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NEMS Freight Transportation Module Improvement Study

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NEMS Freight Transportation Module Improvement Study

The U.S. Energy Information Administration (EIA) contracted with IHS Global, Inc. (IHS) to analyze the relationship between the value of industrial output, physical output, and freight movement in the United States for use in updating analytic assumptions and modeling structure within the National Energy Modeling System (NEMS) freight transportation module, including forecasting methodologies and processes to identify possible alternative approaches that would improve multi-modal freight flow and fuel consumption estimation.

IHS identified primary issues with EIA's NEMS freight transportation module with respect to state-of-the-art modeling, organized a workshop of experts to discuss alternatives to improving the NEMS transportation module, and performed independent research to ascertain improvements to the NEMS model structure. Based on the input from EIA, external experts, and further research, the final report from IHS makes the following recommendations:

- Replacing the use of the Commodity Flow Survey records with Freight Analysis Framework freight flow records as part of the ton-mile historic and projection metric development
- Application of a basic network assignment using geographic information system (GIS) estimation of truck ton-mile shares across census divisions and commodity groups
- Disaggregation of industry classifications used in NEMS to the Standard Classification of Transported Goods (SCTG) level

In addition, IHS recommended study of other issues but did not otherwise recommend immediate action:

- Exploring the potential of creating a multi-modal component to NEMS freight transportation module
- Determining if other mode-split models can be leveraged
- Study how major shifts in the economy and industry technology and management practices affect forecasts of ton-miles

EIA is now using the Freight Analysis Framework in place of the Commodity Flow Survey in the determination of historical census division and commodity ton-mile data, including the derivation of the ton-mile per dollar of industrial output (a key metric used in the travel demand projection methodology). Further, these data include a GIS modeling estimation of the share of freight truck travel between origin and destination points through intermediate census divisions. EIA expects to explore disaggregation of industry into SCTG categories in the future.

EIA will take close note of the potential for creating a multi-modal component to NEMS freight transportation module as recommended, as well as continuing to monitor and understand the changing nature of the economy and industry. IHS did not offer any recommendation on the outstanding issue of modeling the declining historical ton-miles in domestic marine shipping.

Appendix A

Final Report

NEMS Freight Transportation Module Improvement Study

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Executive Summary

This report summarizes findings of a review of the Energy Information Administration's (EIA) freight transportation energy consumption forecasting module conducted by IHS Global, Inc. (IHS). EIA contracted with IHS to analyze the relationship between the value of industrial output, physical output, and freight movement in the United States for use in updating analytic assumptions and modeling structure within the NEMS freight transportation module, including forecasting methodologies and processes to identify possible alternative approaches that would improve multi-modal freight flow and fuel consumption estimation.[1]

The NEMS freight transportation module estimates freight flows by census division, mode of transportation, and commodity type. NEMS inputs industry output in dollars by census division, commodity group, and mode into the freight transportation module, which reports energy consumption forecasts back into NEMS using these same units of evaluation. NEMS uses nine census divisions, ten aggregated commodity groups, and four modes of transportation: truck, rail, marine (domestic barge and intra-coastal as well as international), and air. Coal moving on rail is modeled separately, as this procedure has proven to improve model accuracy.

The primary mechanism of the freight transportation module is a "ton-mile metric" which estimates for each census division, mode, and commodity group the average ton-miles traveled[2] per unit of industrial output. For truck, rail, and domestic marine, this metric is the product of a simple division of base-year industrial output by base-year ton mileage (or modal demand forecasting metric equivalent) reported by various U.S. Government agencies at the national level. This data is disaggregated to the census division and modal level leveraging the Bureau of Transportation Statistics (BTS) and Census Bureau's Commodity Flow Survey (CFS). EIA then essentially calculates a simple weighted average from CFS as a proxy for modal and route assignment, which is used to disaggregate national-level commodity flow forecasts into NEMS units.

IHS identified nine primary issues with EIA's NEMS freight transportation module with respect to state-of-the-practice transportation demand modeling. Possible areas of concern include:

- The use of sub-optimal input data for the specific objectives of the model (i.e., the CFS survey),
- Inaccurate accounting of the effects of time in between CFS base-year surveys,
- Levels of aggregation by commodity and geography might fail to capture system dynamics,
- The ton-mile metric possibly does not adequately account for fluctuations in commodity prices, all else equal,
- The ton-mile metric does not account for changes in product content (hence, weight-to-unit ratios), all else equal,

[1] IHS is a global leader in transportation, energy, and trade modeling,

[2] Freight transportation output is generally measured in ton-miles for all modes except for air cargo, which is measured in freight revenue ton miles, and truck freight, which is measured in both ton-miles and vehicle miles traveled (VMT).

- Proxy methods for disaggregating ton-miles employ macroeconomic techniques, while the state of the practice employs more disaggregate microeconomic techniques,
- Mode share is static and does not take into account possible mode shifts over time,
- The ton-mile metric procedure does not accurately forecast the directionality of domestic marine demand,
- Proxy measures for network assignment and distance estimation are too simplistic and do not employ more rigorous state-of-the-art network assignment techniques.

IHS then organized a workshop with EIA and experts in freight modeling from government and the private sector to discuss alternatives for improving the EIA NEMS freight transportation module. Although state-of-the-art practices offer greater precision in transportation demand modeling, the most rigorous, time-consuming, and costly techniques may not be appropriate for EIA given the more high-level objectives of the NEMS framework. Hence, the benefits of precision must be weighed against the costs in time and human and financial resources. Leveraging its knowledge of the NEMS freight transportation module and its industry experience with freight transportation demand modeling, IHS presented the workshop participants with four over-arching alternatives for debate and consideration. These included:

- Incremental improvements to existing NEMS freight transportation, involving primarily the use of additional variables and minor changes to processes but otherwise retaining the existing data, methodology, and approach,
- Employing econometric techniques to forecast the ton-mile metric,
- Leveraging the BTS Freight Analysis Framework (FAF) data in place of the CFS survey and possibly leveraging other BTS and FHWA resources and processes to improve model forecasting precision,
- Developing a new EIA freight forecasting module explicitly employing more micro-level approaches and more rigorous network assignment modeling techniques.

Feedback from EIA and workshop participants suggested that replacing the CFS survey with FAF would be the most practical approach to improving the NEMS freight transportation module, as it would improve data input accuracy with minimum changes to existing processes. Suggestions were made regarding how to better use base-year data to estimate flows in between FAF publication years. Participants also suggested that lack of precision in distance estimation of freight flows across census divisions could be improved by developing an index of average distance traveled through each census division zone by origin/destination pair. This could improve precision sufficient to EIA’s needs without adding the complexity and cost of a full-fledged network assignment model. The meeting participants all acknowledged that employing a dynamic mode share process would be very difficult and, in fact, FHWA is in the process of exploring how to incorporate such a procedure in its own freight demand forecasting. FHWA and EIA agreed to work together to investigate the possibilities of adding these capabilities to their respective models in the future.

Based on the results of the workshop and consultation with its internal freight modeling experts, IHS has put forth recommendations on improvements to the current NEMS freight transportation ton-mile forecasting process. Included in this document are discussions about steps to implement priority changes and examples and analyses of improvements from implementing new procedures. Documentation of spreadsheet calculations, procedures and related support materials will be delivered to EIA separately.

The primary recommendations for immediate improvement are:

- Replace CFS survey records with FAF freight flow records as part of the ton-mile metric development,
- Apply a basic network assignment developed by IHS using GIS modeling capabilities to the estimation of truck ton-mile shares across census division zones and commodity group types, and study the potential for the development of a similar process for rail,
- Disaggregate industry classifications used in the NEMS freight transportation module to the Standard Classification of Transported Goods (SCTG) level where sufficient sample sizes exist, and study logical aggregations of smaller industry categories.

IHS also recommends that EIA undertake studies to address several other issues with the NEMS freight transportation module, but does not otherwise recommend immediate action. The studies include:

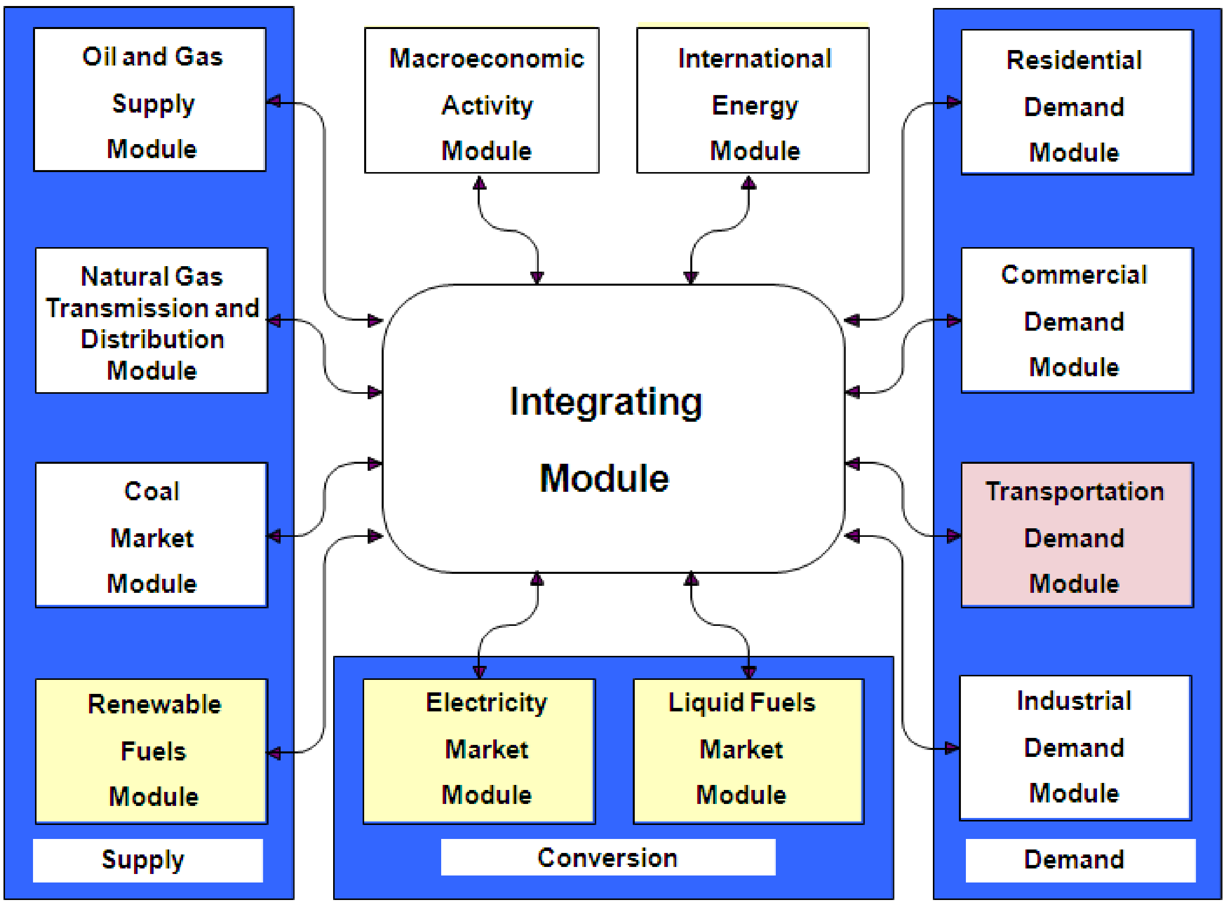
- Exploring the potential benefits and costs of building a multi-modal component to the NEMS freight transportation module based on a conceptual process outlined in this study,
- Work with FHWA to determine if current research on integrating mode-split models in FAF forecasting could be leveraged by EIA and integrated into the NEMS freight transportation module,
- On an as-needed basis, study how major shifts in the economy and industry technology and management practices affect forecasts of individual or groups of industry classifications to develop potential adjustments to ton-mile metric calculations in between CFS/FAF base years.

Table of Contents

Contextual Description of the NEMS Freight Module

The National Energy Modeling System (NEMS) is a general equilibrium model that calculates energy consumption for different end users and from different sources. Energy supplies are calculated in four modules: oil and gas, natural gas, coal, and renewable fuels. Similarly, four modules represent demand for energy: residential, commercial, transportation, and industrial. Other modules of the integrated model include international energy and macroeconomic activity, as well as two conversion modules (electricity and liquid fuels). Demand for energy for freight movement is included as part of the transportation demand module.

Figure 1: NEMS Model Schematic



The NEMS freight module forecasts consumption of different fuel types by mode (heavy-duty truck, rail, domestic and international marine, and air), geography (census division), and commodity group. Whereas heavy-duty truck demand is reported in vehicle miles traveled (VMT), rail and domestic marine are reported in ton-miles. Air is represented in freight revenue ton-miles, and international marine is not reported as travel demand. Freight travel demand is driven by the value of industrial output generated by NEMS for heavy-duty truck, rail, and domestic marine. Imports and exports drive air freight and international marine. This report does not explore freight movement by aircraft or international marine vessels. Coal transport (by rail) is informed by a separate coal market module in NEMS.

Heavy-duty Truck

EIA organizes historic freight movement data by truck from two sources: VMT from the Federal Highway Administration (FHWA) and ton-miles from the Surface Transportation Board (STB), both at the national level. VMT and ton-mile truck movement data reported by EIA are also organized at the census division level. The Commodity Flow Survey (CFS) produced by the Bureau of Transportation Statistics (BTS) provides ton-mile by origin/destination state and commodity every five years (1997, 2002, and 2007 with a pending full release for 2012).

NEMS assumes direct relationships between VMT, ton-miles, and industrial output. National VMT data is disaggregated by commodity ton-mile data estimated from the CFS for each census division. For intermediate years between CFS updates, shares are calculated by assuming a linear pattern of growth. A ton-miles per dollar metric is developed and publicly reported by EIA for each commodity and census division by dividing industrial output estimates in NEMS by ton-miles associated with each division and commodity (again, reported by census division and commodity group by the most recent CFS estimates; currently, CFS 2007). VMT projections are calculated directly by the change in ton-miles forecasted by these ton-miles per dollar output variables by commodity and census division. The assumption of a static relationship between VMT, ton-miles, and industrial output means that the VMT forecasts by census division have a direct linear relationship to the ton-mile per dollar of output metric and EIA's industrial output forecasts by commodity group. In other words, cargo content and prices are assumed to be constant.

Rail

EIA forecasts rail freight flows following a similar process employed for heavy-duty truck, except that no conversion is made from ton-miles to VMT and that certain cargo is estimated independently. For freight moving by rail, national ton-mile data is provided by the Surface Transportation Board (STB) for Class I Railroads only. EIA then separates coal and non-coal ton-mile data at the national level prior to the calculation of census division and commodity shares. Otherwise, like the heavy-duty truck forecast, ton-miles origin/destination data are extracted from the CFS for years in which these values are available to calculate shares by census division. Intermediate year forecasts are estimated as a linear function of CFS historical data and the ton-miles per dollar estimates by commodity and census division are created and publicly reported by dividing NEMS industrial output by CFS 2007 ton-miles. A static relationship between ton-miles and industrial output is assumed in this case.

Coal shipments are kept separate from the broader mining category in this model. Instead, the separate coal markets module is used to project growth in coal ton-miles by rail.

Domestic Marine

Similar to EIA's rail freight forecasts, domestic marine freight forecasts are reported in ton-miles by census division and commodity, except that coal is not excluded. Historical commodity ton-mile movement data for domestic marine (primarily river and intra-coastal barge shipments) comes from the U.S. Army Corps of Engineers, specifically Waterborne Commerce. Ton-mile shares are taken from the CFS for years in which these values are available. In intermediate between CFS publication years, shares are calculated between following a linear pattern. Ton-miles per dollar by commodity and census division are created and publicly reported using CFS 2007 ton-miles by mode and commodity in conjunction with industrial output from NEMS.

Unlike the rail forecasts, however, EIA calibrates the ton-mile forecasts downward to account for recent divergence in industrial output and domestic marine freight transportation demand. Essentially, demand for domestic marine freight is declining despite increased industrial output on account of factors outside the NEMS modeling environment. EIA adjusts ton-miles forecasts between 2007 and 2011 by an average of -3.12%, owing to this historical decline in the use of domestic waterborne shipment. This adjustment is held forward until 2020, then adjusted by -1.56% through 2030 and -0.78% between 2030 and 2040.

Issues with the Freight Transportation Module

Preliminary potential issues with the ton-mile/VMT per value-of-output metric were identified and were explored as part of the NEMS freight transportation module. These issues include, but are not limited to:

- **Availability and use of data**: Like any model, the quality of outputs is related to the quality of inputs. Alternative data sources exist. Their appropriateness needs to be evaluated with respect to costs of acquisition, terms of use for EIA public disclosure requirements, and compatibility with other NEMS model data and processes.
- **The effects of time**: The freight transportation module in NEMS relies heavily on the CFS, which is published every five years and with a lag. Thus, the accuracy of the module is highly vulnerable to interim changes occurring, for example, in goods manufacturing and supply chains; freight technology and operations; global, national, and regional trade and logistics; and economic volatility.
- **Levels of disaggregation**: The current aggregation of regions and commodity groups may not fully capture the dynamics within each region and across various industries.
- **Changes in price**: There is not necessarily a direct correspondence between aggregate value and aggregate weight. Changes in the pricing of goods would increase or decrease the value of industrial output, but not necessarily the tonnage of output or the distance traveled. Thus, the ton-mile metric might overestimate or underestimate freight demand.
- **Changes in product content**: Similar to price changes, changes in the design and content of certain products (e.g., consumer electronics, automobiles, etc.) may alter the ratio of value of output to unit weight. Hence, the ratio of output value to tonnage of a newly designed product may be different than in previous editions, all else equal.
- **O/D weights**: The weighting of goods movement by region and commodity may be flawed, either in execution or perhaps more fundamentally. Flaws in execution may result from issues previously discussed, including levels of disaggregation by commodity and region and failure to capture dynamic changes over the course of time. Moreover, it may be that other variables need to be considered. Concerns about fundamental approaches center on the validity of using highly-aggregated macroeconomic data to capture travel behavior. Travel demand modeling tends to employ microeconomic techniques at the most disaggregate levels possible, and then aggregating this output up to the desired geographic level. The issue is whether or not the current proxy measures of flows are appropriate given time, budget, and data constraints and, if so, how current processes could be re-designed to increase accuracy.
- **Modal shares of value:** EIA uses a static measure of mode share for each commodity group based on the historical value of an industrial output metric associated with each mode. This means calculating a ton-mile per dollar industrial output for each mode based solely on each mode's historical ton-miles and total industrial value. Additionally, goods movement across multiple modes is a challenge. One possible enhancement would be employing a more dynamic mode share model. This may or may not be possible or advantageous but it warrants consideration.

- **Linear year calculations:** The domestic marine mode's forecast is currently replaced with a negative linear growth rate regardless of NEMS industrial output trends. The rate of decline, in this case, is -3.12% through 2020, -1.56% through 2030, and -0.78% between 2030 and 2040. This assumption is based on declining historic domestic ton-mile trends.
- **Distance as a critical driver:** Assignment of commodity flows to census divisions—currently calculated as 50% to the origin and 50% to the destination—does not accurately account for shares of distance traveled in each census division. Furthermore, intermediate census divisions are excluded that may account for a substantial portion of a given origin/destination pair's flows.

Conceptual Solutions

This section outlines IHS's preliminary evaluation of alternative methodologies or approaches, the potential benefits, and the potential challenges for improving the NEMS freight transportation module. Issues of concern include model accuracy and reliability, data availability and cost, human resource availability and cost, and other NEMS and DOE constraints. IHS also acknowledges that there may be other alternatives or hybrids of the following alternatives, which will be addressed.

The purpose of this preliminary analysis was to develop an initial framework for evaluating alternative approaches to forecasting freight movement in NEMS. That framework was used to direct more in-depth research of these alternatives, structure a workshop composed of experts to provide advice and recommendations to the EIA and IHS project teams, and to facilitate dialogue between EIA, IHS, and outside experts on the path forward.

Incremental Improvements

Using incremental improvements to curtail some of the problems in the NEMS freight module would allow EIA to retain as much of the current forecast process and metrics as possible, as well as most of the key input data. One possible improvement could be employing different aggregation or disaggregation of input and output data in commodity and regional groupings. Alternatively, additional process steps and/or variables could be integrated into the freight transportation module to calibrate forecasts more accurately to historical trends and provide flexibility to address future uncertainties.

There are numerous advantages to making incremental changes to the freight module. Most importantly, this would probably be the lowest-effort alternative, whereby many processes would remain the same but could be enhanced and refined. With regard to explanation and publication, this strategy would be simpler. Existing data feeding the model would be retained, whose sources and use in NEMS are already documented. New process development would be minimal as many of the existing processes would remain the same.

The drawbacks to this approach are also clear. The criticism remains of the freight module as a top-down approach using aggregate macroeconomic data rather than a bottom-up approach using microeconomic techniques. The fundamental weaknesses of the ton-mile approach are not directly addressed, but instead numerous short-term fixes are implemented that may not stand the test of time. Accurately forecasting freight movement as origin/destination “flows” will be a challenge regardless of refinements given the processes in place.

Econometric Approaches

A more sophisticated econometric model could be implemented to forecast ton-miles (and energy consumption) using output from the NEMS integrated model. The benefit of this approach is that it could offer a more reliable predictor of VMT or ton-miles at a given level of disaggregation (by commodity or region) using publicly available data.

Although an econometric approach could provide a more robust model of ton-miles and VMT, the modeling process would still require some method of disaggregation by region (and possibly by commodity and mode) given that the forecasts are derived from national-level data. If the forecasts were developed at a less aggregate level (e.g., separate models for each region), there could be challenges in maintaining an internally coherent model once aggregated. Developing regional-level forecasts independent of one another could lead to a situation where the flows across regions would not "match up". Therefore additional constraints and processes might be included to ensure that inflows and outflows across regions are internally consistent and roll up to an accurate national forecast.

Leveraging the FHWA Freight Analysis Framework (FAF)

One methodological option could be leveraging the Freight Analysis Framework (FAF) from FHWA. FAF, which covers gaps in some goods movement not included in CFS, could replace the latter to enhance the accuracy of EIA forecasts. These gaps include, for example, some agriculture freight flows that are generally not covered in the CFS survey. There is an additional benefit to using FAF, as FHWA and BTS staff members have expressed a willingness to provide assistance to EIA on how to best use the data set for energy consumption forecasting applications.

FHWA also routes FAF flows on the muti-modal transportation network; however, the routed data set is confidential. EIA could choose to develop or contract with a third party to route the FAF data in a manner similar to the one employed by FHWA, thus replacing the current origin/destination weights process with a more explicit and disaggregate accounting of freight flows. EIA could then consider altering the ton-mile metric to a more reliable measure relating industrial output (or some other economic measure(s)) to freight transportation demand. The advantages of fully employing processes similar to FHWA's routing model will be described in the next section on network assignment models.

Using FAF forecasts does not, however, solve one other key problem with the current process. As FAF is updated with the CFS, adjustments need to be made within five-year intervals. Thus, intermediate years must still be estimated. Other issues, such as a lack of a mode share model, would also persist.

Network Assignment Models

A final alternative approach to the NEMS freight module could be the use of an actual network assignment model. This would enhance the current origin/destination matrix and ton-mile metric process with either a new internal freight forecasting process or the purchase of commercial data.

This network assignment model could employ a dataset that explicitly forecasts freight flows in the U.S. using more disaggregate, microeconomic approaches, similar to the approach that FHWA employs to route FAF forecasts onto the multi-modal transportation network. Depending upon the quality of the model or dataset purchase, it may be possible to improve upon the limitations of FAF. This could lead to a model that is more explicitly driven by state-of-the-practice transportation demand modeling and may be more flexible in addressing some of the acknowledged weaknesses of the current NEMS process.

Although this approach would more directly employ transportation modeling theory and common practice, it is likely that it would be impractical for EIA. There is a possibly that costs (including development time) would outweigh any potential benefits in model robustness and forecast accuracy. Challenges might include new skill development within EIA, contracting for additional commercial services, and possibly altering the manner in which NEMS industrial forecasts are fed into the freight transportation module and how demand metrics are reported back into the model framework. Furthermore, any use of commercial data would be challenging due to issues of transparency, in that proprietary data may come with restrictions on release to the public.

Table 1: Conceptual Alternative Solutions

	Advantages	Disadvantages
Incremental Improvements to Existing Processes	• Most likely the lowest-effort alternative • Retains simplicity of approach for explanation and publication • Retains most of the existing data sources feeding the model, whose sources and use in NEMS are already documented • Retains as much of the existing processes as possible to minimize new process development	• May be criticized for retaining a top-down approach using aggregate macroeconomic data rather than a bottom-up approach • Does not directly address fundamental weaknesses of the ton-mile approach; instead replaces with numerous "patches" that may not stand the test of time • Capturing O/D "flows", especially, will be a challenge regardless of refinements
Employ Econometrics to the Ton-mile Calculation	• Could offer a more reliable predictor of VMT/ton-miles at a given level of disaggregation (by commodity or region) using other publicly available data	• If at the national level, the modeling process would still require some method of disaggregation. • If at a more disaggregate level, there may be challenges with maintaining an internally coherent model once aggregated.
Leveraging US Department of Transportation FAF Forecasts	• Employs a dataset that explicitly forecasts freight flows in the US using more disaggregate, microeconomic approaches (e.g., O/D surveys of actual carriers, 123 FAF regions rather than nine Census Divisions, etc.) • Makes use of free data, owned and produced by the US DOT • Otherwise maintains the data, processes, and institutional knowledge embedded in the existing NEMS freight module	• FAF is updated with the CFS, so adjustments need to be made within five-year intervals • Employing FHWA freight routing processes, if pursued, could be expensive and time consuming while possibly also requiring new skill development within EIA

	Advantages	Disadvantages
Develop a New EIA Network Freight Forecasting Module	• Could employ a dataset that explicitly forecasts freight flows in the US using more disaggregate microeconomic approaches • Depending upon the data quality, it may be possible to improve upon the limitations of FAF • Leads to a model that is more explicitly driven by state-of-the-practice transportation modeling, and may be more flexible for addressing some acknowledged weaknesses of the current process	• While this approach more directly employs theory and common practice, it may be impractical for EIA (e.g., the costs may outweigh the benefits) • Any use of commercial data will challenge transparency issues • It may be challenging to develop the new module within the NEMS architecture

Industry Workshop Summary

A workshop was held at the IHS office in Washington, DC to foster a discussion with experts in freight transportation modeling. In attendance at the workshop were representatives from:

- American Transportation Research Institute (ATRI),
- Energy Information Administration (EIA),
- IHS Global, Inc. (IHS),
- United States Department of Transportation (U.S. DOT): Federal Highway Administration (FHWA), Bureau of Transportation Statistics (BTS), and the Volpe National Transportation System Center.

First, EIA presented the current state of the freight module in NEMS to the workshop participants. IHS made a short presentation on the issues identified with the freight module and potential solutions. Finally, a group discussion moderated by IHS explored ways to improve the freight module. This section summarizes the workshop discussion topics and recommendations from the participants.

Primary Discussion Topics

The greater part of the discussion focused on the possibility of leveraging FAF for the NEMS freight module. This was due in part to the abundance of representatives from FHWA, who were able to assist with practical considerations in using FAF, but also because the advantages of leveraging FAF quickly became apparent.

FAF began in its first generation as a dataset developed from proprietary data, but has evolved into one using public data so that it can be disseminated to the general public. There are two aspects of FAF: an origin/destination matrix of commodity flows for all modes and a dataset of those flows assigned to the network. The challenges with the development of the origin/destination matrix are different from those concerning network flows modeling at FHWA, the latter of which is not available for dissemination outside of FHWA.

The workshop participants agreed that, at the very least, EIA should use FAF instead of CFS for ton-miles inputs to the NEMS freight module. This would improve the freight module because FAF uses CFS as a base (about 2/3 of the freight flows) but estimates additional commodity movements not reported in CFS. These additional data include shipments originating on farms and international flows, including truck and rail to and from Canada and Mexico.

Like CFS, FAF reports commodity flows in ton-miles, and EIA could use very simple methods to sum up from FAF zones to the census division level. EIA could also backcast FAF to provide intermediary years of data rather than simply using linear trends between FAF years. Additionally, customer demand for FAF has grown in recent years, and customers are pushing for greater levels of disaggregation and detail in both the origin/destination and network datasets, which suggests that FAF could be improved over the next few years.

There are disadvantages to using FAF, though most of these are also true of CFS. FAF has some weaknesses on muti-modal commodity flows. The freight demand and network assignment models are the weakest aspects of FAF, and network assignment is done using proprietary data. Also, FHWA's models are not currently very strong with respect to adjusting for policy decisions. In terms of updating FAF, the gap between 2007 and the hypothetical 2012 dataset will have completely missed major shifts in industry production and logistics (e.g., Bakken shale oil, Great Recession, etc.). Further weaknesses exist in multi-modal and mail categories.

FHWA suggested that it faces similar challenges in the development of FAF as EIA experiences with the NEMS freight transportation module. With this in mind, a closer collaboration between the two agencies could yield improvements to the transportation modules in NEMS as well as to FHWA's output.

A secondary topic of conversation in the workshop concerned mode choice and how this dynamic is represented in the NEMS freight module. EIA currently does not model modal shifts for given commodities other than what is implicit as changes in industrial output. This is particularly problematic for truck vs. rail freight movement, which is interchangeable to a larger extent than other mode pairs. EIA expressed concern that a full-fledged mode choice model as part of the freight module would increase processing time. External research could be used to apply mode share to the NEMS freight module. One example cited in the workshop was the Intermodal Transportation and Inventory Cost Model (ITIC) from FHWA.

ATRI collects data from trucking companies on freight movements. These data could serve as primary inputs to the NEMS freight module or as a way of validating modeled movements based on FAF. ATRI is also working on a calibration tool for FAF to account for samples that are biased to larger carriers. This collaborative research could also contribute to EIA's estimation of truck movements, as there are ways of linking truck GPS data used by ATRI to commodity flow volumes; although ATRI recognized that this could be very arduous.

Diagrams of the NEMS freight module and further discussion of replacing CFS with FAF can be found in the next major section of this report, "In-depth Analysis of FAF as a NEMS Solution".

Finally, workshop participants discussed how high-level metrics could be used to estimate distances traveled within each zone (e.g., percentage of ton-miles between origin/ destination pairs falling in each census division). Hence, some of the precision of employing network assignment models could be partially gained without the expense in time and costs associated with building a full-fledged model. The "O/D distance model" sub-section in the "Exploration of Future Improvements" section of this report details potential alternative methodological approaches.

Decisions and Next Steps

Members of the workshop agreed that at the very least EIA can incorporate FAF instead of CFS into the NEMS freight module. This change would require minimal effort and it is believed that this change would greatly improve accuracy. Although it will not address all of the existing issues with the freight module, it will address some of them without creating major new ones. This is because, at its core, FAF is the same as CFS with the addition of freight flows for some industry segments that CFS does not sample (e.g., international freight and truck shipments from farms).

After implementation of FAF as an input instead of CFS, some additional relatively-low-effort, high-potential-benefit modifications will be explored. Using a more sophisticated origin/ destination matrix could improve the accuracy in aggregating flows to the census division level. FAF origin-destination matrices merged with routing and distance-traveled assumptions developed in a GIS program could allow a more accurate ton-mile share calculation across census divisions without requiring a full-fledged network assignment model.

Addressing Issues with Modeling Freight Demand in the NEMS Environment

The preliminary analysis by IHS and the feedback received from experts at the workshop suggests a pathway to improving the NEMS freight transportation demand module at minimal cost. The pathway would consist of maintaining the existing overarching NEMS environment architecture, while making the following improvements to the preparation of data fed into the freight transportation module:

1. Replacing CFS data with FAF data for the calculation of ton-mile shares,
2. Employing a separate route optimization process to estimate the ton-mile shares attributable to each of the nine census divisions for each origin-destination pair,
3. Disaggregating commodity groups or, more precisely, eliminating the aggregation of some or all of the 43 SCTG industry classifications for which NEMS forecasts industry output,
4. Employing a commodity-group-specific inflation correction matrix to adjust for changes in prices.

This section will also address other issues identified in this study that are considered lower-priority due to the high costs and uncertain benefits of potential solutions. For example, IHS will make recommendations on future studies on the possibility of addressing dynamic mode share analyses and muti-modal goods movement, which we believe to be potentially feasible but which would require substantial investment and, moreover, would present challenges to reconciliation with the NEMS framework. Included in this section will be conceptual descriptions of potential solutions and discussions about potential costs and benefits.

NEMS Freight Transportation Module Process Overview

It is important to elaborate further on the existing methodologies and procedures in the NEMS Freight Transportation Module to provide context for the suggested improvements and other recommendations in this section of the report. These processes, the challenges, and potential solutions have thus far been described at a high level. This section attempts to provide more in-depth analysis and guidance for updates and improvements.

As previously described freight transportation ton-miles estimated in NEMS are aggregated to the census division level. There are nine census divisions, and Figure 2 illustrates the states organized at this geographical scale. Currently, ton-miles between two different regions are attributed 50% to their origin and 50% to their destination. As the map illustrates, a 50-50% split of ton mileage between regions fails not only to account for the relative distances traveled within the respective origin and destination regions, but also all of the census divisions in between. The possibility of introducing a network assignment procedure to the freight module will be discussed in detail later in this section.

Figure 2: **Census Divisions**

For the purposes of reporting census-division ton-miles, EIA aggregates the 43 SCTG commodity classifications used in CFS (and FAF) to the ten TSIC (e.g., EIA-defined aggregated industry classifications) categories shown in Table 2. SCTG 99 (unknown commodity) is not represented in these groupings. Furthermore, SCTG 16 (crude petroleum), which was previously omitted from the aggregated CFS inputs, is included in TSIC 5 (petroleum products). For the rail module, SCTG 15 (coal) is removed from the broader mining category and treated on its own. This is due to the fact the NEMS model has a module estimating coal production and demand.

Table 2: EIA Commodity Crosswalk

TSIC (NEMS)	SCTG (FAF)
1. Chemicals, rubber, and plastic	20. Basic chemicals 21. Pharmaceutical products 22. Fertilizers 23. Chemical products and preparations 24. Plastics and rubber
2. Primary metals	32. Base metal in primary or semi-finished forms and in finished basic shapes 33. Articles of base metal 41. Waste and scrap
3. Processed food	5. Meat, fish, seafood, and their preparations 6. Milled grain products and preparations, and bakery products 7. Other prepared foodstuffs and fats and oils
4. Paper products	27. Pulp, newsprint, paper, and paperboard 28. Paper or paperboard articles
5. Petroleum products	16. Crude petroleum 17. Gasoline and aviation turbine fuel 18. Fuel oils 19. Coal and petroleum products
6. Stone, clay, glass, concrete	31. Nonmetallic mineral products
7. Metal durables	34. Machinery 35. Electronic and other electrical equipment and components and office equipment 36. Motorized and other vehicles (including parts) 37. Transportation equipment 38. Precision Instruments and Apparatus
8. Other manufacturing	8. Alcoholic beverages 9. Tobacco Products 25. Logs and other wood in the rough 26. Wood products 29. Printed products 30. Textiles, leather, and articles of textiles or leather 39. Furniture, mattresses and mattress supports, lamps, lighting fittings, and illuminated signs 40. Miscellaneous manufactured products 43. Mixed freight
9. Agriculture	1. Live animals and live fish 2. Cereal grains 3. Other agricultural products 4. Animal feed and products of animal origin
10. Mining	10. Monumental or building stone 11. Natural sands 12. Gravel and crushed stone 13. Nonmetallic minerals 14. Metallic ores and concentrates 15. Coal

EIA then employs a series of steps to calculate the ton-miles metric by census division and TSIC code. Figure 3, Figure 4, and Figure 5 diagram the current processes for converting raw data to the ton-mile metrics for each respective mode, including truck, rail, and domestic marine. These process flowcharts are similar among the modes—with the exception of some inputs—but their calculations are done entirely separately. The appropriateness of the complete separation of these modes, particularly between truck and rail, will be further explored later in this section.

The primary input of interest in this study is the CFS share, which appears in the top right corner of each of the modal diagrams. As detailed previously, the CFS sample is used as proxy or benchmark for the distribution of ton-mile shares by commodity and census division. This study has already documented the limitations of CFS for informing this analysis, and the replacement of CFS with FAF will be detailed later in this section.

IHS will not recommend replacing any additional inputs to the current process. As referenced previously in this section, however, we will make suggestions and recommendation for the enhancements of some elements of the model, which may involve inputting new and additional data and/or updating and changing various processes.

Figure 3: NEMS Freight Module Diagram (Truck)

AEO2014 Freight Model Truck Flow Diagram

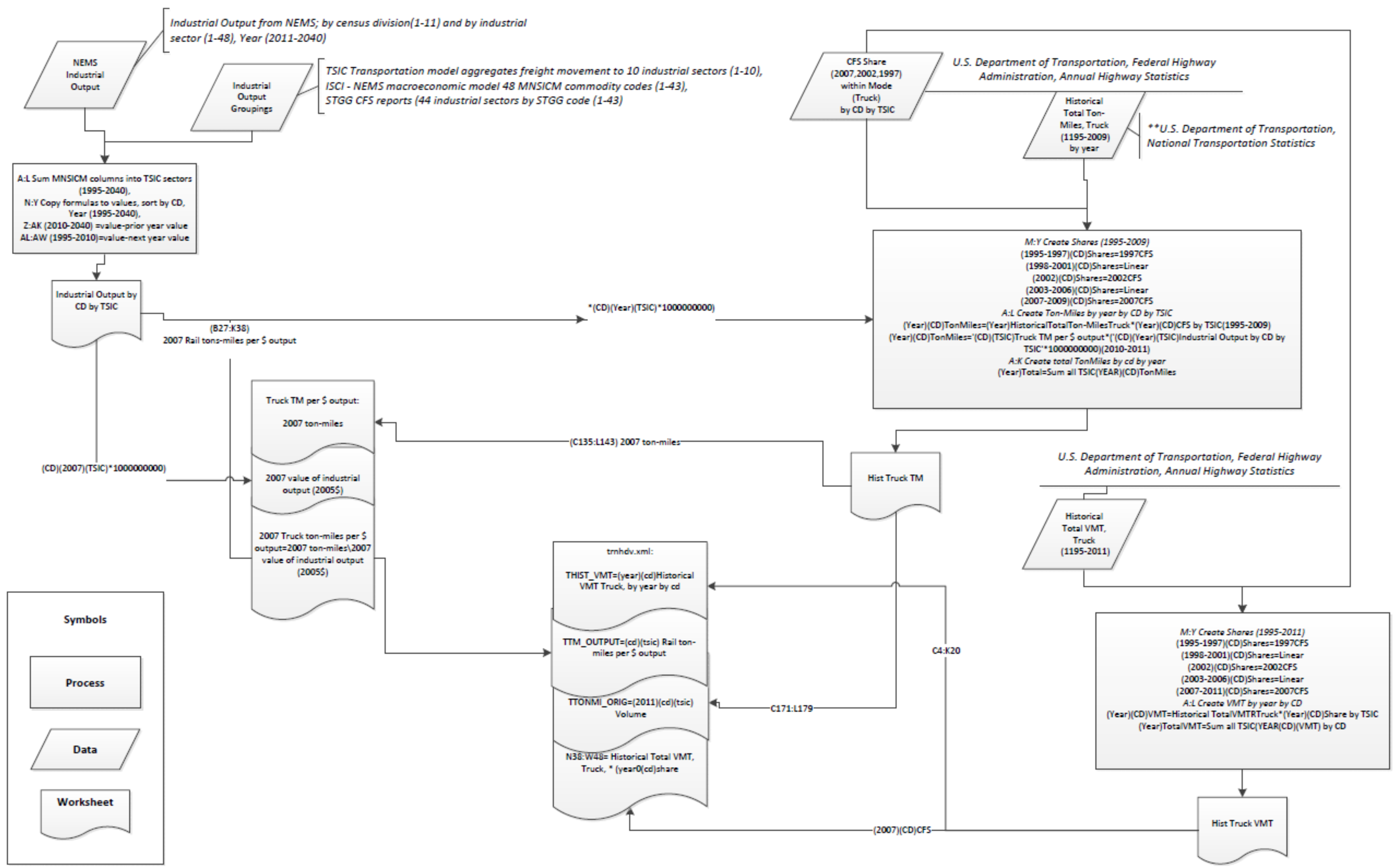


Figure 4: NEMS Freight Module Diagram (Rail)

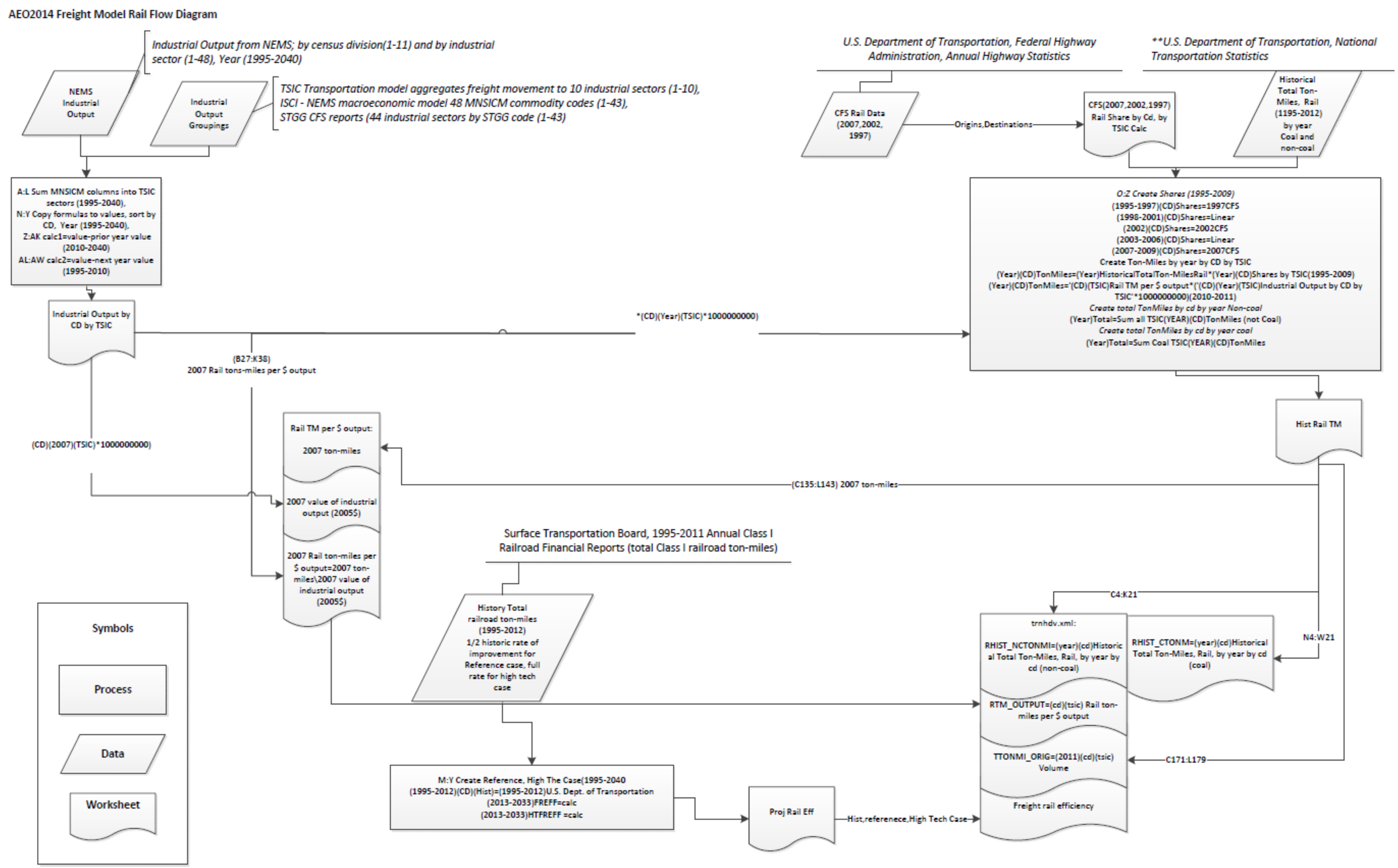
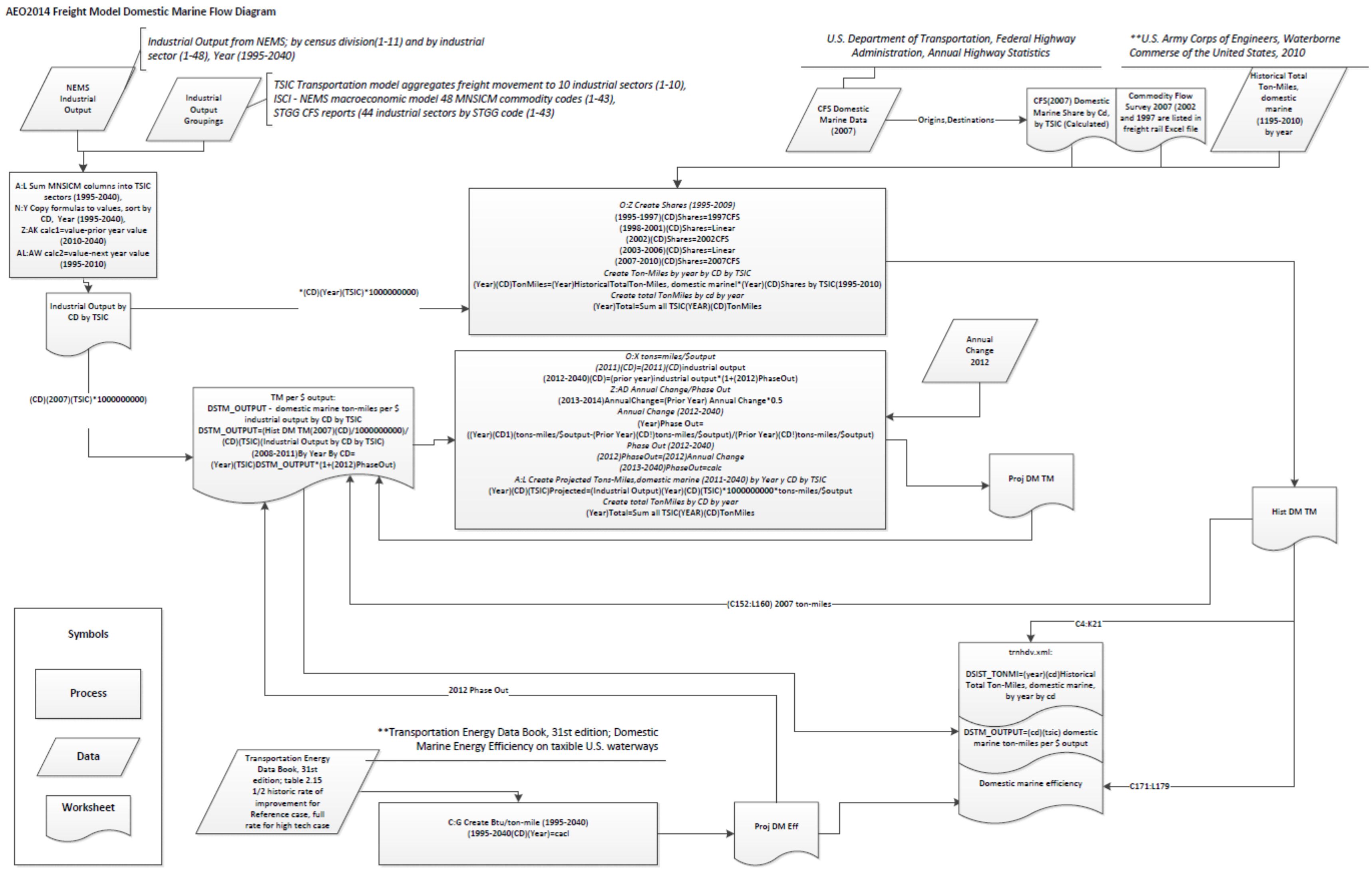


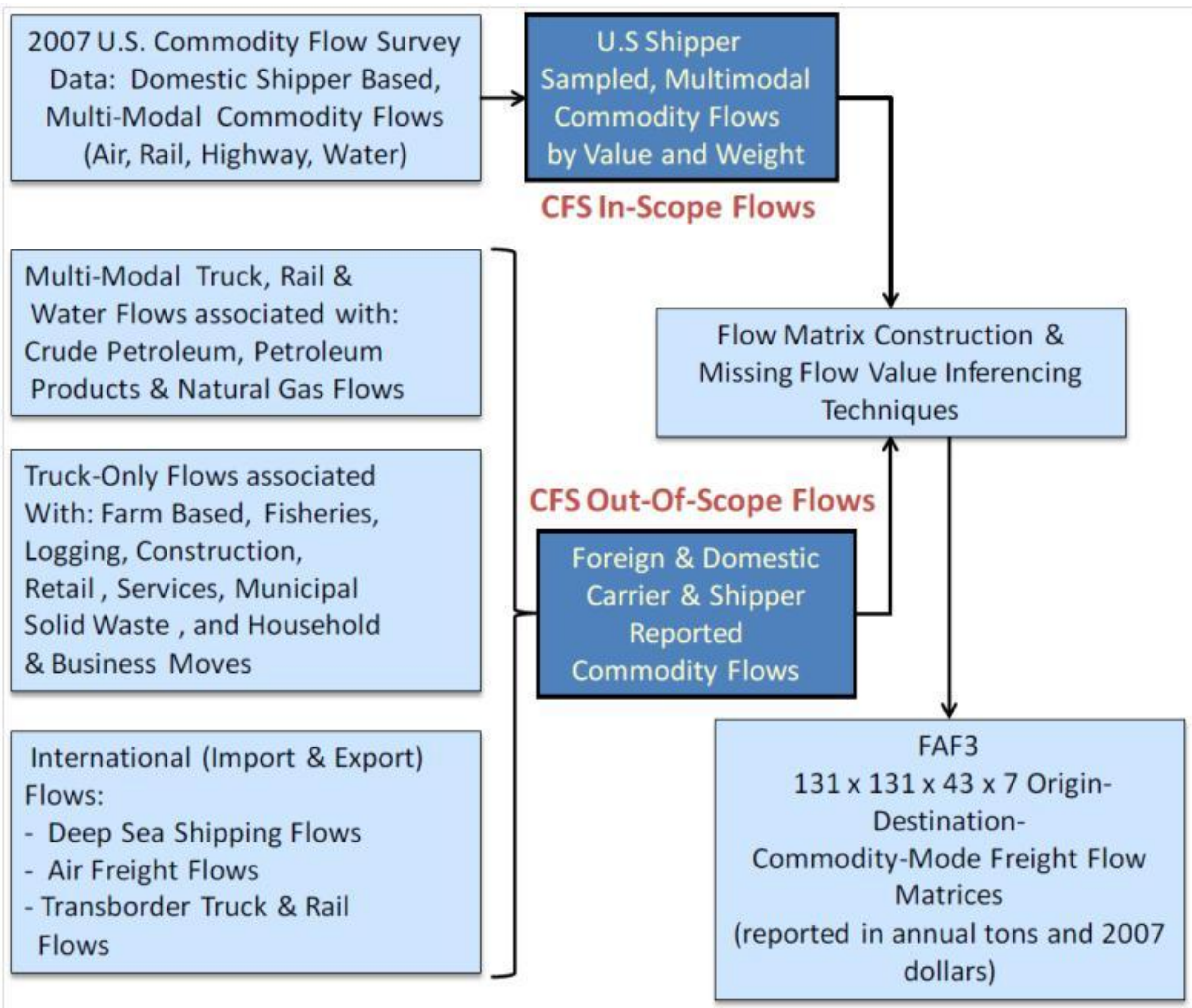
Figure 5: NEMS Freight Module Diagram (Domestic Marine)



Availability and Use of Data: FAF as a NEMS Solution

The primary take-away from the workshop discussion was that, at the very least, EIA should replace the CFS inputs to the NEMS freight transportation module with corresponding inputs from FAF. This is due to the improvements made in producing FAF over and above the data that is collected in the CFS. As detailed in Figure 6, FAF supplements CFS with other external resources to cover a number of holes in the survey. The additional flows reported in FAF are primarily concentrated in three areas that are under-represented in CFS: truck flows for agriculture and many non-manufacturing goods; multi-modal crude petroleum, petroleum products, and natural gas flows; and any international flows.

Figure 6: FAF Flow Matrix[3]



[3] Source: Southworth, F., Peterson, B.E., Hwang, H., Chin, S., and Davidson, D. (2011). *The Freight Analysis Framework Version 3 (FAF3)*. Prepared for the Federal Highway Administration, Washington, DC. Accessed 16 April 2014 at: http://faf.ornl.gov/fafweb/Data/FAF3ODDoc611.pdf.

Based on recommendations of the experts present at the workshop and the analysis of IHS's freight transportation modeling experts, this section explores the use of FAF in place of CFS to improve the ton-mile share metrics in the NEMS freight transportation module. Additionally, IHS provides a demonstration of the results by replicating the current NEMS freight transportation module data preparation process using FAF data rather than CFS.

The full FAF origin/destination datasets were used for 1997, 2002, and 2007 at the state level. The procedure for the development of these shares is as follows:

1. State-to-state flows at the SCTG commodity level are transposed into a state-by-commodity table, which also takes the step of assigning 50% of flows to the origin state and 50% of the flows to the destination state, according to the procedure for calculating CFS shares.[4]
2. FAF multi-modal flows[5] are distributed among the CFS multi-modal pair categories (e.g., rail-to-truck, etc.) as a ratio consistent with the shares of multi-modal ton-miles associated with each relevant CFS bi-modal category. This is done because while CFS reports multi-modal flows by bi-modal category, while FAF does not. IHS developed ratios by mode and commodity.
3. Multi-modal ton-miles are then distributed among each mode in each bi-modal category as a 50-50% split, replicating the process employed by EIA for distributing CFS-derived bi-modal ton-mile shares within each category.
4. The tables are aggregated from the SCTG commodity level to the TSIC commodity according to the commodity group map in Table 2. Coal (SCTG 15) is omitted from TSIC 10 for the rail tables in each year[6].
5. The tables are aggregated from the state level to the census division level according to the census division map in Figure 2.
6. Total commodity flows are divided by totals of all commodity groups and census divisions to calculate ton-mile shares.

The census division and commodity group shares calculated from FAF are detailed in this report, as well as in a separate spreadsheet deliverable. Table 3, Table 4, and Table 5 contain the aggregated ton-mile shares using 1997 FAF data for truck, rail, and domestic marine, respectively. Table 6, Table 7, and Table 8 contain the aggregated ton-mile shares using 2002 FAF for truck, rail, and domestic marine, respectively. Table 9, Table 10, and Table 11 contain the aggregated ton-mile shares using 2007 FAF for truck, rail, and domestic marine, respectively.

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[4] For the purposes of demonstration, the current 50-50% share is maintained. An improved network assignment process will be discussed later in this section.
[5] FAF aggregates multi-modal flows as a single category, while CFS shares these out among multi-modal categories. CFS does not, however, distribute the ton mileage aboard each mode pair. In CFS, various multi-modal categories account for about 12.5% of total ton-miles. These flows account for only 6.5% of domestic ton-miles in FAF.
[6] This report will recommend removing the process of aggregating to 10 TSIC groups. For the purposes of demonstrating the impacts of replacing CFS with FAF, however, we maintain the current commodity aggregation process.

Table 3: FAF Truck Shares (1997)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.46%	0.40%	0.26%	0.20%	0.26%	0.17%	0.20%	0.77%	0.25%	0.38%	*3.35%*
	2	0.85%	1.26%	0.93%	0.40%	0.72%	0.67%	0.48%	1.21%	0.58%	1.75%	*8.84%*
	3	1.46%	2.49%	1.36%	0.73%	1.11%	1.38%	1.13%	1.82%	2.03%	3.10%	*16.61%*
	4	0.60%	0.85%	1.03%	0.23%	0.58%	0.60%	0.41%	1.23%	3.73%	1.47%	*10.72%*
	5	1.48%	1.54%	1.23%	0.62%	1.15%	1.62%	0.79%	3.79%	1.38%	2.98%	*16.57%*
	6	0.47%	0.86%	0.47%	0.28%	0.48%	0.61%	0.41%	1.45%	0.76%	1.71%	*7.50%*
	7	1.45%	1.54%	0.96%	0.45%	2.06%	0.99%	0.76%	2.28%	2.19%	2.13%	*14.81%*
	8	0.42%	0.55%	0.43%	0.13%	0.83%	0.59%	0.35%	1.02%	0.98%	1.13%	*6.45%*
	9	1.40%	1.42%	1.30%	0.58%	2.18%	0.95%	1.05%	2.75%	1.65%	1.86%	*15.14%*
	∑	*8.59%*	*10.91%*	*7.98%*	*3.61%*	*9.38%*	*7.59%*	*5.59%*	*16.31%*	*13.54%*	*16.51%*	*100%*

Table 4: FAF Rail Shares (1997)

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.15%	0.28%	0.08%	0.14%	0.10%	0.06%	0.03%	0.25%	0.10%	0.15%	0.08%	*1.42%*
	2	0.65%	0.64%	0.39%	0.28%	0.49%	0.08%	0.16%	0.37%	0.19%	0.43%	1.28%	*4.95%*
	3	1.72%	1.42%	0.81%	0.80%	0.60%	0.20%	0.74%	0.62%	2.10%	1.58%	5.53%	*16.11%*
	4	1.15%	0.53%	0.91%	0.25%	0.85%	0.11%	0.20%	0.50%	4.35%	1.37%	3.19%	*13.41%*
	5	2.21%	0.57%	0.51%	0.52%	0.33%	0.22%	0.22%	0.79%	1.00%	1.24%	6.81%	*14.43%*
	6	0.54%	0.51%	0.22%	0.39%	0.31%	0.13%	0.08%	0.36%	0.39%	0.32%	3.53%	*6.79%*
	7	3.06%	0.96%	0.43%	0.44%	0.83%	0.22%	0.31%	0.83%	1.97%	1.04%	3.87%	*13.96%*
	8	1.18%	0.41%	0.20%	0.37%	0.32%	0.23%	0.20%	0.76%	0.45%	0.76%	14.08%	*18.95%*
	9	1.47%	0.80%	0.85%	0.48%	0.89%	0.32%	0.34%	1.40%	2.93%	0.34%	0.17%	*9.98%*
	∑	*12.12%*	*6.11%*	*4.40%*	*3.67%*	*4.72%*	*1.57%*	*2.27%*	*5.88%*	*13.48%*	*7.23%*	*38.53%*	*100%*

Table 5: FAF Domestic Marine Shares (1997)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.08%	0.03%	0.02%	0.01%	0.27%	0.02%	0.03%	0.06%	0.07%	0.08%	*0.67%*
	2	0.21%	0.17%	0.09%	0.03%	1.13%	0.04%	0.11%	0.16%	0.25%	2.41%	*4.59%*
	3	0.90%	0.26%	0.23%	0.05%	0.79%	0.55%	0.21%	0.17%	5.44%	4.96%	*13.56%*
	4	0.18%	0.07%	0.09%	0.01%	0.84%	0.09%	0.07%	0.08%	3.42%	1.76%	*6.63%*
	5	1.11%	0.13%	0.17%	0.07%	3.27%	0.17%	0.14%	0.23%	0.55%	3.17%	*9.01%*
	6	0.47%	0.20%	0.10%	0.06%	2.55%	0.23%	0.08%	0.39%	0.91%	4.27%	*9.25%*
	7	3.29%	0.35%	0.35%	0.05%	11.03%	0.26%	0.08%	0.29%	9.26%	2.24%	*27.20%*
	8	0.03%	0.03%	0.01%	0.01%	0.84%	0.01%	0.04%	0.06%	0.03%	0.89%	*1.95%*
	9	0.52%	0.42%	0.42%	0.15%	22.47%	0.17%	0.37%	0.64%	1.56%	0.43%	*27.14%*
	∑	*6.79%*	*1.66%*	*1.48%*	*0.43%*	*43.19%*	*1.54%*	*1.13%*	*2.08%*	*21.49%*	*20.22%*	*100%*

Table 6: FAF Truck Shares (2002)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.39%	0.28%	0.29%	0.20%	0.22%	0.15%	0.12%	0.57%	0.22%	0.26%	*2.70%*
	2	1.41%	1.21%	1.10%	0.40%	0.66%	0.56%	0.53%	1.40%	0.56%	1.40%	*9.23%*
	3	1.59%	2.48%	1.73%	0.60%	1.05%	1.22%	1.69%	2.05%	1.69%	2.86%	*16.97%*
	4	0.75%	0.77%	1.25%	0.20%	0.51%	0.86%	0.50%	1.01%	3.18%	1.39%	*10.42%*
	5	1.65%	1.49%	1.41%	0.69%	0.87%	1.28%	0.85%	3.44%	1.20%	2.66%	*15.55%*
	6	0.72%	0.92%	0.60%	0.31%	0.69%	0.56%	0.55%	1.58%	0.69%	1.12%	*7.74%*
	7	1.85%	1.71%	1.15%	0.36%	1.75%	1.13%	0.98%	2.03%	1.80%	1.86%	*14.63%*
	8	0.60%	0.53%	0.61%	0.14%	0.89%	0.50%	0.34%	1.16%	0.88%	1.10%	*6.75%*
	9	1.44%	1.42%	1.66%	0.46%	1.87%	1.28%	1.09%	2.97%	1.69%	2.13%	*16.00%*
	∑	*10.41%*	*10.81%*	*9.80%*	*3.35%*	*8.51%*	*7.55%*	*6.67%*	*16.22%*	*11.92%*	*14.78%*	*100%*

Table 7: FAF Rail Shares (2002)

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.10%	0.09%	0.04%	0.16%	0.03%	0.01%	0.02%	0.22%	0.07%	0.16%	0.08%	*0.98%*
	2	0.62%	0.48%	0.33%	0.21%	0.45%	0.06%	0.16%	0.37%	0.53%	0.46%	1.93%	*5.59%*
	3	1.68%	1.23%	0.69%	0.41%	0.63%	0.18%	0.82%	0.86%	2.11%	1.70%	5.80%	*16.10%*
	4	0.88%	0.53%	1.02%	0.26%	0.32%	0.16%	0.19%	0.70%	4.44%	1.21%	2.96%	*12.66%*
	5	1.80%	0.60%	0.41%	0.42%	0.39%	0.30%	0.22%	0.61%	1.15%	1.28%	5.02%	*12.21%*
	6	0.67%	0.33%	0.18%	0.32%	0.51%	0.30%	0.15%	0.25%	0.37%	0.54%	3.73%	*7.36%*
	7	2.47%	0.60%	0.42%	0.36%	0.66%	0.30%	0.41%	0.59%	2.18%	0.90%	5.32%	*14.21%*
	8	0.64%	0.29%	0.17%	0.12%	0.32%	0.25%	0.06%	0.56%	0.38%	0.68%	16.62%	*20.09%*
	9	1.03%	0.68%	0.81%	0.28%	0.86%	0.24%	0.47%	1.97%	3.17%	0.64%	0.65%	*10.80%*
	∑	*9.89%*	*4.83%*	*4.07%*	*2.53%*	*4.17%*	*1.79%*	*2.49%*	*6.13%*	*14.41%*	*7.56%*	*42.12%*	*100%*

Table 8: FAF Domestic Marine Shares (2002)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.05%	0.02%	0.01%	0.01%	0.13%	0.01%	0.03%	0.05%	0.08%	0.03%	*0.40%*
	2	0.23%	0.77%	0.08%	0.02%	2.57%	0.06%	0.17%	0.28%	0.17%	1.32%	*5.67%*
	3	1.09%	1.08%	0.29%	0.05%	1.20%	0.44%	0.47%	0.39%	5.14%	6.41%	*16.56%*
	4	0.23%	0.69%	0.07%	0.01%	0.40%	0.15%	0.07%	0.11%	7.21%	1.95%	*10.89%*
	5	0.45%	0.21%	0.21%	0.07%	2.82%	0.15%	0.19%	0.32%	0.44%	1.41%	*6.26%*
	6	0.51%	1.09%	0.16%	0.03%	1.99%	0.20%	0.11%	0.15%	0.69%	2.43%	*7.35%*
	7	2.99%	1.16%	0.41%	0.04%	9.56%	0.24%	0.30%	0.21%	12.84%	2.13%	*29.87%*
	8	0.05%	0.03%	0.02%	0.01%	1.18%	0.02%	0.04%	0.07%	0.03%	1.12%	*2.56%*
	9	0.50%	0.53%	0.59%	0.12%	14.88%	0.22%	0.62%	0.95%	1.21%	0.82%	*20.44%*
	∑	*6.10%*	*5.58%*	*1.85%*	*0.35%*	*34.73%*	*1.47%*	*1.98%*	*2.53%*	*27.79%*	*17.62%*	*100%*

Table 9: FAF Truck Shares (2007)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.44%	0.32%	0.31%	0.17%	0.30%	0.14%	0.14%	0.46%	0.22%	0.34%	*2.84%*
	2	1.03%	1.52%	1.18%	0.39%	0.72%	0.40%	0.55%	1.53%	0.69%	1.40%	*9.42%*
	3	1.78%	2.58%	1.57%	0.65%	0.72%	0.83%	1.41%	1.86%	2.29%	2.27%	*15.95%*
	4	0.81%	0.97%	1.14%	0.20%	0.46%	0.58%	0.51%	0.94%	3.85%	1.42%	*10.87%*
	5	1.86%	1.73%	1.49%	0.71%	0.96%	1.29%	0.89%	3.00%	1.28%	2.56%	*15.77%*
	6	0.65%	1.02%	0.54%	0.30%	0.50%	0.46%	0.48%	1.39%	0.53%	1.85%	*7.71%*
	7	1.97%	1.96%	1.20%	0.41%	1.85%	0.93%	1.00%	1.80%	1.69%	1.84%	*14.65%*
	8	0.58%	0.65%	0.60%	0.15%	0.51%	0.67%	0.33%	1.07%	1.24%	1.19%	*7.00%*
	9	1.50%	1.86%	1.95%	0.56%	0.96%	1.19%	1.34%	2.96%	1.99%	1.47%	*15.79%*
	∑	*10.62%*	*12.61%*	*9.98%*	*3.53%*	*6.99%*	*6.47%*	*6.66%*	*15.02%*	*13.78%*	*14.33%*	*100%*

Table 10: FAF Rail Shares (2007)

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.16%	0.10%	0.03%	0.12%	0.03%	0.01%	0.02%	0.11%	0.03%	0.09%	0.02%	*0.72%*
	2	0.78%	0.50%	0.24%	0.19%	0.34%	0.03%	0.10%	0.39%	0.36%	0.22%	0.97%	*4.12%*
	3	1.64%	0.90%	0.45%	0.37%	0.66%	0.15%	0.57%	0.54%	1.79%	1.54%	6.67%	*15.28%*
	4	1.06%	0.44%	0.85%	0.22%	0.29%	0.11%	0.09%	0.62%	4.07%	1.05%	4.33%	*13.14%*
	5	1.50%	0.44%	0.27%	0.37%	0.38%	0.15%	0.13%	0.38%	0.72%	0.65%	6.48%	*11.47%*
	6	0.78%	0.42%	0.11%	0.25%	0.18%	0.06%	0.10%	0.17%	0.32%	0.49%	4.32%	*7.22%*
	7	3.03%	0.66%	0.40%	0.42%	1.40%	0.11%	0.29%	0.43%	1.92%	1.37%	5.50%	*15.54%*
	8	1.37%	0.34%	0.18%	0.11%	0.51%	0.16%	0.10%	0.41%	0.53%	0.65%	19.90%	*24.26%*
	9	1.07%	0.57%	0.70%	0.38%	0.83%	0.17%	0.35%	1.15%	2.35%	0.31%	0.35%	*8.25%*
	∑	*11.41%*	*4.38%*	*3.25%*	*2.44%*	*4.62%*	*0.94%*	*1.76%*	*4.21%*	*12.09%*	*6.37%*	*48.54%*	*100%*

Table 11: FAF Domestic Marine Shares (2007)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.02%	0.02%	0.01%	0.03%	0.28%	0.00%	0.02%	0.05%	0.01%	0.02%	*0.46%*
	2	0.77%	0.17%	0.06%	0.05%	1.57%	0.02%	0.04%	0.12%	0.05%	1.61%	*4.46%*
	3	0.96%	0.42%	0.09%	0.08%	2.50%	0.50%	0.14%	0.27%	5.04%	6.15%	*16.14%*
	4	0.17%	0.05%	0.17%	0.02%	0.87%	0.19%	0.05%	0.12%	6.36%	2.10%	*10.09%*
	5	0.58%	0.14%	0.07%	0.10%	2.49%	0.06%	0.08%	0.16%	0.36%	1.35%	*5.39%*
	6	0.58%	0.62%	0.03%	0.05%	1.79%	0.14%	0.04%	0.06%	1.51%	2.55%	*7.36%*
	7	3.63%	0.75%	0.16%	0.07%	9.86%	0.30%	0.06%	0.23%	12.41%	2.09%	*29.56%*
	8	0.06%	0.04%	0.03%	0.02%	0.11%	0.07%	0.04%	0.10%	0.02%	0.37%	*0.87%*
	9	0.26%	0.15%	0.34%	0.13%	21.43%	0.24%	0.18%	0.61%	0.76%	1.57%	*25.67%*
	∑	*7.03%*	*2.37%*	*0.95%*	*0.55%*	*40.90%*	*1.51%*	*0.67%*	*1.72%*	*26.52%*	*17.79%*	*100%*

Figure 7, Figure 8, and Figure 9 illustrate shares of flows by census division for truck, rail, and domestic marine modes, respectively, for 1997, 2002, and 2007. These figures show that, generally, FAF shares are stable across survey years. The most noticeable exception is domestic marine in the Pacific census division, which has an extreme dip in 2002. Rail flows in the Mountain census division (CD 8) are the most prominent out of all other census divisions due to the coal extraction in that region, but there are virtually no domestic marine flows in CD 8 due to lack of commercially navigable inland waterways.

Figure 7: Truck Flows by Census Division

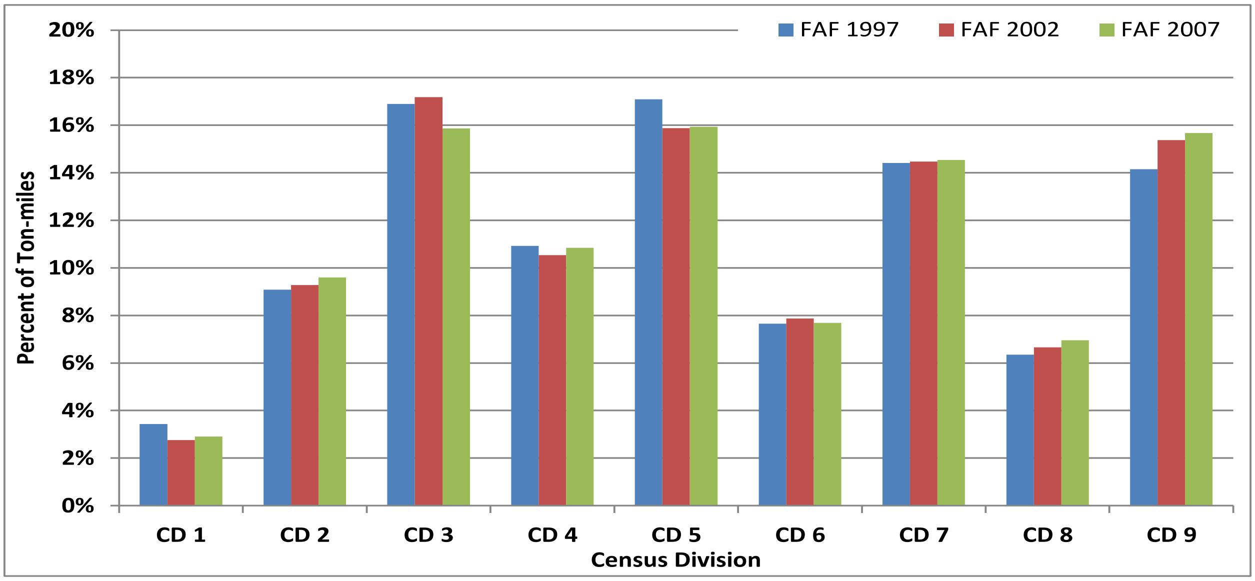


Figure 8: Rail Flows by Census Division

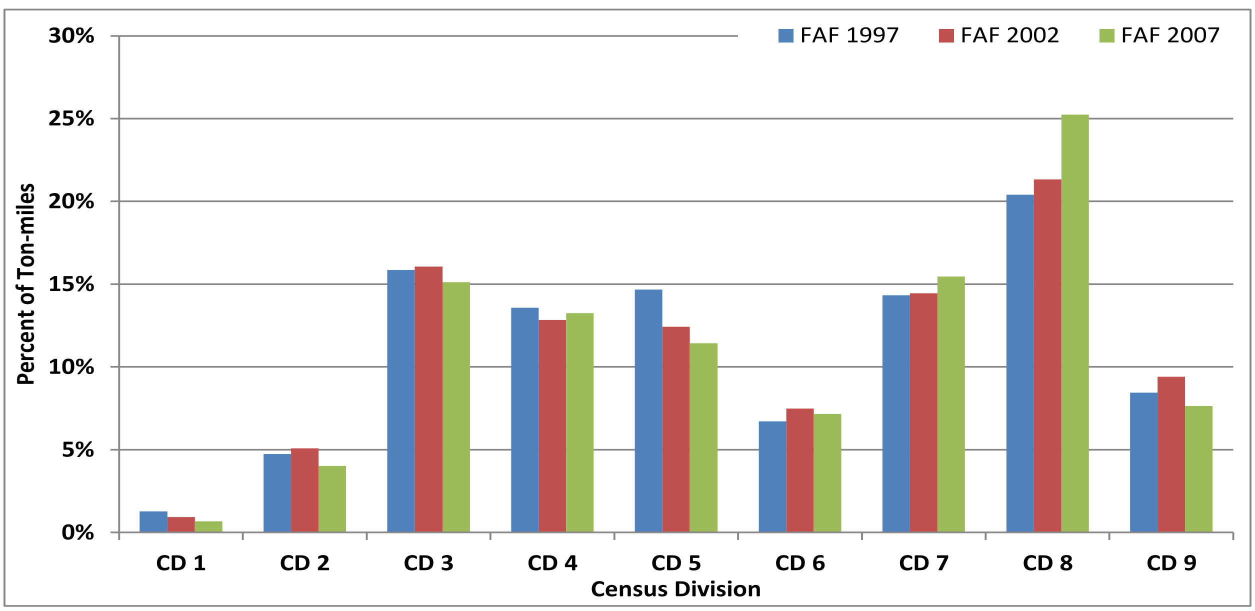


Figure 9: Domestic Marine Flows by Census Division

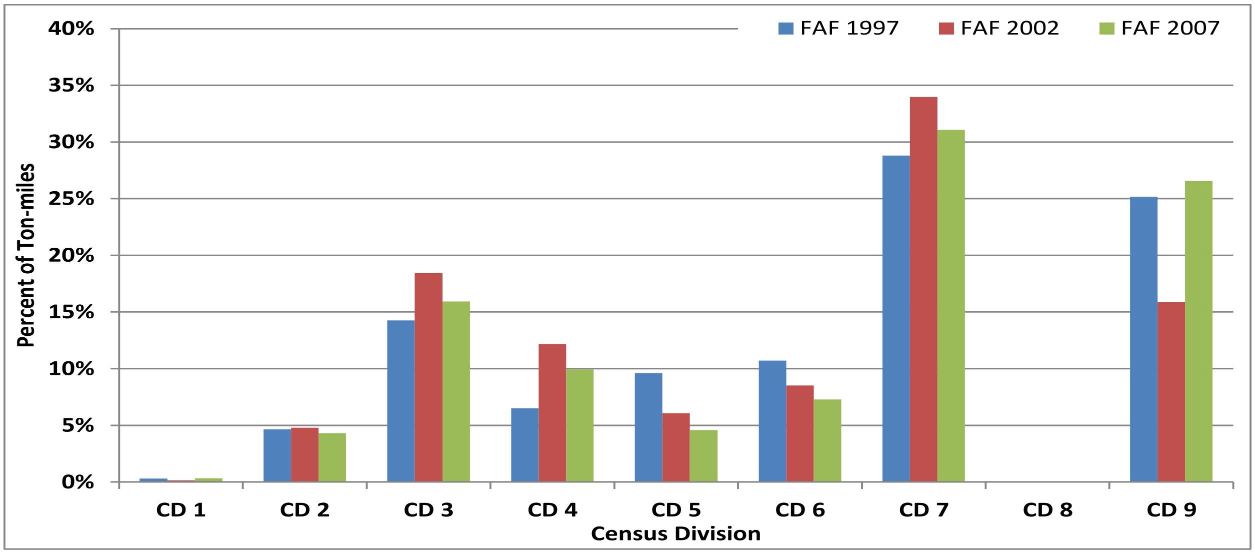


Table 12, Table 13, and Table 14 illustrate the change in percent ton-mile shares attributable to each census division and TSIC classification using FAF instead of CFS for 2007. The purpose of these tables is to illustrate how the use of FAF changes the *relative allocation* of shares of ton-mileage across commodities and census divisions compared to the calculation of ton-mile shares using CFS. These changes in relative shares do not address the *absolute* total ton-miles reported by EIA, which are derived from other sources (e.g., the FHWA National Transportation Statistics for highway VMT). Hence, replacing the CFS-derived ton-mile shares in the NEMS freight transportation module with the FAF-derived ton-mile shares will simply re-allocate the national ton-mile/VMT forecast by commodity and census division. The use of alternative data sets for NEMS for the top-line national freight figures will be addressed in the conclusion of this report.

Table 12 – 2007 Difference in Ton-mile Shares Using FAF Versus CFS, Truck
(Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.22%	0.14%	-0.14%	-0.03%	0.14%	0.01%	0.06%	0.04%	0.14%	0.18%	0.77%
	2	-0.19%	0.45%	-0.82%	-0.15%	0.22%	0.00%	0.02%	-0.01%	0.23%	0.33%	0.08%
	3	-0.72%	-0.54%	-1.44%	-0.50%	0.11%	-0.22%	-0.50%	-0.50%	1.46%	0.64%	-2.22%
	4	-0.02%	0.33%	-0.76%	-0.08%	0.06%	-0.03%	-0.06%	-0.07%	2.08%	0.11%	1.57%
	5	-0.48%	0.42%	-0.91%	-0.40%	0.17%	-0.16%	-0.03%	-0.43%	0.46%	0.65%	-0.71%
	6	-0.20%	-0.01%	-0.41%	-0.26%	0.17%	-0.19%	-0.17%	-0.09%	0.34%	0.50%	-0.32%
	7	-0.50%	0.08%	-0.89%	-0.28%	0.35%	-0.39%	-0.10%	-0.40%	0.98%	0.31%	-0.84%
	8	0.01%	0.29%	-0.22%	-0.02%	0.09%	-0.03%	0.15%	-0.15%	0.83%	0.36%	1.30%
	9	-0.02%	1.01%	-1.61%	-0.36%	0.05%	0.12%	0.33%	-0.30%	0.66%	0.49%	0.37%
	∑	-1.90%	2.17%	-7.19%	-2.08%	1.37%	-0.88%	-0.29%	-1.92%	7.16%	3.57%	0.00%

Table 13 – 2007 Difference in Ton-mile Shares Using FAF Versus CFS, Rail
(Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.06%	0.08%	0.02%	0.04%	0.02%	0.01%	0.02%	0.04%	0.01%	0.03%	0.02%	0.35%
	2	0.32%	0.36%	0.05%	0.12%	0.07%	0.02%	0.09%	0.20%	0.11%	0.18%	-0.07%	1.46%
	3	0.45%	0.39%	0.19%	0.16%	0.25%	0.06%	0.38%	0.32%	0.91%	0.72%	-2.57%	1.26%
	4	0.72%	0.29%	0.03%	0.16%	0.19%	0.03%	0.06%	0.37%	1.61%	0.33%	-1.58%	2.20%
	5	0.51%	0.30%	0.16%	0.14%	0.26%	0.05%	0.03%	0.25%	0.26%	0.32%	-2.29%	-0.02%
	6	0.10%	0.17%	0.07%	0.05%	0.05%	0.03%	0.08%	0.13%	0.17%	0.16%	-1.23%	-0.20%
	7	-0.13%	0.33%	0.07%	0.04%	0.26%	0.05%	0.24%	0.22%	0.66%	0.15%	-3.12%	-1.23%
	8	1.06%	0.29%	0.11%	0.05%	0.12%	0.07%	0.08%	0.16%	0.30%	0.44%	-9.98%	-7.28%
	9	0.57%	0.37%	0.09%	0.03%	0.47%	0.15%	0.24%	0.41%	1.34%	0.11%	-0.30%	3.48%
	∑	3.67%	2.59%	0.79%	0.79%	1.67%	0.46%	1.23%	2.10%	5.37%	2.45%	-21.12%	0.00%

Table 14 – 2007 Difference in Ton-mile Shares Using FAF Versus CFS, Domestic Marine
(Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.02%	0.02%	0.01%	0.03%	0.28%	0.00%	0.02%	0.05%	0.01%	0.02%	0.46%
	2	0.77%	0.17%	0.06%	0.05%	1.56%	0.02%	0.03%	0.10%	0.05%	-1.40%	1.42%
	3	0.44%	-0.02%	0.09%	0.08%	2.31%	0.15%	0.14%	-0.17%	-4.60%	-3.34%	-4.92%
	4	-0.16%	0.05%	0.17%	0.02%	0.64%	-0.07%	0.04%	0.12%	-7.46%	-3.69%	-10.35%
	5	0.58%	0.07%	0.07%	0.09%	0.73%	0.01%	0.08%	0.12%	0.36%	0.85%	2.97%
	6	0.38%	0.13%	0.03%	0.05%	0.60%	-0.09%	0.04%	0.06%	-0.54%	-1.79%	-1.12%
	7	1.96%	0.45%	0.00%	0.07%	3.77%	0.28%	0.06%	-0.23%	-12.88%	-2.21%	-8.73%
	8	0.05%	0.04%	0.02%	0.02%	0.11%	0.07%	0.04%	0.02%	0.02%	0.37%	0.77%
	9	0.18%	0.08%	-0.50%	0.10%	20.14%	-0.20%	-0.22%	-0.05%	0.70%	-0.74%	19.49%
	∑	4.21%	1.00%	-0.05%	0.52%	30.14%	0.17%	0.25%	0.02%	-24.34%	-11.92%	0.00%

Using FAF in place of CFS for calculating ton-mile shares makes a non-trivial impact on the resulting matrices, particularly for certain TSIC groups. For trucks, the most notable shifts are in the increased overall shares attributable to agriculture (TSIC 9), mining products (TSIC 10), and primary metals (TSIC 2). This conforms to the hypothesis that FAF better captures non-manufactured goods moving on trucks, which are under-represented in CFS. Interestingly, much of the percentage share increases if agriculture appears to come at the relative expense of processed foods and beverages (TSIC 3). It is important to reiterate, however, that a decline in relative share is not synonymous with a decline in absolute ton-miles when comparing the CFS and FAF forecast data sets. Again, FHWA estimates that the FAF forecast counts 50 percent greater ton-miles than CFS. If EIA continues to use the same source in the NEMS freight transportation module for total national ton-miles and VMT; however, the FAF ton-mile metrics will reduce or increase the total freight figures for each census division-commodity combination by the percentage shares deltas.

For rail, a dramatic shift occurs in the share of ton-mile shares from coal to all other TSIC groups. Moreover, and intuitively, a large geographic shift in ton-mile shares occurs from the Mountain Region (CD 8) where much of the coal is mined to other parts of the country, especially the East and West coasts. Interestingly, the absolute total ton-mile forecasts for coal, specifically, in CFS and FAF are nearly identical. Therefore, the lower shares of coal in CFS are entirely due to increases in ton-mile estimates for other TSIC groups. Again, agriculture, mining products, and primary metals enjoy large share gains, conforming to the assumption that FAF captures these freight flows better than CFS alone. Chemicals (TSIC 1), many of which are imported and exported, also not surprisingly see relative gains.

Domestic marine ton-mile shares experience dramatic shifts in three TSIC categories and three census division regions. With respect to commodities, agriculture (TSIC 9) and mining products (TSIC 10, including coal) ton-mile shares fall dramatically, while crude and petroleum products (TSIC 5) rise substantially. Most of the relative gains are in the Pacific census division (CD 9), while most of the relative losses are in census divisions adjacent to and immediately west of the Mississippi River (CDs 4 and 7). IHS hypothesizes that FAF is capturing a higher quantity of marine flows of crude oil from Alaska to other West Coast refineries. This is plausible given that the US West Coast generally receives substantial portions of feedstocks from Alaska and given CFS's weaknesses in capturing crude. Since agriculture and coal constitute such a high percentage of freight flows recorded on U.S. inland waterways, especially via the Mississippi River, it is logical that these commodities and regions would fall the greatest by increasing crude and petroleum volumes, all else equal.

In the previous tables, IHS reviewed relative differences in ton-mile shares using FAF versus CFS for all modes in 2007. Approximately similar trends are apparent in previous year estimates. These comparisons are included in Appendix B.

Without complete knowledge of how FHWA develops FAF, IHS cannot validate the appropriateness of using FAF versus CFS for the NEMS freight transportation module ton-mile share calculation. Our analysis, however, identifies specific weaknesses that are possibly related to using CFS data and demonstrates how some of these weaknesses appear to be at least partially addressed with FAF. First, the FAF dataset is larger and richer, while it is generally acknowledged that CFS poorly captures at least some commodity types and flows. This may distort ton-mile share calculations. Second, EIA can benefit from working with professional staff at FHWA who are familiar with both data sets and, after having attended the workshop, have an understanding of EIA's specific needs and objectives. Third, employing FAF in place of CFS to calculate the ton-mile metric is a simple solution, whereby EIA need only change the source data but otherwise maintains all existing NEMS freight transportation module processes.

Given the low level-of-effort required to run the NEMS freight transportation module with FAF data as the source of the ton-mile share, IHS recommends that EIA employ (at least internally) both approaches for a period of time to determine which data set offers more accurate forecasts. If EIA determines that fundamental problems remain that may be related to the use of either CFS or FAF for the ton-mile share calculation, the agency can reassess whether to develop a different data set or modeling procedure.

Employing a Route Optimization Proxy to Improve Network Assignment

There are many possible ways to improve upon the current 50-50% assignment of ton-mileage between origin and destination census divisions. As previously described, state-of-the-practice techniques would likely require a more fundamental change to the current design of the NEMS freight transportation module and, possibly, to the NEMS model itself. In the workshop, however, experts suggested possible approaches that could improve accuracy with minimal additional effort and resources and without fundamentally altering NEMS or the NEMS freight transportation module.

In this sub-section, IHS demonstrates a relatively simple approach to improving the network assignment for truck ton-mileage. This approach involves developing a general (not commodity-specific) "optimal" assignment of goods movement onto the road network for all state-by-state origin/destination pairs. For each of these origin/destination pairs, the process calculates the total mileage within each state along the optimized route and divides this figure by the total route mileage. The result is a percentage of distance traveled through each state, which can be used as a proxy for ton-mileage. State-by-state ton-mile shares can then be aggregated to the census division levels using a weighted average of the market shares of each corresponding state-by-state pair therein.[7]

In this study, IHS provides an example for truck freight only. There are several reasons why a simple network assignment model as described in the previous paragraph may work for truck. First, there are numerous truck movements in every state over a dense roadway network such that the designing of a single "average" route might offer a close enough approximation of overall behavior. Second, truck freight movements tend to follow relatively simple rules, especially for long-haul shipments. IHS believes, essentially, that a shortest path routing approximates the typical decision-making paradigm for truckers, or at least sufficiently for the purposes of estimating ton-mile allocations to the network.

IHS applied the following procedure to develop a network assignment matrix to estimate ton-mile allocations across each census division for each state-by-state origin/destination pair:

1. Load a transportation network shape file into a GIS-based software with a transportation network analysis capability[8],
2. Develop centroids[9] for each state,
3. Map the centroids onto the transportation network, (See Figure 10)
4. Estimate the shortest paths between state-by-state centroids (See example in Figure 11, which illustrates, as an example, the shortest path for all Alabama origin-destination truck flows) [10],

[7] Total FAF ton-mileage associated with each corresponding state-by-state pair is a logical benchmark to apply for the weighted average calculation.

[8] For the first three steps in this process, IHS used ArcGIS software.

[9] Centroids are essentially a central location in a given area which is used as the proxy origin or destination point for all flows. For this example, IHS used the geographic center of each state as the centroid. More complex analyses might include a weighted measure by population or origination of freight activity, etc.

[10] For this study, IHS applied a shortest-path algorithm using TransCAD software. Other algorithms could also be used (e.g., lowest, cost, etc.).

5. Overlay a map of the shortest paths with the census divisions to determine the share of goods movement between any two states in each census division.

Figure 10: Lower 48 States with Geographic Centroids Mapped with the Primary Road Network

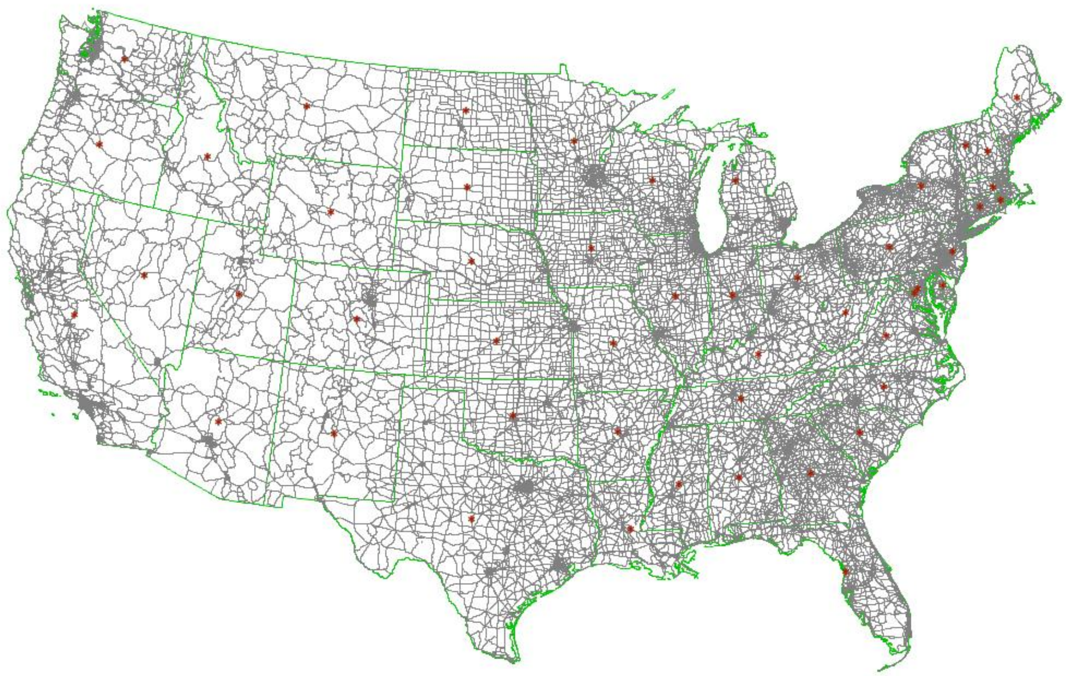
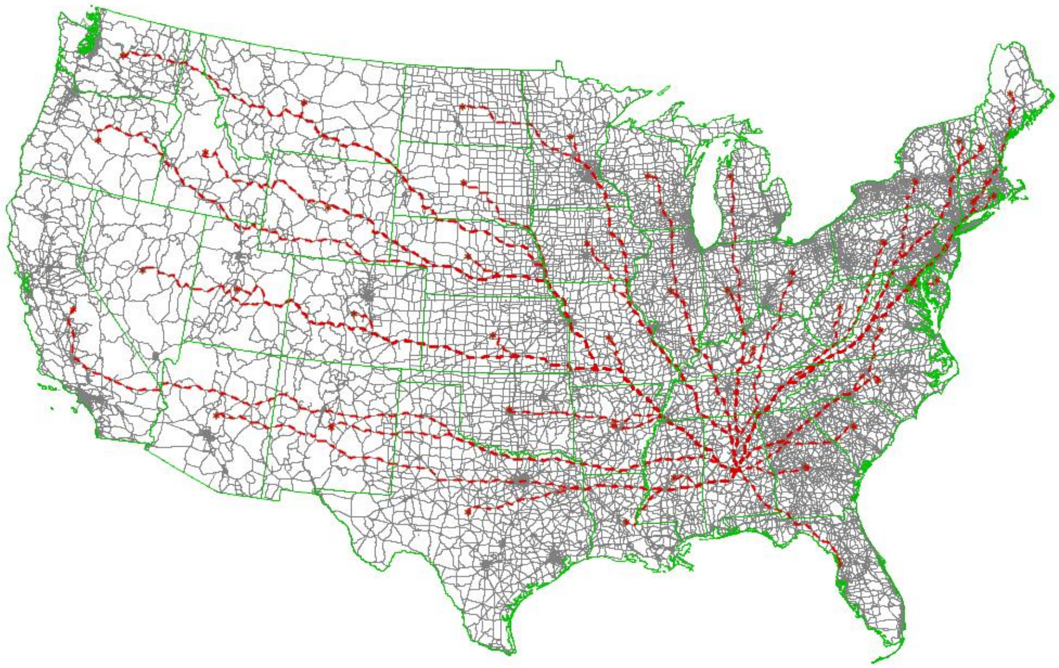


Figure 11: Commodity Agnostic Shortest Path Estimate for all Alabama Origin/Destination Truck Flows



IHS then joined the network assignment matrix results to the FAF data sets for 1997, 2002, and 2007 to estimate new ton-mile shares. The procedure is as follows:

1. Create a data set using the FAF ton-mile records of each instance of a freight shipment between each state,
2. Join the census division allocations estimated in the network assignment matrix (e.g., nine new fields) to each shipment record,
3. For each record, create nine new fields containing the products of the total ton-mileage reported and the origin/destination-specific network assignment allocations associated with each of the nine census divisions,
4. For all records, sum the total ton-miles associated with each census division and TSIC group,
5. Divide each census-division-TSIC ton-mileage datum by the sum of all ton-mileage in FAF.

The following tables illustrate the results of the new network assignment procedure for each of the three most recent FAF base years and compare these to the FAF-based estimates calculated with 50-50% census division network assignments. All previous model steps and updates, including the procedures for allocating FAF multi-modal flows to bi-modal classifications and allocating these ton-miles to individual *modes* on a 50-50% basis, are maintained.

Table 15: 1997 FAF Truck Ton-Mile Shares Calculated by Roadway Shortest Path

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.15%	0.22%	0.12%	0.09%	0.22%	0.12%	0.07%	0.47%	0.13%	0.25%	1.84%
	2	0.60%	1.04%	0.69%	0.34%	0.65%	0.70%	0.35%	1.11%	0.45%	1.71%	7.64%
	3	1.50%	2.59%	1.44%	0.74%	1.16%	1.46%	1.16%	2.29%	2.32%	3.41%	18.08%
	4	0.99%	1.09%	1.27%	0.40%	0.70%	0.77%	0.72%	1.64%	3.70%	1.50%	12.80%
	5	1.33%	1.49%	1.12%	0.57%	1.13%	1.36%	0.61%	3.26%	1.28%	2.91%	15.06%
	6	0.90%	1.16%	0.66%	0.38%	0.55%	0.72%	0.48%	1.63%	0.97%	1.81%	9.25%
	7	1.32%	1.36%	0.89%	0.38%	2.01%	0.95%	0.78%	2.26%	2.00%	2.01%	13.96%
	8	1.20%	0.97%	1.07%	0.37%	0.86%	0.80%	0.95%	1.75%	1.57%	1.29%	10.83%
	9	0.60%	0.99%	0.71%	0.33%	2.09%	0.72%	0.47%	1.90%	1.12%	1.61%	10.55%
	∑	8.59%	10.91%	7.98%	3.61%	9.38%	7.59%	5.59%	16.31%	13.54%	16.51%	100%

Table 16: 1997 FAF Truck Ton-Mile Shares – Comparing Shortest Path Assignment to 50-50% Split (Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	-0.31%	-0.18%	-0.14%	-0.11%	-0.05%	-0.05%	-0.12%	-0.30%	-0.12%	-0.13%	-1.51%
	2	-0.25%	-0.21%	-0.24%	-0.06%	-0.07%	0.03%	-0.13%	-0.10%	-0.13%	-0.04%	-1.20%
	3	0.03%	0.10%	0.09%	0.02%	0.05%	0.08%	0.03%	0.47%	0.30%	0.31%	1.46%
	4	0.40%	0.24%	0.25%	0.17%	0.12%	0.16%	0.31%	0.41%	-0.03%	0.04%	2.08%
	5	-0.15%	-0.05%	-0.11%	-0.05%	-0.01%	-0.26%	-0.18%	-0.53%	-0.10%	-0.06%	-1.51%
	6	0.43%	0.30%	0.18%	0.11%	0.07%	0.10%	0.07%	0.18%	0.21%	0.10%	1.75%
	7	-0.13%	-0.18%	-0.07%	-0.06%	-0.05%	-0.05%	0.02%	-0.02%	-0.19%	-0.12%	-0.85%
	8	0.78%	0.42%	0.64%	0.24%	0.03%	0.21%	0.59%	0.73%	0.59%	0.15%	4.38%
	9	-0.80%	-0.43%	-0.60%	-0.25%	-0.09%	-0.22%	-0.59%	-0.84%	-0.53%	-0.25%	-4.60%
	∑	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 17: 2002 FAF Truck Ton-Mile Shares Calculated by Roadway Shortest Path

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.11%	0.16%	0.13%	0.09%	0.18%	0.08%	0.06%	0.33%	0.11%	0.21%	1.45%
	2	0.72%	0.91%	0.81%	0.34%	0.59%	0.43%	0.37%	1.05%	0.38%	1.21%	6.82%
	3	1.66%	2.55%	1.88%	0.65%	1.10%	1.26%	1.64%	2.20%	1.95%	3.25%	18.14%
	4	1.19%	1.03%	1.54%	0.31%	0.57%	1.01%	0.87%	1.62%	3.24%	1.40%	12.79%
	5	1.79%	1.43%	1.21%	0.65%	0.85%	1.19%	0.69%	3.13%	1.07%	2.63%	14.63%
	6	1.49%	1.16%	0.79%	0.39%	0.68%	0.63%	0.61%	1.75%	0.90%	1.22%	9.62%
	7	1.47%	1.57%	1.09%	0.34%	1.77%	1.11%	0.97%	2.08%	1.64%	1.79%	13.84%
	8	1.36%	1.08%	1.55%	0.33%	1.08%	0.96%	0.97%	2.30%	1.52%	1.13%	12.29%
	9	0.63%	0.90%	0.79%	0.24%	1.69%	0.87%	0.49%	1.76%	1.09%	1.95%	10.42%
	∑	10.41%	10.81%	9.80%	3.35%	8.51%	7.55%	6.67%	16.22%	11.92%	14.78%	100%

Table 18: 2002 FAF Truck Ton-Mile Shares – Comparing Shortest Path Assignment to 50-50% Split
(Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	-0.28%	-0.11%	-0.16%	-0.11%	-0.04%	-0.07%	-0.07%	-0.24%	-0.11%	-0.05%	-1.25%
	2	-0.69%	-0.30%	-0.29%	-0.06%	-0.07%	-0.13%	-0.16%	-0.35%	-0.18%	-0.19%	-2.42%
	3	0.07%	0.07%	0.15%	0.05%	0.05%	0.04%	-0.05%	0.15%	0.26%	0.39%	1.17%
	4	0.45%	0.26%	0.29%	0.12%	0.06%	0.15%	0.36%	0.61%	0.06%	0.01%	2.37%
	5	0.13%	-0.05%	-0.20%	-0.04%	-0.02%	-0.09%	-0.16%	-0.32%	-0.13%	-0.03%	-0.92%
	6	0.77%	0.24%	0.20%	0.08%	-0.02%	0.07%	0.05%	0.17%	0.21%	0.10%	1.88%
	7	-0.38%	-0.13%	-0.06%	-0.02%	0.01%	-0.02%	-0.01%	0.04%	-0.16%	-0.07%	-0.79%
	8	0.76%	0.55%	0.94%	0.20%	0.19%	0.45%	0.62%	1.14%	0.65%	0.03%	5.53%
	9	-0.81%	-0.53%	-0.87%	-0.21%	-0.17%	-0.41%	-0.60%	-1.21%	-0.60%	-0.18%	-5.58%
	∑	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Table 19: 2007 FAF Truck Ton-Mile Shares Calculated by Roadway Shortest Path

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.13%	0.20%	0.16%	0.08%	0.29%	0.10%	0.05%	0.25%	0.08%	0.26%	1.61%
	2	0.76%	1.22%	0.81%	0.32%	0.58%	0.33%	0.34%	1.08%	0.54%	1.37%	7.35%
	3	1.78%	2.69%	1.70%	0.66%	0.83%	0.87%	1.36%	2.05%	2.53%	2.52%	16.99%
	4	1.25%	1.16%	1.49%	0.35%	0.45%	0.56%	0.96%	1.56%	3.91%	1.33%	13.02%
	5	1.60%	1.69%	1.29%	0.63%	0.88%	1.25%	0.66%	2.68%	1.12%	2.50%	14.31%
	6	1.22%	1.32%	0.78%	0.41%	0.69%	0.54%	0.59%	1.64%	0.73%	2.00%	9.94%
	7	1.77%	1.78%	1.14%	0.37%	1.77%	0.91%	0.99%	1.76%	1.60%	1.76%	13.84%
	8	1.43%	1.10%	1.58%	0.39%	0.60%	0.94%	1.15%	2.20%	1.98%	1.25%	12.62%
	9	0.68%	1.45%	1.04%	0.31%	0.89%	0.96%	0.56%	1.80%	1.29%	1.35%	10.33%
	∑	10.62%	12.61%	9.98%	3.53%	6.99%	6.47%	6.66%	15.02%	13.78%	14.33%	100%

Table 20: 2007 FAF Truck Ton-Mile Shares – Comparing Shortest Path Assignment to 50-50% Split
(Red – Increase; Green – Decrease; Blue – Unchanged)

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	-0.31%	-0.13%	-0.15%	-0.09%	-0.01%	-0.04%	-0.10%	-0.21%	-0.13%	-0.08%	-1.24%
	2	-0.27%	-0.30%	-0.38%	-0.07%	-0.14%	-0.07%	-0.21%	-0.45%	-0.15%	-0.03%	-2.07%
	3	0.00%	0.11%	0.13%	0.02%	0.11%	0.04%	-0.05%	0.19%	0.24%	0.25%	1.04%
	4	0.44%	0.19%	0.35%	0.15%	-0.01%	-0.01%	0.45%	0.61%	0.06%	-0.09%	2.15%
	5	-0.26%	-0.04%	-0.20%	-0.07%	-0.08%	-0.03%	-0.23%	-0.32%	-0.16%	-0.06%	-1.46%
	6	0.57%	0.31%	0.24%	0.11%	0.19%	0.08%	0.11%	0.26%	0.20%	0.15%	2.23%
	7	-0.20%	-0.18%	-0.06%	-0.04%	-0.08%	-0.02%	-0.01%	-0.05%	-0.09%	-0.08%	-0.81%
	8	0.85%	0.44%	0.97%	0.24%	0.09%	0.27%	0.82%	1.13%	0.74%	0.06%	5.62%
	9	-0.82%	-0.42%	-0.91%	-0.25%	-0.07%	-0.22%	-0.78%	-1.16%	-0.70%	-0.12%	-5.46%
	∑	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

A pattern emerges that is generally consistent across all three base years. The ton-mile shares drop along the census divisions touching the Atlantic, Pacific, and most of the Gulf coasts and increase in the central census divisions. The following figures illustrate these results vividly.

Figure 12: Shifts in Truck Ton-mile Share Percentages Using Network Shortest Path Network Assignment, 1997

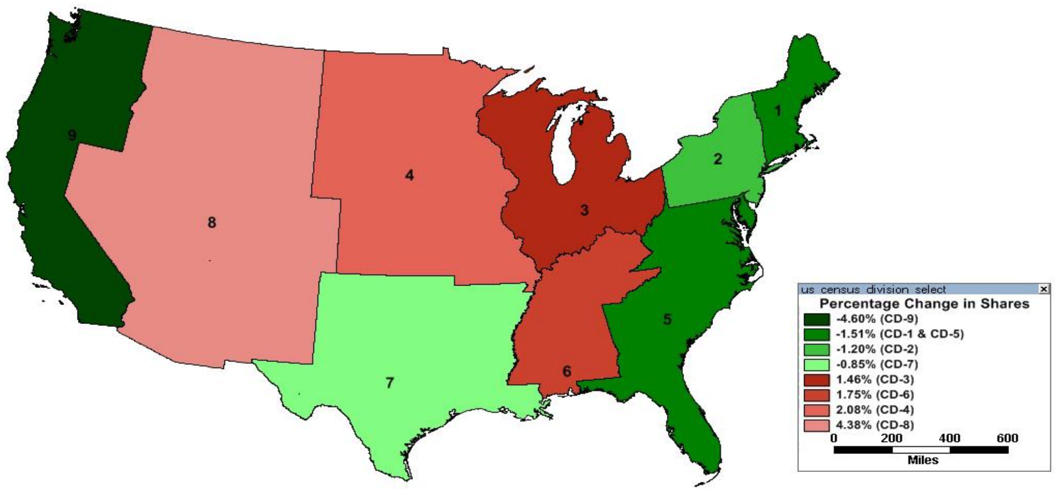


Figure 13: Shifts in Truck Ton-mile Share Percentages Using Network Shortest Path Network Assignment, 2002

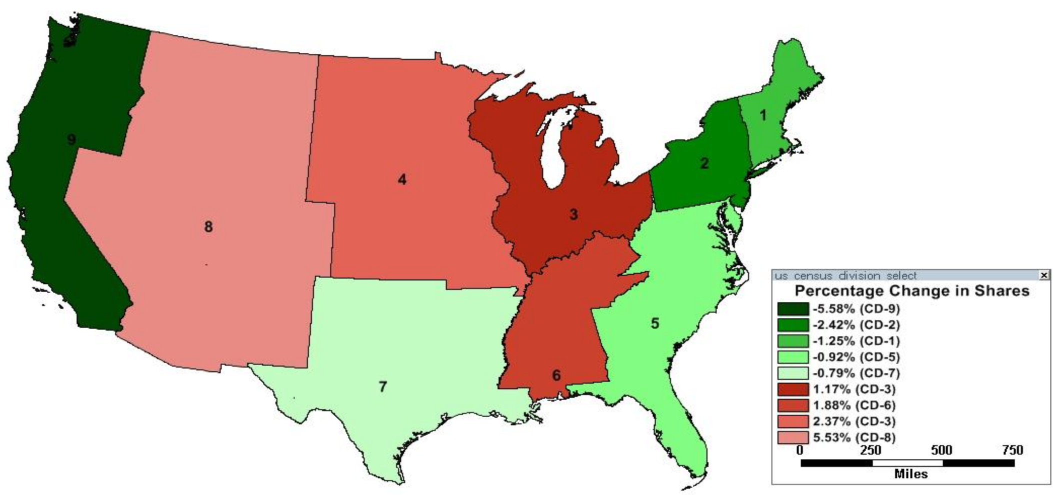
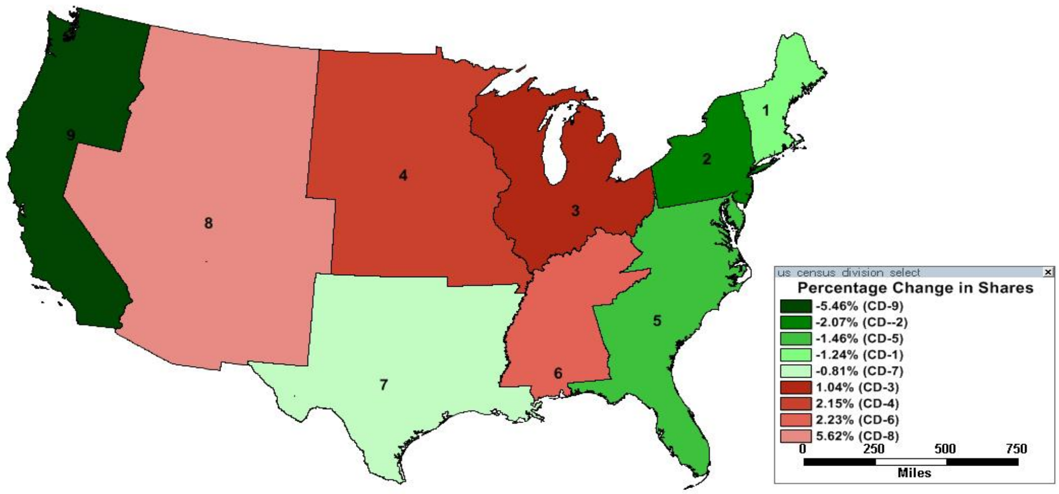


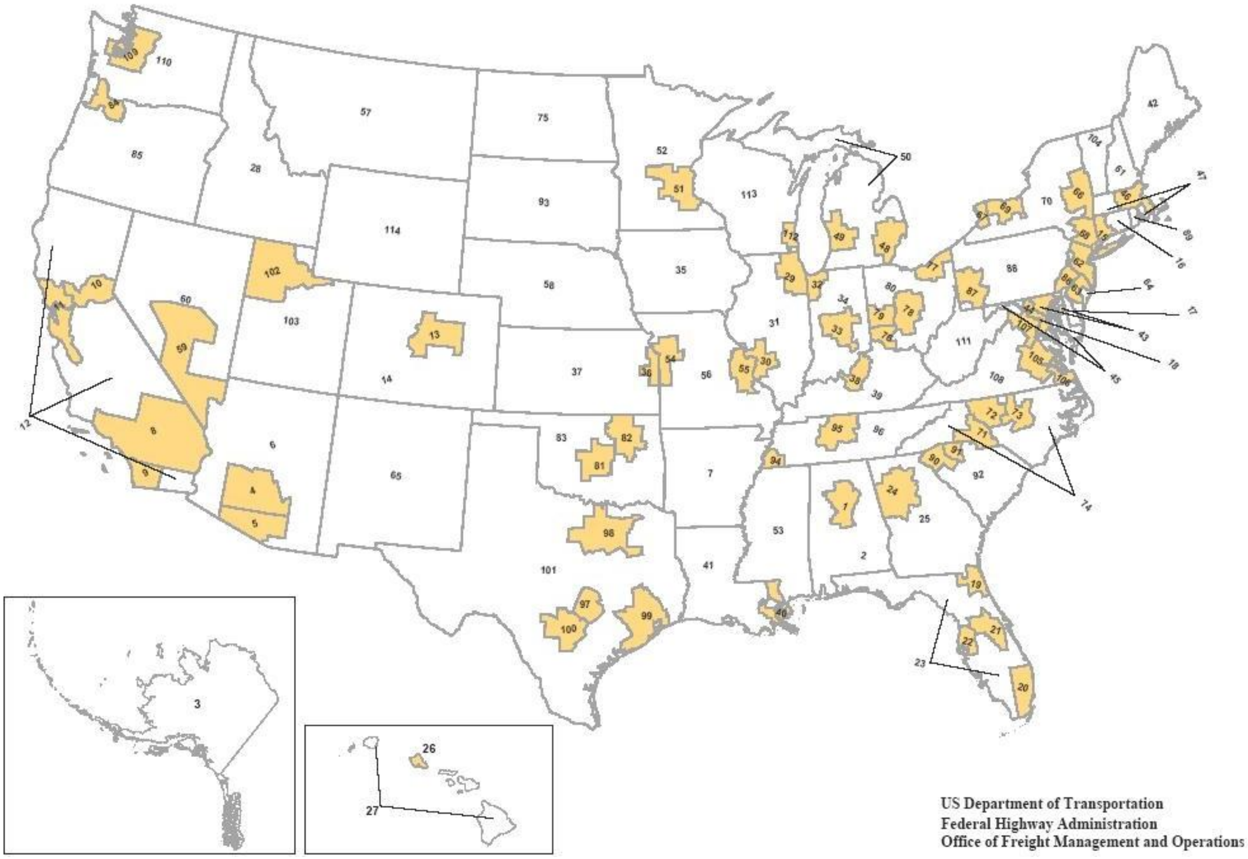
Figure 14: Shifts in Truck Ton-mile Share Percentages Using Network Shortest Path Network Assignment, 2007



These results are consistent with the hypothesis that the 50-50% network assignment of ton-mileage between census division origins and destinations fails to account for geographic (and energy consumption) movements through intermediate regions. While Census Division 7 is a centrally-located region, it is also a coastal region and a destination for many goods shipped across the country. These two offsetting forces result in a minimal impact.

The extent to which this adjustment to the ton-mile metric calculation improves other weaknesses of the current NEMS freight transportation network assignment process is beyond the scope of this study. However, EIA can test the results over time to determine the extent to which this process generates greater accuracy. Other options might include further breaking down the initial route optimization to the FAF region (see Figure 15) rather than the state level. IHS recommends that EIA at minimum implement and test the procedures outlined in this section.

Figure 15: **Geographic Areas for FAF and CFS**



IHS recommends further study of an improved approach to rail network assignment that can be applied in the NEMS environment. Rail freight network assignment is more complicated than truck because of the structure of the industry, where routing decisions must consider competition (or lack thereof) between multiple railroads with different network and operational configurations, trackage rights and other operational agreements, and other complex criteria. It would be difficult to estimate an “average” path using simple rules, but EIA might consider further study. Possibly a similar methodology used for truck could be applied to rail shipments, but with straight-line distances between state (or FAF-zone) centroids rather than network distances. This would strike a balance between capturing intermediate zones and avoiding venturing into rail assignment which would be a virtual black box. Nonetheless, IHS first recommends exploring the feasibility and benefits of a more in-depth model.

For domestic marine freight, while a 50-50% split does not accurately represent distance traveled, the estimate likely serves as a reasonable proxy from the standpoint of energy consumption. Presumably barges and maritime vessels fuel at origins at the beginning of trips and again upon making return trips from the destination back to the origin. Of course, vessels might be loaded in both directions, but over the course of numerous trips the averages may work out. Otherwise, assigning actual ton-miles to the network will be extraordinarily challenging. For example, nearly 40% of marine transportation ton-mileage in NEMS is assigned to the Lower Mississippi census divisions (6 and 7). The Mississippi River actually forms the border between these regions, complicating the task of physically assigning ton-mileage. The same issue occurs for transport along the Ohio River, which also forms a census division border. Ton-miles between far-away census divisions, such as the Pacific and South Atlantic, move over international waters for large portions of most trips. As described later, the domestic marine forecasts face more fundamental challenges; therefore, IHS does not recommend any changes to the process of domestic marine network assignment until these other issues are addressed.

Disaggregating Census Divisions and TSIC Categories

The NEMS freight module is highly aggregated, using only the nine census divisions as geographical units and ten TSIC categories as commodity groupings. The level of aggregation is not necessarily believed to be one of the more critical problems identified in the freight module, but less aggregated inputs could improve model accuracy.

Disaggregation could be particularly beneficial for the accuracy of NEMS if applied to the commodity grouping scheme. Some of the TSIC commodity groupings contain combinations of commodities that—while theoretically related—are not necessarily similar in terms of shipping practices. For example, refined petroleum products and crude petroleum are both included in TSIC 5, but are shipped from different states and locations, and by different modes.

For the geographical unit of the NEMS freight module output, the census division level is appropriate. First, the desired output for the full NEMS general equilibrium model is at the census division level. Second, a great degree of precision can be added to state-level estimates prior to census-division aggregation, which will occur before the freight module is implemented into the full iterative process.

Disaggregating to the SCTG level is relatively simple, requiring just the removal of the TSIC aggregation step from the preparation of data for the NEMS freight transportation freight model. Table 21, Table 22, and Table 23 illustrate results of full disaggregation by SCTG level for 2007 truck, rail, and domestic marine ton-miles, respectively, after also employing FAF data in place of CFS for ton-mile metric development (for the truck example, we have used the updated ton-mile metric data after also applying the network assignment process described in the previous sub-section).

State-of-the-art transportation modeling employs micro-level approaches that tend to favor disaggregating data as much as possible; however, an argument for aggregation is to reduce potential estimation error and model sensitivity by aggregating small sample groups with similar behavioral attributes. It is challenging to generalize with small sample sizes, and there may be instances where it would be preferable to aggregate SCTG commodities where the total quantity shipped is very small.

It is beyond the scope of this study to recommend specific groupings of SCTG codes and, again, it is IHS position that disaggregation is preferable when reasonable sample sizes are available. EIA might consider further study of what constitutes too small a sample size so as to warrant aggregation with like commodities.

Table 21: 2007 Truck Ton-mile Shares Disaggregated by SCTG Code (with FAF Data and Shortest Path Network Assignment)

		Census Division									
		1	2	3	4	5	6	7	8	9	∑
SCTG Code	1	0.00%	0.02%	0.09%	0.21%	0.14%	0.08%	0.17%	0.08%	0.06%	0.85%
	2	0.02%	0.17%	1.55%	2.36%	0.31%	0.26%	0.78%	0.72%	0.39%	6.56%
	3	0.04%	0.25%	0.57%	0.77%	0.42%	0.24%	0.34%	0.91%	0.67%	4.21%
	4	0.02%	0.10%	0.33%	0.57%	0.25%	0.15%	0.31%	0.27%	0.17%	2.16%
	5	0.02%	0.11%	0.27%	0.34%	0.26%	0.18%	0.29%	0.26%	0.14%	1.86%
	6	0.02%	0.14%	0.37%	0.32%	0.19%	0.16%	0.18%	0.30%	0.17%	1.84%
	7	0.13%	0.57%	1.05%	0.83%	0.84%	0.44%	0.67%	1.02%	0.73%	6.28%
	8	0.02%	0.11%	0.19%	0.16%	0.20%	0.06%	0.16%	0.21%	0.17%	1.27%
	9	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.03%
	10	0.00%	0.03%	0.04%	0.01%	0.04%	0.01%	0.03%	0.05%	0.05%	0.26%
	11	0.03%	0.13%	0.29%	0.25%	0.29%	0.10%	0.40%	0.15%	0.24%	1.87%
	12	0.15%	0.61%	1.32%	0.61%	1.52%	1.24%	0.82%	0.48%	0.84%	7.59%
	13	0.04%	0.34%	0.36%	0.18%	0.38%	0.13%	0.23%	0.28%	0.19%	2.11%
	14	0.00%	0.04%	0.22%	0.06%	0.03%	0.05%	0.13%	0.06%	0.02%	0.61%
	15	0.03%	0.23%	0.29%	0.22%	0.26%	0.47%	0.14%	0.24%	0.01%	1.89%
	16	0.00%	0.00%	0.01%	0.01%	0.00%	0.00%	0.03%	0.03%	0.02%	0.10%
	17	0.12%	0.13%	0.25%	0.11%	0.35%	0.13%	0.52%	0.14%	0.35%	2.10%
	18	0.10%	0.17%	0.17%	0.12%	0.24%	0.14%	0.47%	0.15%	0.15%	1.70%
	19	0.08%	0.27%	0.41%	0.21%	0.29%	0.41%	0.74%	0.28%	0.38%	3.08%
	20	0.06%	0.28%	0.51%	0.32%	0.44%	0.41%	0.65%	0.46%	0.18%	3.29%
	21	0.00%	0.03%	0.04%	0.04%	0.05%	0.03%	0.04%	0.04%	0.02%	0.27%
	22	0.01%	0.03%	0.22%	0.22%	0.32%	0.16%	0.20%	0.14%	0.10%	1.41%
	23	0.02%	0.18%	0.41%	0.28%	0.32%	0.24%	0.34%	0.33%	0.16%	2.28%
	24	0.04%	0.24%	0.60%	0.40%	0.46%	0.38%	0.55%	0.47%	0.23%	3.37%
	25	0.04%	0.08%	0.16%	0.06%	0.58%	0.51%	0.26%	0.09%	0.21%	1.99%
	26	0.07%	0.22%	0.45%	0.39%	0.69%	0.39%	0.40%	0.60%	0.65%	3.86%

	Census Division									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**∑**
27	0.06%	0.19%	0.41%	0.19%	0.45%	0.28%	0.21%	0.22%	0.18%	2.19%
28	0.02%	0.13%	0.25%	0.16%	0.18%	0.13%	0.16%	0.17%	0.13%	1.34%
29	0.02%	0.10%	0.19%	0.13%	0.11%	0.07%	0.06%	0.11%	0.05%	0.85%
30	0.01%	0.11%	0.17%	0.16%	0.25%	0.15%	0.18%	0.27%	0.11%	1.42%
31	0.10%	0.33%	0.87%	0.56%	1.25%	0.54%	0.91%	0.94%	0.96%	6.47%
32	0.05%	0.44%	1.28%	0.44%	0.49%	0.62%	0.67%	0.34%	0.19%	4.52%
33	0.03%	0.16%	0.45%	0.28%	0.33%	0.27%	0.46%	0.35%	0.19%	2.53%
34	0.02%	0.12%	0.40%	0.34%	0.23%	0.20%	0.34%	0.35%	0.15%	2.14%
35	0.01%	0.09%	0.23%	0.23%	0.17%	0.14%	0.32%	0.34%	0.14%	1.67%
36	0.01%	0.12%	0.68%	0.35%	0.25%	0.23%	0.29%	0.42%	0.25%	2.60%
37	0.00%	0.01%	0.03%	0.02%	0.01%	0.01%	0.02%	0.01%	0.01%	0.12%
38	0.00%	0.01%	0.02%	0.02%	0.01%	0.01%	0.02%	0.03%	0.02%	0.12%
39	0.01%	0.06%	0.15%	0.14%	0.14%	0.09%	0.13%	0.22%	0.11%	1.04%
40	0.02%	0.11%	0.28%	0.22%	0.22%	0.13%	0.19%	0.30%	0.14%	1.62%
41	0.11%	0.62%	0.95%	0.45%	0.87%	0.43%	0.66%	0.40%	1.06%	5.56%
43	0.07%	0.28%	0.46%	0.29%	0.49%	0.24%	0.37%	0.38%	0.36%	2.94%
∑	1.61%	7.35%	16.99%	13.02%	14.31%	9.94%	13.84%	12.62%	10.33%	100%

Table 22: 2007 Rail Ton-mile Shares Disaggregated by SCTG Code (with FAF Data and 50-50% Origin-Destination Split)

		Census Division									
		1	2	3	4	5	6	7	8	9	∑
SCTG Code	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.01%	0.26%	1.33%	3.21%	0.49%	0.20%	1.57%	0.35%	1.91%	9.31%
	3	0.01%	0.04%	0.16%	0.35%	0.08%	0.07%	0.12%	0.05%	0.22%	1.09%
	4	0.02%	0.06%	0.30%	0.52%	0.14%	0.05%	0.23%	0.13%	0.22%	1.68%
	5	0.00%	0.01%	0.00%	0.01%	0.01%	0.00%	0.01%	0.00%	0.04%	0.08%
	6	0.01%	0.05%	0.10%	0.21%	0.07%	0.01%	0.16%	0.08%	0.13%	0.83%
	7	0.02%	0.18%	0.34%	0.63%	0.19%	0.10%	0.24%	0.10%	0.54%	2.34%
	8	0.01%	0.12%	0.15%	0.22%	0.05%	0.01%	0.12%	0.08%	0.14%	0.90%
	9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
	11	0.00%	0.02%	0.21%	0.05%	0.02%	0.02%	0.29%	0.11%	0.03%	0.75%
	12	0.04%	0.04%	0.41%	0.15%	0.21%	0.22%	0.69%	0.05%	0.11%	1.91%
	13	0.05%	0.10%	0.15%	0.22%	0.40%	0.11%	0.26%	0.25%	0.09%	1.63%
	14	0.00%	0.05%	0.76%	0.63%	0.03%	0.15%	0.13%	0.24%	0.07%	2.06%
	15	0.02%	0.97%	6.67%	4.33%	6.48%	4.32%	5.50%	19.90%	0.35%	48.54%
	16	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.04%
	17	0.01%	0.01%	0.00%	0.00%	0.03%	0.01%	0.04%	0.00%	0.08%	0.17%
	18	0.00%	0.00%	0.04%	0.01%	0.03%	0.01%	0.07%	0.05%	0.04%	0.25%
	19	0.02%	0.33%	0.61%	0.28%	0.31%	0.16%	1.28%	0.46%	0.71%	4.17%
	20	0.07%	0.50%	0.78%	0.40%	0.67%	0.56%	1.71%	1.02%	0.63%	6.34%
	21	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.03%
	22	0.00%	0.06%	0.39%	0.43%	0.51%	0.09%	0.34%	0.28%	0.18%	2.28%
	23	0.02%	0.04%	0.11%	0.07%	0.06%	0.02%	0.14%	0.01%	0.06%	0.53%
	24	0.06%	0.18%	0.37%	0.17%	0.26%	0.11%	0.83%	0.07%	0.19%	2.23%
	25	0.00%	0.00%	0.01%	0.01%	0.01%	0.00%	0.01%	0.01%	0.00%	0.06%
	26	0.09%	0.17%	0.27%	0.35%	0.24%	0.14%	0.25%	0.28%	0.81%	2.60%

	Census Division									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**∑**
27	0.10%	0.13%	0.27%	0.17%	0.32%	0.22%	0.36%	0.08%	0.29%	1.93%
28	0.02%	0.07%	0.10%	0.06%	0.05%	0.03%	0.06%	0.03%	0.09%	0.51%
29	0.00%	0.01%	0.02%	0.01%	0.01%	0.00%	0.01%	0.00%	0.02%	0.07%
30	0.00%	0.06%	0.01%	0.01%	0.02%	0.00%	0.01%	0.02%	0.06%	0.19%
31	0.01%	0.03%	0.15%	0.11%	0.15%	0.06%	0.11%	0.16%	0.17%	0.94%
32	0.04%	0.22%	0.68%	0.21%	0.19%	0.30%	0.38%	0.24%	0.38%	2.65%
33	0.00%	0.03%	0.07%	0.07%	0.03%	0.04%	0.14%	0.07%	0.05%	0.51%
34	0.00%	0.01%	0.05%	0.01%	0.02%	0.01%	0.04%	0.01%	0.02%	0.17%
35	0.01%	0.01%	0.03%	0.01%	0.03%	0.01%	0.01%	0.01%	0.06%	0.18%
36	0.01%	0.07%	0.48%	0.05%	0.07%	0.08%	0.21%	0.07%	0.26%	1.30%
37	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.03%	0.01%	0.00%	0.09%
38	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%
39	0.00%	0.01%	0.01%	0.00%	0.01%	0.00%	0.01%	0.00%	0.02%	0.07%
40	0.01%	0.01%	0.02%	0.02%	0.02%	0.00%	0.02%	0.01%	0.04%	0.16%
41	0.06%	0.25%	0.14%	0.16%	0.22%	0.09%	0.14%	0.03%	0.14%	1.22%
43	0.00%	0.01%	0.05%	0.01%	0.03%	0.00%	0.01%	0.01%	0.06%	0.17%
∑	0.72%	4.12%	15.28%	13.14%	11.47%	7.22%	15.54%	24.26%	8.25%	100%

Table 23: 2007 Domestic Marine Ton-mile Shares Disaggregated by SCTG Code (with FAF Data and 50-50% Origin-Destination Split)

		Census Division									
		1	2	3	4	5	6	7	8	9	∑
SCTG Code	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.02%	3.57%	4.89%	0.31%	1.20%	9.32%	0.01%	0.62%	19.94%
	3	0.00%	0.01%	1.27%	1.40%	0.02%	0.29%	2.93%	0.01%	0.07%	6.01%
	4	0.01%	0.01%	0.21%	0.06%	0.03%	0.02%	0.16%	0.01%	0.06%	0.57%
	5	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.10%	0.12%
	6	0.00%	0.01%	0.02%	0.06%	0.02%	0.01%	0.05%	0.01%	0.05%	0.22%
	7	0.01%	0.04%	0.06%	0.12%	0.05%	0.02%	0.11%	0.02%	0.19%	0.61%
	8	0.01%	0.02%	0.14%	0.04%	0.02%	0.00%	0.13%	0.01%	0.12%	0.49%
	9	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	10	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%
	11	0.01%	0.03%	0.16%	0.06%	0.01%	0.08%	0.13%	0.08%	0.01%	0.57%
	12	0.00%	0.16%	2.43%	1.25%	0.21%	0.74%	1.08%	0.02%	0.05%	5.95%
	13	0.00%	0.01%	0.63%	0.10%	0.03%	0.08%	0.63%	0.07%	0.14%	1.69%
	14	0.00%	1.40%	0.47%	0.50%	0.00%	0.01%	0.12%	0.00%	1.36%	3.86%
	15	0.00%	0.01%	2.46%	0.19%	1.09%	1.63%	0.13%	0.20%	0.00%	5.70%
	16	0.00%	0.15%	0.00%	0.00%	0.10%	0.07%	2.06%	0.00%	12.90%	15.30%
	17	0.00%	0.33%	0.05%	0.00%	0.77%	0.47%	1.05%	0.00%	0.34%	3.01%
	18	0.05%	0.18%	0.11%	0.09%	0.44%	0.32%	1.68%	0.02%	1.11%	4.00%
	19	0.22%	0.91%	2.33%	0.77%	1.18%	0.93%	5.07%	0.09%	7.09%	18.59%
	20	0.00%	0.71%	0.68%	0.03%	0.17%	0.49%	2.89%	0.01%	0.04%	5.02%
	21	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.05%
	22	0.00%	0.00%	0.19%	0.10%	0.28%	0.06%	0.53%	0.02%	0.04%	1.22%
	23	0.00%	0.01%	0.03%	0.01%	0.06%	0.01%	0.08%	0.01%	0.07%	0.28%
	24	0.01%	0.04%	0.06%	0.02%	0.07%	0.02%	0.13%	0.02%	0.09%	0.45%
	25	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.03%
	26	0.01%	0.02%	0.04%	0.02%	0.03%	0.03%	0.05%	0.04%	0.25%	0.49%

	Census Division									
	1	2	3	4	5	6	7	8	9	∑
27	0.03%	0.04%	0.08%	0.01%	0.09%	0.04%	0.06%	0.02%	0.10%	0.48%
28	0.00%	0.01%	0.01%	0.00%	0.01%	0.01%	0.01%	0.00%	0.03%	0.08%
29	0.00%	0.01%	0.02%	0.01%	0.01%	0.00%	0.01%	0.01%	0.02%	0.09%
30	0.01%	0.02%	0.02%	0.01%	0.03%	0.01%	0.01%	0.01%	0.04%	0.15%
31	0.00%	0.02%	0.50%	0.19%	0.06%	0.14%	0.30%	0.07%	0.24%	1.51%
32	0.01%	0.14%	0.28%	0.03%	0.08%	0.32%	0.44%	0.02%	0.07%	1.41%
33	0.00%	0.01%	0.06%	0.01%	0.01%	0.01%	0.05%	0.01%	0.04%	0.20%
34	0.00%	0.01%	0.02%	0.01%	0.02%	0.02%	0.01%	0.01%	0.03%	0.12%
35	0.01%	0.02%	0.03%	0.01%	0.03%	0.01%	0.02%	0.01%	0.06%	0.20%
36	0.00%	0.01%	0.09%	0.02%	0.03%	0.02%	0.02%	0.02%	0.08%	0.29%
37	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%
38	0.00%	0.01%	0.01%	0.00%	0.01%	0.00%	0.00%	0.00%	0.01%	0.04%
39	0.00%	0.01%	0.00%	0.00%	0.01%	0.00%	0.01%	0.00%	0.01%	0.05%
40	0.01%	0.02%	0.03%	0.02%	0.03%	0.01%	0.02%	0.01%	0.05%	0.20%
41	0.00%	0.02%	0.09%	0.01%	0.05%	0.28%	0.25%	0.00%	0.04%	0.75%
43	0.00%	0.01%	0.03%	0.01%	0.02%	0.00%	0.01%	0.01%	0.11%	0.21%
∑	0.46%	4.46%	16.14%	10.09%	5.39%	7.36%	29.56%	0.87%	25.67%	100%

Adjusting for Prices Using Commodity-Specific Inflation Factors

IHS investigated the concern that the ton-mile metric may inadequately address fluctuations in product prices. Since the ton-mile metric assumes a static relationship between price and unit weight, any changes in the price-to-weight ratio will adversely affect the accuracy of the ton-mile metric. Hence, use of nominal dollars in industrial output forecasts would distort ton-mile metric calculations derived from base-year FAF (or CFS) dollar-per-unit ratios.

Correcting for changing prices can typically be achieved by applying an inflation index to forecasts. This is not necessary for NEMS, however, as the industry output forecast data used in the freight transportation model is entered in real dollars by commodity groups. Therefore, changes in commodity prices are accounted for in the ton-mile metric, at least on a year-by-year basis.

Since constant dollars are used in NEMS, concerns about the affect of pricing are mostly moot. There is still a potential issue concerning the volatility of prices within periods of a given year. Given that the EIA publishes NEMS forecasts annually, however, use of annual real-dollar industry output metrics is likely sufficient to address the impact of changing prices on model accuracy.

Modeling Multi-modal Goods Movement and Introducing a Dynamic Mode-Share Process

This section explores two issues concerning modal alternatives for freight. These issues were identified as challenges within the NEMS freight transportation module whose potential solutions might require substantial levels-of-effort with uncertain likelihood of success or significant improvement. Nonetheless, conceptual solutions are discussed at a high level and maintaining the following boundaries:

- Any updates to the methodology must fit into the NEMS model framework,
- A balance must be struck between increased sophistication and added complexity and processing time.

EIA expressed concern about the current inability to accurately account for freight moving from its origin to its ultimate destination across multiple modes of transportation in the NEMS freight transportation module ton-mile calculation. As previously discussed, both CFS and FAF account for mixed-mode shipments in separate modal classifications, with the former providing additional details about which combination of modes are utilized.

IHS believes that it is possible to more accurately account for multi-modal freight movement in the NEMS ton-mile metric calculation and offers a conceptual procedure. This procedure assumes the adoption of FAF in place of CFS in the NEMS freight transportation module and the development by EIA of capabilities (or budget to procure) to build network assignment models in GIS-based software. It also assumes that EIA is able to develop a network assignment procedure for the national railway network. EIA would continue to process all uni-modal freight data as previously, except excluding adjustments for multi-modal classified ton-mileage, while adding the following key conceptual steps:

1. For each state-by-state (of FAF zone, if preferred) origin-destination combination develop a multi-modal network assignment model[11] for all types of “mixed-mode” classifications in FAF (e.g., truck-barge, rail-barge, etc.). EIA would also need to develop rules by which the network routing rationalization would follow (e.g., some combination of impedance factors by mode, or certain rules for the way commodities travel on different modes, etc.),
2. Assign each FAF mixed-mode record to the corresponding minimum impedance factors, rules, etc., developed in the previous step and estimate the number of ton-miles traveled across each state (or FAF zone) by mode,
3. Develop three separate tables for truck, rail, and domestic marine that display ton-miles allocated to each mode from the mixed-mode records. The tables should display 56 rows (if using a state-by-state matrix) and as many columns as necessary for all commodity classifications (10 TSIC codes, all 43 SCTG codes, or whichever level of aggregation EIA deems most appropriate),
4. Merge the three new modal tables associated with the separated mixed-mode records to the three tables already developed from uni-modal ton-mile records.

For this last step, EIA would have several options to integrate the uni-modal and mixed mode ton-mile estimates in the ton-mile metric calculations. The two major options include:

1. Sum uni-modal and mixed mode ton-mile calculations for all FAF records (preferably before aggregating to the census-division level to improve accuracy) and then calculate modal ton-mile shares including all data. This would result in a table for each of three modes with nine rows (census division) and as many columns as needed to report commodity classifications,
2. Calculate ton-mile shares for uni-modal and mixed mode records separately in the same table. This will result in a table for each of three modes with nine rows (census division) and double the amount of columns as the previous alternative (i.e., there would be a uni-modal and a mixed mode field associated with each commodity classification).

The above procedure would allow EIA to account for multi-modal goods movement in the forecasting of freight energy demand. For the final step, the second option would allow for greater flexibility to account for the impacts of industrial output on uni-modal and multi-modal goods flows separately. Since all commodity classifications roll-up to the census-division level, the solution should be feasible in NEMS. The only modification would be the application of industry output forecasts twice, once for uni-modal commodity forecasts and once for multi-modal commodity forecasts. These could later be summed to represent total ton-mileage associated with each mode, census division, and commodity.

Integrating multi-modal goods movement into the NEMS freight transportation module offers opportunities for greater forecasting accuracy, but the degree of improvement is yet unknown. Moreover the costs in resources to develop this procedure are high. Freight modelers at IHS are

[11] Similar to the network assignment solution proposed in this report for uni-modal goods movement, the simplest approach would be a commodity-agnostic network assignment, but some accuracy might be compromised.

challenged to estimate the level-of-effort precisely, but believe that it could be a multi-month effort employing one or more freight network modeling experts.

Even if EIA were to integrate multi-modal goods movement into its NEMS freight transportation module, the shares of ton-miles assigned by mode would still be static. That is, the dynamics of changing logistical patterns for the movement of goods and the choice of modes would not be accounted for during the intervals between CFS/FAF base years. With regard to mode choice, one of the most problematic aspects of the NEMS freight module is that rail, truck, and domestic marine forecasts are modeled separately. Therefore, it is assumed that goods shipped by truck will continue to be shipped by truck, goods shipped by rail will continue to be shipped by rail, and goods shipped by domestic marine will continue to move on water. In the case of multi-modal freight, it is assumed that whatever share of goods movement across each mode will continue in that proportion. In reality, most commodities can be shipped by either truck or rail, and a decision is made whether to ship by truck or rail based on various considerations including but not limited to cost, volume, and time sensitivity.

In transportation modeling, the state of the practice is to include a mode choice model as a discrete step. It is typical to employ a multinomial logit model to estimate the probability of any shipment choosing a given mode among a set of alternatives, and simulating the flows on the network. However, in this case, adding a full-scale mode share model to the NEMS freight module would drastically increase complexity and, possibly, NEMS processing time.

Mode choice is particularly challenging for freight modeling at a national scale. IHS understands that EIA previously attempted to build such a model but encountered many problems. Such an option could be explored again in the future. An alternative is coordinating with other federal agencies currently conducting mode share modeling research such as FHWA. Existing mode share forecasts could be used to rebalance ton-mile shares across modes in between CFS/FAF base years. The Intermodal Transportation and Inventory Cost Model[12] mentioned in the workshop could serve as a useful resource in rebalancing mode share.

Modeling intermodal freight movements and developing dynamic mode share models for the NEMS freight transportation module carry high costs, but development of such innovations potentially come with added benefits. Although EIA does not directly model inter-modal transfers, the existing model indirectly accounts for all freight VMT and/or ton-miles as top-line national forecasts are applied. The loss in fidelity is in the development of accurate forecasts of ton-mileage using industry-output data based on the ton-mile shares allocated by mode and census division. If EIA were to adopt a more disaggregate, microeconomic approach to freight demand forecasting based on trips generated at the firm level (i.e., state-of-the-practice techniques in transportation demand modeling), incorporating inter-modal transfers and modal shifts might be more straightforward.

Given the limitations of resources and the constraints of NEMS environment, IHS recommends that EIA instead consider studying the proposed process outlined in this sub-section to account for multi-modal

[12] https://www.fhwa.dot.gov/policy/otps/061012/iticst_info.htm

goods movement, revisit the development of an internal EIA freight mode-share model, and/or explore opportunities to leverage research on freight mode share models being developed by federal government colleagues at FHWA.

Accounting for Changes in Product Content and Industry Operations and the Effects of Time

IHS and EIA discussed other issues identified in the NEMS freight transportation module for which potential solutions may be feasible, but which are likely to be challenging to address systematically. Similar to the issue concerning the impacts on ton-mile forecasts due to price changes, changes in product content and changes in manufacturing, logistics, and supply chain practices primarily impact ton-mile forecasts in intermediate periods between CFS/FAF base years. Unlike changes in price, however, it would be difficult to systematically apply adjustment metrics (e.g., real dollars) to the NEMS freight transportation module to correct for industry changes in technology and management of production and distribution.

While subtle shifts may occur across all industries, the most significant changes in industry production and distribution landscape are often tied primarily to one or several industries. For example, since 2007 the landscape for US oil and gas production, distribution, and refining has shifted dramatically. The U.S. has become a net producer and net exporter, or at least a less voluminous importer, of numerous petroleum and petrochemical products. This shift has altered the geography of production and distribution, much of which would not be reflected accurately in forecasts calculated from CFS (or FAF) 2007 ton-mile shares.

In terms of product content, the industries potentially experiencing significant changes within any five-year period in relative weight-to-unit ratios are limited. Automotive, aviation, and various high technology industries would be some of the likely candidates, as innovation in product design continues to drive lighter and more efficient output. Many industries, however, are unlikely to see major shifts in weight-to-unit ratios such as agriculture, oil, steel, wood products, etc.

IHS recommends that EIA consider intermediate-year adjustments on a case-by-case basis. It is likely that major problems will be easily identified by users of EIA forecasts and/or from following trends in the wider economy. EIA can then try to address these issues surgically rather than making drastic changes to NEMS transportation freight module and/or ton-mile share forecasts for unaffected industries. Those minor “patch” solutions can then carry EIA’s NEMS freight transportation module forecasts forward until the next CFS/FAF base year when changes in industry practices in intermediate years should become fully incorporated into the model.

Correcting NEMS Forecasts for Domestic Marine

Based on a review of the challenges of forecasting domestic marine, where positive industry output growth coincides with declining ton-miles recorded, IHS concludes that the ton-mile metric may be inadequate for accurate estimations in NEMS. It appears that other factors besides industry output are influencing domestic marine ton-mileage. These might include, but are not limited to, increased pipeline investment reducing barge traffic, a lack of domestic marine terminal investment to handle containers leading to diversion to truck and rail, and shifting centers of production.

EIA has, essentially, come to the same conclusion as IHS and has for a period of time overwritten the ton-mile forecasts for domestic marine with a trend-line analysis of historical demand. This solution will probably suffice for the time being. It is entirely possible that such a trend may reverse, for example, if increased containerization is paired with successful investment in container intermodal services at US inland ports. Therefore, EIA should continue to monitor these trends. Moreover, IHS would recommend that EIA also explore the development of a systematic, valid, transparent, and well-defended process for estimating and applying the ton-mile override.

Changes to other Data Inputs to NEMS

For the purposes of this study, IHS explored mostly process changes (e.g., new network assignment proxies, disaggregation of TSICs, etc.). The only input change explored in detail was replacing CFS with FAF data in the ton-mile metric calculation. There may be opportunities, however, for exploring the use of other input data to improve model accuracy.

Data inputs that may especially warrant further scrutiny are the top-line national ton-mile and VMT data. EIA uses CFS (and now, potentially, FAF) for calculating only the *shares* of total national ton-miles and VMT allocated to census divisions and commodity groups. For trucks and rail, the top-line data comes from FHWA National Transportation Statistics, while domestic marine top-line national ton-mile forecasts come from U.S. Army Corps of Engineers Waterborne Commerce data. These data provide EIA with more up-to-date national-level forecasts (2009 for truck, 2012 for rail, and 2010 for domestic marine) than CFS or FAF. Nonetheless, EIA may consider exploring replacing National Transportation Statistics and Waterborne Commerce data with other sources such as FAF forecasts, at least for rail and waterborne (truck metrics would still need to be adjusted for VMT output).

It is possible that using FAF as both the primary top-line freight volume data input as well as for the ton-mile metric calculation may improve model accuracy. Moreover, it could make the model more internally coherent. Nonetheless, while there is evidence to suggest that FAF may provide an improvement over CFS for the ton-mile metric calculation, it is not clear whether FAF forecasts of total national ton-miles would be any more or less accurate than existing FHWA and U.S. Army Corps of Engineers data. Certainly, truck VMT calculations would be a challenge.

IHS makes no immediate recommendation for changing other data inputs to the NEMS freight transportation module. However, experimentation with different data sets can be a worthwhile exercise in quality control and consideration for future model development updates.

Conclusions

EIA NEMS freight transportation module demand and energy consumption forecasts can be significantly improved with relatively low-effort changes to existing processes. The resulting methodologies may not conform to state-of-the-art or state-of-the-practice transportation demand modeling techniques, but they offer potentially useful and relatively accurate solutions for the scale and objectives of the NEMS model. Many of these suggested improvements can be implemented with a combination of additional government data, while others may require either a combination of software license procurement and staff training or assistance from an outside vendor.

The following table lists the key issues identified with NEMS, the recommended courses of action, summaries of implementation processes, and a high-level, initial summary of the resources required to implement each proposed solution.

Table 24: Summary of Recommendations

	Recommendation	Summary of Implementation	Level of Effort/Resource Requirements
Availability and Use of Data	• Replace CFS with FAF as the primary survey data for estimating the ton-mile metric	• Replace CFS data input into ton-mile spreadsheet calculations with FAF records • Update any cells to ensure the accurate capture and calculation of FAF records within the existing framework • Make adjustments to break-out FAF "mixed-mode" ton-miles by bi-modal category	• EIA staff should be able to download FAF and update files • IHS has provided sample spreadsheet calculations that can be leveraged by EIA staff to update spreadsheet calculations
Network Assignment	• Employ a GIS-based network assignment proxy for estimating truck ton-mile distances across states for each census division origin/destination pair • Study alternatives for building a similar network assignment procedure for rail • Maintain 50-50% origin/destination split for domestic marine	• Develop a shortest-path GIS model for truck freight goods movement at a state-by-state (or FAF region) level using geographic centriods and transportation network shapefiles • Intersect the FAF records with the GIS model to estimate ton-miles attributable to each state for each census-division origin/destination pair • Re-calculate ton-miles for each commodity using the updated census-division shares	• IHS has developed a proxy network assignment for trucks using FAF 1997, 2002, 2007 data and has provided documentation of the procedure • EIA would need to identify an internal GIS resource, license GIS and/or GIS-based transportation demand • Development of a process for rail should involve a more in-depth study, but relatively simple solutions (a similar process as that with IHS employed for trucks may be feasible)
Levels of Disaggregation	• Disaggregate commodity groups to the SCTG level when sample sizes are determined to be large enough • For small sample sizes, conduct a study of a logical re-mapping of commodity groupings	• For disaggregation, eliminate one aggregation procedure in the NEMS freight transportation module • For any new aggregations, develop new spreadsheet formulas in the freight-ton metric calculation spreadsheets	• IHS has provided a full disaggregation by STCG code for all modes using 2007 FAF data and a new network assignment process for truck • Time and resources will be needed to study logical groupings, but the procedures for updating the NEMS freight transportation module are straightforward spreadsheet exercises

	Recommendation	Summary of Implementation	Level of Effort/Resource Requirements
Intermodal and Mode Share Models	• No immediate changes • Study the possibility of incorporating a multi-modal route distance estimation procedure and integrating the uni-modal ton-mile calculations with mixed-mode ton-mile estimates • Work with FHWA to determine if it may be possible to leverage current research on potential mode share models at USDOT to improve the NEMS freight transportation module	• The immediate implementation tasks are largely studies and coordination with other federal government agencies (FHWA) • In the long-term, a potential implementation would include building complex models to account for ton-mile shares attributable to multi-modal freight and synthesizing these estimates with uni-modal ton-mile metric calculations • Conceptual mode share model procedures are difficult to delineate at this time	• Studies can be completed by EIA staff with or without the help of outside service vendors, depending upon scope • The long-term implementation of mode share and multi-modal models within the NEMS freight transportation module would likely require a significant engagement with subject-matter and technical experts
Changes in Industry Technology and Management	• Track changes in industry technology and management that could impact product content, distribution patterns, and other factors affecting the accuracy of ton-mile forecasts in intermediate periods between CFS/FAF base years • On a case-by-case basis explore periodic adjustments to individual or small groups of industry ton-mile forecasts when circumstances suggest dramatic inaccuracies	• Follow major changes in industry trends • Create custom adjustments to ton-mile forecasts for specified industries until the next CFS/FAF base-year survey data becomes available	• EIA staff would need to track industry trends and develop spreadsheet calculation adjustments as needed

	Recommendation	Summary of Implementation	Level of Effort/Resource Requirements
Domestic Marine Trends	• Continue to employ EIA's current procedure for over-riding the ton-mile forecast with trend line estimates • Observe if other recommended model changes improve the accuracy of the ton-mile estimate for domestic marine freight flows • Develop a systematic, valid, transparent, and well-defended process for estimating and applying the ton-mile override	• Work to improve the trend-line estimation process using defensible assumptions, variables, and output	• EIA staff is already fully engaged in this process • Some supplementary work on improving and documenting methodology may be required

Appendix A: Workshop Participants

- American Transportation Research Institute (ATRI)
    - Jeff Short
- Energy Information Administration (EIA)
    - Nicholas Chase
    - John Maples
- IHS Global, Inc. (IHS)
    - Bob Brodesky, Transportation Consulting
    - Rich Fullenbaum, Economic Consulting
    - Chris Grillo, Transportation Consulting
    - Tyler Kreider, Transportation Consulting
- United States Department of Transportation (U.S. DOT)
    - Peter Bang, FHWA Freight Office
    - Don Pickrell, Volpe Center
    - Rolf Schmidt, Bureau of Transportation Statistics
    - Mike Sprung, Bureau of Transportation Statistics
    - Ed Strocko, FHWA Freight Office
    - Coral Torres, FHWA Freight Office

Appendix B: Additional Comparison Tables for FAF Versus CFS

The following tables compare ton-mile metric calculations using FAF versus CFS for truck and rail for 1997, 2002, and 2007 and domestic marine for 1997 and 2002.

Table 25 – 1997 FAF Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.46%	0.40%	0.26%	0.20%	0.26%	0.17%	0.20%	0.77%	0.25%	0.38%	3.35%
	2	0.85%	1.26%	0.93%	0.40%	0.72%	0.67%	0.48%	1.21%	0.58%	1.75%	8.84%
	3	1.46%	2.49%	1.36%	0.73%	1.11%	1.38%	1.13%	1.82%	2.03%	3.10%	16.61%
	4	0.60%	0.85%	1.03%	0.23%	0.58%	0.60%	0.41%	1.23%	3.73%	1.47%	10.72%
	5	1.48%	1.54%	1.23%	0.62%	1.15%	1.62%	0.79%	3.79%	1.38%	2.98%	16.57%
	6	0.47%	0.86%	0.47%	0.28%	0.48%	0.61%	0.41%	1.45%	0.76%	1.71%	7.50%
	7	1.45%	1.54%	0.96%	0.45%	2.06%	0.99%	0.76%	2.28%	2.19%	2.13%	14.81%
	8	0.42%	0.55%	0.43%	0.13%	0.83%	0.59%	0.35%	1.02%	0.98%	1.13%	6.45%
	9	1.40%	1.42%	1.30%	0.58%	2.18%	0.95%	1.05%	2.75%	1.65%	1.86%	15.14%
	∑	8.59%	10.91%	7.98%	3.61%	9.38%	7.59%	5.59%	16.31%	13.54%	16.51%	100%

Table 26 – 1997 CFS Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.21%	0.17%	0.28%	0.26%	0.08%	0.10%	0.10%	0.56%	0.08%	0.12%	1.96%
	2	1.31%	1.46%	1.90%	0.73%	0.53%	0.84%	0.62%	1.42%	0.32%	1.38%	10.51%
	3	2.42%	4.23%	3.32%	1.35%	0.84%	1.21%	2.41%	2.25%	0.91%	2.00%	20.93%
	4	0.80%	0.78%	2.10%	0.33%	0.26%	0.66%	0.60%	0.98%	1.87%	0.73%	9.13%
	5	1.98%	1.40%	2.42%	1.16%	0.94%	1.49%	1.02%	3.86%	0.64%	1.89%	16.81%
	6	0.76%	1.16%	0.88%	0.55%	0.32%	0.65%	0.68%	1.66%	0.22%	1.00%	7.89%
	7	2.07%	1.44%	2.01%	0.83%	0.78%	1.33%	0.93%	2.19%	0.81%	1.02%	13.40%
	8	0.47%	0.34%	0.67%	0.13%	0.39%	0.52%	0.14%	0.73%	0.25%	0.34%	3.99%
	9	1.45%	1.21%	2.65%	1.04%	0.91%	1.10%	1.06%	3.70%	1.26%	0.99%	15.37%
	∑	11.48%	12.18%	16.22%	6.39%	5.06%	7.92%	7.58%	17.35%	6.36%	9.45%	100%

Table 27 – 1997 Truck FAF-CFS Percent Shares

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.25%	0.23%	-0.02%	-0.06%	0.18%	0.07%	0.10%	0.21%	0.17%	0.26%	1.39%
	2	-0.46%	-0.20%	-0.97%	-0.33%	0.19%	-0.17%	-0.14%	-0.21%	0.26%	0.37%	-1.67%
	3	-0.96%	-1.74%	-1.96%	-0.62%	0.27%	0.17%	-1.28%	-0.43%	1.12%	1.10%	-4.32%
	4	-0.20%	0.07%	-1.07%	-0.10%	0.32%	-0.06%	-0.19%	0.25%	1.86%	0.74%	1.59%
	5	-0.50%	0.14%	-1.19%	-0.54%	0.21%	0.13%	-0.23%	-0.07%	0.74%	1.09%	-0.24%
	6	-0.29%	-0.30%	-0.41%	-0.27%	0.16%	-0.04%	-0.27%	-0.21%	0.54%	0.71%	-0.39%
	7	-0.62%	0.10%	-1.05%	-0.38%	1.28%	-0.34%	-0.17%	0.09%	1.38%	1.11%	1.41%
	8	-0.05%	0.21%	-0.24%	0.00%	0.44%	0.07%	0.21%	0.29%	0.73%	0.79%	2.46%
	9	-0.05%	0.21%	-1.35%	-0.46%	1.27%	-0.15%	-0.01%	-0.95%	0.39%	0.87%	-0.23%
	∑	-2.89%	-1.27%	-8.24%	-2.78%	4.32%	-0.33%	-1.99%	-1.04%	7.18%	7.06%	0.00%

Table 28 – 1997 FAF Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.15%	0.28%	0.08%	0.14%	0.10%	0.06%	0.03%	0.25%	0.10%	0.15%	0.08%	1.42%
	2	0.65%	0.64%	0.39%	0.28%	0.49%	0.08%	0.16%	0.37%	0.19%	0.43%	1.28%	4.95%
	3	1.72%	1.42%	0.81%	0.80%	0.60%	0.20%	0.74%	0.62%	2.10%	1.58%	5.53%	16.11%
	4	1.15%	0.53%	0.91%	0.25%	0.85%	0.11%	0.20%	0.50%	4.35%	1.37%	3.19%	13.41%
	5	2.21%	0.57%	0.51%	0.52%	0.33%	0.22%	0.22%	0.79%	1.00%	1.24%	6.81%	14.43%
	6	0.54%	0.51%	0.22%	0.39%	0.31%	0.13%	0.08%	0.36%	0.39%	0.32%	3.53%	6.79%
	7	3.06%	0.96%	0.43%	0.44%	0.83%	0.22%	0.31%	0.83%	1.97%	1.04%	3.87%	13.96%
	8	1.18%	0.41%	0.20%	0.37%	0.32%	0.23%	0.20%	0.76%	0.45%	0.76%	14.08%	18.95%
	9	1.47%	0.80%	0.85%	0.48%	0.89%	0.32%	0.34%	1.40%	2.93%	0.34%	0.17%	9.98%
	∑	12.12%	6.11%	4.40%	3.67%	4.72%	1.57%	2.27%	5.88%	13.48%	7.23%	38.53%	100%

Table 29 – 1997 CFS Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.03%	0.06%	0.05%	0.13%	0.00%	0.00%	0.00%	0.23%	0.00%	0.13%	0.00%	0.63%
	2	0.48%	0.88%	1.31%	0.21%	0.02%	0.01%	0.05%	0.27%	0.07%	0.13%	2.17%	5.60%
	3	1.23%	1.62%	1.13%	0.47%	0.11%	0.01%	0.44%	0.50%	1.01%	0.50%	7.77%	14.80%
	4	0.31%	0.06%	0.78%	0.09%	0.03%	0.03%	0.13%	0.22%	2.89%	0.81%	5.36%	10.70%
	5	1.54%	0.11%	0.32%	0.57%	0.07%	0.06%	0.13%	0.49%	0.82%	0.78%	8.31%	13.20%
	6	0.55%	0.23%	0.41%	0.51%	0.05%	0.02%	0.03%	0.23%	0.09%	0.13%	4.07%	6.34%
	7	3.38%	0.49%	0.34%	0.63%	0.46%	0.15%	0.11%	0.41%	0.42%	0.46%	7.25%	14.10%
	8	0.73%	0.10%	1.59%	0.03%	0.13%	0.08%	0.02%	0.92%	0.00%	0.83%	22.67%	27.11%
	9	0.88%	0.32%	0.84%	0.77%	0.27%	0.05%	0.17%	1.38%	2.34%	0.11%	0.39%	7.53%
	∑	9.14%	3.88%	6.77%	3.40%	1.14%	0.41%	1.08%	4.65%	7.64%	3.89%	58.00%	100%

Table 30 – 1997 Rail FAF-CFS Percent Shares

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.12%	0.22%	0.03%	0.01%	0.10%	0.06%	0.03%	0.02%	0.10%	0.02%	0.08%	0.79%
	2	0.17%	-0.24%	-0.92%	0.07%	0.47%	0.07%	0.11%	0.10%	0.12%	0.30%	-0.89%	-0.65%
	3	0.49%	-0.20%	-0.32%	0.33%	0.49%	0.19%	0.30%	0.12%	1.09%	1.08%	-2.24%	1.31%
	4	0.84%	0.47%	0.13%	0.16%	0.82%	0.08%	0.07%	0.28%	1.46%	0.56%	-2.17%	2.71%
	5	0.67%	0.46%	0.19%	-0.05%	0.26%	0.16%	0.09%	0.30%	0.18%	0.46%	-1.50%	1.23%
	6	-0.01%	0.28%	-0.19%	-0.12%	0.26%	0.11%	0.05%	0.13%	0.30%	0.19%	-0.54%	0.45%
	7	-0.32%	0.47%	0.09%	-0.19%	0.37%	0.07%	0.20%	0.42%	1.55%	0.58%	-3.38%	-0.14%
	8	0.45%	0.31%	-1.39%	0.34%	0.19%	0.15%	0.18%	-0.16%	0.45%	-0.07%	-8.59%	-8.16%
	9	0.59%	0.48%	0.01%	-0.29%	0.62%	0.27%	0.17%	0.02%	0.59%	0.23%	-0.22%	2.45%
	∑	2.98%	2.23%	-2.37%	0.27%	3.58%	1.16%	1.19%	1.23%	5.84%	3.34%	-19.47%	0.00%

Table 31 – 2002 FAF Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.39%	0.28%	0.29%	0.20%	0.22%	0.15%	0.12%	0.57%	0.22%	0.26%	2.70%
	2	1.41%	1.21%	1.10%	0.40%	0.66%	0.56%	0.53%	1.40%	0.56%	1.40%	9.23%
	3	1.59%	2.48%	1.73%	0.60%	1.05%	1.22%	1.69%	2.05%	1.69%	2.86%	16.97%
	4	0.75%	0.77%	1.25%	0.20%	0.51%	0.86%	0.50%	1.01%	3.18%	1.39%	10.42%
	5	1.65%	1.49%	1.41%	0.69%	0.87%	1.28%	0.85%	3.44%	1.20%	2.66%	15.55%
	6	0.72%	0.92%	0.60%	0.31%	0.69%	0.56%	0.55%	1.58%	0.69%	1.12%	7.74%
	7	1.85%	1.71%	1.15%	0.36%	1.75%	1.13%	0.98%	2.03%	1.80%	1.86%	14.63%
	8	0.60%	0.53%	0.61%	0.14%	0.89%	0.50%	0.34%	1.16%	0.88%	1.10%	6.75%
	9	1.44%	1.42%	1.66%	0.46%	1.87%	1.28%	1.09%	2.97%	1.69%	2.13%	16.00%
	∑	10.41%	10.81%	9.80%	3.35%	8.51%	7.55%	6.67%	16.22%	11.92%	14.78%	100%

Table 32 – 2002 CFS Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.22%	0.14%	0.26%	0.33%	0.12%	0.06%	0.06%	0.43%	0.08%	0.13%	1.82%
	2	1.07%	1.34%	1.50%	0.71%	0.33%	0.45%	0.58%	1.66%	0.14%	0.79%	8.58%
	3	2.22%	3.81%	2.83%	1.21%	0.81%	1.04%	2.76%	2.77%	0.31%	1.91%	19.67%
	4	0.54%	0.75%	1.84%	0.30%	0.34%	0.34%	0.72%	1.15%	1.01%	0.83%	7.81%
	5	1.85%	1.43%	2.70%	1.29%	0.81%	1.44%	1.02%	4.70%	0.47%	2.00%	17.70%
	6	0.71%	1.15%	1.05%	0.54%	0.41%	0.28%	0.77%	1.77%	0.15%	0.92%	7.74%
	7	2.04%	1.55%	1.87%	0.78%	1.50%	1.86%	1.27%	2.45%	0.61%	1.00%	14.92%
	8	0.34%	0.34%	0.74%	0.14%	0.80%	0.58%	0.13%	1.01%	0.31%	0.48%	4.88%
	9	1.46%	1.01%	3.34%	0.98%	1.30%	1.72%	0.93%	3.83%	1.03%	1.28%	16.87%
	∑	10.43%	11.51%	16.11%	6.29%	6.44%	7.76%	8.23%	19.77%	4.11%	9.35%	100%

Table 33 – 2002 Truck FAF-CFS Percent Shares

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.17%	0.14%	0.03%	-0.13%	0.10%	0.09%	0.06%	0.14%	0.14%	0.13%	0.88%
	2	0.34%	-0.13%	-0.40%	-0.31%	0.33%	0.11%	-0.05%	-0.26%	0.42%	0.61%	0.65%
	3	-0.63%	-1.33%	-1.10%	-0.61%	0.24%	0.18%	-1.07%	-0.72%	1.38%	0.95%	-2.70%
	4	0.21%	0.02%	-0.59%	-0.10%	0.17%	0.52%	-0.22%	-0.14%	2.17%	0.56%	2.61%
	5	-0.20%	0.06%	-1.29%	-0.60%	0.06%	-0.16%	-0.17%	-1.26%	0.73%	0.66%	-2.15%
	6	0.01%	-0.23%	-0.45%	-0.23%	0.28%	0.28%	-0.22%	-0.19%	0.54%	0.20%	0.00%
	7	-0.19%	0.16%	-0.72%	-0.42%	0.25%	-0.73%	-0.29%	-0.42%	1.19%	0.86%	-0.29%
	8	0.26%	0.19%	-0.13%	0.00%	0.09%	-0.08%	0.21%	0.15%	0.57%	0.62%	1.87%
	9	-0.02%	0.41%	-1.68%	-0.52%	0.57%	-0.44%	0.16%	-0.86%	0.66%	0.85%	-0.87%
	∑	-0.02%	-0.70%	-6.31%	-2.94%	2.07%	-0.21%	-1.56%	-3.55%	7.81%	5.43%	0.00%

Table 34 – 2002 FAF Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.10%	0.09%	0.04%	0.16%	0.03%	0.01%	0.02%	0.22%	0.07%	0.16%	0.08%	0.98%
	2	0.62%	0.48%	0.33%	0.21%	0.45%	0.06%	0.16%	0.37%	0.53%	0.46%	1.93%	5.59%
	3	1.68%	1.23%	0.69%	0.41%	0.63%	0.18%	0.82%	0.86%	2.11%	1.70%	5.80%	16.10%
	4	0.88%	0.53%	1.02%	0.26%	0.32%	0.16%	0.19%	0.70%	4.44%	1.21%	2.96%	12.66%
	5	1.80%	0.60%	0.41%	0.42%	0.39%	0.30%	0.22%	0.61%	1.15%	1.28%	5.02%	12.21%
	6	0.67%	0.33%	0.18%	0.32%	0.51%	0.30%	0.15%	0.25%	0.37%	0.54%	3.73%	7.36%
	7	2.47%	0.60%	0.42%	0.36%	0.66%	0.30%	0.41%	0.59%	2.18%	0.90%	5.32%	14.21%
	8	0.64%	0.29%	0.17%	0.12%	0.32%	0.25%	0.06%	0.56%	0.38%	0.68%	16.62%	20.09%
	9	1.03%	0.68%	0.81%	0.28%	0.86%	0.24%	0.47%	1.97%	3.17%	0.64%	0.65%	10.80%
	∑	9.89%	4.83%	4.07%	2.53%	4.17%	1.79%	2.49%	6.13%	14.41%	7.56%	42.12%	100%

Table 35 – 2002 CFS Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.02%	0.00%	0.01%	0.12%	0.00%	0.00%	0.00%	0.09%	0.00%	0.01%	0.05%	0.30%
	2	0.33%	0.07%	0.25%	0.13%	0.00%	0.00%	0.02%	0.19%	0.02%	0.48%	2.68%	4.18%
	3	0.72%	0.53%	0.47%	0.30%	0.08%	0.02%	0.25%	0.39%	0.18%	2.61%	11.30%	16.85%
	4	0.27%	0.04%	0.70%	0.13%	0.01%	0.01%	0.07%	0.14%	1.07%	2.01%	6.24%	10.69%
	5	0.79%	0.05%	0.17%	0.34%	0.01%	0.08%	0.09%	0.16%	0.05%	0.44%	9.08%	11.27%
	6	0.40%	0.07%	0.16%	0.36%	0.00%	0.00%	0.02%	0.02%	0.10%	0.09%	5.95%	7.17%
	7	2.73%	0.16%	0.24%	0.41%	0.56%	0.15%	0.10%	0.39%	0.07%	0.60%	7.81%	13.23%
	8	0.14%	0.06%	0.00%	0.01%	0.12%	0.04%	0.01%	0.31%	0.03%	0.23%	31.31%	32.27%
	9	0.30%	0.24%	0.40%	0.42%	0.09%	0.00%	0.10%	1.58%	0.56%	0.03%	0.36%	4.05%
	∑	5.69%	1.21%	2.40%	2.22%	0.88%	0.30%	0.66%	3.27%	2.07%	6.51%	74.78%	100%

Table 36 – 2002 Rail FAF-CFS Percent Shares

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.08%	0.09%	0.03%	0.04%	0.03%	0.01%	0.02%	0.13%	0.07%	0.15%	0.03%	0.68%
	2	0.29%	0.41%	0.08%	0.08%	0.45%	0.06%	0.14%	0.18%	0.51%	-0.02%	-0.75%	1.41%
	3	0.96%	0.70%	0.22%	0.11%	0.55%	0.16%	0.57%	0.47%	1.93%	-0.91%	-5.50%	-0.75%
	4	0.61%	0.49%	0.32%	0.13%	0.31%	0.15%	0.12%	0.56%	3.37%	-0.80%	-3.28%	1.97%
	5	1.01%	0.55%	0.24%	0.08%	0.38%	0.22%	0.13%	0.45%	1.10%	0.84%	-4.06%	0.94%
	6	0.27%	0.26%	0.02%	-0.04%	0.51%	0.30%	0.13%	0.23%	0.27%	0.45%	-2.22%	0.19%
	7	-0.26%	0.44%	0.18%	-0.05%	0.10%	0.15%	0.31%	0.20%	2.11%	0.30%	-2.49%	0.98%
	8	0.50%	0.23%	0.17%	0.11%	0.20%	0.21%	0.05%	0.25%	0.35%	0.45%	-14.69%	-12.18%
	9	0.73%	0.44%	0.41%	-0.14%	0.77%	0.24%	0.37%	0.39%	2.61%	0.61%	0.29%	6.75%
	∑	4.20%	3.62%	1.67%	0.31%	3.29%	1.49%	1.83%	2.86%	12.34%	1.05%	-32.66%	0.00%

Table 37 – 2007 FAF Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.44%	0.32%	0.31%	0.17%	0.30%	0.14%	0.14%	0.46%	0.22%	0.34%	2.84%
	2	1.03%	1.52%	1.18%	0.39%	0.72%	0.40%	0.55%	1.53%	0.69%	1.40%	9.42%
	3	1.78%	2.58%	1.57%	0.65%	0.72%	0.83%	1.41%	1.86%	2.29%	2.27%	15.95%
	4	0.81%	0.97%	1.14%	0.20%	0.46%	0.58%	0.51%	0.94%	3.85%	1.42%	10.87%
	5	1.86%	1.73%	1.49%	0.71%	0.96%	1.29%	0.89%	3.00%	1.28%	2.56%	15.77%
	6	0.65%	1.02%	0.54%	0.30%	0.50%	0.46%	0.48%	1.39%	0.53%	1.85%	7.71%
	7	1.97%	1.96%	1.20%	0.41%	1.85%	0.93%	1.00%	1.80%	1.69%	1.84%	14.65%
	8	0.58%	0.65%	0.60%	0.15%	0.51%	0.67%	0.33%	1.07%	1.24%	1.19%	7.00%
	9	1.50%	1.86%	1.95%	0.56%	0.96%	1.19%	1.34%	2.96%	1.99%	1.47%	15.79%
	∑	10.62%	12.61%	9.98%	3.53%	6.99%	6.47%	6.66%	15.02%	13.78%	14.33%	100%

Table 38 – 2007 CFS Truck Share

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.22%	0.18%	0.45%	0.20%	0.16%	0.13%	0.08%	0.42%	0.08%	0.16%	2.07%
	2	1.22%	1.07%	2.00%	0.55%	0.49%	0.40%	0.53%	1.54%	0.46%	1.08%	9.34%
	3	2.51%	3.12%	3.01%	1.14%	0.61%	1.05%	1.91%	2.36%	0.84%	1.63%	18.17%
	4	0.82%	0.64%	1.89%	0.28%	0.40%	0.60%	0.57%	1.01%	1.77%	1.31%	9.30%
	5	2.34%	1.31%	2.39%	1.10%	0.79%	1.45%	0.92%	3.44%	0.82%	1.91%	16.48%
	6	0.84%	1.03%	0.94%	0.56%	0.33%	0.65%	0.65%	1.48%	0.19%	1.34%	8.02%
	7	2.47%	1.88%	2.09%	0.69%	1.50%	1.32%	1.10%	2.21%	0.71%	1.53%	15.49%
	8	0.57%	0.36%	0.83%	0.17%	0.42%	0.69%	0.18%	1.23%	0.41%	0.82%	5.70%
	9	1.52%	0.85%	3.56%	0.92%	0.91%	1.07%	1.01%	3.27%	1.34%	0.98%	15.42%
	∑	12.52%	10.44%	17.17%	5.61%	5.62%	7.36%	6.95%	16.94%	6.62%	10.76%	100%

Table 39 – 2007 Truck FAF-CFS Percent Shares

		Commodity										
		1	2	3	4	5	6	7	8	9	10	∑
Census Division	1	0.22%	0.14%	-0.14%	-0.03%	0.14%	0.01%	0.06%	0.04%	0.14%	0.18%	0.77%
	2	-0.19%	0.45%	-0.82%	-0.16%	0.23%	0.00%	0.02%	-0.01%	0.23%	0.32%	0.08%
	3	-0.73%	-0.54%	-1.44%	-0.49%	0.11%	-0.22%	-0.50%	-0.50%	1.45%	0.64%	-2.22%
	4	-0.01%	0.33%	-0.75%	-0.08%	0.06%	-0.02%	-0.06%	-0.07%	2.08%	0.11%	1.57%
	5	-0.48%	0.42%	-0.90%	-0.39%	0.17%	-0.16%	-0.03%	-0.44%	0.46%	0.65%	-0.71%
	6	-0.19%	-0.01%	-0.40%	-0.26%	0.17%	-0.19%	-0.17%	-0.09%	0.34%	0.51%	-0.31%
	7	-0.50%	0.08%	-0.89%	-0.28%	0.35%	-0.39%	-0.10%	-0.41%	0.98%	0.31%	-0.84%
	8	0.01%	0.29%	-0.23%	-0.02%	0.09%	-0.02%	0.15%	-0.16%	0.83%	0.37%	1.30%
	9	-0.02%	1.01%	-1.61%	-0.36%	0.05%	0.12%	0.33%	-0.31%	0.65%	0.49%	0.37%
	∑	-1.90%	2.17%	-7.19%	-2.08%	1.37%	-0.89%	-0.29%	-1.92%	7.16%	3.57%	0.00%

Table 40 – 2007 FAF Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.16%	0.10%	0.03%	0.12%	0.03%	0.01%	0.02%	0.11%	0.03%	0.09%	0.02%	0.72%
	2	0.78%	0.50%	0.24%	0.19%	0.34%	0.03%	0.10%	0.39%	0.36%	0.22%	0.97%	4.12%
	3	1.64%	0.90%	0.45%	0.37%	0.66%	0.15%	0.57%	0.54%	1.79%	1.54%	6.67%	15.28%
	4	1.06%	0.44%	0.85%	0.22%	0.29%	0.11%	0.09%	0.62%	4.07%	1.05%	4.33%	13.14%
	5	1.50%	0.44%	0.27%	0.37%	0.38%	0.15%	0.13%	0.38%	0.72%	0.65%	6.48%	11.47%
	6	0.78%	0.42%	0.11%	0.25%	0.18%	0.06%	0.10%	0.17%	0.32%	0.49%	4.32%	7.22%
	7	3.03%	0.66%	0.40%	0.42%	1.40%	0.11%	0.29%	0.43%	1.92%	1.37%	5.50%	15.54%
	8	1.37%	0.34%	0.18%	0.11%	0.51%	0.16%	0.10%	0.41%	0.53%	0.65%	19.90%	24.26%
	9	1.07%	0.57%	0.70%	0.38%	0.83%	0.17%	0.35%	1.15%	2.35%	0.31%	0.35%	8.25%
	∑	11.41%	4.38%	3.25%	2.44%	4.62%	0.94%	1.76%	4.21%	12.09%	6.37%	48.54%	100%

Table 41 – 2007 CFS Rail Share

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.10%	0.02%	0.02%	0.08%	0.01%	0.00%	0.00%	0.07%	0.02%	0.06%	0.00%	0.38%
	2	0.46%	0.14%	0.19%	0.07%	0.28%	0.00%	0.01%	0.19%	0.25%	0.03%	1.04%	2.66%
	3	1.19%	0.51%	0.26%	0.20%	0.40%	0.09%	0.20%	0.23%	0.88%	0.82%	9.24%	14.02%
	4	0.34%	0.15%	0.82%	0.06%	0.11%	0.08%	0.04%	0.25%	2.46%	0.72%	5.92%	10.95%
	5	0.99%	0.14%	0.12%	0.23%	0.12%	0.10%	0.09%	0.12%	0.46%	0.34%	8.78%	11.49%
	6	0.68%	0.25%	0.05%	0.20%	0.13%	0.02%	0.03%	0.03%	0.15%	0.33%	5.55%	7.42%
	7	3.16%	0.33%	0.33%	0.38%	1.14%	0.06%	0.05%	0.22%	1.26%	1.22%	8.63%	16.78%
	8	0.31%	0.05%	0.07%	0.06%	0.40%	0.09%	0.01%	0.25%	0.23%	0.20%	29.87%	31.54%
	9	0.50%	0.20%	0.61%	0.36%	0.37%	0.02%	0.11%	0.75%	1.01%	0.20%	0.65%	4.77%
	∑	7.73%	1.79%	2.46%	1.65%	2.95%	0.47%	0.53%	2.11%	6.72%	3.92%	69.66%	100%

Table 42 – 2007 Rail FAF-CFS Percent Shares

		Commodity											
		1	2	3	4	5	6	7	8	9	10	Coal	∑
Census Division	1	0.06%	0.08%	0.01%	0.04%	0.02%	0.01%	0.02%	0.04%	0.01%	0.03%	0.02%	0.34%
	2	0.32%	0.36%	0.05%	0.12%	0.06%	0.03%	0.09%	0.20%	0.11%	0.19%	-0.07%	1.46%
	3	0.45%	0.39%	0.19%	0.17%	0.26%	0.06%	0.37%	0.31%	0.91%	0.72%	-2.57%	1.26%
	4	0.72%	0.29%	0.03%	0.16%	0.18%	0.03%	0.05%	0.37%	1.61%	0.33%	-1.59%	2.19%
	5	0.51%	0.30%	0.15%	0.14%	0.26%	0.05%	0.04%	0.26%	0.26%	0.31%	-2.30%	-0.02%
	6	0.10%	0.17%	0.06%	0.05%	0.05%	0.04%	0.07%	0.14%	0.17%	0.16%	-1.23%	-0.20%
	7	-0.13%	0.33%	0.07%	0.04%	0.26%	0.05%	0.24%	0.21%	0.66%	0.15%	-3.13%	-1.24%
	8	1.06%	0.29%	0.11%	0.05%	0.11%	0.07%	0.09%	0.16%	0.30%	0.45%	-9.97%	-7.28%
	9	0.57%	0.37%	0.09%	0.02%	0.46%	0.15%	0.24%	0.40%	1.34%	0.11%	-0.30%	3.48%
	∑	3.68%	2.59%	0.79%	0.79%	1.67%	0.47%	1.23%	2.10%	5.37%	2.45%	-21.12%	0.00%

Table 43 – 2007 FAF Domestic Marine Share

Census Division		Commodity 1	2	3	4	5	6	7	8	9	10	∑
	1	0.02%	0.02%	0.01%	0.03%	0.28%	0.00%	0.02%	0.05%	0.01%	0.02%	0.46%
	2	0.77%	0.17%	0.06%	0.05%	1.57%	0.02%	0.04%	0.12%	0.05%	1.61%	4.46%
	3	0.96%	0.42%	0.09%	0.08%	2.50%	0.50%	0.14%	0.27%	5.04%	6.15%	16.14%
	4	0.17%	0.05%	0.17%	0.02%	0.87%	0.19%	0.05%	0.12%	6.36%	2.10%	10.09%
	5	0.58%	0.14%	0.07%	0.10%	2.49%	0.06%	0.08%	0.16%	0.36%	1.35%	5.39%
	6	0.58%	0.62%	0.03%	0.05%	1.79%	0.14%	0.04%	0.06%	1.51%	2.55%	7.36%
	7	3.63%	0.75%	0.16%	0.07%	9.86%	0.30%	0.06%	0.23%	12.41%	2.09%	29.56%
	8	0.06%	0.04%	0.03%	0.02%	0.11%	0.07%	0.04%	0.10%	0.02%	0.37%	0.87%
	9	0.26%	0.15%	0.34%	0.13%	21.43%	0.24%	0.18%	0.61%	0.76%	1.57%	25.67%
	∑	7.03%	2.37%	0.95%	0.55%	40.90%	1.51%	0.67%	1.72%	26.52%	17.79%	100%

Table 44 – 2007 CFS Domestic Marine Share

Census Division		Commodity 1	2	3	4	5	6	7	8	9	10	∑
	1	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	3.00%	3.03%
	3	0.52%	0.44%	0.00%	0.00%	0.18%	0.35%	0.00%	0.44%	9.64%	9.48%	21.06%
	4	0.32%	0.00%	0.00%	0.00%	0.23%	0.26%	0.01%	0.00%	13.82%	5.79%	20.44%
	5	0.00%	0.07%	0.00%	0.00%	1.76%	0.05%	0.00%	0.04%	0.00%	0.49%	2.42%
	6	0.20%	0.48%	0.00%	0.00%	1.19%	0.22%	0.00%	0.01%	2.05%	4.33%	8.49%
	7	1.68%	0.29%	0.16%	0.00%	6.09%	0.01%	0.00%	0.46%	25.29%	4.29%	38.29%
	8	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	0.09%
	9	0.08%	0.07%	0.84%	0.02%	1.30%	0.44%	0.40%	0.65%	0.06%	2.31%	6.18%
	∑	2.82%	1.36%	1.00%	0.03%	10.76%	1.34%	0.42%	1.69%	50.86%	29.71%	100%

Table 45 – 2007 Domestic Marine FAF-CFS Percent Shares

Census Division		Commodity 1	2	3	4	5	6	7	8	9	10	∑
	1	0.02%	0.02%	0.01%	0.03%	0.28%	0.00%	0.02%	0.05%	0.01%	0.02%	0.46%
	2	0.77%	0.17%	0.06%	0.05%	1.57%	0.02%	0.03%	0.11%	0.05%	-1.39%	1.43%
	3	0.44%	-0.02%	0.09%	0.08%	2.32%	0.15%	0.14%	-0.17%	-4.60%	-3.33%	-4.92%
	4	-0.15%	0.05%	0.17%	0.02%	0.64%	-0.07%	0.04%	0.12%	-7.46%	-3.69%	-10.35%
	5	0.58%	0.07%	0.07%	0.10%	0.73%	0.01%	0.08%	0.12%	0.36%	0.86%	2.97%
	6	0.38%	0.14%	0.03%	0.05%	0.60%	-0.08%	0.04%	0.05%	-0.54%	-1.78%	-1.13%
	7	1.95%	0.46%	0.00%	0.07%	3.77%	0.29%	0.06%	-0.23%	-12.88%	-2.20%	-8.73%
	8	0.05%	0.04%	0.03%	0.02%	0.11%	0.07%	0.04%	0.02%	0.02%	0.37%	0.78%
	9	0.18%	0.08%	-0.50%	0.11%	20.13%	-0.20%	-0.22%	-0.04%	0.70%	-0.74%	19.49%
	∑	4.21%	1.01%	-0.05%	0.52%	30.14%	0.17%	0.25%	0.03%	-24.34%	-11.92%	0.00%