade, the price 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. Figure 6 shows the average annual fuel prices for MGO and VLSFO for Los Angeles, Houston, Amsterdam, and Singapore from 2019 to 2023.[14]

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[13] Bunker Index, 2023

[14] iBID.

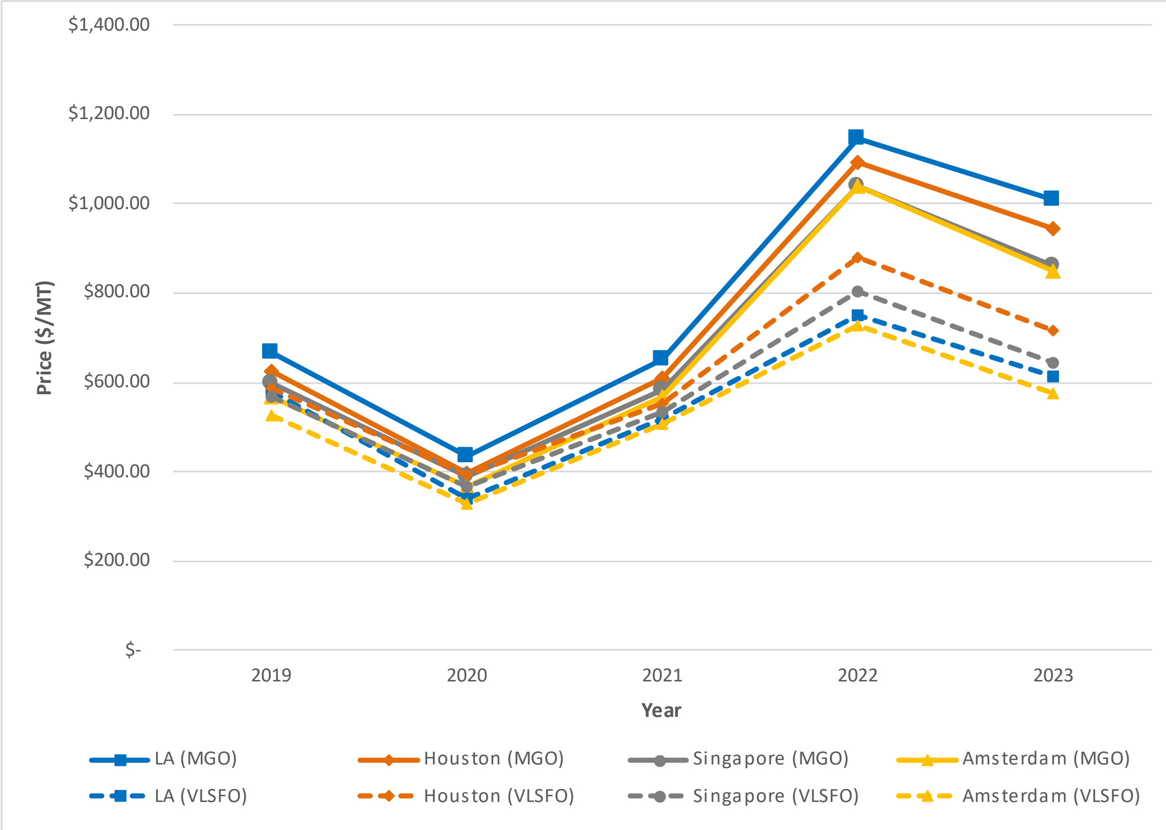


**Figure 6. Average Annual Fuel Prices by Fuel Type and Port**

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.

#### *3.2.1.2 Recommended Port Mix for Acquiring Fuel Prices*

Multiple carriers expressed some concern and provided feedback on the specific ports they deemed appropriate for inclusion in the BAF. Several carriers also suggested methodological changes to how ports were selected, either averaging top global ports or by selecting ports frequented by U.S. flag vessels. In response to carrier concerns, USTRANSCOM asked Volpe to review the selected ports, the methodology for selection, and the service used to source prices.

Volpe used a two-step approach to select ports as fuel price sources. First, ports were ranked by the total number of USC cargo records that moved through a given port. Second, the top ports identified were compared to the list of ports suggested by the carriers. Any ports that were on both lists were flagged for consideration.

For each port under consideration, Volpe assessed what fuel prices were available at these ports – it was important to select ports that had the same prices available from the same pricing service. Volpe reviewed several pricing services including Argus Media, Bunker Index, Bunker World, and Ship & Bunker. The services are relatively similar in that they provide bunker prices at a variety of ports across the world. They can be distinguished by their ease of use, the supported features (some are more extensive in terms of the research capabilities and insights they offer), and which ports and what fuel types are included. Volpe reviewed both Bunker World, the current pricing service, and Bunker Index, a potential new service focusing on USTRANSCOM's stated needs.

- For Bunker Index, the fuel prices considered were VLSFO 0.5% and MGO
- For Bunker World, the fuel prices considered were Marine Fuel 0.5% and low-sulfur MGO (LSMGO)[15]

In considering the 30 most frequently visited ports, only twelve had pricing for both Maritime Fuel 0.5% and MGO at relevant Bunker World ports; ten ports were available from Bunker Index.

The final decision of which ports to use depends largely on how Volpe's recommendations will be implemented. At minimum, Volpe recommends averaging the prices from the chosen ports and applying a single average to all lanes. Currently in USC-9, lanes are assigned to one of two CONUS ports, regardless of whether the lane touches either of those two ports. Given that there can be some regional variation, it would be preferable to average the prices, creating a single worldwide value that could be used to set the baseline and new monthly fuel prices for all lanes. This average would be a more accurate representation of the fuel prices facing U.S. flag carriers than the price at any single port. The final Volpe recommendations are as follows,

- USTRANSCOM should average the prices from whichever ports are ultimately selected and a single fuel price for each fuel type should be applied to all lanes.
- **Status Quo Recommendation**, two CONUS ports – Los Angeles and Norfolk with prices sourced from Bunker Index (requires USTRANSCOM switch price provider).
- **Low Effort Recommendation**, one CONUS and one OCONUS port – Los Angeles and Antwerp with prices sourced from either Bunker Index or Bunker World.
- **High Effort Recommendation**, global basket of ports – Los Angeles, Antwerp, Kuwait, and Houston with prices sourced from Bunker World (the current source).

### 3.2.2 Setting the Baseline Price

USC 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.

[15] Bunker World does have MGO pricing for ports; however, it is not sufficiently low in sulfur for use across ECA zones and ports. USTRANSCOM should continue collecting the LSMGO prices.

The formula for the BAF baseline for a given lane is shown below in Equation 2:

$$Baseline\ Price = Price_{Over\ Ocean} \times Fuel\ Mix\ Factor_{Over\ Ocean,lane} + Price_{ECA\ /\ Port} \times Fuel\ Mix\ Factor_{ECA\ /\ Port,lane}$$

**Equation 2. BAF Baseline Price for a Given Lane**

Where,

- Price is the average prices of relevant fuels (VLSO and MGO) for the 3-month period immediately preceding the issue date of the solicitation and,
- Fuel Mix Factors describe the unique fuel mix based on origin and destination, local regulations, and route distance for each lane.

These inputs are described further in subsequent sections.

#### *3.2.2.1 Calculating the Fuel Mix Factors*

Due to regulations limiting emissions in different areas, each lane has a unique fuel mix requirement based on routing between origin and destination. This analysis assumes that carriers may use up to two types of fuel per journey (Over Ocean and ECA / port). The use of these fuels is determined by vessel operations and the regulations that prevail along the route where a vessel is sailing or at the ports at which the vessel is calling. The mix of fuels is determined using the average route on the lane which provides the distances sailed in the relevant regulation areas. See Section 3.4.4.1 for a complete description of how routes were determined.

The fuel share for ports is assumed to be 5 percent for all lanes with the remaining 95 percent of the mileage separated into the "Over Ocean" and ECA portions.

$$Fuel\ Share_{Port} = total\ nautical\ miles_{lane}\ x\ 0.05$$

**Equation 3. Fuel Share for Ports**

The Fuel Share for ECA is the share of nautical miles on the route within the ECA zone multiplied by 0.95. as shown in Equation 4.

$$Fuel\ Share_{ECA,lane} = \frac{ECA\ nautical\ miles_{lane}}{total\ nautical\ miles_{lane}} \times 0.95$$

**Equation 4. Fuel Share for ECA by Lane**

As vessels use MGO in both ports and ECA zones, these fuel shares can be combined into one fuel mix factor for ECA and ports.

$$\boldsymbol{Fuel\ Mix\ Factor_{ECA\ /\ Port,lane} = Fuel\ Share_{Port,lane} + Fuel\ Share_{ECA,lane}}$$

**Equation 5: Fuel Mix Factor for ECA / Port by lane**

The Fuel Mix Factor for Over Ocean is 1 minus the fuel mix factor for ECA and Ports as shown below in Equation 6.

$$Fuel\ Mix\ Factor_{Over\ Ocean,lane} = 1 - Fuel\ Mix\ Factor_{ECA\ /\ Port,lane}$$

**Equation 6. Fuel Mix Factor for Over Ocean by lane**

For the full list of fuel mix factors by lane, see Appendix C: Fuel Mix Factors.

#### *3.2.2.2 Re-Baselining*

Annual re-baselining of fuel prices is a critical requirement of the BAF and contracting process. Under the USC, 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, then 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. By definition, 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 7. Red circles indicate the period when the baseline is set, and the buffer adjusts around that price for the subsequent contracting period.

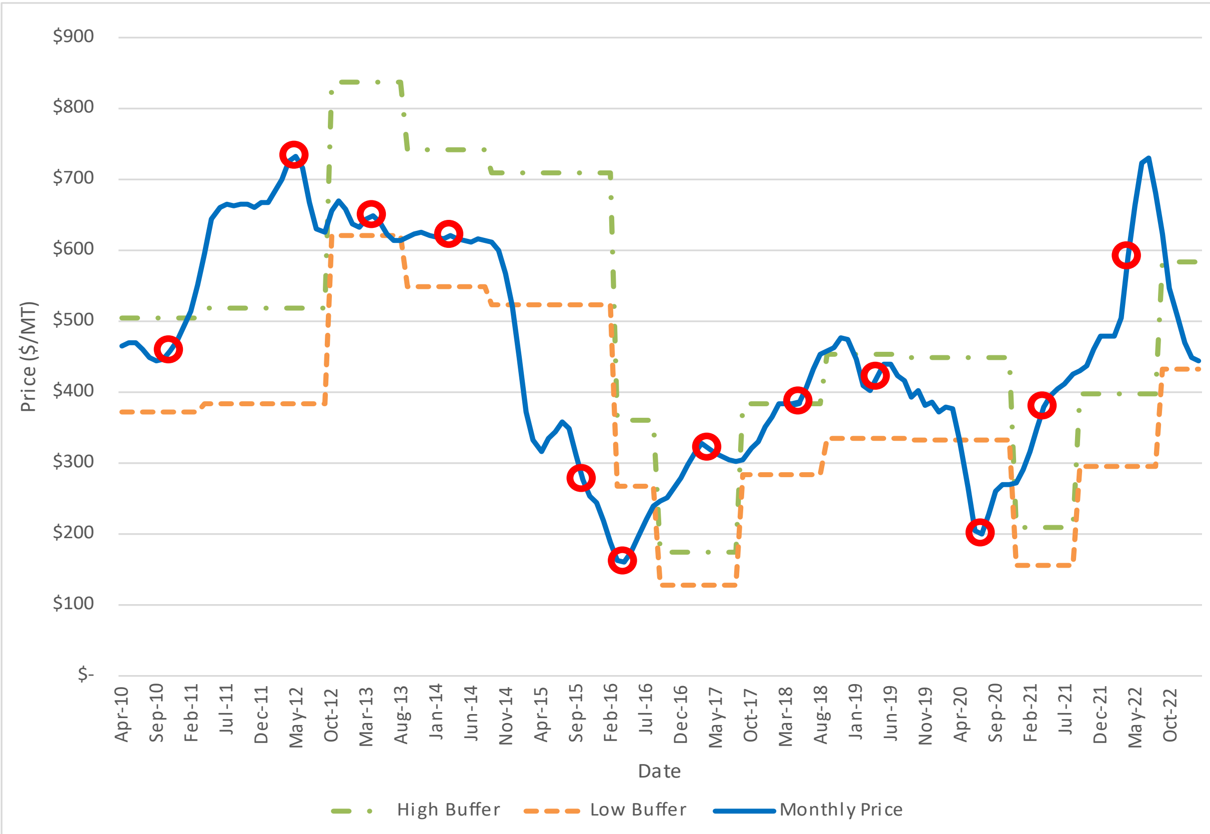


**Figure 7. Notational Depiction of Annual Re-baselining**[16]

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 infrequently and only at the beginning of contracting periods, as is done in Figure 8, the baseline will fail to move in tandem with base ocean rates resulting in the majority of the burden of fuel prices shifting to the shipper.

[16] 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 (2009-2023), BunkerWorld MGO and IFO380 average monthly fuel prices for Los Angeles and Norfolk (2007-2009).

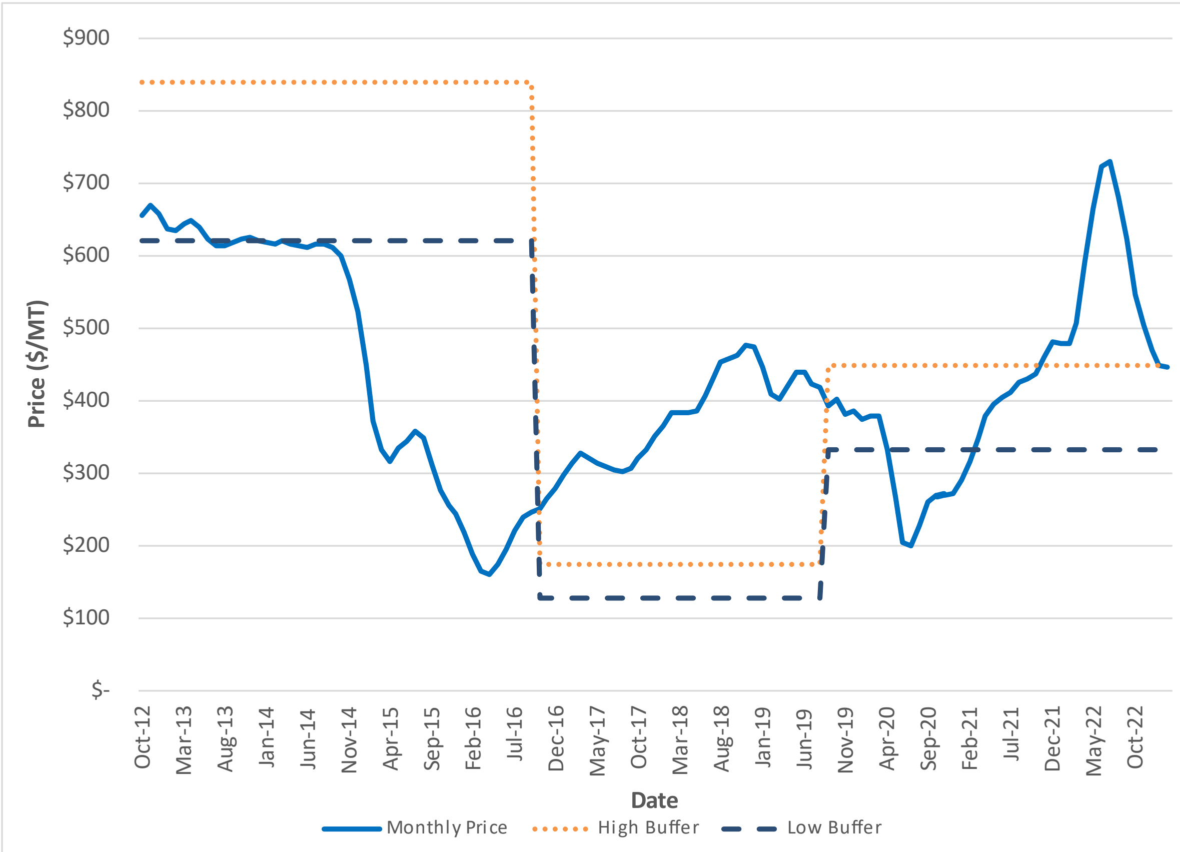


**Figure 8. No Re-Baselining** [17]

Whereas the price trend in Figure 7 is, at times, between the high and low buffer and no BAF is paid, Figure 8 depicts a price trend almost exclusively outside the buffer zone, requiring a BAF payment for most periods. In instances where fuel prices were significantly higher than the buffer zone for a prolonged period, it's possible in setting the rates that the carrier essentially passes on all fuel price volatility to the shipper. At that point, 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.

#### *3.2.2.3 Calculating the Baseline*

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

Recalling Equation 2,

$$Price_{Over\ Ocean} \times Fuel\ Mix\ Factor_{Over\ Ocean,lane} + Price_{ECA\ /\ Port} \times Fuel\ Mix\ Factor_{ECA\ /\ Port,lane}$$

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

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 ECA / Port Zone fuel (MGO) is $401.00 per ton.
- The three-month average price of Over Ocean fuel (VLSFO) is $363.50 per ton.
- 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 4,

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

From Equation 5,

$$\begin{aligned} Fuel\,Mix\,Factor_{ECA\,/\,Port} &= Port\,Share + (1 - Port\,Share) \times Fuel\,Share_{ECA} \\ &= 0.05 + (1 - 0.05)(0.25) = 0.2875 \end{aligned}$$

Recalling Equation 6,

$$Fuel\,Mix\,Factor_{Over\,Ocean} = 1 - Fuel\,Mix\,Factor_{ECA\,/\,Port}$$

$$Fuel\,Mix\,Factor_{Over\,Ocean} = 1 - 0.2875 = 0.7125$$

In summary, the fuel mix factors would be 29 percent for ECA / Port Zones, and 71 percent for Over Ocean.

From Equation 2,

$$Price_{\,Over\,Ocean} \times Fuel\,Mix\,Factor_{Over\,Ocean} + Price_{ECA\,/\,Port} \times Fuel\,Mix\,Factor_{ECA\,/\,Port}$$

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

$$\$363.50 \text{ per ton} \times 0.7125 + \$401.00 \text{ per ton} \times 0.2875 = \$374.28 \text{ per ton}$$

For this fictional route, the baseline would be set at $374.28 per ton.

### 3.2.3 Establishing the "New" Price Level

USTRANSCOM publishes the BAF for a shipment within a given month two months ahead—for March 2024, the BAF report is updated in January 2024 using the average fuel prices from December 2023. This ensures carriers have advance knowledge on what the BAF payment will be before agreeing to any individual shipment.

The “new” price is calculated using Equation 2 with some adjustments, as in

$$Baseline\ Price = New\ Price_{Over\ Ocean} \times Fuel\ Mix\ Factor_{Over\ Ocean,lane} + New\ Price_{ECA\ /\ Port} \times Fuel\ Mix\ Factor_{ECA\ /\ Port,lane}$$

**Equation 7. BAF Re-Baselining Price by Lane**

The fuel mix factors remain unchanged as the route is 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.

Building on the fictional route example described in Section 3.2.2.3, assuming all prices increase by 20 percent, the “new” price level would be calculated as follows:

- The “new” price for ECA Zone / Port fuel (MGO) is: $481.20 per ton.
- The “new” price for Over Ocean fuel (VLSFO) is: $436.20 per ton.
- The fuel mix factors are unchanged at 28.75 percent for ECA Zone / Port, and 71.25 percent for Over Ocean.

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

$$New\ Price_{Over\ Ocean} \times Fuel\ Mix\ Factor_{Over\ Ocean,\ lane} + New\ Price_{ECA\ /\ Port} \times Fuel\ Mix\ Factor_{ECA\ /\ Port,\ lane}$$

$$= \$436.20 \text{ per ton} \times 0.7125 + \$481.20 \text{ per ton} \times 0.2875 = \$449.14 \text{ per ton}$$

## 3.3 Calculating the BAF Payment

BAF payments occur if the “new” price of fuel at the time of shipping exceeds the baseline price above or below a buffer in percentage terms.

### 3.3.1 Net Fuel Price Change

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

$$\%\Delta_{price} = \frac{New\ Price - Baseline\ Price}{Baseline\ Price}$$

**Equation 8. Percent Price Change**

This percent price difference, $\%\Delta_{price}$, is compared to the buffer range to determine whether the price change is considered normal volatility.

### 3.3.2 Establishing the BAF Buffer

The buffer zone is the percentage deviation from the baseline fuel price that is considered normal volatility. 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 by lane 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), and
- 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 USCs 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 is 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.

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 9 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 9. 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 February 2023 is used.[18] The first period ran from June 2009 to May 2010, with the baseline set in January 2009. The last period was January 2019 to February 2020, with the baseline set as the October 2018 average.[19]

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[20,21,22]).

Mathematically, this adjustment is represented below in Equation 10 as:

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

**Equation 10. Volatility Adjustment**

Values that do not meet this criterion are removed from the initial average volatility dataset. After this adjustment has been made, Equation 9 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)

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

[19] Details on the CAF buffer data and calculation can be found in Section 4.2.2

[20] Clark et al., 2004

[21] Kenen et al, 1986

[22] Schnabl, 2007

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 has been required since 2020 is anticipated to price closer to, although still less than, MGO and ECA fuels).

#### *3.3.2.1 BAF Buffer Results*

Results from applying the buffer methodology are presented in Figure 9 below, which shows both the average monthly volatility (relative to the baseline) for MGO, IFO380 and crude oil from 2009 through February 2020 (prior to COVID) and the adjusted typical average volatility across the entire time frame.[23] While it is preferable to base the buffer calculation on MGO and VLSFO which are the primary fuel types used by U.S. flag carriers, the VLSFO is a relatively new fuel type and given the limited price history. Most of the VLSFO fuel price history occurs during COVID-19 pandemic period and the Ukrainian-Russian conflict so the fuel price data is not representative of normal price volatility.

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.

[23] The full dataset runs through February 2020, but because the chart shows the baseline month, it runs through October 2018. The baseline month is showing the first month of a 17-month period of analysis as the baseline is set 5 months ahead of the 12-month period over which the average is calculated. The chart stops at the final baseline month where the full analysis period is before onset of the COVID-19 pandemic.

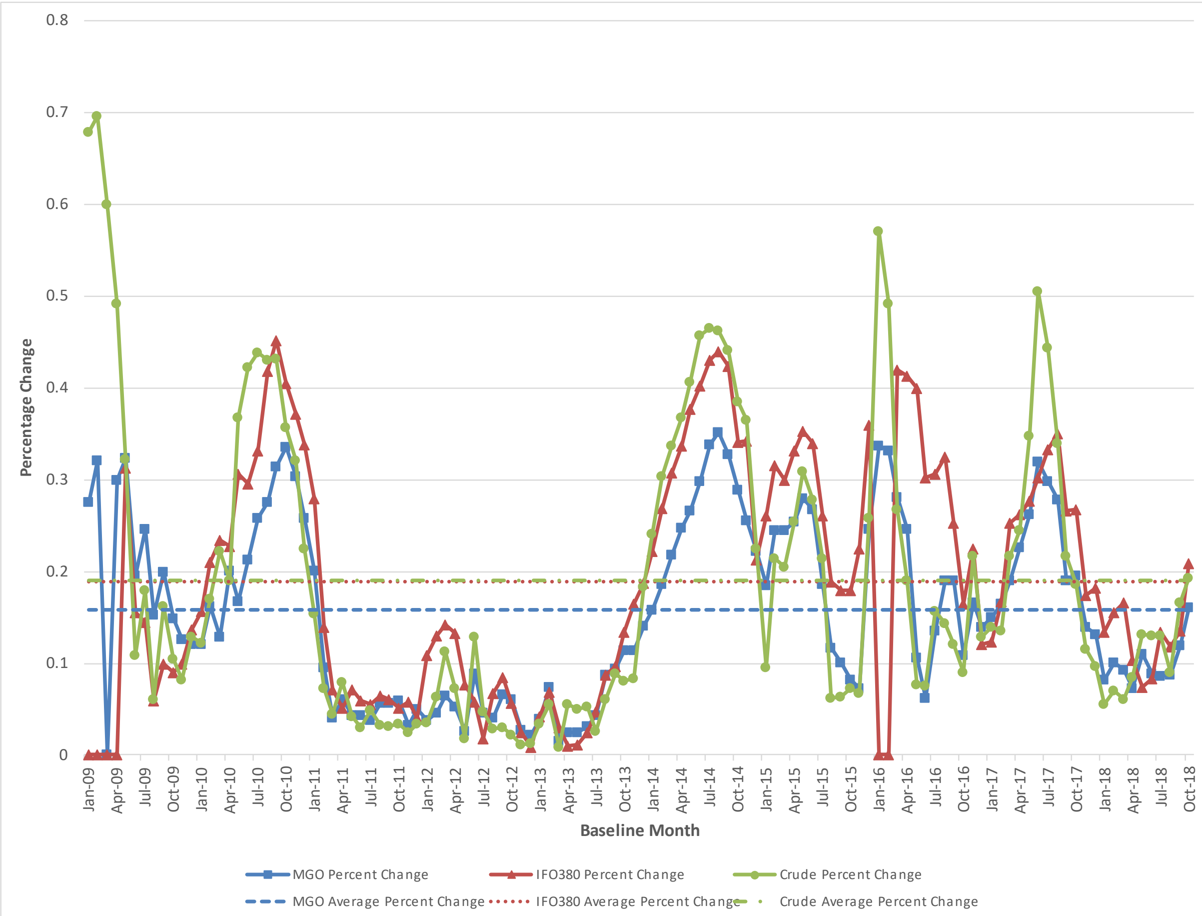


**Figure 9. Graph of Average Volatilities**[24]

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 | 19.1% |
| IFO380 | 18.9% |
| MGO | 15.7% |

Based on these results, and since MGO prices currently track closely with the new 2020 low-sulfur fuel price, it is recommended that MGO typical volatility be used as the buffer for the BAF in USC-10. [25] Therefore, the buffer will remain at 15 percent.

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[24] Source: United States EIA Europe Brent Spot Price, Bunker Index MGO and IFO380 monthly average fuel price

[25] While these prices may diverge for unanticipated reasons, the current best guess is that VLSFO and MGO prices will track each other closely in price.

**Alternative Historical Time Period Analysis**

Volpe explored the impact of alternative time periods used to construct the historical baseline based on carrier and USTRANSCOM comment. Carriers suggested 3-to-4 years of fuel price data and USTRANSCOM requested Volpe also consider a 7-year period. The choice of the historical baseline is important because the time period should reflect the long-run historical volatility that is expected in the market. Using a time period with exceptionally high or low volatility can bias the expected fuel price volatility and lead to inaccurate BAF payments. For instance, if a period included in the analysis has a higher than average volatility and would make BAF payments less frequent and potentially lower.

Below, Table 2 summarizes the average volatility for MGO, IFO380 and Crude Oil. The average volatility values are what the fuel price buffer is based on.

**Table 2. Calculated Average Volatility for Various Historical Periods**

| Fuel Type | 4-Year | 7-Year | All-Years | No COVID |
|---|---|---|---|---|
| MGO | 30.20% | 26.51% | 21.69% | 15.76% |
| IFO380 | 26.65% | 28.61% | 22.60% | 18.86% |
| Crude | 33.22% | 28.32% | 23.69% | 19.06% |

Using 4-years of fuel price data, the average volatility of MGO is 30 percent, which would equate to a buffer zone of 30 percent. A 30 percent buffer would reduce the administrative burden of the BAF for USTRANSCOM. The BAF would be paid to either party less frequently as the fuel prices would need to increase or decrease more than 30 percent of the baseline fuel price instead of the current 15 percent. The base rates submitted by carriers should account for some change in fuel price over the course of the contract, but at 30 percent, Volpe felt this was an unreasonable burden to place on carriers.

Volpe also estimated average volatility for three other historical periods including the most recent7-years of data, all-years of data (since 2009), and all years of data (since 2009) excluding the COVID-19 pandemic (from 2020 to 2023). The results of these analyses are also shown in Table 2. The No COVID period provided the lowest expected average volatility which is closest to the long-run historical average. It also provides the smallest fuel price buffer which has been requested by both USTRANSCOM and the carriers in previous EPA studies.

### 3.3.3 Percentage versus Fixed Value Buffer

Volpe considered an alternative approach to implementing the buffer which treats the buffer as a fixed dollar value rather than a percentage value. An important question for developing this approach was how the fixed value would be determined. Volpe recommends the percentage buffer approach because it inherently captures the variable nature of fuel prices, while a fixed buffer may not sufficiently provide the risk sharing nature of the BAF if the fuel price is much higher or lower on average over the contract period than the base price. Volpe determined the best approach for a fixed price buffer is to apply the calculated percent buffer to the average price of MGO over the pre-COVID historical data (prior to

March 2020). Based on this approach, the average price of MGO was $709.84 per ton as such the recommended fixed value buffer would be $105.

The buffer approach is a negotiated value between USTRANSCOM and the USC-10 carriers. Volpe recommends the percentage buffer approach based on its inherent ability to incorporate fuel price changes during the contract period.

#### 3.3.4 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 exceeds the 15 percent buffer.

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

**Equation 11. Excess Volatility Calculation**

Below, Figure 10 visually describes the excess volatility calculation shown above in Equation 12 for USC-9 option years 2 and 3 (9/1/2021-10/1/2023). 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 period.

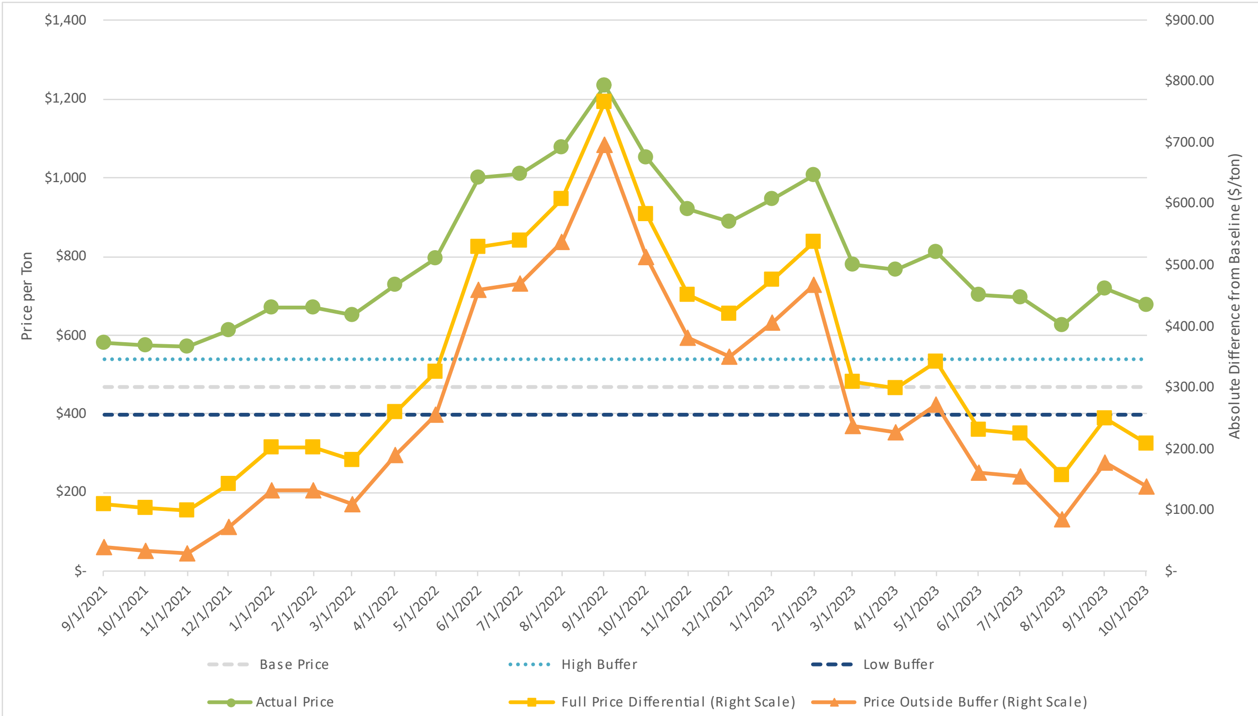


**Figure 10. Fuel Price Differential, with Threshold**[26,27]

When the actual price is greater than the upper buffer value, 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 base price and the actual price, the result is the full price differential line. The actual price will vary depending on market forces as shown in the figure where there is at least some marginal price change in each period. The excess fuel price volatility, equal to the difference between the actual price and the relevant buffer price, is shown as the lowest solid line with triangular markers (price outside buffer).

Building on the fictional route example described in Section 3.2.2.3 and Section 3.2.3, and recalling the absolute price volatility calculated in Section 3.3.1, 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 fuel price volatility beyond the buffer zone. This

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

[27] Note that while the estimated buffer does not include the period between March 2020 and February 2023 to avoid biasing the buffer with anomalous exogenous events (see Section 3.2.4.2), in practice the BAF is activated in any period where the actual price exceeds the buffer as it does in the example Figure 10.

calculation is shown below in Equation 12.

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

**Equation 12. Fictional Route Excess Volatility Calculation**

BAF payments are made only on the excess fuel price 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 $18.71 (5 percent of the base price, $374.28 per ton) upon which the BAF payment is based as shown in Equation 13.

$$\$18.71 = 5\%_{Excess\ Volatility} \times \$374.28\ per\ ton_{Baseline\ Price}$$

**Equation 13. Excess Volatility Amount for BAF Calculations**

## 3.4 Estimating Fuel Consumption

BAF transactions (payments to carriers or rebates to USTRANSCOM) are add-ons to the base rate for each individual unit of cargo. If the fuel price change triggers a BAF payment, the excess fuel price 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 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 average fuel consumption of vessels on the lane and the average distance on the lane.

The USTRANSCOM BAF uses actual shipment data from the Integrated Mission Support for Surface Deployment and Distribution Command (iSDDC) as well as carrier provided data and a commercially available vessel database, Clarkson Research Services' World Fleet Register, to identify those vessels that serve a given USTRANSCOM lane. For each lane an average vessel and route are constructed. The average vessel includes estimated average capacity, speed, and fuel consumption; average distances of lanes were estimated using Netpas Distance software; and total fuel consumption to move a unit of cargo is estimated based on average vessel and distances for each lane.

### 3.4.1 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 14.

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

**Equation 14. Calculating the Fuel Consumption Factor, per Cargo Unit**

Each of the terms from Equation 14 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 Average Vessel

Fuel consumption per day is the total fuel consumed by a vessel per steaming day, operating at its average speed, and is measured in tons per day. See Section 3.4.3 for a discussion of fuel consumption per day.

- $Steaming_{Days}$ , Steaming Days of the Average Vessel and Average Distance

As fuel consumption is measured in tons per day, the typical length of a voyage in days 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 lane. Steaming days on a lane is the average distance of voyages on the lane divided by the average vessel's speed on that lane. See Section 3.4.4 for a discussion of steaming days.

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

Vessel capacity is the cargo capacity of a vessel, in units relevant to a cargo 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 Roll-On/Roll-Off vessels (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 3.4.5 for a discussion of vessel capacity.

The following subsections describe each of the terms from Equation 14 including their source data and methods of calculation.

### 3.4.2 Average Vessel Characteristics Data Analysis

The average vessel characteristics used in the BAF are meant to represent the operational and capacity characteristics of vessels that will carry USTRANSCOM cargo as the BAF is meant to compensate either party for fluctuations in fuel price for fuel used while moving USTRANSCOM cargo. While vessels that service USTRANSCOM shipping needs will change over time due to market forces, the vessels used in a previous USC are the best predictor of those that will be used in the following USC. A representative vessel is constructed for each lane and cargo type based on vessels that shipped USTRANSCOM cargo in USC-9, where the representative vessel is the shipment-weighted average of vessel capacity, speed and fuel consumption. The characteristics of this average vessel are then used to populate the terms of Equation 14 to estimate the fuel consumption factor per cargo unit for each lane.

In response to carrier comment requesting that the average vessel per lane represent only U.S. flagged vessels, the methodology of calculating average vessel has changed in the following ways.

#### *3.4.2.1 Average Vessel Data Sources*

Vessels were identified using USTRANSCOM Integrated Mission Support for Surface Deployment and Distribution Command (iSDDC) Ocean Freight module shipping data between January 2018 and March 2023 which is the available shipment data from the USC-9 period. The iSDDC Ocean Freight module links individual cargo movements to origin and destinations as well as to the vessel(s) performing each move by vessel name. The USC-9 carriers provided vessel characteristics for a subset of vessels that shipped USC-9 cargo, including IMO number, name, capacity, speed, and fuel consumption. The Maritime Administration (MARAD) provided a dataset with all U.S.-flagged vessels with the vessel type as a resource for matching and data analysis. Some additional data were collected from Clarkson's World Fleet Register, which contains all IMO-registered containership and RORO vessels. The three data sources were matched by vessel name to create the average vessel for each lane.

iSDDC 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 522,000 USC shipments between January 2018 and March 2023. 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. Based on MARAD 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. ConRo vessels, those which can ship both containers and breakbulk, were treated as both container and RORO vessels when moving containerized or breakbulk cargo – they were allocated the full container capacity when moving containers and allocated the full RORO capacity when moving breakbulk. The Container category includes all vessels that move only containers (TEUs and FEUs)—container vessels and geared containers.

Clarkson Research Services' World Fleet Register contains data on shipping vessels worldwide. As a majority of vessel characteristics data came directly from the carriers, Clarkson's data was used to identify the TEU capacity for some vessels and the average sailing speeds for vessels in recent years. Clarkson's sailing speed data are estimates of sailing speed while underway based on automatic identification system (AIS) location data.

#### *3.4.2.2 Merging USC Cargo-Carrying Vessels to Vessel Characteristics*

The iSDDC data does not include the IMO number for departing and arriving vessels so vessels had to be linked to their IMO number to merge vessel characteristics data from multiple sources. The iSDDC arriving and departing vessel names were matched to an IMO number using Clarkson's data which includes vessel name, ex name, alt name and associated IMO number. In some cases, other relevant data were used including the vessel's age, country flag, AIS tracking relative to USC-9 shipment location, and other identifying information. The success of this matching method depended on using multiple names and correcting for differences in punctuation and other potential matching errors. The matched dataset was manually reviewed as well to identify any differences in naming conventions.

#### *3.4.2.3 Calculating the Average Vessel*

An average vessel for capacity, speed and fuel consumption was developed based on available data for each lane. The average vessel is the shipment-weighted average using the iSDDC shipment data so that vessels booked more frequently on a lane have greater representation of the average vessel. A data validation approach was used to determine whether to use the lane-specific data or U.S.-flagged fleetwide average data.

1. Lane- and Cargo Type-Specific Average of U.S.-flagged Vessels: the shipment-weighted average characteristics of all U.S. vessels that ply a given lane.
2. Cargo Type Average of All U.S.-flagged Vessels: If there were five or fewer shipments on a lane, the U.S. flag weighted average vessel for each cargo type was used.

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 shows the count of lanes by the data source and cargo type.

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

| Data Source | Container | RORO |
|---|---|---|
| Lane-Specific Average of U.S.-flagged Vessels | 62 | 56 |
| Average of U.S.-flagged Vessels | 29 | 35 |

Table 4 shows an example subset of the average vessel characteristics (Lanes 1 through 5), for both container and RORO vessels including their speed in knots (nautical miles per hour) fuel used (tons per day), capacity in TEUs for container vessels and MTONS for RORO and non-container vessels, the number of shipment observations and whether the characteristics are based on lane observations or the U.S. fleet. 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 Average Speed (Knots) | Container Fuel Con.(tons/day) | Container Obs. | Container Data Source | RORO Capacity (MTONs) | RORO Average Speed (Knots) | RORO Fuel Con. (tons/day) | RORO Obs. | RORO Data Source |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 5,661 | 17.6 | 64 | 113,239 | 1 | 57,764 | 16.9 | 42 | 8,193 | 1 |
| 02 | 4,031 | 15.8 | 59 | 3,014 | 1 | 46,057 | 16.4 | 43 | 39 | 1 |
| 03 | 2,868 | 20.9 | 55 | 22,209 | 1 | 8,911 | 20.0 | 54 | 1,0504 | 1 |
| 04 | 3,323 | 15.2 | 47 | 2,504 | 1 | 47,949 | 16.3 | 45 | 3,338 | 1 |
| 05 | 4,563 | 16.9 | 73 | 71,171 | 1 | 48,244 | 16.1 | 41 | 12,843 | 1 |

### 3.4.3 Fuel Consumption per Day

Generally, fuel consumption varies by vessel type, size, and speed. Target sailing speeds and associated fuel consumption data were provided by the carriers for a subset of vessels in the U.S. flag fleet. For vessels without speed or fuel consumption, Volpe identified sister ships using Clarkson's sister ship analysis and other vessel characteristics, MARAD's sister ship list, and other public data sources to determine similar vessels in terms of speed and fuel consumption, and applied an average speed and fuel consumption using the carrier-provided real-world speed and fuel consumption to vessels that did not have carrier-provided data. A fuel consumption measure is estimated for each lane and vessel type using the average vessel calculation procedure described in Section 3.4.2.3

### 3.4.4 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. The average vessel fuel consumption for a lane is converted from a daily consumption rate to the total fuel consumption value for the entire lane. Total steaming days is a function of the total distance (nautical miles) divided by average vessel speed (knots; nautical miles per hour) divided by 24 hours.

$$Steaming\ Days = \frac{Distance\ (nautical\ miles)}{Speed\ (knots)} \div 24\ hours$$

**Equation 15. Calculating Steaming Days**

#### *3.4.4.1 Lane Distance Methodology*

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.

The BAF lane distances are a generalized representation of distances traveled by goods on a lane because lanes comprise multiple origin-destination combinations that cannot be modeled due to administrative burden and other technical issues regarding routing and circuity. The representative distance includes an estimate of the ECA and non-ECA portions of the lane. See Section 3.2.2.1 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 shipments 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 beyond the scope of what is the USTRANSCOM representative distance.

Lane distances are calculated for each cargo type, container and breakbulk, as these cargo types may require different ports due to vessel operations or differences in port infrastructure. In contrast to USC-9, in recognition that vessels may carry both containers and breakbulk, USC-10 uses the cargo type to categorize shipments, not vessel type, as container and ROROs occasionally ship their unintended cargo. This approach also removes the need to group ConRos into one category or the other. Importantly, this does not apply to the calculation of each lane's average vessel, this information is sourced from MARAD and is discussed in more detail in Section 3.4.2. The port weighting for container shipments uses TEUs while for breakbulk it uses MTONs. The lane distance is calculated as the cargo-weighted average of the distances by cargo type for each lane. The single distance represents the distance a unit of cargo may travel within the lane. For example, Table 6 provides the cargo type weighted average for Lane 1.

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

| Vessel Type | ECA distance | Non-ECA Distance | Total |
|---|---|---|---|
| RORO | 658 | 5,510 | 6,168 |
| Container | 1,706 | 5,491 | 7,197 |
| Weighted Average | 1,578 | 5,493 | 7,071 |

Lane distances are calculated based on USTRANSCOM origin and destination ports for shipments during USC-9. Ports are selected for each lane and cargo type using, at a minimum, the top three shipment-weighted ports in each region of the lane with additional ports if shipment volume represents at least 10 percent of shipment volume for the lane region to ensure that all significant ports on a lane are included. Ports in close geographic proximity such as Portsmouth and Norfolk, Virginia are treated as one origin or destination. The port groups were created consistent with USC-9 Request for Proposal

(RFP) Attachment 3.[28]

The distance estimates come from NETPAS Distance software package which can calculate the nautical miles between ports using standard shipping lanes and routing. NETPAS provides the total distance travelled as well as the share of the trip that is within an ECA zone.

#### *3.4.4.2 Example Distance Calculation for Lane 1 Container Shipments*

An example calculation of the distance in NETPAS can be seen in Figure 11. 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:
  - San Diego, U.S., port group
  - Los Angeles, U.S. port group (including Los Angeles, Long Beach, San Pedro, Wilmington, and Terminal Island)
  - Port Hueneme, U.S.
- 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 6,168 nautical miles and the distance travelled in an ECA zone is 658 nautical miles. As discussed above, this distance is used to calculate a single lane distance which is calculated as the MTON-weighted average of the container and RORO distances. The result is a single distance for each lane.

[28]United States Transportation Command, 2022

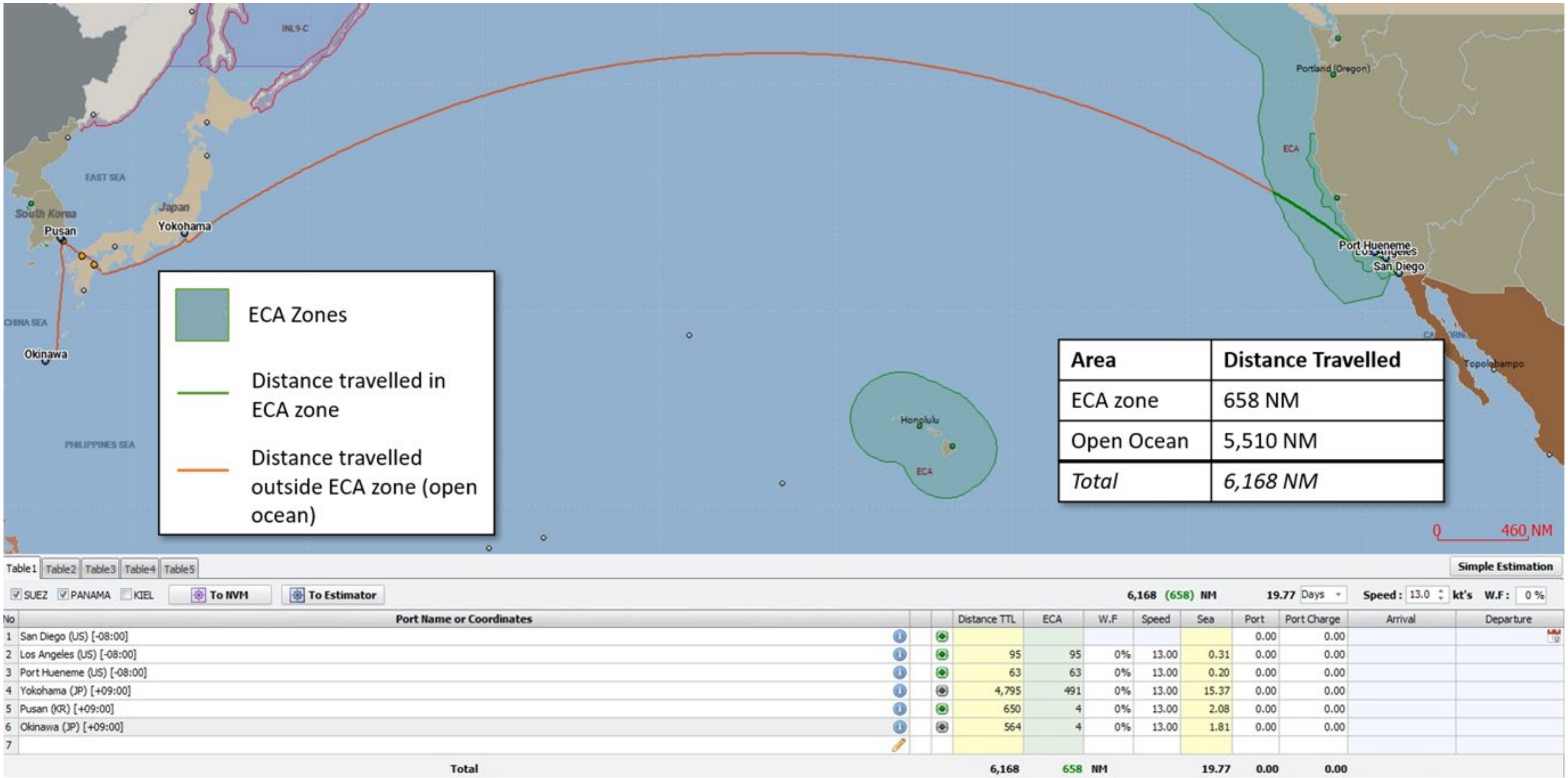


**Figure 11. Calculation of Distance for Lane 1 using NETPAS Software**

#### *3.4.4.3 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. For example, in the case of South America, 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.

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.

#### *3.4.4.4 Vessel Speed*

Carriers provided speed and fuel consumption values for a subset of vessels that carried USC-9 shipments which were used to determine vessel speeds and calculate a lane's average vessel speed as described above in Section 3.4.2.3. Results for the speed of average vessels for Lanes 1-5 are shown in Table 6.

**Table 6. Average Speed (knots) by Vessel Type for Lanes 1-5**

| Lane | Speed (Container) | Speed (RORO) |
|---|---|---|
| 01 | 17.6 | 16.9 |
| 02 | 15.8 | 16.4 |
| 03 | 20.9 | 20.0 |
| 04 | 15.2 | 16.3 |
| 05 | 16.9 | 16.1 |

#### *3.4.4.5 Distance, Speed, and Steaming Days Results*

As discussed in Section 3.4.4, steaming days are computed from the total lane distance divided by the average vessel speed on that lane divided by 24 hours. 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 16.8 steaming days.

Recalling Equation 15,

$$Steaming\ Days = \frac{Distance\ (\text{nautical miles})}{Speed\ (knots)} \div 24\ hours = \frac{7{,}071\ (nautical\ miles)}{17.6\ (knots)} \div 24\ hours = 16.8\ _{Steaming\ Days}$$

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), each average vessel type has its own speed and therefore steaming days. Distances, speeds, and steaming days are unidirectional, meaning a Lane 01 shipment of the same cargo type will have the same resulting steaming days regardless of whether it is traveling from the Far East to the U.S. West Coast or in the opposite direction. 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 | 7,071 | 17.6 | 16.9 | 16.8 | 17.4 |
| 02 | 7,153 | 15.8 | 16.4 | 18.9 | 18.1 |
| 03 | 3,835 | 20.9 | 20.0 | 7.6 | 8.0 |
| 04 | 911 | 15.2 | 16.3 | 2.5 | 2.3 |
| 05 | 4,352 | 16.9 | 16.1 | 10.8 | 11.3 |

### 3.4.5 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. ConRos vessel were treated as containers or RORO when carrying containers or breakbulk cargo. In other words, when a ConRo vessel carries containers, it was assumed to carry only containers and was allocated the full container capacity listed on Clarkson's or provided by the carrier; when a ConRo carried breakbulk, it was allocated the entire breakbulk capacity as denoted by either Clarkson's or provided by the carrier.

#### *3.4.5.1 Capacity Data*

Capacity for container vessels is measured in TEUs and capacity for RORO vessels are measured in MTONs. Capacity data were provided by carriers for a subset of U.S. flag vessels and from Clarkson's. Previously, RORO vessel capacity in the BAF was measured by Net Registered Tonnage (NRT) which 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 and is 2.5 times the vessel capacity in MTONs; however, Volpe employed a different methodology for this refresh.

MTONs were not available for all breakbulk carrying vessels and so the Volpe center identified capacity using several methods. First, Volpe visited every U.S. flag carrier website and reviewed fleet information for potentially relevant characteristics – MTONs, Grain Cubic Meters, Cubic Meters, RT43/number of vehicles, etc. MARAD provided Volpe with a dataset from S&P Global which also contained capacity information. For vessels where capacity information was still missing, Volpe used the following approach:

- For vessels with capacity provided in cubic meters, the number of cubic meters were converted to MTONs.
- For Pure Car Carriers and other vessels with capacity measured in vehicles, Volpe approximated the MTONs capacity using the industry standard practice of using the volume of a 1966 Toyota Corona as the sample vehicle.[29]
- Volpe reviewed the Clarkson's Sister Ship classification and, when possible assigned capacities based on sister ship designation.
- Otherwise, Volpe assigned tonnage based on best professional assessments of vessels with similar characteristics (vessel type, owner, deadweight tonnage, net tonnage, etc.). A total of 14 vessels were estimated, less than 10 percent of the entire dataset.

#### 3.4.5.2 *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. Breakbulk cargo is typically irregularly shaped and containership capacity can be limited by the volume and weight of cargo within individual containers.

##### 3.4.5.2.1 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. Based on carrier input from a May 2023 RFI, USTRANSCOM revised the broken stowage factor to a 35 percent loss of cargo capacity from 28 percent. In calculating the daily fuel consumption per cargo unit, the vessel cargo capacity was multiplied by 0.65 to adjust for this loss.

##### 3.4.5.2.2 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 is a

[29] Coia, 2013

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.

#### *3.4.5.2.2.1 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 factor, 2.0). However, this relationship 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 only 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 factor) 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 also adds 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.[30]

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.

#### *3.4.5.2.2.2 Vessel Constraint, Cargo Carrying Capacity*

A vessel is constrained by its space capacity, measured in TEUs. Because a 40-foot container takes up

[30] OCEMA, n.d

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.

##### *3.4.5.2.2.3 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 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 USC shipping data contained in iSDDC database from January 2018 to March 2023 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 of the 327,000 total USC container shipments were made using 40-foot containers (this translates into approximately 265,000 40-foot containers compared with 49,000 20-foot containers); of the 40-foot containers, 92 percent weigh 40,000 lbs. or less; and in the case of 20-foot containers, 86 percent weigh less than 20,000 lbs. Cargo in 20-foot containers tend not to weight out above 40,000 lbs. (2 percent).

The rules used to infer a conversion factor for an individual container are outlined in Table 8. These rules were applied to the 522,000 USC shipments that occurred during January 2018 to March 2023 from the iSDDC 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 factor of 1.0.

Between 20,000 lbs. and 40,000 lbs. the factor 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.

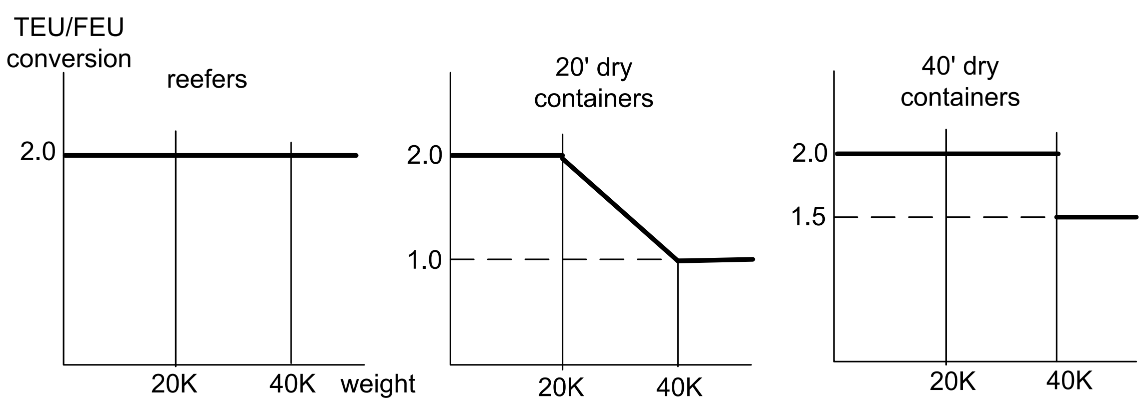


**Figure 12. Notional Representation of TEU/FEU Conversion Function.**

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 factor 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 factor 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 1.96 FEUs for each

TEU.

**Table 9. TEU/FEU Conversion Factor**[31]

| Description | Factor |
|---|---|
| 20-foot Container Average Conversion Factor | 1.94 |
| 40-foot Container Average Conversion Factor | 1.96 |
| 20-foot as percent of all containers | 15% |
| 40-foot as percent of all containers | 83% |
| Combined Weighted Conversion Factor in BAF | 1.96 |

The 20-foot container average conversation factor is the conversion for 20-foot-containers to forty-foot-containers meaning that 1.94 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 1.96 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 2018 to March 2023 period, the share of 20-foot dry containers was 15 percent, and the share of 40-foot dry container was 83 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 2019 value of 1.94, 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.

### 3.4.6 Calculating Fuel Consumption Factor per Cargo Unit

Recalling Equation 14, from Section 3.4.1,

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

$Fuel_{Day}$ 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:

$$Fuel_{CU} = \frac{Fuel_{Day} \times Steaming_{Days}}{Capacity_{vessel}} = \frac{64_{\frac{tons}{day}} \times 16.8_{Days}}{5{,}661\,TEU\ Capacity_{vessel}} = 0.190^{tons}/_{TEU}$$

**Equation 16. 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

[31] Estimated from SDDC data. There are other container sizes recorded in the USC shipment data, but they are a small percent of total shipments (2%) with the largest share of this percentage being 45-foot containers (1%).

on an average length trip. 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.

## 3.5 Input Substitution Factor

This section describes the third term from the general structure of the BAF, the *Input Substitution Factor*. Fuel prices can change significantly during contract years (base and option years). For example, bunker fuel rates rose 30.2 percent in Q4 2021 and rose an additional 18.2 percent quarter-over-quarter Q1 2022.[32] Year-over-year changes in fuel prices are managed through re-baselining which allows carriers to incorporate realized and expected fuel price changes into their rates.

The BAF is a mechanism for addressing significant fuel price changes within a given contract year, but both parties to the USC, USTRANSCOM and the carriers, are not equally positioned to manage those changes. As the principal operators, the carriers have some short-term options to adjust the inputs to their production to reduce fuel consumption specifically when fuel prices rise. The Input Substitution Factor is a mechanism to account for and incentivize a carrier's ability to economize its operation.

### 3.5.1 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 prices exhibit significantly more volatility than 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 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. However, it's worth noting that every fuel saving measure, like slow steaming, comes with additional tradeoffs that limit its viability, like

[32] Hasan, 2023

scheduling constraints.

In theory, 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 as carriers will attempt to substitute one input for another to the extent possible. 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 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 such as 0.75, would mean that for every dollar increase in the price of fuel, total costs would increase by $0.75. 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.

A simple, notional 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.

**Table 10. Numerical Example of Input Substitution**

| Variable Factors | Initial Price | Initial 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 |
| % Change in Total Cost | - | - | - | 42% | - | 32% |
| Efficient cost % of fixed Input Cost | - | - | - | - | - | 93% |
| Fuel Share of Total Cost | - | 33% | - | 53% | - | 33% |

### 3.5.2 Operational Changes and Capital Investments

Carriers are uniquely positioned to adjust fuel consumption during the contract period. Table 11 identifies some methods that carriers could employ to adjust their fuel efficiency prior to the next re-baselining. If the price of fuel goes up relative to other inputs, the producer should shift its input mix to use less of the relatively scarce input.

The operational changes might include 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.

While the maritime shipping market is not a fully competitive market as in economic theory where price is minimized to cost, as carriers operate in some trades and not others (e.g., some RORO carriers only operate ROROs, and do so only in some lanes), carriers do compete on price and have strong incentive to reduce the fuel used.

One-time capital adjustments, such as changes to propellors or bow shapes, etc., could be implemented in the within a given contract year, assuming availability of dry-dock and implementation is cost-beneficial, so that a carrier could mitigate a fuel price increase within a base or option year, however, as the capital investment cannot be repeated and the impact of the improvement does not expire or diminish (investments are long-term), the fuel efficiency improvement would then be part of the carriers competitive advantage in the following bids. The improvement would allow the carrier to reduce their bid rates. This lagged effect of input substitution, specifically from switching from using more fuel to spending on capital improvements, has a long-run impact of reducing the cost of shipping (assuming a competitive market). The incentive structure for the BAF should ensure that carriers are not disincentivized in the short run from making these capital investments.

Table 11 below shows various capital and operational adjustments that carriers could make in response to fuel prices with a description of the time frame required for implementation, the idle time required to make that adjustment, whether the adjustment is a short-term or long-term impact, and the estimated fuel savings and the citation for the information (ABS 2013; WBW 2015;[33] and CR 2016[34]). The table is ordered by the estimated fuel savings rate. Notably, the highest potential savings, with the exception of speed adjustment/slow steaming, are actions that carriers will already be required to do per regulation (the Ship Energy Efficiency Management Plan (SEEMP)) or would require significant dry-docking which requires time to schedule and complete and are thus not viable as short-term responses to fuel reduction. While some of these adjustments are possible to implement in the short run-in response to fuel price increases, practically, in most cases, increasing the efficiency of a ship is complicated process that requires significant planning to be cost effective.[35]

[33] Winkel et al., 2015

[34] Caughlin & Reynolds, 2016

[35] Barreiro et al., 2022.

Table 11. Fuel Consumption Adjustments

| Input Factor | Implementation time and/or dry-docking required? | Long- or Short-term | Estimated Fuel Savings | Citation |
|---|---|---|---|---|
| **Autopilot Improvements** | Integrating software into vessel management systems; idle time not significant | Long-term | 1% | ABS 2013; |
| **Trim/Draft Optimization** | Requires time to test and optimize, but no dry-docking | Long-term | 1-2% | ABS 2013; |
| **Main Engine Performance Monitoring and Control** | Portable equipment or fixed equipment installation; no dry-docking required | Long-term | 1-2% | ABS 2013 |
| **Main engine de- rating (reduce design speed** | For loads lower than max design load; may require dry-docking | Short-term | 2-4% | WBW, 2015 |
| **Wake Equalizing and Flow Separation Alleviating Devices** | For vessels with suboptimal hull forms; requires dry-docking | Long-term | 0-5% | ABS 2013 |
| **Rudder Improvements: Twisted Rudder, Rubber Blub,** | Requires dry-docking | Long-term | 2-5% | WBW 2015 |
| **Propeller Roughness Management** | Part of regular maintenance; does not require dry docking | Short-term | 0-6% | ABS 2013 |
| **Higher Strength Steel** | New builds only | Long-term | 10% | ABS 2013 |
| **Waste heat recovery** | New builds only | Long-term | 8-11%; 6-10% | ABS 2013; WBW 2015 |
| **Hull Antifouling Coatings** | Requires dry-docking | Short-term | 5-12%; 1-9% | ABS 2013; WBW 2015 |
| **High Efficiency Propellers, including Ducted, Contra-rotating, Post swirl fins/ Pre-swirl Devices, Wheels** | Some options only possible for new builds; some only possible for some ships | Long-term | 2-13%; 3-20%; 3-10% | ABS 2013; WBW 2015; Glosten 2016 |
| **Hull Form Optimization** | New builds only | Long-term | 2-20% | CR2016 |
| **Ship Energy Efficiency Management Plan (SEEMP)** | Required by IMO 2023 regulation[36]; | Short-term | 20% | ABS 2013 |
| **Bow Optimization** | Requires dry-docking | Long-term | 2.5-20% | WBW 2015 |
| **Speed adjustment/Slow Steaming** | Immediate; No dry-docking required | Short-term | 17-22% | ABS 2013; WBW 2015 |
| **Air Lubrication** | New builds only | Long-term | 0-10%, 5-25% | ABS 2013; Glosten 2016 |
| **Hull Maintenance/ Cleaning** | Regular practice; requires dry-docking | Short-term | 7-30%, 1-5% | ABS 2013; Glosten 2016 |

[36] IMO, 2022

### 3.5.3 Speed and Fuel Consumption

For previous USCs, the Input Substitution Factor also served as a real-world adjustment to the speed and fuel consumption values that were calculated based on vessel service speed rather than actual sailing speed. A vessel's service speed is typically much higher than its actual operating speed and because of the cubic relationship between speed and fuel consumption, the fuel consumption estimates based on service speed are higher than those based on actual speed. The service speed and fuel consumption were therefore an overestimate of fuel consumption in previous USCs. 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.

In previous studies, it was necessary to adjust the BAF model assumptions about fuel consumption and speed because, it would have significantly overestimated fuel consumed by carriers. However, for USC-10, USC carriers provided real-world speed and fuel consumption values for most vessels in the U.S. flag fleet that carry USTRANSCOM goods under USC. This adjustment to the data source and accuracy means that the Input Substitution factor no longer needs to incorporate the real-world adjustment to speed and fuel consumption.

Table 12 and Table 13 show the change in shipment-weighted average speed and fuel consumption between those from USC-9 and those for USC-10. The fleet composition of USC-9 which is used to calculate the USC-10 representative vessels has changed since USC-8, which was used for USC-9 representative vessel calculations, so the changes in speed and fuel consumption are not a direct comparison between the carrier-provided data and the Clarkson's service speed data. The tables show reductions in speed for containers and RORO vessels of 24 and 15 percent respectively, and a greater change in fuel consumption (consistent with the cubic relationship between speed and fuel consumption) of 54 and 18 percent respectively.

**Table 12: Shipment-Weighted Average Speed Change for USC-10 Compared to USC-9**

| Vessel Type | Speed (Knots) 2019 | Speed (Knots) 2023 | Percent Change |
|---|---|---|---|
| Container | 23.3 | 17.8 | -24% |
| RORO | 19.5 | 16.6 | -15% |

**Table 13: Shipment-Weighted Average Fuel Consumption for USC-10 Compared to USC-9**

| Vessel Type | Fuel Consumption (tons/day) 2019 | Fuel Consumption (tons/day) 2023 | Percent Change |
|---|---|---|---|
| Container | 146.4 | 67.2 | -54% |
| RORO | 52.8 | 43.2 | -18% |

Volpe analyzed the potential fuel consumption savings based on carrier-provided fuel consumption values with a 10 percent reduction in speed using published speed-fuel consumption formulas for container vessels.[37] Table 14 demonstrates the percent reductions in fuel consumption for container vessels based on a 10 percent reduction in speed for each of the TEU sizes and includes the number of

[37] Yao et al., 2011

lanes on which a representative vessel is of the specified TEU size. Based on the Yao et al. speed-fuel consumption values, there is roughly 8-14 percent reduction of fuel consumption expected for a 10 percent reduction in speed for the representative vessel. This is a significant reduction from expected fuel consumption based on moving from 22 knots that was estimated in the 2019 report to 17.5 knots (average between 20-40 % reduction in fuel), as shown in Table 15.

**Table 14. Potential Fuel Consumption Savings for 10 Percent Reduction in Speed by Container Vessel Size**

| TEU | Fuel Consumption at 17.8 Knots (tons/day) | Fuel Consumption at 16 Knots (tons/day) | Percent Reduction in Fuel Consumption (relative to ~10% reduction in Speed) | Lanes with Representative Vessel at TEU Capacity |
|---|---|---|---|---|
| 0-1,000 | 31.41 | 24.50 | 22.0% | 0 |
| 1,001-2,000 | 42.33 | 35.24 | 16.8% | 5 |
| 2,001-3,000 | 54.66 | 47.72 | 12.7% | 5 |
| 3,001-4,000 | 75.32 | 64.89 | 13.8% | 39 |
| 4,001-5,000 | 93.81 | 83.41 | 11.1% | 9 |
| 5,001-6,000 | 112.55 | 101.29 | 10.0% | 15 |
| 6,000+ | 125.52 | 115.17 | 8.2% | 17 |

**Table 15: 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 17.5 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% |

Based on schedule constraints, it is not expected that carriers can significantly reduce their average speed lower than 10 percent. While the RORO fuel consumption change was not estimated due to lack of general speed-fuel consumption equations, Volpe expects similar fuel reduction for similar reductions in speed for RORO vessels. Thus, the 0.90 Input Substitution Factor is a reasonable adjustment for carrier capacity to adjust fuel consumption.

### 3.5.4 Regulatory Constraints

The IMO has promulgated two regulations requiring significant reductions in sulfur and carbon emissions for maritime trade vessels. The requirements, which include introducing new energy-efficient fuels and implementing stricter regulations for carbon emissions, target reductions in the environmental impact of sea freight transport on a global scale. As discussed in previous reports, the IMO 2020 regulations set limits on the sulfur content of emissions in open ocean sailing (as ECA and port regulations require further sulfur reductions). The IMO 2023 regulations set Greenhouse Gas (GHG) Emissions reductions targets of 50 percent by 2050 and carbon emissions reductions of 40 percent by 2030 and 70 percent by 2050 (compared to 2008 emissions levels).[38] The standards required a 1 percent improvement in carbon and GHG emissions from 2020-2022 and starting in 2023 require a 2 percent improvement per year. Improvement requirements after 2026 have not yet been determined.

Under IMO 2023 vessels of 400+ gross tonnage (GT) vessels will be monitored using the Energy Efficiency Existing Ship Index (EEXI) and vessels of 5,000+ GT vessels will be monitored with the Carbon Intensity Indicator (CII).[39] EEXI is a rating system that assesses the energy performance of existing ships based on energy consumption data and other key metrics such as speed, power, and engine size. EEXI is based on ship specifications not actual operating performance. Non-compliant vessels that receive an EEXI rating below a certain threshold may be subject to IMO 2023 penalties and restrictions and may need to make modifications to engines or systems. The CII is being used to rank and monitor the efficiency of individual ships. It links the GHG emissions to the amount of cargo carried and the distance travelled ratio. The CII rating threshold will become stricter over time and will therefore determine the annual carbon reduction factor needed to ensure compliance. Each vessel will receive a grade from A (good) to E (poor), starting in 2023. Ships that receive three years of D grades or one E grade will have to put a corrective action into place.

The impacts of these regulations are far-ranging. Carriers will need to make investments into energy-efficient measures and technologies to comply with IMO requirements. Based on these regulations, carriers may also face new restrictions on ship operations such as limitations on speed or the use of older vessels. Both EEXI and CII could negatively affect shipping capacity, EEXI may require vessels to idle for modifications, and CII may incentivize carriers to slow steam to reduce fuel consumptions (thus reducing CO2 emissions).[40]

The regulations will also have an impact on the industry in terms of impacting the underlying assumptions of the Input Substitution factor as the regulations will require carriers to continually adjust operations to reduce fuel consumption to reduce controlled emissions. This will reduce the carrier's ability to adjust to fuel price changes in that they will already be required to make adjustments.

Table 16 shows the share of new vessels that meet the 2013 EEDI and the share of vessels build between 2013-2017 that meet the future 2025 EEDI targets, which represents a significant share of container and general cargo vessels (RORO vessels are not called out specifically). As the U.S. flag fleet is recapitalized in the future with new vessels, they are more likely to meet the energy efficiency requirements of regulation and will achieve improvements in fuel efficiency. These improvements fuel efficiency will be incorporated into carrier bid rates and limit the extent to which they can adjust fuel

[38] IMO, 2019

[39] IMO, 2022

[40] Martin, 2022

efficiency mid-contract year as it will mean many fuel efficiency methods are already incorporated into ship design.

**Table 16: Energy efficiency trends on different types of cargo ships**[41]

| Type of cargo ship | Efficiency improvements of new ships relative to the baseline EEDI value of 2013. | Share of ships built in 2013–2017 already complying with the post-2025 EEDI target. |
|---|---|---|
| Containerships | 58% more efficient | 71% of built containerships |
| General cargo ships | 57% more efficient | 69% of built general cargo ships |
| Gas carriers | 42% more efficient | 13% of built gas carriers |
| Oil Tankers | 35% more efficient | 26% of built oil tankers |
| Bulk Carriers | 27% more efficient | 1% of built Bulk Carriers |

### 3.5.5 Input Substitution Factor Value

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 would be 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.

The Input Substitution Factor incentivizes them to make optimal decisions about their input mix in the face of rising fuel costs. Accordingly, the value for the substitution factor for USC-10 is set at 0.9, an increase from the 0.8 value recommended in recent versions of the USTRANSCOM BAF. The 0.9 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.

In a rising price scenario, the Input Substitution Factor compensates carriers for 90% of the estimated cost of fuel needed to move each cargo unit on a lane's estimated journey. A value less than 1 maintains the economic incentive of carriers to economize on fuel. As values approach 1, this is consistent with lower fuel substitution and higher fuel compensation. Values below 0.9 assume higher substitution of other inputs for fuel and subsequently lower fuel price compensation for carriers. That is, as fuel prices increase, carriers will respond to changes in input prices by using the more expensive input (fuel) less intensively and using other inputs (such as more labor from longer voyages with slow steaming) more intensively. Fuel *is* more expensive, but carriers are now using it less intensively relative to the daily consumption estimated by carriers during the solicitation period and included in their base rates. Accordingly, the entire price increase is not returned as a rebate to the carriers, offsetting a lower

[41] Barreiro et al., 2022

absolute quantity of fuel consumed by vessels traveling at lower speeds.

In a falling price scenario, with a rebate to USTRANSCOM, a value of 0.9 results in less than full compensation. This is in line with the expected change in production inputs as noted above. As the price of fuel drops, carriers can travel faster, substituting the other inputs for the now less expensive fuel. This higher speed increases vessel fuel consumption relative to the daily consumption estimated by carriers during the solicitation period and included in their submitted base rates. Accordingly, the entire price decrease is not returned as a rebate to USTRANSCOM, offsetting a higher absolute quantity of fuel consumed by vessels traveling at higher speeds.

In the IMO 2020 and IMO 2023 regulatory environment, carriers have significantly more constraints on whether they can mitigate rising fuel prices in the short run as they are required to meet certain emissions targets which already require lower fuel consumption rates. It is anticipated that over USC-10, carriers will be required to sail at slower speeds and invest significantly in capital investments that improve fuel consumption. As the Input Substitution factor depends on the conditions of the market, it should be reviewed closely again in future USCs to determine whether it correctly accounts for carrier's flexibility to adjust operations and respond in the short run to fuel price volatility.

## 3.6 Risk Distribution Factor

This section describes the Risk Distribution Factor which is a negotiated term in the BAF Equation 1 that is intended to fairly share the risk of fuel price change among parties commensurate with the parties' abilities to mitigate that risk.

### 3.6.1 Theory of Risk Distribution Factor

When estimating the future cost of fuel for setting base rates, the length of USC-10 adds temporal risk to both parties.[42] If USTRANSCOM could instantaneously book ad hoc cargo moves without a fixed contract term, the price quoted at the time of shipment would reflect all current input price information, including the current market price of fuel. However, The USC-10 length requires fixed contract rates for up to 17 months, increasing the temporal risk that prices at the time of shipping are beyond a range of normal volatility easily incorporated by carriers into their rate.

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 when the prices are re-baselined in each option year. Alternatively, if the risk is largely not in either party's control, and USTRANSCOM can absorb the

[42] The same principal applies to the CAF and exchange rates.

uncertainty of not knowing actual costs until the time of delivery, then they can bear the risk. The Risk Distribution Factor is the mechanism for assigning risk to each party.

The length of the USC 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).

### 3.6.2 Buffer and Risk Distribution

The BAF contains two components that allocate price volatility risk between the shipper and the carrier: the Risk Distribution Factor and the buffer: the higher the risk distribution factor, the larger the share of risk that is borne by USTRANSCOM, the shipper. The wider the buffer thresholds are (e.g., 25 percent upper and lower buffer), the more the carrier bears the fuel price risk. The interaction of these two aspects is described in in Table 17.

**Table 17. Interaction of Buffer Threshold and Risk Distribution Factor**

| Buffer Range: Narrow or Wide | Lower Risk Distribution Factor (closer to 0) | Higher Risk Distribution Factor (Closer to 1) |
|---|---|---|
| Narrow Buffer Range | 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 |
| Wide Buffer Range | 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.

### 3.6.3 Carrier Risk Mitigation Strategies

USTRANSCOM has limited ability to reduce fuel price risk, but carriers are experienced actors in the world shipping and fuel markets and can minimize their exposure to fuel price risk with hedging and fuel sourcing. These approaches are in addition to operational strategies noted in Section 3.5.2, carriers.

Strategies for reducing the impacts of uncertainty and volatility are generically referred to as hedging. Carriers are able to take a financial position in the fuel market that protects them from fuel price volatility such as by purchasing futures or options contracts on the commodities market [43]. The practice generally involves reducing some of the upside potential of fuel price changes (i.e., fuel price decreases) to limit their exposure to downside risk (i.e., fuel price increases). Fuel price hedging can be accomplished, 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.

In addition to market positions, carriers can also hedge by adjusting their freight rate bids or freight rates, by offering higher bids to offset the potential for fuel price increases. However, this strategy carries additional risk of lost revenue due to losing bids. As all carriers face fuel price volatility (with limited variation in port source pricing) when they compete on bids using the same or similar fuel types, therefore they face similar tradeoffs for bid strategies.

Carriers can also act directly in the fuel production and sourcing markets by partnering 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. [44] and Europe [45] 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 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.

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[43] 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).

[44] gCaptain, 2019.

[45] World Maritime News, 2019.

### 3.6.4 Risk Distribution Factor Value

The Risk Distribution Factor is a further adjustment to the BAF payments for carriers in the event of fuel price increases above the upper BAF buffer. The Risk Distribution Factor is a policy choice on the part of the shipper which can be negotiated with the carriers for USC-10. It is not an empirically derived value for which Volpe can provide a recommended value. The Risk Distribution Factor can vary between 0, where no BAF is paid, and 1, where the full BAF is paid on any excess volatility.

The length of USC-10 adds a significant level of uncertainty, and therefore USTRANSCOM should bear a majority of this risk. The previously recommended value for the Risk Distribution Factor is 0.75, compensating the affected party for 75% of the excess fuel price volatility.

In a rising price scenario, the Risk Distribution Factor compensates carriers for 75% of the estimated cost to move cargo in each lane. While USTRANSCOM imposes uncertainty given the length of the contract, carriers are in a better position to manage the risk of price volatility overall. Carriers have multiple levers at their disposal unavailable to USTRANSCOM, including fuel hedging and preferential agreements with fuel producers and storage companies. Carriers can also mitigate the risk of price volatility by incorporating their expectations into their base rates. All of these options are unavailable to USTRANSCOM when faced with the requirement to move goods at a given time and location.

In a falling price scenario with a rebate, a value of 0.75 results in less than full compensation to USTRANSCOM. This reflects the risk that USTRANSCOM is expected to bear for the length of the contract term. A shorter contract period would allow carriers to amend and resubmit their base rates to reflect current fuel price levels. The length of the contract is a constraint on carriers imposed by USTRANSCOM and should result in less than full compensation for USTRANSCOM.

## 3.7 Combined Technical Factors

The Technical Factor for each lane is the product of the average fuel consumption (Section 3.4), the Input Substitution Factor (Section 3.5), and the Risk Distribution Factors (Section 3.6), as shown in Equation 17 below:

$$Technical\ Factor_{lane} = Fuel_{CU,lane} \times Input\ Substitution\ Factor \times Risk\ Distribution\ Factor$$

**Equation 17. Composite Technical Factor for Lane 1**

Where the $Fuel_{CU,lane}$ is the fuel consumption factor estimate for the lane (0.190 as shown in Equation 16), *Input Substitution Factor* Section 3.5.5, recommended earlier to be 0.9, and the *Risk Distribution Factor* from Section 3.6.4 is 0.75. The resulting Technical Factor for Lane 1 can be calculated as:

$$0.128 = 0.190 \times 0.9 \times 0.75$$

**Equation 18. Technical Factor for Lane 1, per TEU**

The final technical factors for each lane and cargo type (TEU, FEU, and MTONs) are in Appendix D: Comparison of USC-10 BAF Technical Factors.

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. 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.

The BAF technical factors have decreased for USC-10 compared to USC-9 due to the use of real-world speeds provided by the carriers which are significantly lower than the "service speeds" used in USC-9 technical factors. The Input Substitution Factor was adjusted upward to 0.90 from 0.80 in USC-9 to account for lower fuel consumption at the real-world speeds which moderated the impact of using real-world speeds rather than service speeds.

### 3.7.1 Applying the Technical Factors

The combined final Technical Factors by lane incorporate the vessel and cargo fuel consumption estimates, broken stowage factor, Input Substitution and Risk Distribution Factors. To calculate the BAF payment, the Technical Factors are multiplied by the price differential from Section 3.2. 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 18 and the Excess Volatility Amount from Equation 13, the final BAF payment using Lane 1 vessel data and fictional prices is calculated as:

$$\$BAF_{per\ Cargo\ Unit} = Technical\ Factor_{Lane} \times Excess\ Volatility$$

**Equation 19. Example BAF Payment Calculation**

$$\$2.40_{per\ TEU} = 0.128_{Lane\ 1\ TEU\ Tech\ Factor} \times \$18.71_{Excess\ Volatility}$$

**Equation 20. Example BAF Payment Calculation**

Section 3.8 describes the accompanying workbook that can be used to calculate BAF payments.

## 3.8 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 include in the appropriate calculations.
- Use the model results to determine whether a BAF is warranted, and if so, which party is compensated.

### 3.8.1 BAF Workbook

Provided with this report is an Excel workbook that can be used to calculate the USTRANSCOM BAF payments. The workbook contains tabs of input data and secondary calculations used in the final calculation of the BAF technical 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.

Each of the tabs and their purpose are described below:

- **Fuel Price & Buffer Assumptions**: This sheet allows the user to select the Solicitation Month, The Shipping Month, the Price Buffer, the Input Substitution Factor, the Risk Distribution Factor, the TEU to FEU Adjustment Factor, and whether the Mediterranean Sea is an ECA. It also allows the user to enter fuel price data for each month for up to 8 ports for Over Ocean Fuel (VLSFO) and ECA/Port Fuel (MGO).
- **Trade Technical Factors:** This sheet calculates the technical factors using the based fuel per unit rates and the input values selected on the Fuel Price and Buffer Assumptions sheet.
- **BAF Payments:** This sheet contains the BAF payments for each cargo type and for each lane based on the Solicitation Month and the Shipping Month selected.

## 3.9 Conclusion

The goal of the BAF is to provide a theoretically consistent and practically implementable risk-sharing mechanism that can function within the constraints of the firm fixed-price USC-10. The USTRANSCOM BAF meets these requirements by using a fuel price differential representing the change in the unit price of fuel from the baseline to the current period; a fuel consumption quantity for the transit of the vessel from load port to discharge port, allocated to units of cargo; an Input Substitution Factor that recognizes carrier flexibility in promoting fuel economy; and a Risk Distribution Factor that allows USTRANSCOM and the carriers to negotiate risk sharing.

The 2023 BAF methodology presented in this report is consistent with those implemented in previous USCs with improvements to the implementation and data analysis.

### 3.9.1 BAF Recommendations and Changes

The recommendations and revisions to the BAF for USC-10 include the following:

- **Recalculated Fuel Price Buffer.** The recommended fuel price buffer was recalculated using additional fuel price data collected over USC-9 but remains +/- 15%. While data were collected through March 2023, the highly volatile years of 2020-2023 were ultimately excluded from the analysis to avoid biasing the buffer.
- **Revised Representative Vessels:** The methodology for representative vessels has been adjusted to consider only U.S. flagged vessels that moved cargo on a USC tariff between January 1, 2019, and March 8, 2023. Additionally, carriers supplied Volpe with real world vessel data describing speed, capacity, and fuel consumption which was used to improve the technical factor accuracy. The method for assigning a representative vessel to a lane was adjusted to consider only either the shipment-weighted average of vessels that moved goods on a lane or the shipment-weighted average of U.S. flag vessels across all lanes.
- **Revised Input Substitution Factor:** The recommended Input Substitution value for USC-10 has been revised to 0.90. In previous studies, the Input Substitution Factor was used to account for the use of design speed and fuel consumption which is higher than actual speeds. For this study, carriers provided real-world speed data so that the Input Substitution Factor does not need to account for the real-world adjustment. The factor was also revised to reflect new IMO regulations requiring carriers to reduce vessel emissions which in turn makes vessels more fuel efficient.
- **Mediterranean ECA**: Volpe calculated two sets of BAF technical factors to account for the Mediterranean Sea becoming an ECA zone in May 2025. This is a significant change that will impact the BAF fuel mix factor. The two sets of technical factors are provided so that USTRANSCOM can updated the technical factors in May 2025 to reflect the ECA expansion into the Mediterranean.
- **Fuels Price Sourcing:** Volpe maintains the recommendation to use prices for VLSFO and MGO to calculate the baseline and BAF payments. It recommends the following four approaches for fuel price sourcing:
    - USTRNASCOM should average the prices from whichever ports are ultimately selected and a single fuel price for each fuel type should be applied to all lanes.
    - **Status Quo Recommendation**, two CONUS ports – Los Angeles and Norfolk with prices sourced from Bunker Index (this would require USTRANCSOM switch price provider).
    - **Low Effort Recommendation**, one CONUS and one OCONUS port – Los Angeles and Antwerp with prices sourced from either Bunker Index or Bunker World.
    - **High Effort Recommendation**, global basket of ports – Los Angeles, Antwerp, Kuwait, and Houston with prices sourced from Bunker World (the current source). Ultimately, USTRANSCOM will need weigh the administrative burden of implementing the fuel price port sourcing recommendations when selecting the approach for USC-10.

Ultimately, USTRANSCOM will need weigh the administrative burden of implementing the fuel price port sourcing recommendations when selecting the approach for USC-10.

### 3.9.2 BAF Cloud-based System Recommendations

During the USC-10 period, USTRANSCOM and Surface Deployment and Distribution Command (SDDC) will migrate the existing IBS and CARE II systems to a cloud-based format that may allow for some improvements to how the EPAs are implemented. Volpe is providing some recommendations for USTRANSCOM's consideration that will not be possible to implement in advance of USC-10 due to the existing development plan for the cloud-based systems. However, as the cloud-based system will be implemented during USC-10 and there will be opportunities to continue to improve the system design before USC-11 when the EPA methodologies and implementation will be reviewed again, Volpe is providing design recommendations USTRANSCOM and SDDC that may be deployed to assist in the potential future USC-11 EPA review.

- USTRANSCOM and SDDC could consider including vessel IMO number, which is available in the booking system, in the SDDC data so that the data is available to Volpe during each refresh.
- USTRANSCOM and SDDC should consider adding flexibility to ingest and compute the average of multiple fuel source values for each lane. Based on discussions with SDDC staff, the cloud-based system is expected to already allow multiple fuel types and multiple ports for fuel prices (up to three ports as currently configured in the requirements documentation), but it may not be designed to calculate an average fuel price across multiple ports. Assigning individual lanes to a basket of ports, or even an average price of existing ports, would better reflect a lane's likely bunkering options (versus only Los Angeles or Rotterdam prices). As the cloud-based system requirements documentation allows three ports as currently configured, USTRANSCOM and SDDC should consider using one U.S. East Coast, one West Coast port, and one foreign port to account for lanes that do not have a U.S. port origin or destination, such as Gibraltar.
- USTRANSCOM and SDDC could consider using actual port-to-port distances for BAF payments rather than average lane distance. The benefit of this approach is that the BAF payment would be paid on the correct port-to-port distance rather than an approximation. Based on the variation in the lane distance each refresh, there is enough variability in the OD ports where the actual shipping distance for each shipment could be much more accurate rather than basing the distance on the OD patterns of the previous USC. The actual distance could be calculated for each shipment in the IBS and CARE II using a matrix of origin and destinations populated using historic origins and destinations[46] and data collection. This adjustment would require many more calculations than the current BAF approach and is only recommended if a BAF payment is able to be automatically calculated based on a carrier's booking information.

[46] It is possible that a booking could use an OD pair not present in the historic data. In this scenario, it would be recommended to still include a lane-based BAF that could be applied in these instances of a new OD pair until the new OD pair could be added to the main list.

# 4. Currency Adjustment Factor (CAF)

## 4.1 Introduction

Businesses and organizations engaged in international trade use a CAF to acknowledge risk and uncertainty from exchange rate volatility. This uncertainty results 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, 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 is $120. If this service is provided 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 the dollar cost of the service will 10 percent lower than the invoice cost leaving the carrier better off. This uncertainty imposes a cost on firms trading internationally, and as a result of this transaction risk[47] carriers may determine they need to hold large reserves of foreign currency, diverting these funds from other more productive purposes.

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 USCs this is the U.S. dollar). As carriers bid their base shipping rates for a USC, the expectation is that the exchange rate at the time of bidding 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). The bidirectional nature of exchange rate uncertainty is accounted for in the structure of the CAF. Specifically, this is done through the bidirectional buffer, which captures both currency depreciation and appreciation relative to a base rate. The CAF compensates ocean carriers when the U.S. dollar depreciates and provide rebates to USTRANSCOM when it appreciates.

## 4.2 Developing the 2023 CAF Recommendations

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[47] 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.

Theoretically, the CAF could include currencies for all possible USTRANSCOM shipping origin and destinations. However, that approach would impose a significant administrative burden on USTRANSCOM, and any potential benefit would not justify the additional cost. There are trade lanes (and currencies) that have little or no USTRANSCOM shipments for which the additional effort of collecting currency data would not be cost-beneficial.

There are three primary steps to updating the CAF – reviewing USTRANSCOM's shipping patterns, calculating the buffer, and refreshing the CAF Technical Factor and the CAF Risk Distribution Factor. Below is a high-level discussion of the process for updating the CAF and or a more in-depth discussion of methodology, please see the previous studies.[48]

### 4.2.1 USTRANSCOM Shipment Review

The review of USTRANSCOM's shipping patterns is based on data collected from USTRANSCOM's iSDDC.

#### *4.2.1.1 Shipment Data*

USTRANSCOM's ocean shipping data from January 1, 2019, and March 8, 2023, were collected from iSDDC and cleaned to identify relevant moves. Shipment data is limited to include goods moved under USC by vessels during the period between the previous and current EPA refresh studies. The data is also filtered to remove non-relevant move types. For the CAF, this includes all moves without a domestic leg (i.e., OCONUS to OCONUS moves) and those to/from Guantanamo Bay, Cuba. A total of 399,083 records were identified as relevant and were included in the CAF analysis.

#### *4.2.1.2 Superlanes*

Shipment records are grouped by geographic location into Superlanes, which are then ranked by number of moves (each record constitutes one move regardless of how many pieces of cargo are moved). All lanes comprising at least 10 percent of relevant cargo moves are included in the CAF. During the 2023 refresh, there were no changes to the Superlanes recommended for inclusion in the CAF. Table 18 presents the distribution of international cargo movements by Superlane.

**Table 18. Superlane Volume**

| Superlane | Cargo Moves | Percent of Cargo Moves |
|---|---|---|
| Africa | 6,750 | 2% |
| Black Sea | 6,028 | 2% |
| Caribbean | 14,464 | 4% |
| Central | 1,846 | 0% |

[48] *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. *Universal Service Contract-9 Economic Price Adjustment Factor Update*, August 2019.

| Superlane | Cargo Moves | Percent of Cargo Moves |
|---|---|---|
| America & Mexico | | |
| Europe & the Med | 131,977 | 33% |
| Far East | 108,780 | 27% |
| Middle East & South Asia | 102,147 | 26% |
| Oceania | 26,545 | 7% |
| South America | 558 | 0% |

The Europe and the Med., the Far East, and the Middle East & South Asia Superlanes account for the largest volume of cargo moves, 86 percent of CONUS/OCONUS and 73 percent of total USC cargo movements.[49]

#### *4.2.1.3 Relevant Currencies*

Moves are aggregated by Superlane, country, and currency and ranked by number of moves. Currencies that are used in at least 1 percent of Superlane transactions ("relevant currencies") are included in the CAF. Below in Table 19, is an example of this decision process for the Europe and the Med Superlane.

**Table 19. Example CAF Currency Analysis**

| Currency | Count of Moves | Percentage of Total Moves |
|---|---|---|
| Icelandic krona | 1 | 0.0% |
| Gibraltar pound | 3 | 0.0% |
| Croatian kuna | 19 | 0.0% |
| Albanian lek | 253 | 0.2% |
| Lebanese pound | 426 | 0.3% |
| Israeli new shekel | 542 | 0.4% |
| Danish krone | 852 | 0.6% |
| Norwegian krone | 1,522 | 1.2% |
| Pound sterling | 3,534 | 2.7% |
| Turkish lira | 5,175 | 3.9% |
| Polish zloty | 9,079 | 6.9% |
| European euro | 110,571 | 83.8% |
| Total | 131,977 | 100% |

Table 19 shows 12 different currencies, however, only five of them account for at least 1 percent (unrounded) of all moves and are therefore the "relevant currencies" for the Europe and the Med

[49] The previous study accounted for 78 percent of USC traffic.

Superlane.

Changes in USTRANSCOM shipping patterns since 2019 have resulted in some changes in recommended currencies. The Norwegian Krone and Saudi Arabian Riyal have been added to the currency basket while the Djiboutian Franc and Moroccan Dirham have been removed.

#### *4.2.1.4 Trade Weights*

For “relevant currencies,” trade weights are calculated for each currency based on the share of relevant Superlane transactions handled by each currency. The trade weights differ from the above percentage of moves because they’re calculated relative to only the relevant currencies. Below in Table, we see the currency weight calculations for the Europe and the Med Superlane.

**Table 20. Example Trade Weight Calculation**

| Country | Currency | Volume | % Volume |
|---|---|---|---|
| Norway | Norwegian krone | 1,522 | 1.17% |
| Great Britain | Pound sterling | 3,534 | 2.72% |
| Turkey | Turkish lira | 5,175 | 3.98% |
| Poland | Polish zloty | 9,079 | 6.99% |
| Eurozone | European euro | 110,571 | 85.13% |
| **Total** | **Relevant Superlane Volume** | 129,881 | 100% |
| **Total** | **Total Superlane Volume** | 131,977 | 98% |

The Europe and the Med Superlane includes five currencies for a total of 129,881 moves. Relative to the total volume of Superlane moves, those five “relevant currencies” account for 98 percent of moves. Trade weights for all the relevant currencies are shown below in Table 21.

Table 21. Trade Weights

| Superlane Name | Currency Name | Trade Weight |
|---|---|---|
| Europe & the Med | Norwegian krone | 1% |
| Europe & the Med | Pound sterling | 3% |
| Europe & the Med | Turkish lira | 4% |
| Europe & the Med | Polish zloty | 7% |
| Europe & the Med | European euro | 85% |
| Far East | Singapore dollar | 2% |
| Far East | South Korean won | 34% |
| Far East | Japanese yen | 64% |
| Middle East & South Asia | Omani rial | 1% |
| Middle East & South Asia | Pakistani rupee | 2% |
| Middle East & South Asia | Jordanian dinar | 6% |
| Middle East & South Asia | United Arab Emirates (UAE) dirham | 6% |
| Middle East & South Asia | Bahraini dinar | 8% |
| Middle East & South Asia | Qatari riyal | 8% |
| Middle East & South Asia | Saudi Arabian riyal | 19% |
| Middle East & South Asia | Kuwaiti dinar | 49% |

From 2019-2023, the European Euro, Japanese Yen, and Kuwaiti Dinar represent the largest trade flows in their respective Superlanes. Collectively, these 16 currencies account for 99 percent of trade within these Superlanes. Within each Superlane, the chosen currencies account for at least 90 percent of total Superlane-specific cargo volumes: currencies account for 98 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.

### 4.2.2 Buffer Calculations

The buffer is calculated using the exchange rates for the relevant currencies. The buffer reflects the historically observed deviations in an exchange rate around a baseline. It is expected that carriers can identify and hedge against the risk from typical currency fluctuations. Currency volatility exceeding the buffer, volatility that is more challenging to effectively hedge against, should be apportioned across both carrier and shipper through the application of a CAF with a risk-sharing factor.

The buffer symmetric around the baseline because the currency volatility risk is symmetric, and it is consistent with FAR and DFARS regulations for the application of EPAs.

#### *4.2.2.1 Individual Currency Volatility*

No changes were made to the buffer zone calculation as part of the 2023 refresh.

The methodology calculates a 12-month moving absolute average percent change to identify normal volatility, consistent with the BAF methodology (see Section 3.3.2). To mirror the typical duration of the USC 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. A rolling average was used to ensure the 12-month periods were not chosen arbitrarily. The formula for calculating the base moving average percent change is shown in Equation 21.

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

**Equation 21. Period 1 Moving Average Percent Change Calculation**

Where:

- New Price is the currency exchange rate 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 March 2023. Periods of extreme volatility were removed from the buffer calculation as the CAF buffer is meant to reflect typical currency volatility. Absolute values greater than one standard deviation above the mean were deemed to be atypical volatility and were removed to avoid bias as the buffer is meant to capture normal volatility. The decision rule for removing outliers is shown in Equation 22.

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

**Equation 22. Decision Rule for Removing Outliers**

In response to the May 2023 RFI, the carriers request consideration of using a shorter historical period (4 years rather than 7 years) in the buffer and baseline calculations. Volpe explored the impact of setting the individual currency buffers using four different time horizons – the full universe of data (2010-Present), 7-years (2015-Present), 4-years (2018-Present), and excluding the Black Swan events of 2020-2023, which were discussed earlier. These periods are consistent with those explored for the BAF buffer.[50] Individual currency buffers by analysis period are shown below in Table 23. Currencies that show 0 percent volatility are pegged to the dollar and have no variation over the analysis period.

[50] The start years of each of the time horizons represents the month of the baseline. So, the November 2018 value represents the change in volatility from November 2018 to April 2018 (a 5-month lag).

Table 22. Individual Currency Volatility

| Superlane | FULL | 7-Years | 4-Year | No COVID |
|---|---|---|---|---|
| Norwegian krone | 5% | 5% | 6% | 5% |
| Pound sterling | 5% | 5% | 4% | 5% |
| Turkish lira | 14% | 18% | 25% | 14% |
| Polish zloty | 5% | 8% | 10% | 5% |
| European euro | 5% | 4% | 5% | 5% |
| Singapore dollar | 2% | 2% | 2% | 2% |
| South Korean won | 4% | 4% | 5% | 4% |
| Japanese yen | 5% | 4% | 4% | 5% |
| Omani rial | 0% | 0% | 0% | 0% |
| Pakistani rupee | 5% | 8% | 10% | 5% |
| Jordanian dinar | 0% | 0% | 0% | 0% |
| UAE dirham | 0% | 0% | 0% | 0% |
| Bahraini dinar | 0% | 0% | 0% | 0% |
| Qatari riyal | 0% | 0% | 0% | 0% |
| Saudi Arabian riyal | 0% | 0% | 0% | 0% |
| Kuwaiti dinar | 1% | 1% | 1% | 1% |

Currencies that show 0 percent volatility are pegged to the dollar and as such have essentially no variation over the analysis period.

#### *4.2.2.2 Superlane Buffers*

Superlane buffers are calculated by multiplying the individual currency volatility values by the trade weights and summing all currencies by Superlane. The below table (Table 23) notes the differences in buffers at the Superlane levels.

Table 23. Sensitivity Analysis, Buffers under Different Historical Conditions

| Superlane | FULL | 7 Year | 4 Year | No COVID |
|---|---|---|---|---|
| **Europe & the Med** | 5.16% | 5.19% | 5.94% | 4.98% |
| **Far East** | 4.95% | 4.24% | 4.79% | 4.91% |
| **Middle East & South Asia** | 0.68% | 0.54% | 0.68% | 0.65% |
| **Global Mean** | 5.68% | 6.28% | 7.75% | 4.75% |

Foreign exchange markets experienced unprecedented strain over the period 2020-2023 with atypical exchange rate volatility. Some stable currencies such as the Euro, Yen and the Singapore dollar became less volatile, while other currencies, the Pakistani Rupee and the Turkish Lira, had marked increases in volatility ranging between 3 and 4 percent higher than 2018 values. We see the higher volatility translate to higher Superlane buffers, especially when moving towards a 4-year average, a time period dominated by the COVID-19 pandemic, relative to the full set of available historical data.

#### *4.2.2.3 Global Buffer*

In addition to buffers for individual currencies and for each Superlane, a global mean value (see Table 23) is calculated by taking the average of currency buffers for currencies not pegged to the U.S. Dollar or a basket of currencies. The global mean is an average of nine currencies: Great British Pound, European Euro, Norwegian Krone, Japanese Yen, Pakistani Rupee, Polish Zloty, Singapore Dollar, Kuwaiti Dinar, and Turkish Lira.

#### *4.2.2.4 Final Buffer Selection*

The CAF buffer zone for Superlanes and the global buffers are calculated on a trade-weighted basis. This approach can lead to bias in cases where a single, or a small group of currencies can skew the size of a Superlane buffer zone such as when the majority of cargo moves to a country with a comparatively stable exchange rate (note: pegged currencies are already omitted from this analysis) so that the buffer would be overly narrow and not reflect the higher variation in the other currencies. To avoid this bias against smaller trade-weighted currencies, a second constraint to the buffer size is applied requiring the use of the global mean rather than the Superlane mean if the Superlane mean is smaller than the global mean. In effect, the rule selects the larger buffer of the Superlane or the global buffer. Based on this rule, the global mean is applied to all three of the relevant Superlanes – Europe & the Med, Far East, and Middle East & South Asia.

In terms of implementation, the Volpe recommendation is to either apply the buffer based on the rule above, or to apply the global buffer to all Superlanes.

As discussed earlier, the recommendation of Volpe is to use the "No COVID" values as such the buffer recommendations are as follows,

- **World Buffer (status quo)**, USTRANSCOM applies a single buffer to all currencies, – the buffer should be set at 4.75%
- **Superlane-Specific Buffer**, UTRANSCOM applies the larger buffer of the Superlane or the global buffer – the Europe & the Med buffer should be set at 4.98%, the Far East Buffer should be set at 4.91%, and the Middle East & South Asia buffer should be set at 4.75%

The decision of which recommendation to apply, either the World Buffer (status quo) or the Superlane-Specific Buffer, is at the discretion of USTRANSCOM and is largely dependent upon the existing capabilities of IBS/CARE system and the future capabilities of the cloud-based System. The existing system is only capable of applying a single buffer so the Status Quo recommendation should be applied. Once USTRANSCOM migrates to their new cloud-based system, the expanded capabilities may allow for individual Superlane buffers to be applied. Applying individual Superlane buffers more closely links relevant currency movements to the specific buffer applied to individual lanes – the values are more representative of the shipping movements they're applied to. If such flexibility is available, USTRANSCOM should consider applying Superlane-Specific buffers otherwise the Status Quo buffer option is an accurate representation of relevant currency volatility and is an appropriate choice.

## 4.3 CAF Risk Distribution Factor

The CAF Risk Distribution Factor is the mechanism via which a portion of the currency risk can be assigned to each party. 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. This is a negotiated value ranging between 0 and 1; at 0 the currency risk is placed entirely onto the carriers and at 1 USTRANSCOM carries all of the risk. How this risk is distributed is subject to negotiation and USTRANSCOM policy.

## 4.4 CAF Technical Factor

The final component of the CAF is the Technical Factor, which represents the portion of costs in the base freight rate that requires carrier 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. Volpe reviewed available literature and determined that while costs have increased significantly over the past few years, the ratio of port costs to other expenses does not appear to have significantly changed and the recommendation is unchanged from that in the 2018 EPA Refresh Study.

Terminal costs are estimated to be approximately 23 percent of total costs. Applying this value to direct voyage costs provides an indication of what percent of costs are 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.

## 4.5 Implementing the CAF

Central to implementing the CAF is establishing the currency baseline. The baseline exchange rate establishes the expected conversion rate at the time the USC 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 period are then measured by comparing the baseline rate to the “new” rate (the monthly average exchange rate at the time of shipment).

Under existing methodology (consistent with the 2018 EPA Refresh Study), the baseline is 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. In past, carriers have requested greater stability over the course of the USC, in which case baseline should be set at the beginning of the contracting period and remain unchanged throughout all the option years. Alternatively, if USTRANSCOM preferred the baseline be more representative of market conditions during the rate refresh period, the baseline should be set ahead of the base, option years, and any extensions. The decision of how frequently to set the baseline is at the discretion of USTRANSCOM.

In response to carrier request, Volpe updated the CAF Excel workbook to allow the selection of different baseline calculation periods:

- full analysis, which is status quo, same as what was recommended as part of the 2018 EPA Refresh Study;
- 4-Year, which sets the baseline and buffer using a 4-year rolling average;
- 7-Year, which sets the baseline and buffer using a 7-year rolling average; and
- No COVID, which sets the baseline and buffer using a historical average that excludes data from during the COVID-19 pandemic, March 2020 – February 2023.

Table 24 shows how CAF payments and rebates would be paid using these different baseline calculation periods for cargo shipped in June 2020 (assuming a USC-9 solicitation month of December 2018).

Table 24. Hypothetical CAF Payments under Different Historical Periods

| Country | Direction (Full) | Payment Factor (Full) | Direction (4-Year) | Payment Factor (4-Year) | Direction (7-Year) | Payment Factor (7-Year) | Direction (No COVID) | Payment Factor (No COVID) |
|---|---|---|---|---|---|---|---|---|
| Norway | REBATE | 0.00903 | REBATE | 0.01037 | REBATE | 0.02113 | REBATE | 0.00952 |
| United Kingdom | NONE | NO CAF | REBATE | 0.00227 | REBATE | 0.00725 | NONE | NO CAF |
| Turkey | REBATE | 0.00764 | REBATE | 0.04386 | REBATE | 0.07022 | REBATE | 0.00811 |
| Poland | REBATE | 0.00035 | NONE | NO CAF | REBATE | 0.00475 | REBATE | 0.00078 |
| Euro Zone | NONE | NO CAF | NONE | NO CAF | REBATE | 0.00166 | NONE | NO CAF |
| Singapore | NONE | NO CAF | NONE | NO CAF | REBATE | 0.00060 | NONE | NO CAF |
| South Korea | REBATE | 0.00152 | REBATE | 0.00006 | REBATE | 0.00182 | REBATE | 0.00199 |
| Japan | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | PAYMENT | 0.00006 |
| Oman | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| Pakistan | REBATE | 0.00772 | REBATE | 0.02299 | REBATE | 0.02763 | REBATE | 0.00835 |
| Jordan | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| UAE | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| Bahrain | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| Qatar | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| Saudi Arabia | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |
| Kuwait | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF | NONE | NO CAF |

The choice of historical duration has some impact on the frequency with which a CAF is paid, but its primary impact is on the magnitude of the payment factor. This choice of which method to use is ultimately up to USTRANSCOM but does need to be decided upon before issuing the RFP – carriers will need to understand the methodology ahead of submitting their bids.

### 4.5.1 CAF Workbook

Provided with this report is an Excel workbook that can be used to calculate the USTRANSCOM CAF buffer. The workbook allows the user to select the buffer methodology among the options recommended in this report:

- **Superlane Buffer**, which applies Superlane specific buffers for relevant Superlanes.
- **World Buffer**, which applies a single global mean buffer to relevant Superlanes.
- **Individual Currencies**, which applies a currency-specific buffer to relevant currencies.

The general process for updating the workbook remains largely the same with some additional features designed to streamline the update process.

- **1 – Exchange Rates**: This sheet is for entering the exchange rates for relevant currencies in

Columns E through V. Subsequent columns will auto-populate with relevant data. Adjust columns A and/or B to change which Superlanes or currencies are included in the analysis. Exchange rates are in units of relevant currency per $1 USD.

- **2 – CAF Static Values**: This sheet is for selecting the solicitation month, shipping month, buffer type, and baseline type. As different selections are made, the Buffer Sizes will update accordingly. Should contract negotiations produce alternative CAF Calculation Factors to the ones suggested by Volpe, those input values can be edited (cells D33 and D34).
- **3 – CARE Report Values**: This sheet provides a summary of the results of the CAF calculation. It does not require any user-entered values.

## 4.6 Conclusions and Recommendations

This report presents the details of the updated USTRANSCOM CAF EPA. The calculation of the data driven elements of the CAF remains the same as previous studies—Superlanes, currencies, trade weights, buffer, and technical factor. As in previous years, 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. Consistent with the FAR and DFAR regulations, the buffer accounts for typical exchange rate volatility, which carriers are better positioned to manage through various hedging techniques.

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 excess currency volatility, the amount outside the buffer zone.

The CAF EPA is separated into three Superlanes, which represent more than 85 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 majority 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 currency must capture at least one percent of trade within their respective Superlanes to be included in the buffer calculation. 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.

### 4.6.1 Recommendations

There are no recommended changes to the underlying CAF methodology. The below suggested updates are the result of included USC-9 data in the analysis.

#### 4.6.1.1 Recommended Currencies

There are some changes to the recommended currencies.

- Recommend the removal of: Djibouti Franc and the Moroccan Dirham
- Recommend the inclusion of: Norwegian Krone and the Saudi Arabian Riyal

These changes are based on evolving shipping patterns of USTRANSCOM.

#### 4.6.1.2 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—4.98 percent
  - Far East—4.91 percent
  - Middle East & South Asia—4.75 percent

If USTRANSCOM decides to apply a single global buffer, 4.75 percent should be used.

### 4.6.2 CAF Cloud-Based System Recommendations

During the USC-10 period, USTRANSCOM and SDDC will migrate the existing IBS and CARE II systems to a cloud-based format that may allow for improvement on how the EPAs are implemented. Volpe is providing some recommendations for USTRANSCOM's consideration that will not be possible to implement in advance of USC-10 due to the existing development plan for the cloud-based systems. However, as the cloud-based system will be implemented during USC-10 and there will be opportunities to continue to improve the system design before USC-11 when the EPA methodologies and implementation will be reviewed again, Volpe is providing design recommendations USTRANSCOM and SDDC that may be deployed to assist in the potential future USC-11 EPA review.

USTRANSCOM and SDDC could consider implementing functionality to allow individual buffers to be applied to top trade-weighted, non-U.S.-pegged currencies and use a global buffer only for low trade-weighted currencies. The benefit of this change is that some carriers may be burdened by single world buffer when the exchange rate volatility is significantly higher than the world average (i.e., Turkish Lira exchange rate is significantly more volatile than others in the Euro zone). There are 16 currencies are that form the dominant share of USTRANSCOM shipping destinations, but only 8 are not pegged to U.S. dollar or a basket of currencies and most of those are stable so this would only affect a few currencies. Alternatively, USTRANSCOM and SDDC could consider individual buffers for component combatant commands rather than using Superlanes or a single world buffer.

# 5. Inland Intermodal Fuel Adjustment Factor (FAF)

## 5.1 Introduction

This section of the EPA study reviews the development and use of inland transportation fuel surcharges, or a FAF[51], 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 cargo movements. CONUS FAFs together with supporting technical factors to manage the consequences of significant and unexpected fluctuations in fuel prices applicable to inland transportation. It was initially developed by overland common carriers (specifically U.S. trucking companies) to pass fuel price volatility along to shippers. USTRANSCOM established a FAF for USC-06, and the methodology was reviewed in the 2009 refresh for compliance with the EPA provisions of the FAR and DFAR regulations as well as to be consistent with standard commercial practice while not presenting significant barriers to efficient administration. In 2013 and 2018, Volpe refreshed the FAF input values, but made no changes to the general FAF methodology.

This current report presents the results of an update to the FAF methodology, similar to the 2018 report. The focus of the current effort was on updating the data inputs used in calculating the FAF rather than developing a different FAF calculation approach. Per the request of USTRANSCOM, Volpe has added recommendations on the appropriate inputs to use to apply a FAF to inland shipments in Alaska and Hawaii. Apart from this recommendation, Volpe generally 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 2018 Volpe study. In addition, the recent literature was reviewed 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 shipping data on inland destination/origin to/from CONUS ports from 2022 and 2023. 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

[51] 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.

calculator.

The remainder of this chapter presents a review of when to apply a FAF (Section 5.2), the key components of USTRANSCOM's FAF (Section 5.3), 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 5.5). Section 5.6 concludes this chapter and summarizes Volpe's recommendations for the FAF.

## 5.2 When to Apply a FAF

The FAF is applied symmetrically to diesel fuel price risk which can be either upside or downside risk. 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 historically 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 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. Previous Volpe studies limited CONUS strictly to the continental U.S., excluding Alaska and Hawaii. For the purposes of this refresh, the applicability of the FAF has expanded to all U.S. states, including Alaska and Hawaii. For these moves, a FAF is always applied.

Unlike the BAF and the CAF, there is no buffer which picks out normal volatility that either party is expected carry without compensation and therefore 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-09 Base Year, Option Year 1, Option Year 2, and several months of Option Year 3. 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 – East Coast to East Coast**[52]

## 5.3 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 5.4, discusses how these components come together to create a FAF payment.

### 5.3.1 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 significantly different from the base rate.

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

### 5.3.2 Current Rate

The current rate is the fuel price 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 greater than the baseline, then there will be a FAF payment to the carriers. If the current rate is less than the baseline, then there will be a FAF rebate to USTRANSCOM.

### 5.3.3 Average Distances

Previous Volpe studies determined the FAF methodology should use a distance-based approach based on an examination of FAF industry practice and the availability of required data. The FAF surcharge is paid on a per container basis in line with current ocean carrier industry practice. The best approach given data availability and administrative limitations is to use an average distance applied to each container movement. 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 32 unique average distance values used in the FAF which are calculated for each combination of 8 zone pairs and 4 container types which are described in the following sections.

#### *5.3.3.1 Zones*

The FAF average distance are calculated by "zone" which are constructed using 6 U.S. state groupings. 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, Gulf Coast states, Alaskan ports, and Hawaiian ports. The zones can be seen in Figure 14, which colors the three port zones, Alaska, and Hawaii. Most of the states are not in a port zone.

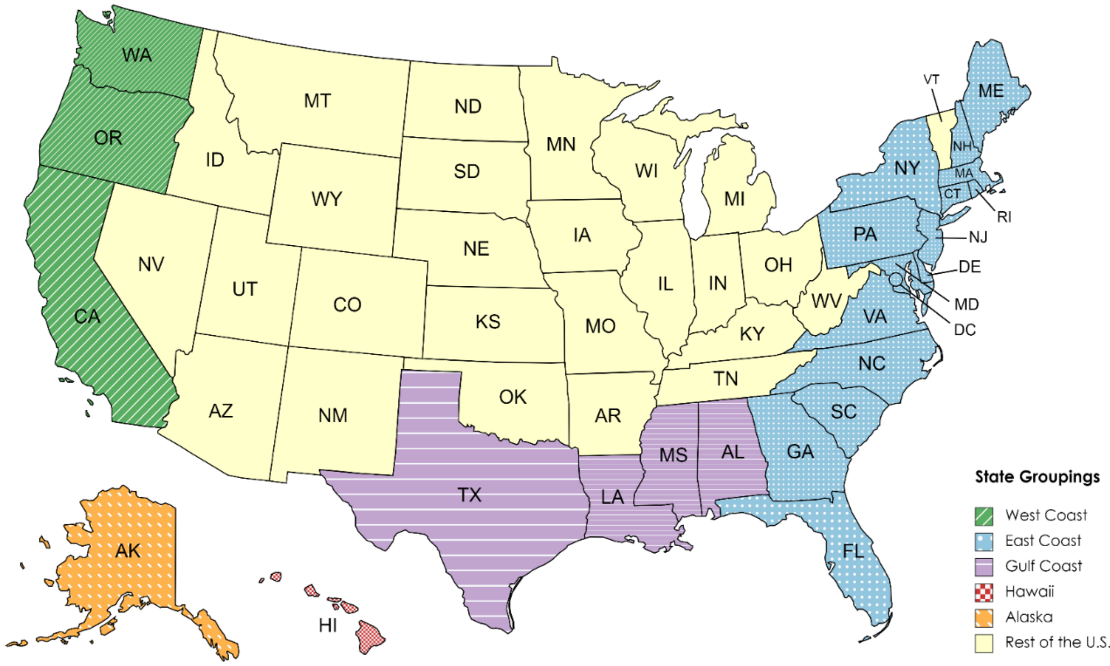


**Figure 14. FAF Zones**[53]

An average distance is calculated for five "within" zones (including Alaska and Hawaii in USC-10) and three between zone calculations. The eight zones are as follows:

- 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.
- Alaskan ports to Alaskan cities
- Hawaiian ports to Hawaiian cities

### *5.3.3.2 Cargo Type*

In addition to zones, FAF calculations are also separated based on the cargo type being shipped because the cargo type (essentially, size and weight) affects the fuel consumption and the transportation mode

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

that can be used. The four container types 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 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 ship via truck in most instances,[54] 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 cargo types each have an average distance calculated for the eight zones, resulting in 32 average distance values and 32 unique FAF calculations.

### 5.3.4 Mode of Transportation

USTRANSCOM goods can be shipped on different modes for inland movements, including freight truck and rail. However, 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 5.3.5), which will differ depending on if the shipment travels by truck or by rail.

Carrier data is used where possible to determine the likely mode of transportation. In Volpe's earlier studies, the carriers indicated that reefer shipments and breakbulk 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.

According to industry, dry containers sometimes move by rail and the decision is based on travel distance, as rail is typically competitive with trucking at larger distances. As part of the FAF refresh, Volpe reviewed literature to determine the appropriate distance at which rail becomes competitive with

[54] Carriers noted that several door moves for foreign military sales breakbulk cargo are conducted using rail service each year.

trucks. The results of this review can be found in Section 5.5.3.

### 5.3.5 Fuel Consumption

Fuel consumption rates are multiplied by the trip average distance to estimate 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. All 32 of the FAF calculations require an estimate of fuel consumption to calculate the FAF payment, with certain equations requiring two fuel consumption values, one for truck and one for rail.

The fuel consumption values for trucks, specialized heavy hauler trucks, and rail are all in gallons/container(cargo) mile. As one truck carries one container (or cargo; 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 (piece of cargo), gallons/mile would not be equivalent to gallons/container mile for rail. The rail gallons/container mile fuel consumption value is based on the truck value, as will be explained in Section 5.5.4.3. 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).

## 5.4 Application of the FAF

The FAF calculations displayed below apportion the price differential to container shipments based on distance. Each FAF calculation multiplies the average distance by the fuel consumption for the cargo type to get an estimated total gallons of fuel per trip. The total gallons of fuel used per trip is multiplied by the price differential between the base fuel price and the current fuel price; this gives the FAF payment amount per shipment, as shown in Equation 23:

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

**Equation 23. 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:

$$FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ cargo\ mile\ \times Average\ Distance)$$

**Equation 24. 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 the average distance for the truck portion of the trip and truck fuel consumption, and the second time using average distance for the rail portion of the trip and rail fuel consumption. The two calculations are then summed to get the FAF payment:

$$FAF\ Payment = (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Intermodal\ rail\ gallons\ per\ cargo\ mile\ \times Average\ Rail\ Distance) + (Monthly\ Average\ Fuel\ Price - Baseline\ Fuel\ Price) \times (Truck\ gallons\ per\ cargo\ mile\ \times Average\ Truck\ Distance)$$

**Equation 25. 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, as shown in Equation 26

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

**Equation 26. 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 5.5.5.

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.

## 5.5 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.

### 5.5.1 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 5.4 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 27. 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 28. 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 29. 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 30. Calculation for Reefer Containers between Zones**

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

**Equation 31. Calculation for Normal Breakbulk within Zones**

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

**Equation 32. Calculation for Normal Breakbulk between Zones**

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

**Equation 33. Calculation for Overweight Breakbulk within Zones**

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

**Equation 34. Calculation for Overweight Breakbulk between Zones**

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

### 5.5.2 Average Distances

USTRANSCOM provided Volpe with iSDDC data from approximately January 2022 through April 2023. Data fields for each shipment included an inland OD pair (using Consignor/Consignee per USTRANSCOM recommendation), the type of shipment, and the weight of the shipment. The data was filtered to ensure that all moves were CONUS (plus Hawaii and Alaska) USC 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 32 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. The distances between OD pairs were estimated using the same data from the 2018 study for routes that existed in 2018, and new routes were estimated using distances from Direct Freight's mileage calculator.[55] An average overall distance was estimated using the number of shipments per route. Any differences between the 2018 and 2023 distance values only reflect the changes in the USTRANSCOM shipping data.

#### *5.5.2.1 Dry Containers*

Table 25 shows the average distance for 2018 and 2023, and the difference between the two values for dry containers. The truck distances were estimated using the Intermodal Association of North America's Intermodal Facilities Directory[56], 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

[55] Direct Freight, 2023

[56] Intermodal Association of North America (2018)

averaged by number of shipments.

Table 25. Dry Containers – Average Distances (miles) in 2018 and 2023 FAF Updates

| Zone | 2018 Average Distance | 2023 Average Distance | Average Distance Difference |
|---|---|---|---|
| East Coast to East Coast | 137 | 146 | +9 |
| Gulf Coast to Gulf Coast | 303 | 280 | -23 |
| West Coast to West Coast | 76 | 86 | +10 |
| East Coast to the rest of the U.S. | 908 | 1,127 | +219 |
| Truck Component | 56 | 45 | -11 |
| Gulf Coast to the rest of the U.S. | 1,647 | 1,403 | -244 |
| Truck Component | 93 | 54 | -39 |
| West Coast to the rest of the U.S. | 2,064 | 2,540 | +476 |
| Truck Component | 53 | 30 | -23 |
| Within Hawaii | N/A | 12 | N/A |
| Within Alaska | N/A | 83 | N/A |

#### 5.5.2.2 *Reefer Containers*

Table 26 shows the average distance for 2018 and 2023 and the difference between the two values for reefer containers.

Table 26. Reefer Containers – Average Distances (miles) in 2018 and 2023 FAF Updates

| Zone | 2018 Average Distance | 2023 Average Distance | Average Distance Difference |
|---|---|---|---|
| East Coast to East Coast | 89 | 266 | +177 |
| Gulf Coast to Gulf Coast | 275 | 263 | -12 |
| West Coast to West Coast | 41 | 77 | +36 |
| East Coast to the rest of the U.S. | 1,421 | 1,370 | -51 |
| Gulf Coast to the rest of the U.S. | 1,167 | 1,477 | +310 |
| West Coast to the rest of the U.S. | 1,806 | 2,730 | +924 |
| Within Hawaii | N/A | 7 | N/A |
| Within Alaska | N/A | 83 | N/A |

#### 5.5.2.3 *Normal Breakbulk*

Table 27 shows the average distance for 2018 and 2023, and the difference between the two values for breakbulk under 50,000 lbs.

Table 27. Normal Breakbulk – Average Distances (miles) in 2018 and 2023 FAF Updates

| Zone | 2018 Average Distance | 2023 Average Distance | Average Distance Difference |
|---|---|---|---|
| East Coast to East Coast | 218 | 267 | +49 |
| Gulf Coast to Gulf Coast | 429 | 399 | -30 |
| West Coast to West Coast | 204 | 200 | -4 |
| East Coast to the rest of the U.S. | 1,076 | 1,651 | +575 |

| Zone | 2018 Average Distance | 2023 Average Distance | Average Distance Difference |
|---|---|---|---|
| Gulf Coast to the rest of the U.S. | 1,071 | 1,672 | +601 |
| West Coast to the rest of the U.S. | 1,789 | 2,040 | +251 |
| Within Hawaii | N/A | 16 | N/A |
| Within Alaska | N/A | 246 | N/A |

#### 5.5.2.4 *Overweight Breakbulk*

Table 28 shows the average distance for 2018 and 2023, and the difference between the two values for breakbulk above 50,000 lbs.

**Table 28. Overweight Breakbulk – Average Distances in 2018 and 2023 FAF Updates**

| Zone | 2018 Average Distance | 2023 Average Distance | Average Distance Difference |
|---|---|---|---|
| East Coast to East Coast | 202 | 155 | -47 |
| Gulf Coast to Gulf Coast | 456 | 560 | +104 |
| West Coast to West Coast | 163 | 173 | +10 |
| East Coast to the rest of the U.S. | 1,253 | 1,275 | +22 |
| Gulf Coast to the rest of the U.S. | 973 | 1,287 | +314 |
| West Coast to the rest of the U.S. | 1,574 | 2,002 | +428 |
| Within Hawaii | N/A | 12 | N/A |
| Within Alaska | N/A | 75 | N/A |

### 5.5.3 Truck/Rail Breakpoint

In order to accurately estimate the fuel consumption (and fuel cost) associated with the inland movement of cargo, it is necessary to know the transportation mode – whether by truck or by rail intermodal. However, USTRANSCOM does not collect this information in IBS. In the absence of historical mode data, it is assumed the mode of transport is based on the distance moved. This approach has been used in all of Volpe's previous FAF analyses, and in 2018 Volpe used 500 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 600 miles, but this results in no functional difference in the FAF calculations.

Volpe's literature review found three new sources that gave values, or a range of values, for the "breakpoint" distance at which rail becomes competitive with trucks. The first source is a 2020 book that discusses how distance effects the cost function of various transportation modes, and estimated the truck-rail breakpoint between 500 and 700 miles.[57] The second reference 2019 book on the impacts of policy-induced modal shifts in freight transport which discussed the specific factors involved in freight

[57] Jean-Paul Rodrigue, 2020

mode choice, and estimated the truck-rail breakpoint between 600 and 700 miles.[58] The third source U.S. Bureau of Transportation Statistics (BTS) article that provided several statistics and data tables relating to freight movements within the U.S, and estimated the truck-rail breakpoint around 750 miles.[59] Considering these new valuations as well as the values from Volpe's 2018 study, the 2023 recommendation for the truck-rail breakpoint is the average of the new sources at 600 miles.

The truck-rail breakpoint is used to determine whether dry containers are carried by truck or rail. This is determined by the average distances calculated for each zone. If the average distance is below 600 miles, then the truck fuel consumption is used. If the average distance is above 600 miles, then the calculation includes an element for both the rail and truck portions of the trip.

As with previous, the eight within zone calculations for dry containers fall below the truck/rail breakpoint, and the three between zone calculations are above the truck-rail breakpoint. Therefore, there are no recommended changes to the calculations. Both of the new calculations for dry containers within Alaska and Hawaii also fall below the truck/rail breakpoint and are therefore included with CONUS within zone shipments as only moving via truck.

In examining this issue further, it was found that typical truck movements associated with intermodal rail movements are not available in the provided data. There is also little information in the literature on distances by truck to/from intermodal rail terminals. Most published comparative analyses present the “dray” as an additional fixed cost.

On the port end Volpe was able to obtain “typical” distances from dock to intermodal rail terminal. These are for Houston (25 miles), Los Angeles/Long Beach (14 miles), and the Port of Virginia (11 miles). For those shipments traveling more than 600 miles, the truck component was calculated as the sum of the movement from the port to/from a rail terminal and the movement from a rail terminal to/from the origin/destination. The distances at the port end were taken from the reference above with Los Angeles representing West Coast ports, Houston representing Gulf Coast ports, and the Port of Virginia representing East Coast ports.

The Intermodal Association of North America (IANA) North American Intermodal Facilities Directory[60] was used to identify the location of rail intermodal terminals in the states containing the inland origin/destination cities. Rail distance was determined as total distance minus the sum of the truck distances at origin and destination, based on the IANA data.

This approach was only applied to dry container shipments, since little refrigerated traffic moves by rail.

As part of the FAF update an attempt was made to identify data on dray distances that might have become available since Volpe’s last report to USTRANSCOM. There was no more recent information in

[58] National Academies of Sciences, Engineering, and Medicine, 2019

[59] U.S. Department of Transportation Bureau of Transportation Statistics, 2022

[60] Intermodal Association of North America (2018)

the literature that would warrant changing the port dray assumptions used in the development of the current FAF methodology. However, as noted above, the inland dray distances were recomputed based on the dry container shipments reported in iSDDC for 2022.

### 5.5.4 Fuel Consumption

Volpe conducted a literature review 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.

#### *5.5.4.1 Trucks*

In 2018, Volpe calculated the truck fuel consumption as seven miles per gallon (MPG) (equivalent to 0.1426 gallons/mile). Based on the literature review, Volpe recommends updating truck fuel consumption to roughly 8.8 MPG (equivalent to 0.1264 gallons/ mile) due to prevailing improvements in fuel efficiency. Fuel consumption data show that truck fuel efficiency is improving over time although different trucks have different fuel consumption values. The fuel consumption values from new sources all provided larger values than the 2018 values.

**Table 29. Fuel Consumption Values 2023**

| Vehicle Type | MPG | Gallons per Mile |
|---|---|---|
| Freight Trucks | 7.6[61] | 0.1316 |
| New Commercial Light Truck | 16.1[62] | 0.0621 |
| Stock Commercial Light Truck | 13.7[63] | 0.0730 |
| Single Unit Trucks | 7.5[64] | 0.1333 |
| Combination Trucks | 6.1[65] | 0.1639 |
| Single-unit and Combination trucks | 6.6[66] | 0.1515 |
| Class 7-8 | 6.25[67] | 0.1600 |
| Class 4-6 | 8.1[68] | 0.1235 |
| Class 8 tractor-trailers | 7.23[69] | 0.1383 |

The average fuel consumption is approximately 8.8 mpg or 0.1264 gallons per mile. Therefore, Volpe

[61] U.S. Energy Information Administration, *Independent Statistics and Analysis*, 2023
[62] Ibid.
[63] Ibid.
[64] Federal Highway Administration, *Highway Statistics*, 2021
[65] Ibid
[66] Ibid.
[67] U.S. Energy Information Administration, Annual Energy Outlook, 2021
[68] Ibid.
[69] North American Council for Freight Efficiency, 2021

recommends updating the truck fuel consumption to 0.1264 gallons per cargo mile.

#### *5.5.4.2 Overweight Breakbulk*

In 2018, Volpe calculated the fuel consumption for overweight breakbulk as 0.2192 gallons per cargo mile. Based on a literature review, 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. Therefore, Volpe recommends using the 2018 Overweight Breakbulk fuel consumption of 0.2192 gallons per cargo mile.

#### *5.5.4.3 Rail*

Based on literature review, Volpe recommends basing the rail fuel consumption on the truck fuel consumption, as was done in 2018. Sources that discussed rail fuel consumption did so in relation to truck fuel consumption but rarely provided a quantitative value for rail fuel consumption. Based on the availability of truck fuel consumption data and a simple approach for converting truck to rail capacity (assuming 4 car loads per rail engine), the fuel consumption for rail is estimated as the truck fuel consumption divided by 4 (a four-fold efficiency difference between the modes).

This assumption is consistent with new information published since the 2018 report, between 2019 and 2022 , suggests that rail was on average four times more efficient than trucks.[70] [71] [72] An additional source from 2023 indicated that rail is generally between three to four times more efficient.[73] This updated literature found values similar to those from the 2018 update, hence it is recommended to keep the rail fuel consumption estimate based on the truck values, using the assumption being that rail is four times more efficient than trucks.

Volpe recommends updating rail fuel consumption from 0.036 gallons/container mile to 0.032 gallons/container mile, to reflect the reduction in the truck fuel consumption value.

#### *5.5.4.4 Reefers*

Volpe found two new sources that confirmed the value for reefer fuel consumption recommended in 2018. A 2023 source indicated that reefers on average use 0.75 gallons of fuel an hour.[74] A 2022 source provided a range of values for reefer fuel consumption from 0.4 to 1.1 gallons an hour.[75] Based on this information, Volpe recommends that the reefer fuel consumption value remain at 0.8 gallons/hour as in the 2018 refresh.

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[70] Freightera, 2023

[71] Federal Rail Administration, 2020

[72] RSI Logistics, 2022

[73] Association of American Railroads, 2023

[74] Dryjowicz, 2023

[75] Waqar, n.d.

### 5.5.5 Off Duty Time

As discussed in Section 5.3.3.2, reefer containers require additional fuel to ensure the unit remains refrigerated. This is the case regardless of whether the truck is actively moving. Some trips can be completed within a day, while other trips are long enough that the driver must stop and rest. The reefer container still burns fuel when the driver is resting and therefore the FAF reefer calculations need to account for this additional 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.[76] Assuming an average speed of 50 mph, which is consistent with Volpe's previous studies, 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 2018 FAF update.

Based on the new average distance values calculated as part of the FAF refresh, the off-duty time should be updated 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:

- East Coast ports to the rest of the U.S.: 26 hours
- West Coast ports to the rest of the U.S.: 52 hours
- Gulf Coast ports to the rest of the U.S.: 26 hours

### 5.5.6 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 from the EIA website.[77] As with previous studies, 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 for the monthly updates, and that the monthly averages are used as opposed to the weekly averages to ensure a better representation of current fuel prices.

As with the 2018 recommendations, Volpe 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. 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

[76] Federal Motor Carrier Safety Administration, 2017
[77] https://www.eia.gov/petroleum/gasdiesel/

be calculated and posted in January.

The baseline fuel price data should continue to be collected at the beginning of the solicitation period, as is currently done.

## 5.6 Conclusion and Recommendations

Overall, Volpe recommends the USTRANSCOM's FAF should generally remain unchanged. The primary new recommendation is to add a FAF for Alaska and Hawaii shipments, and then all other recommendations are associated with updating the input values.

Table 30 shows the main FAF input values from 2018 and 2023. The table does not include the average distance values, but does show fuel consumption, the truck/rail breakpoint, and off duty hours.

**Table 30. Summary of Changes to FAF Inputs**

| FAF Input | 2018 Value | 2023 Updated Value |
|---|---|---|
| Truck Fuel Consumption | 0.1426 gallons/container mile | 0.1264 gallons per container mile |
| Reefer Fuel Consumption | 0.8 gallons/hour | 0.8 gallons per hour |
| Rail Fuel Consumption | 0.036 gallons/container mile | 0.032 gallons per container mile |
| Specialized Heavy Hauler Truck Fuel Consumption | 0.2192 gallons/container mile | 0.2192 gallons per container mile |
| Truck/Rail Breakpoint | 500 miles | 600 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 | 52 hours |

Volpe also recommends updating the average distance values, which can be found in Section 5.5.2. 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.

### 5.6.1 FAF Cloud-based System Recommendations

During the USC-10 period, USTRANSCOM and SDDC will migrate the existing IBS and CARE II systems to a cloud-based system that may potentially some improvements to how the EPAs are implemented. Volpe is providing some recommendations for USTRANSCOM's consideration that will not be possible to implement in advance of USC-10 due to the existing development plan for the cloud-based systems. However, as the cloud-based system will be implemented during USC-10 and there will be opportunities to continue to improve the system design before USC-11 when the EPA methodologies and implementation will be reviewed again, Volpe is providing design recommendations USTRANSCOM and SDDC that may be deployed to assist in the potential future USC-11 EPA review.

The recommendations for cloud-based system for the FAF include:

- USTRANSCOM and SDDC could consider revisions to how OD data are collected to clearly identify the ODs using new or existing fields, particularly if they are different than the Consignor/Shipper address. Additionally, it would be beneficial to ensure that OD addresses are consistent among entries, as it would reduce the time required to make the address data consistent in future EPA studies.

- USTRANSCOM and SDDC could consider requesting information from the carriers about whether they will or may consider using rail to move a shipment. The current system assumes shipments are moved by truck and otherwise it is up to the discretion of the carrier to determine whether rail is their best alternative for all or part of moving the shipment.

- USTRANSCOM and SDDC could consider using actual trip distances rather than using the FAF zone distances to calculate FAF payments. The FAF zone approach may result in inaccurate payments for carriers where the average zone-to-zone distance is significantly different than the actual distance moved. For example, the average distance for an East Coast to East Coast Breakbulk Over cargo average distance is 155 miles, the range is 5 to 1,271 miles with a standard deviation of 243 miles—many trips will accordingly be traveling either shorter or longer distances than the average. When trip lengths are significantly different than average, the FAF payments to either party may either overestimate or underestimate the appropriate fuel costs. The actual distance could be calculated for each shipment in the IBS and CARE II using a matrix of origin and destinations populated using historic origins and destinations[78] and data collection. This adjustment would require many more calculations than the current FAF approach, and is only recommended if a FAF payment is able to be automatically calculated based on a carrier's booking information.

[78] It is possible that a booking could use an OD pair not present in the historic data. In this scenario, it would be recommended to still include a zone-based FAF that could be applied in these instances of a new OD pair until the new OD pair could be added to the main list.

# 6. Appendix A: The "Average" Vessel by Lane

Table 31 shows the average vessel characteristics for container and RORO service, number of observations and data source by lane. [79,80]

**Table 31: Characteristics of Average Container Vessels by Lane**

| Lane | Container Capacity (TEU) | Container Average Speed (Knots) | Container Fuel Con.(tons/day) | Container Obs. | Container Data Source | RORO Capacity (MTONs) | RORO Average Speed (Knots) | RORO Fuel Con. (tons/day) | RORO Obs. | RORO Data Source |
|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 5,661 | 17.6 | 64 | 113,239 | 1 | 57,764 | 16.9 | 42 | 8,193 | 1 |
| 02 | 4,031 | 15.8 | 59 | 3,014 | 1 | 46,057 | 16.4 | 43 | 39 | 1 |
| 03 | 2,868 | 20.9 | 55 | 22,209 | 1 | 8,911 | 20.0 | 54 | 10,504 | 1 |
| 04 | 3,323 | 15.2 | 47 | 2,504 | 1 | 47,949 | 16.3 | 45 | 3,338 | 1 |
| 05 | 4,563 | 16.9 | 73 | 71,171 | 1 | 48,244 | 16.1 | 41 | 12,843 | 1 |
| 06 | 5,345 | 16.8 | 79 | 16,173 | 1 | 44,198 | 15.8 | 40 | 8,910 | 1 |
| 07 | 5,083 | 16.7 | 74 | 40,775 | 1 | 48,432 | 16.0 | 41 | 32,863 | 1 |
| 08 | 6,211 | 17.5 | 93 | 277 | 1 | 49,796 | 15.4 | 33 | 646 | 1 |
| 10 | 3,843 | 16.0 | 65 | 72 | 1 | 45,343 | 16.0 | 41 | 7,988 | 1 |
| 11 | 4,307 | 17.6 | 73 | 5,302 | 1 | 45,012 | 16.1 | 41 | 12,364 | 1 |
| 12 | 4,923 | 16.0 | 71 | 4,230 | 1 | 39,170 | 15.9 | 39 | 3,895 | 1 |
| 13 | 5,185 | 16.8 | 76 | 8,933 | 1 | 48,395 | 16.1 | 41 | 38,434 | 1 |
| 14 | 3,969 | 17.3 | 61 | 1 | 2 | 52,324 | 15.5 | 34 | 324 | 1 |
| 15 | 3,969 | 17.3 | 61 | 2 | 2 | 12,671 | 19.5 | 52 | 1 | 2 |
| 16 | 4,885 | 18.4 | 58 | 424 | 1 | 65,407 | 16.3 | 41 | 485 | 1 |
| 18 | 3,969 | 17.3 | 61 | 2 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 19 | 5,195 | 15.4 | 57 | 3,880 | 1 | 53,013 | 15.8 | 38 | 2,778 | 1 |
| 20 | 3,077 | 13.0 | 45 | 5 | 1 | 60,500 | 16.5 | 46 | 300 | 1 |
| 23 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 24 | 4,941 | 15.9 | 71 | 12 | 1 | 51,850 | 16.1 | 41 | 294 | 1 |
| 25 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 26 | 1,688 | 19.0 | 50 | 1,907 | 1 | 8,126 | 21.5 | 75 | 7,573 | 1 |
| 27 | 4,150 | 18.4 | 66 | 17 | 1 | 12,671 | 19.5 | 52 | 4 | 2 |
| 28 | 3,969 | 17.3 | 61 | 0 | 2 | 29,679 | 15.0 | 37 | 249 | 1 |
| 29 | 1,668 | 19.0 | 50 | 6 | 1 | 8,407 | 21.5 | 75 | 38 | 1 |
| 31 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 32 | 4,302 | 15.7 | 66 | 476 | 1 | 42,467 | 16.1 | 40 | 4,428 | 1 |
| 33 | 4,671 | 15.8 | 70 | 207 | 1 | 47,187 | 16.3 | 42 | 9 | 1 |

[79] NOTE: Data source refers to which data source was used given USTRANSCOM's priority of data quality described in Section 3.4.2.3.

[80] Methodology for calculating TEU and MTON capacity is discussed in the Vessel Capacity Section, Section 3.4.5

| Lane | Container Capacity (TEU) | Container Average Speed (Knots) | Container Fuel Con.(tons/day) | Container Obs. | Container Data Source | RORO Capacity (MTONs) | RORO Average Speed (Knots) | RORO Fuel Con. (tons/day) | RORO Obs. | RORO Data Source |
|---|---|---|---|---|---|---|---|---|---|---|
| 34 | 4,092 | 15.9 | 52 | 280 | 1 | 20,303 | 16.1 | 36 | 310 | 1 |
| 35 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 36 | 3,548 | 23.0 | 50 | 5 | 1 | 12,671 | 19.5 | 52 | 4 | 2 |
| 37 | 3,032 | 18.6 | 70 | 14,255 | 1 | 3,801 | 18.8 | 49 | 1,452 | 1 |
| 39 | 6,325 | 17.6 | 87 | 10 | 1 | 34,806 | 16.4 | 44 | 289 | 1 |
| 40 | 6,234 | 18.1 | 120 | 21 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 41 | 3,027 | 21.5 | 75 | 9 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 42 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 43 | 5,939 | 17.4 | 80 | 11 | 1 | 18,272 | 16.0 | 34 | 76 | 1 |
| 44 | 2,046 | 20.1 | 55 | 174 | 1 | 17,392 | 16.0 | 34 | 65 | 1 |
| 47 | 5,590 | 15.5 | 61 | 3,955 | 1 | 63,774 | 15.8 | 38 | 1,686 | 1 |
| 48 | 4,718 | 17.6 | 74 | 23 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 49 | 6,557 | 16.2 | 71 | 114 | 1 | 37,591 | 15.4 | 40 | 14 | 1 |
| 50 | 6,551 | 15.7 | 68 | 10 | 1 | 52,547 | 15.5 | 32 | 142 | 1 |
| 51 | 5,420 | 15.5 | 59 | 197 | 1 | 18,332 | 15.7 | 34 | 127 | 1 |
| 52 | 6,173 | 17.5 | 93 | 2,324 | 1 | 31,770 | 15.9 | 39 | 1,368 | 1 |
| 53 | 3,969 | 17.3 | 61 | 1 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 54 | 3,009 | 21.0 | 50 | 36,403 | 1 | 16,234 | 19.3 | 50 | 2,440 | 1 |
| 55 | 6,104 | 17.7 | 90 | 118 | 1 | 28,015 | 15.7 | 41 | 193 | 1 |
| 56 | 6,380 | 17.8 | 89 | 13 | 1 | 27,577 | 15.4 | 36 | 16 | 1 |
| 57 | 5,402 | 16.8 | 78 | 317 | 1 | 41,348 | 16.2 | 43 | 650 | 1 |
| 58 | 3,969 | 17.3 | 61 | 4 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 59 | 6,228 | 17.7 | 97 | 403 | 1 | 44,198 | 16.0 | 41 | 1,914 | 1 |
| 60 | 6,180 | 17.5 | 92 | 3,634 | 1 | 26,556 | 15.6 | 36 | 1,116 | 1 |
| 61 | 1,623 | 14.3 | 27 | 2,077 | 1 | 52,532 | 15.7 | 38 | 410 | 1 |
| 62 | 3,969 | 17.3 | 61 | 0 | 2 | 6,746 | 11.0 | 24 | 21 | 1 |
| 64 | 4,465 | 15.6 | 68 | 27 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 65 | 3,969 | 17.3 | 61 | 1 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 66 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 67 | 6,824 | 15.9 | 71 | 212 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 68 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 2 | 2 |
| 69 | 3,969 | 17.3 | 61 | 1 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 70 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 71 | 5,646 | 17.5 | 81 | 396 | 1 | 21,564 | 15.1 | 35 | 7 | 1 |
| 72 | 3,008 | 22.5 | 44 | 5 | 1 | 49,082 | 16.1 | 41 | 11 | 1 |
| 73 | 6,188 | 17.6 | 93 | 973 | 1 | 34,772 | 16.2 | 41 | 233 | 1 |
| 74 | 6,318 | 17.6 | 88 | 263 | 1 | 33,517 | 15.1 | 44 | 240 | 1 |
| 75 | 5,752 | 17.3 | 90 | 931 | 1 | 48,769 | 16.3 | 46 | 120 | 1 |
| 76 | 3,969 | 17.3 | 61 | 0 | 2 | 35,015 | 16.4 | 44 | 9 | 1 |

| Lane | Container Capacity (TEU) | Container Average Speed (Knots) | Container Fuel Con.(tons/day) | Container Obs. | Container Data Source | RORO Capacity (MTONs) | RORO Average Speed (Knots) | RORO Fuel Con. (tons/day) | RORO Obs. | RORO Data Source |
|---|---|---|---|---|---|---|---|---|---|---|
| 77 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 78 | 3,969 | 17.3 | 61 | 0 | 2 | 23,306 | 15.3 | 31 | 12 | 1 |
| 79 | 2,770 | 21.0 | 42 | 607 | 1 | 64,041 | 16.7 | 44 | 929 | 1 |
| 80 | 1,395 | 13.9 | 24 | 13 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 81 | 1,324 | 13.7 | 21 | 269 | 1 | 19,696 | 13.5 | 35 | 24 | 1 |
| 82 | 5,312 | 17.2 | 64 | 17 | 1 | 57,772 | 15.7 | 37 | 74 | 1 |
| 83 | 1,575 | 18.0 | 38 | 20 | 1 | 12,671 | 19.5 | 52 | 2 | 2 |
| 84 | 2,400 | 19.0 | 50 | 16 | 1 | 16,198 | 16.2 | 39 | 56 | 1 |
| 85 | 3,029 | 20.5 | 45 | 11 | 1 | 22,631 | 14.5 | 37 | 50 | 1 |
| 86 | 3,969 | 17.3 | 61 | 1 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 87 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 88 | 2,986 | 15.7 | 53 | 10 | 1 | 42,664 | 15.9 | 40 | 588 | 1 |
| 89 | 3,969 | 17.3 | 61 | 1 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 90 | 7,055 | 16.4 | 77 | 5 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 91 | 5,365 | 17.4 | 88 | 11 | 1 | 25,384 | 15.9 | 35 | 351 | 1 |
| 92 | 3,969 | 17.3 | 61 | 3 | 2 | 44,031 | 16.9 | 51 | 273 | 1 |
| 93 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 94 | 6,261 | 17.7 | 89 | 8 | 1 | 12,671 | 19.5 | 52 | 1 | 2 |
| 95 | 5,756 | 17.6 | 111 | 23 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 96 | 3,969 | 17.3 | 61 | 0 | 2 | 19,148 | 14.4 | 30 | 325 | 1 |
| 97 | 6,352 | 17.3 | 86 | 12 | 1 | 12,671 | 19.5 | 52 | 0 | 2 |
| 98 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| 99 | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |
| CA | 3,969 | 17.3 | 61 | 0 | 2 | 12,671 | 19.5 | 52 | 0 | 2 |

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

Table 32. Speed, Distance, and Steaming Days by Vessel Type

| Lane | Total Distance | Speed (Container) | Speed (RORO) | Steaming Days (Container) | Steaming Days (RORO) |
|---|---|---|---|---|---|
| 01 | 7,071 | 17.6 | 16.9 | 16.8 | 17.4 |
| 02 | 7,153 | 15.8 | 16.4 | 18.9 | 18.1 |
| 03 | 3,835 | 20.9 | 20.0 | 7.6 | 8.0 |
| 04 | 911 | 15.2 | 16.3 | 2.5 | 2.3 |
| 05 | 4,352 | 16.9 | 16.1 | 10.8 | 11.3 |
| 06 | 6,035 | 16.8 | 15.8 | 15.0 | 15.9 |
| 07 | 9,328 | 16.7 | 16.0 | 23.3 | 24.3 |
| 08 | 11,338 | 17.5 | 15.4 | 26.9 | 30.8 |
| 10 | 5,855 | 16.0 | 16.0 | 15.2 | 15.2 |
| 11 | 5,630 | 17.6 | 16.1 | 13.4 | 14.6 |
| 12 | 7,066 | 16.0 | 15.9 | 18.4 | 18.5 |
| 13 | 10,363 | 16.8 | 16.1 | 25.7 | 26.9 |
| 14 | 15,014 | 17.3 | 15.5 | 36.2 | 40.4 |
| 15 | 6,238 | 17.3 | 19.5 | 15.1 | 13.3 |
| 16 | 5,254 | 18.4 | 16.3 | 11.9 | 13.4 |
| 18 | 256 | 17.3 | 19.5 | 0.6 | 0.5 |
| 19 | 1,314 | 15.4 | 15.8 | 3.6 | 3.5 |
| 20 | 1,528 | 13.0 | 16.5 | 4.9 | 3.8 |
| 23 | 8,892 | 17.3 | 19.5 | 21.5 | 19.0 |
| 24 | 1,920 | 15.9 | 16.1 | 5.0 | 5.0 |
| 25 | 9,227 | 17.3 | 19.5 | 22.3 | 19.7 |
| 26 | 2,252 | 19.0 | 21.5 | 4.9 | 4.4 |
| 27 | 9,959 | 18.4 | 19.5 | 22.5 | 21.3 |
| 28 | 2,652 | 17.3 | 15.0 | 6.4 | 7.4 |
| 29 | 2,280 | 19.0 | 21.5 | 5.0 | 4.4 |
| 31 | 3,040 | 17.3 | 19.5 | 7.3 | 6.5 |
| 32 | 4,818 | 15.7 | 16.1 | 12.8 | 12.5 |
| 33 | 3,172 | 15.8 | 16.3 | 8.4 | 8.1 |
| 34 | 4,134 | 15.9 | 16.1 | 10.9 | 10.7 |
| 35 | 5,535 | 17.3 | 19.5 | 13.4 | 11.8 |
| 36 | 10,954 | 23.0 | 19.5 | 19.8 | 23.4 |
| 37 | 2,335 | 18.6 | 18.8 | 5.2 | 5.2 |
| 39 | 1,767 | 17.6 | 16.4 | 4.2 | 4.5 |
| 40 | 9,075 | 18.1 | 19.5 | 20.9 | 19.4 |

| Lane | Total Distance | Speed (Container) | Speed (RORO) | Steaming Days (Container) | Steaming Days (RORO) |
|---|---|---|---|---|---|
| 41 | 313 | 21.5 | 19.5 | 0.6 | 0.7 |
| 42 | 2,407 | 17.3 | 19.5 | 5.8 | 5.1 |
| 43 | 1,640 | 17.4 | 16.0 | 3.9 | 4.3 |
| 44 | 2,485 | 20.1 | 16.0 | 5.2 | 6.5 |
| 47 | 12,947 | 15.5 | 15.8 | 34.8 | 34.2 |
| 48 | 811 | 17.6 | 19.5 | 1.9 | 1.7 |
| 49 | 11,964 | 16.2 | 15.4 | 30.8 | 32.3 |
| 50 | 10,634 | 15.7 | 15.5 | 28.3 | 28.6 |
| 51 | 7,134 | 15.5 | 15.7 | 19.2 | 19.0 |
| 52 | 6,637 | 17.5 | 15.9 | 15.8 | 17.4 |
| 53 | 4,256 | 17.3 | 19.5 | 10.3 | 9.1 |
| 54 | 8,614 | 21.0 | 19.3 | 17.1 | 18.6 |
| 55 | 6,992 | 17.7 | 15.7 | 16.4 | 18.5 |
| 56 | 5,884 | 17.8 | 15.4 | 13.8 | 16.0 |
| 57 | 5,765 | 16.8 | 16.2 | 14.3 | 14.8 |
| 58 | 10,637 | 17.3 | 19.5 | 25.7 | 22.7 |
| 59 | 7,241 | 17.7 | 16.0 | 17.1 | 18.8 |
| 60 | 8,431 | 17.5 | 15.6 | 20.0 | 22.6 |
| 61 | 6,634 | 14.3 | 15.7 | 19.3 | 17.6 |
| 62 | 1,566 | 17.3 | 11.0 | 3.8 | 5.9 |
| 64 | 1,921 | 15.6 | 19.5 | 5.1 | 4.1 |
| 65 | 5,556 | 17.3 | 19.5 | 13.4 | 11.9 |
| 66 | 6,092 | 17.3 | 19.5 | 14.7 | 13.0 |
| 67 | 13,550 | 15.9 | 19.5 | 35.4 | 29.0 |
| 68 | 3,670 | 17.3 | 19.5 | 8.9 | 7.8 |
| 69 | 8,001 | 17.3 | 19.5 | 19.3 | 17.1 |
| 70 | 2,925 | 17.3 | 19.5 | 7.1 | 6.3 |
| 71 | 5,526 | 17.5 | 15.1 | 13.1 | 15.2 |
| 72 | 11,594 | 22.5 | 16.1 | 21.5 | 30.0 |
| 73 | 9,623 | 17.6 | 16.2 | 22.8 | 24.8 |
| 74 | 5,082 | 17.6 | 15.1 | 12.1 | 14.0 |
| 75 | 5,076 | 17.3 | 16.3 | 12.2 | 13.0 |
| 76 | 1,747 | 17.3 | 16.4 | 4.2 | 4.4 |
| 77 | 14,438 | 17.3 | 19.5 | 34.9 | 30.9 |
| 78 | 11,131 | 17.3 | 15.3 | 26.9 | 30.4 |
| 79 | 5,106 | 21.0 | 16.7 | 10.1 | 12.8 |
| 80 | 6,250 | 13.9 | 19.5 | 18.7 | 13.4 |
| 81 | 1,815 | 13.7 | 13.5 | 5.5 | 5.6 |
| 82 | 4,068 | 17.2 | 15.7 | 9.8 | 10.8 |

| Lane | Total Distance | Speed (Container) | Speed (RORO) | Steaming Days (Container) | Steaming Days (RORO) |
|---|---|---|---|---|---|
| 83 | 5,179 | 18.0 | 19.5 | 12.0 | 11.1 |
| 84 | 1,552 | 19.0 | 16.2 | 3.4 | 4.0 |
| 85 | 9,704 | 20.5 | 14.5 | 19.7 | 27.9 |
| 86 | 4,137 | 17.3 | 19.5 | 10.0 | 8.8 |
| 87 | 13,338 | 17.3 | 19.5 | 32.2 | 28.5 |
| 88 | 4,207 | 15.7 | 15.9 | 11.2 | 11.1 |
| 89 | 9,494 | 17.3 | 19.5 | 22.9 | 20.3 |
| 90 | 9,097 | 16.4 | 19.5 | 23.1 | 19.4 |
| 91 | 10,036 | 17.4 | 15.9 | 24.0 | 26.3 |
| 92 | 8,833 | 17.3 | 16.9 | 21.3 | 21.8 |
| 93 | 8,527 | 17.3 | 19.5 | 20.6 | 18.2 |
| 94 | 3,128 | 17.7 | 19.5 | 7.4 | 6.7 |
| 95 | 5,065 | 17.6 | 19.5 | 12.0 | 10.8 |
| 96 | 584 | 17.3 | 14.4 | 1.4 | 1.7 |
| 97 | 4,330 | 17.3 | 19.5 | 10.4 | 9.3 |
| 98 | 492 | 17.3 | 19.5 | 1.2 | 1.1 |
| 99 | 7,899 | 17.3 | 19.5 | 19.1 | 16.9 |
| CA | 433 | 17.3 | 19.5 | 1.0 | 0.9 |

# 8. Appendix C: Fuel Mix Factors

Table 33 shows the fuel mix factors for over ocean share and the ECA and port share of the distance, for 2024 when the Mediterranean is not in the ECA zone and for 2025 when the Mediterranean is scheduled to become an ECA zone.

**Table 33: Fuel Mix Factors with and without Mediterranean ECA**

| Lane | Lane Name | Over Ocean Fuel Mix Factors (2024) | ECA / Port Fuel Mix Factors (2024) | Over Ocean Fuel Mix Factors (2025) | ECA / Port Fuel Mix Factors (2025) |
|---|---|---|---|---|---|
| 01 | U.S. West Coast - Far East | 74% | 26% | 74% | 26% |
| 02 | Continental Europe, United Kingdom, Ireland - Middle East, South Asia, Indian Ocean | 86% | 14% | 61% | 39% |
| 03 | U.S. West Coast - Hawaii | 42% | 58% | 42% | 58% |
| 04 | Middle East, South Asia, Indian Ocean Interport | 95% | 5% | 95% | 5% |
| 05 | U.S. East Coast - Continental Europe, United Kingdom, Ireland | 36% | 64% | 36% | 64% |
| 06 | U.S. East Coast - Mediterranean | 76% | 24% | 43% | 57% |
| 07 | U.S. East Coast - Middle East, South Asia, Indian Ocean | 78% | 22% | 58% | 42% |
| 08 | U.S. East Coast - Far East | 88% | 12% | 88% | 12% |
| 10 | U.S. Gulf Coast - Scandinavia, Baltic Sea | 41% | 59% | 41% | 59% |
| 11 | U.S. Gulf Coast - Continental Europe, United Kingdom, Ireland | 63% | 37% | 63% | 37% |
| 12 | U.S. Gulf Coast - Mediterranean | 80% | 20% | 52% | 48% |
| 13 | U.S. Gulf Coast - Middle East, South Asia, Indian Ocean | 84% | 16% | 67% | 33% |
| 14 | U.S. Gulf Coast - Far East | 87% | 13% | 87% | 13% |
| 15 | U.S. Gulf Coast - Hawaii | 84% | 16% | 84% | 16% |
| 16 | Hawaii - Far East | 88% | 12% | 88% | 12% |
| 18 | Caribbean Interport | 37% | 63% | 37% | 63% |
| 19 | Far East Interport | 95% | 5% | 95% | 5% |
| 20 | Mediterranean Interport | 95% | 5% | 0% | 100% |
| 23 | U.S. West Coast - Continental Europe, United Kingdom, Ireland | 77% | 23% | 77% | 23% |
| 24 | SCANDINAVIA, BALTIC SEA - CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND | 45% | 55% | 45% | 55% |
| 25 | U.S. West Coast - Mediterranean | 89% | 11% | 72% | 28% |
| 26 | U.S. West Coast - Alaska | 30% | 70% | 30% | 70% |
| 27 | Hawaii - Continental Europe, United Kingdom, Ireland | 83% | 17% | 83% | 17% |

| Lane | Lane Name | Over Ocean Fuel Mix Factors (2024) | ECA / Port Fuel Mix Factors (2024) | Over Ocean Fuel Mix Factors (2025) | ECA / Port Fuel Mix Factors (2025) |
|---|---|---|---|---|---|
| 28 | U.S. West Coast - Central America/Mexico | 89% | 11% | 89% | 11% |
| 29 | Alaska Interport | 87% | 13% | 87% | 13% |
| 31 | U.S. East Coast - Iceland | 33% | 67% | 33% | 67% |
| 32 | U.S. East Coast - Scandinavia, Baltic Sea | 33% | 67% | 33% | 67% |
| 33 | U.S. EAST COAST - AZORES | 54% | 46% | 54% | 46% |
| 34 | Continental Europe, United Kingdom, Ireland - Mediterranean | 78% | 22% | 23% | 77% |
| 35 | U.S. WEST COAST - CARIBBEAN | 74% | 26% | 74% | 26% |
| 36 | Mediterranean - Hawaii | 91% | 9% | 74% | 26% |
| 37 | U.S. East Coast - Caribbean | 42% | 58% | 42% | 58% |
| 39 | U.S. East Coast - Central America/Mexico | 37% | 63% | 37% | 63% |
| 40 | AFRICA INTERPORT | 95% | 5% | 80% | 20% |
| 41 | HAWAII INTERPORT | 0% | 100% | 0% | 100% |
| 42 | U.S. Gulf Coast - Caribbean | 52% | 48% | 52% | 48% |
| 43 | U.S. Gulf Coast - Central America/Mexico | 68% | 32% | 68% | 32% |
| 44 | ALASKA - HAWAII | 78% | 22% | 78% | 22% |
| 47 | U.S. West Coast - Middle East, South Asia, Indian Ocean | 82% | 18% | 82% | 18% |
| 48 | CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND INTERPORT | 40% | 60% | 40% | 60% |
| 49 | Far East - Continental Europe, United Kingdom, Ireland | 89% | 11% | 74% | 26% |
| 50 | Far East - Mediterranean | 95% | 5% | 74% | 26% |
| 51 | Far East - Middle East, South Asia, Indian Ocean | 95% | 5% | 95% | 5% |
| 52 | U.S. East Coast - Black Sea | 72% | 28% | 47% | 53% |
| 53 | U.S. West Coast - South America | 72% | 28% | 72% | 28% |
| 54 | U.S. West Coast - Oceania | 80% | 20% | 80% | 20% |
| 55 | U.S. East Coast - South America | 84% | 16% | 84% | 16% |
| 56 | U.S. Gulf Coast - South America | 87% | 13% | 87% | 13% |
| 57 | Mediterranean - Middle East, South Asia, Indian Ocean | 95% | 5% | 57% | 43% |
| 58 | Far East - South America | 95% | 5% | 95% | 5% |
| 59 | U.S. GULF COAST - BLACK SEA | 80% | 20% | 57% | 43% |
| 60 | U.S. East Coast - Africa | 75% | 25% | 62% | 38% |
| 61 | Far East - Oceania | 95% | 5% | 95% | 5% |
| 62 | Continental Europe, United Kingdom, Ireland - Iceland | 40% | 60% | 40% | 60% |

| Lane | Lane Name | Over Ocean Fuel Mix Factors (2024) | ECA / Port Fuel Mix Factors (2024) | Over Ocean Fuel Mix Factors (2025) | ECA / Port Fuel Mix Factors (2025) |
|---|---|---|---|---|---|
| 64 | CONTINENTAL EUROPE, UNITED KINGDOM, IRELAND - AZORES | 57% | 43% | 57% | 43% |
| 65 | Central America/Mexico - Continental Europe, United Kingdom, Ireland | 88% | 12% | 88% | 12% |
| 66 | Central America/Mexico - Mediterranean | 95% | 5% | 70% | 30% |
| 67 | U.S. West Coast - Africa | 85% | 15% | 85% | 15% |
| 68 | Central America/Mexico - South America | 95% | 5% | 95% | 5% |
| 69 | Central America/Mexico - Oceania | 95% | 5% | 95% | 5% |
| 70 | Azores - Mediterranean | 95% | 5% | 37% | 63% |
| 71 | Continental Europe, United Kingdom, Ireland - Africa | 85% | 15% | 62% | 38% |
| 72 | Continental Europe, United Kingdom, Ireland - Oceania | 89% | 11% | 89% | 11% |
| 73 | U.S. Gulf Coast - Africa | 85% | 15% | 69% | 31% |
| 74 | Mediterranean - Africa | 95% | 5% | 67% | 33% |
| 75 | Africa - Middle East, South Asia, Indian Ocean | 95% | 5% | 95% | 5% |
| 76 | Central America/Mexico Interport | 95% | 5% | 95% | 5% |
| 77 | U.S. East Coast - Oceania | 92% | 8% | 92% | 8% |
| 78 | U.S. Gulf Coast - Oceania | 92% | 8% | 92% | 8% |
| 79 | Hawaii - Oceania | 86% | 14% | 86% | 14% |
| 80 | Oceania - Middle East, South Asia, Indian Ocean | 95% | 5% | 95% | 5% |
| 81 | Oceania Interport | 95% | 5% | 95% | 5% |
| 82 | Alaska - Far East | 90% | 10% | 90% | 10% |
| 83 | Alaska - Oceania | 91% | 9% | 91% | 9% |
| 84 | Caribbean - Central America, Mexico | 85% | 15% | 85% | 15% |
| 85 | Hawaii - Middle East, South Asia, Indian Ocean | 92% | 8% | 92% | 8% |
| 86 | MEDITERRANEAN - SCANDINAVIA, BALTIC SEA | 55% | 45% | 26% | 74% |
| 87 | FAR EAST - SCANDINAVIA, BALTIC SEA | 81% | 19% | 67% | 33% |
| 88 | Continental Europe, United Kingdom, Ireland - Caribbean | 77% | 23% | 77% | 23% |
| 89 | MEDITERRANEAN - OCEANIA | 95% | 5% | 76% | 24% |
| 90 | Far East - Africa | 95% | 5% | 95% | 5% |
| 91 | Alaska - Middle East, South Asia, Indian Ocean | 93% | 7% | 93% | 7% |

| Lane | Lane Name | Over Ocean Fuel Mix Factors (2024) | ECA / Port Fuel Mix Factors (2024) | Over Ocean Fuel Mix Factors (2025) | ECA / Port Fuel Mix Factors (2025) |
|---|---|---|---|---|---|
| 92 | Caribbean - Middle East, South Asia, Indian Ocean | 92% | 8% | 71% | 29% |
| 93 | Far East - Central America/Mexico | 92% | 8% | 92% | 8% |
| 94 | Mediterranean-Black Sea | 95% | 5% | 29% | 71% |
| 95 | Black Sea - Middle East, South Asia, Indian Ocean | 95% | 5% | 80% | 20% |
| 96 | BLACK SEA INTERPORT | 95% | 5% | 95% | 5% |
| 97 | Continental Europe, United Kingdom, Ireland - Black Sea | 83% | 17% | 44% | 56% |
| 98 | SCANDINAVIA, BALTIC SEA INTERPORT | 0% | 100% | 0% | 100% |
| 99 | Caribbean - Africa | 92% | 8% | 76% | 24% |
| CA | Caspian Sea Interport | 95% | 5% | 95% | 5% |

# 9. Appendix D: Comparison of USC-10 BAF Technical Factors

Table 34 shows the technical factors for USC-10.

**Table 34: Technical Factors for USC-9 and USC-10**[81]

| Lane | TEU | FEU | MTONs |
|---|---|---|---|
| 01 | 0.128 | 0.252 | 0.013 |
| 02 | 0.187 | 0.366 | 0.017 |
| 03 | 0.099 | 0.195 | 0.050 |
| 04 | 0.024 | 0.046 | 0.002 |
| 05 | 0.116 | 0.227 | 0.010 |
| 06 | 0.149 | 0.292 | 0.015 |
| 07 | 0.230 | 0.451 | 0.021 |
| 08 | 0.271 | 0.532 | 0.021 |
| 10 | 0.173 | 0.338 | 0.014 |
| 11 | 0.153 | 0.299 | 0.014 |
| 12 | 0.179 | 0.351 | 0.019 |
| 13 | 0.255 | 0.499 | 0.024 |
| 14 | 0.374 | 0.734 | 0.028 |
| 15 | 0.156 | 0.305 | 0.057 |
| 16 | 0.096 | 0.188 | 0.009 |
| 18 | 0.006 | 0.012 | 0.002 |
| 19 | 0.026 | 0.051 | 0.003 |
| 20 | 0.048 | 0.095 | 0.003 |
| 23 | 0.222 | 0.435 | 0.081 |
| 24 | 0.049 | 0.096 | 0.004 |
| 25 | 0.230 | 0.451 | 0.084 |
| 26 | 0.098 | 0.192 | 0.042 |
| 27 | 0.241 | 0.473 | 0.090 |
| 28 | 0.066 | 0.130 | 0.009 |
| 29 | 0.101 | 0.198 | 0.041 |
| 31 | 0.076 | 0.149 | 0.028 |
| 32 | 0.132 | 0.259 | 0.012 |
| 33 | 0.085 | 0.166 | 0.008 |
| 34 | 0.092 | 0.181 | 0.020 |
| 35 | 0.138 | 0.271 | 0.050 |
| 36 | 0.189 | 0.370 | 0.099 |
| 37 | 0.081 | 0.159 | 0.069 |

[81] N/A values in USC-9 were due to lack of shipping data on those lanes in USC-8.

| Lane | TEU | FEU | MTONs |
|---|---|---|---|
| 39 | 0.039 | 0.076 | 0.006 |
| 40 | 0.272 | 0.533 | 0.082 |
| 41 | 0.010 | 0.020 | 0.003 |
| 42 | 0.060 | 0.118 | 0.022 |
| 43 | 0.036 | 0.070 | 0.008 |
| 44 | 0.093 | 0.183 | 0.013 |
| 47 | 0.254 | 0.499 | 0.021 |
| 48 | 0.020 | 0.040 | 0.007 |
| 49 | 0.225 | 0.442 | 0.036 |
| 50 | 0.197 | 0.386 | 0.018 |
| 51 | 0.141 | 0.276 | 0.037 |
| 52 | 0.160 | 0.313 | 0.022 |
| 53 | 0.106 | 0.208 | 0.039 |
| 54 | 0.191 | 0.375 | 0.060 |
| 55 | 0.164 | 0.321 | 0.028 |
| 56 | 0.130 | 0.254 | 0.022 |
| 57 | 0.139 | 0.272 | 0.016 |
| 58 | 0.265 | 0.520 | 0.096 |
| 59 | 0.180 | 0.352 | 0.018 |
| 60 | 0.201 | 0.395 | 0.032 |
| 61 | 0.213 | 0.417 | 0.013 |
| 62 | 0.039 | 0.077 | 0.022 |
| 64 | 0.053 | 0.103 | 0.017 |
| 65 | 0.139 | 0.272 | 0.050 |
| 66 | 0.152 | 0.298 | 0.055 |
| 67 | 0.248 | 0.487 | 0.123 |
| 68 | 0.092 | 0.179 | 0.033 |
| 69 | 0.199 | 0.391 | 0.073 |
| 70 | 0.073 | 0.143 | 0.027 |
| 71 | 0.128 | 0.250 | 0.025 |
| 72 | 0.214 | 0.419 | 0.026 |
| 73 | 0.231 | 0.452 | 0.030 |
| 74 | 0.114 | 0.223 | 0.019 |
| 75 | 0.129 | 0.253 | 0.013 |
| 76 | 0.044 | 0.085 | 0.006 |
| 77 | 0.360 | 0.706 | 0.131 |
| 78 | 0.278 | 0.544 | 0.042 |
| 79 | 0.103 | 0.201 | 0.009 |
| 80 | 0.215 | 0.422 | 0.057 |
| 81 | 0.059 | 0.115 | 0.010 |
| 82 | 0.080 | 0.156 | 0.007 |

| Lane | TEU | FEU | MTONs |
|---|---|---|---|
| 83 | 0.193 | 0.379 | 0.047 |
| 84 | 0.048 | 0.094 | 0.010 |
| 85 | 0.197 | 0.386 | 0.047 |
| 86 | 0.103 | 0.202 | 0.037 |
| 87 | 0.333 | 0.652 | 0.121 |
| 88 | 0.135 | 0.264 | 0.011 |
| 89 | 0.237 | 0.464 | 0.086 |
| 90 | 0.171 | 0.336 | 0.082 |
| 91 | 0.267 | 0.522 | 0.037 |
| 92 | 0.220 | 0.432 | 0.026 |
| 93 | 0.213 | 0.417 | 0.077 |
| 94 | 0.071 | 0.139 | 0.028 |
| 95 | 0.156 | 0.305 | 0.046 |
| 96 | 0.015 | 0.029 | 0.003 |
| 97 | 0.095 | 0.186 | 0.039 |
| 98 | 0.012 | 0.024 | 0.004 |
| 99 | 0.197 | 0.386 | 0.072 |
| CA | 0.011 | 0.021 | 0.004 |

# 10. 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
- District of Columbia (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

Alaskan Zone:

- Alaska

Hawaiian Zone:

- Hawaii

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

# Bibliography

American Bureau of Shipping. May 2013. *Ship Energy Efficiency Measures: Status and Guidance*. Retrieved March 13, 2019, from https://ww2.eagle.org/content/dam/eagle/advisories-and-debriefs/ABS_Energy_Efficiency_Advisory.pdf. Last Accessed: 12 September 2023.

Association of American Railroads. June 2023. *Freight Railroads & Climate Change.* https://www.aar.org/wp-content/uploads/2023/06/AAR-Climate-Change-2023-Report.pdf. Last Accessed: 25 August 2023.

Barreiro, J., Zaragoza, S., Diaz-Casas, V. 2022. *Review of ship energy efficiency*. Ocean Eng. 257, 111594 Available Online: https://doi.org/10.1016/j.oceaneng.2022.111594. Last Accessed: 12 September 2023.

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

Bunker Index. 2023. *Fuel Prices*. Available Online: https://www.bunkerindex.com/. Last Accessed: March 2023.

Bureau of Transportation Statistics. 2022. *Freight Facts and Figures*. Available online: https://data.bts.gov/stories/s/Moving-Goods-in-the-United-States/bcyt-rqmu. Last Accessed: 23 August 2023.

Caughlin, Sean A. PE and Kevin J. Reynolds, PE. April 2016. *Ship Operations Cooperative Program Energy Efficiency White Paper*. Innovative Marine Solutions. Available Online: https://www.maritime.dot.gov/sites/marad.dot.gov/files/2020-12/15099.01_%20SOCP%20Marine%20Vessel%20Energy%20Efficiency_Rev-_signed.pdf. Last Accessed: 12 September 2023.

Clark, P., Tamirisa, N., Wei, S.-J., Sadikov, A., & Zeng, L. May 2004. *Exchange Rate Volatility and Trade Flows - Some New Evidence*. Available Online: https://www.imf.org/external/np/res/exrate/2004/eng/051904.pdf. Last Accessed: 12 September 2023.

CMA CGM. 2017. *Consolidated Financial Statements*. Available Online: https://www.cma-cgm.com/static/Finance/PDFFinancialRelease/2017%20-%20Annual%20Consolidated%20Accounts.pdf. Last Accessed: 12 September 2023.

Coia, Anthony. December 2013. *Global roro report: Moving with the trade winds*. Available online:

https://www.automotivelogistics.media/global-ro-ro-report-moving-with-the-trade-winds/9809.article. Last Accessed: 12 September 2023.

COSCO SHIPPING Holdings Co., Ltd. (2018). *Annual Report 2017*. Available Online: http://en.chinacosco.com/attach/0/Annual%20Report%202017.pdf. Last Accessed: 9 April 2019.

Direct Freight. (2023). *Calculate Mileage.* Available Online: https://www.directfreight.com/home/route. Last Accessed: July 2023.

Dryjowicz, A. (January 2023). *What is Reefer Fuel?.* FreightWaves. Available Online: https://ratings.freightwaves.com/what-is-reefer-fuel/. Last Accessed: 25 August 2023.

Federal Highway Administration. August 2018. *Diesel Fuel Explained: Factors Affecting Diesel Prices.* U.S. Energy Information Administration. https://www.eia.gov/energyexplained/index.php?page=diesel_factors_affecting_prices. Last Accessed: 12 September 2023.

Federal Highway Administration. May 2023. *Highway Statistics 2021*. Available Online: https://www.fhwa.dot.gov/policyinformation/statistics/2021/vm1.cfm. Last Accessed: 25 August 2023.

Federal Maritime Commission. 1984. *The Shipping Act of 1984, Chapter 401—GENERAL.* Federal Maritime Commission. Available Online: https://uscode.house.gov/view.xhtml?path=/prelim@title46/subtitle4/partA&edition=prelim. Last Accessed: 12 September 2023.

Federal Motor Carrier Safety Administration. 2022. *Summary of Hours of Service Regulations.* Federal Motor Carrier Safety Administration. https://www.fmcsa.dot.gov/regulations/hours-service/summary-hours-service-regulations. Last Accessed: 25 August 2023.

Federal Railroad Administration. 2020. *Freight Rail Overview*. Available Online: https://railroads.dot.gov/rail-network-development/freight-rail-overview. Last Accessed: 25 August 2023.

Freightera. June 2023. *Freight Shipping by Train vs. Truck: Advantages and Disadvantages. Freightera.* Available Online: https://www.freightera.com/blog/train-vs-truck-transportation-efficiency-cost-advantages-disadvantages-infographic/#:~:text=Railways%20consume%20up%20to%209x%20less%20energy%20per,Cheaper%20for%20long-distance%20Emit%2075%25%20fewer%20GHG%20emissions. Last Accessed: 25 August 2023.

gCaptain. February 2019. *Maersk Secures U.S. East Coast Low Sulphur Fuel Production.* Available Online: https://gcaptain.com/maersk-secures-u-s-east-coast-low-sulphur-fuel-production/. Last

Accessed: 12 September 2023.

Hasan, Jenan. May 2022. *Effects of recent and expected fuel price increase on maritime logistics.* Available Online: https://www.ti-insight.com/briefs/effects-of-recent-and-expected-fuel-price-increase-on-maritime-logistics/#:~:text=With%20bunker%20fuel%20prices%20up,bunker%20adjustment%20factors%20in%202022. Last Accessed: 12 September 2023.

Hapag-Lloyd. March 2018. *Annual Report 2017*. Available Online: https://www.hapag-lloyd.com/content/dam/website/downloads/ir/Hapag_Lloyd_Annual_Report_2017.pdf. Last Accessed: 12 September 2023.

IMO. 2019. *2023 IMO Strategy on Reduction of GHG Emissions from Ships.* Available Online: https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx#:~:text=The%202023%20IMO%20GHG%20Strategy%20envisages%2C%20in%20particular%2C%20a%20reduction,at%20least%2040%25%20by%202030. Last Accessed: 12 September 2023.

IMO. November 2022. *Rules on ship carbon intensity and rating system enter into force.* Available Online: https://www.imo.org/en/MediaCentre/PressBriefings/pages/CII-and-EEXI-entry-into-force.aspx. Last Accessed: 12 September 2023.

Intermodal Association of North America. 2018. *Intermodal System Maps & Directions. Intermodal Association of North America*. Available Online: https://www.intermodal.org/resource-center/intermodalsystem. Last Accessed: 25 August 2023.

Kenen, P. B., & Rodrik, D. May 1986. *Measuring and Analyzing the Effects of Short-Term Volatility in Real Exchange Rates*. Retrieved from The Review of Economics and Statistics.

Martin, Eric Priante. January 2022. *How 2023's carbon rules could be a 'game changer' for shipping contracts*. Available Online: https://www.tradewindsnews.com/esg/how-2023s-carbon-rules-could-be-a-game-changer-for-shipping-contracts/2-1-1142992?zephr_sso_ott=IbuBMc. Last Accessed: 12 September 2023.

Miller, Greg. 2022. Price of ship fuel falling even as Russia-Ukraine war rages on. Available Online: https://www.freightwaves.com/news/as-russia-ukraine-war-rages-on-the-price-of-ship-fuel-is-falling. Last Accessed: 24 August 2023.

Morel, Sandrine. August 2011. *Is Gibraltar an Environmental Disaster Waiting to Happen?* Time Magazine. Available Online: http://content.time.com/time/world/article/0,8599,2086777,00.html. Last Accessed: 12 September 2023.

National Academies of Sciences, Engineering, and Medicine. 2019. *Impacts of Policy-Induced Freight Modal Shifts*. Washington, DC: The National Academies Press. Available Online: https://nap.nationalacademies.org/catalog/25660/impacts-of-policy-induced-freight-modal-shifts. Last Accessed: 25 August 2023.

Nippon Yusen Kabushiki Kaisha. 2018. *NYK Report 2017*. Available Online: https://www.nyk.com/english/ir/pdf/2017_nykreport_all.pdf. Last Accessed: 12 September 2023.

North American Council for Freight Efficiency. December 2022. *2022 Annual Fleet Fuel Study*. Available Online: https://nacfe.org/wp-content/uploads/edd/2022/12/AFFS-2022-Report-FINAL-1.pdf. Last Accessed: 25 August 2023.

NYK Line. n.d.. *NYK Report 2017*. Available Online: http://www.maritimecsr.com/files/reports/2017/REP-1529666205.pdf. Last Accessed: 17 September 2018.

Orient Overseas (International) Limited. 2018. *Annual Report 2017*. Available Online: https://www.ooilgroup.com/financials/interimandannualreports/Documents/2017/E-00316AR.pdf. Last Accessed: 12 September 2023.

Rodrigue, Jean-Paul. (2020). *The Geography of Transport Systems*, 5th ed. Available Online: https://transportgeography.org/contents/. Last Accessed: 25 August 2023.

RSI Logistics. April 2022. *The Advantages of Rail vs Truck Shipping.* RSI Logistics. Available Online: *https://www.rsilogistics.com/blog/the-advantages-of-rail-vs-truck-shipping/#:~:text=On%20average%2C%20rail%20is%20four%20times%20more%20fuel,the%20business%20a%20promotional%20platform%20for%20sustainability%20initiatives*. Last Accessed: 25 August 2023.

Saul, Jonathan and Chestney, Nina. August 2018. *New fuel rules push shipowners to go green with LNG.* Reuters. Available Online: https://www.reuters.com/article/us-shipping-fuel-lng-analysis/new-fuel-rules-push-shipowners-to-go-green-with-lng-idUSKBN1L01I8. Last Accessed: 12 September 2023.

Schnabl, G. July 2007. *Exchange Rate Volatility and Growth in Small Open Economies at the EMU Periphery: Working Paper Series, no 773*. Retrieved from European Central Bank.

Surface Deployment & Distribution Command. (n.d.). *BAF Monthly Statistics Reports*.

United Nations. December 2022. *The Mediterranean reaches a historic milestone in the regional* *endeavour for greener shipping.* Available Online: https://www.unep.org/unepmap/news/press-release/mediterranean-historic-milestone-MedSOxECA. Last Accessed: 12 September 2023.

U.S. Coast Guard. n.d. *Marpol Annex VI (revised, 2008)*. Available Online: https://homeport.uscg.mil/Lists/Content/Attachments/891/Brief%20on%20MARPOL%20Annex%20VI%20(revised)_.pdf. Last Accessed: 12 September 2023.

U.S. Energy Administration. January 2019. *Short-Term Energy Outlook. U.S. Energy Information Administration*. Available Online: https://www.eia.gov/outlooks/steo/report/prices.php. Last Accessed: 12 September 2023.

U.S. Energy Information Administration. November 2018. *Europe Brent Spot Price*. Retrieved January 31, 2019, from U.S. Energy Information Administration. Available Online: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=M. Last Accessed: 12 September 2023.

U.S. Energy Information Administration. 2022. *Annual Energy Outlook 2022*. U.S. Energy Information Administration. Available Online: https://www.eia.gov/outlooks/aeo/pdf/AEO2022_ChartLibrary_Transportation.pdf. Last Accessed: 25 August 2023.

U.S. Energy Information Administration. *2023. Annual Energy Outlook 2023.* U.S. Energy Information Administration. Available Online: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=7-AEO2023&region=0-0&cases=ref2023&start=2021&end=2023&f=A&linechart=ref2023-d020623a.5-7-AEO2023&map=&sourcekey=0. Last Accessed: 25 August 2023.

United States Transportation Command. 2022. *Universal Service Contract (USC)-9 DRAFT PWS.* USTRANSCOM Command Acquisition. Available Online: https://www.sddc.army.mil/Shared%20Documents/USC-9%20Conformed%20Copy%2015%20Jan%202022.pdf. Last Accessed: 12 September 2023.

Wallenius Wilhelmsen. March 2018. *Annual Report 2017*. Available Online: https://annualreport.walleniuswilhelmsen.com/wwl2017/wp-content/uploads/sites/8/2018/06/WWL-Annual-Report-2017.pdf. Last Accessed: 17 September 2018.

Waqar. n.d. *Reefer Fuel: Things You Need to Know.* Mechanical Boost. Available Online: https://mechanicalboost.com/reefer-fuel/#google_vignette. Last Accessed: 25 August 2023.

Winkel, R., van den Bos, A., & Weddige, U. June 2015. *Study on Energy Efficiency Technologies for Ships: Inventory and Technology Transfer*. Available Online:

http://publications.europa.eu/resource/cellar/302ae48e-f984-45c3-a1c0-7c82efb92661.0001.01/DOC_1. Last Accessed: 12 September 2023.

World Maritime News. August 2018. *Maersk's Fuel Costs Set to Rise by USD 2 Bn from 2020 Sulphur Cap*. Available Online: https://worldmaritimenews.com/archives/259749/maersks-fuel-costs-set-to-rise-by-usd-2-bn-from-2020-sulphur-cap/. Last Accessed: 12 September 2023.

Yao, Zhishuang, Szu Hui Ng, and Loo Hay Lee. July 2011. *A study on bunker fuel management for the shipping liner services.* Computers &OperationsResearch39(2012)1160–1172. Available Online: https://doi.org/10.1016/j.cor.2011.07.012. Last Accessed: 12 September 2023.

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U.S. Department of Transportation
John A. Volpe National Transportation Systems Center
55 Broadway
Cambridge, MA 02142-1093

617-494-2000
www.volpe.dot.gov

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