

## A Methodology to Use FAF2 Data to Forecast Statewide External-External Trips

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**ABSTRACT**

Simulating freight activity in a statewide model requires the development of an origin/destination matrix containing internal-internal trips, internal-external and external-internal trips, and external-external trips. The external-external trips are often difficult to obtain as data for these trips cannot be surveyed through traditional travel surveying techniques. This paper presents a methodology to use the Freight Analysis Framework Version 2 Database (FAF2) to determine the volume of pass through freight for a statewide transportation model in either tons of freight or value of freight. The methodology is presented using a statewide case study, but is applicable to any region from the database. The paper concludes that the ability to obtain accurate pass-through freight data from a federal database for use in transportation modeling is vital to successful planning.

## **INTRODUCTION**

The efficient and effective movement of freight is a critical component in the transformation and growth of the economy. The ability to predict freight transportation requirements is vital to planning the necessary infrastructure improvements that can ensure congestion along a state's highways does not lead to a reduction in economic development (1). Transportation models must include predictions of freight movements. The freight predictions include those internal to the study area, those that either are attracted to or originate from the study area and those external to the study area that are a result of the freight passing through. The trips that have either the origination or destination in the study area are easier to model because the industries or retail outlets responsible for the freight activity are located in the study area and can be surveyed to determine the volume of freight flows produced or attracted. The freight trips that are external to the study area are more difficult to model because the planner is not able to survey industries or retail outlets that produce or attract the freight. The difficulty with obtaining this critical data has been identified in research performed on other statewide models and guides that indicate a trip exchange table for external-external freight transportation is necessary, but no clear guidance is provided to develop the trip table (2).

The goal of this paper is to present a methodology for the development of a forecast of statewide external-external values for use in modeling. The methodology uses a federally developed freight database and is intended to be applied at the state, or major regional level (those included in the federal database) (3). This paper presents a review of the database, then a systematic methodology to extract the external-external values, by commodity and mode, for use in transportation modeling. Finally, the paper presents a pilot application of the methodology using the state of Alabama as the case study. The paper concludes that correct application of this methodology can develop external-external origin/destination tables that can be incorporated, and add significant value, into statewide or major regional transportation models.

## **DATA**

The accuracy of any modeling activity is based on the quality of data entered into the process. For freight applications, the best data that is currently available is the Federal Highway Administration's Freight Analysis Framework (FAF) database.

The second generation of the Freight Analysis Framework (FAF) known as FAF2 is a continuation of the original Freight Analysis Framework developed by the U.S. Department of Transportation, Federal Highway Administration (FHWA) (4). Whereas the original FAF provided the public with generalized freight movement and highway congestion maps without disclosing the underlying data, FAF2 provides a commodity flow origin-destination (O-D) and freight movement data on all highways within the FAF2 highway network. The FAF2 Commodity Origin-Destination Database estimates tonnage and value of goods shipped by type of commodity (see Table 1) and mode of transportation (see Table 2) for 114 FAF2 zones (shown in Figure 1), 7 international trading regions and 17 additional international gateways, (3). The 2002 estimate is primarily derived from the Commodity Flow Survey (CFS) with some of the data voids in the CFS filled in by analysis of the Economic Census and other data sources. Forecasts are included for 2010 to 2035 in 5-year increments (3). The data are available in Microsoft Access format and contain values in million of dollars of value and thousands of short tons.

TABLE 1 Listing of commodities on FAF2 database (5)

<b>BTS/Census Full Commodity Name</b>	<b>FAF Abbreviation</b>
Live animals and live fish	Live animals/fish
Cereal grains	Cereal grains
Other agricultural products	Other ag prods.
Animal feed and products of animal origin, n.e.c.1	Animal feed
Meat, fish, seafood, and their preparations	Meat/seafood
Milled grain products and preparations, bakery products	Milled grain prods.
Other prepared foodstuffs and fats and oils	Other foodstuffs
Alcoholic beverages	Alcoholic beverages
Tobacco products	Tobacco prods.
Monumental or building stone	Building stone
Natural sands	Natural sands
Gravel and crushed stone	Gravel
Nonmetallic minerals n.e.c.1	Nonmetallic minerals
Metallic ores and concentrates	Metallic ores
Coal	Coal
Crude Petroleum	Crude petroleum
Gasoline and aviation turbine fuel	Gasoline
Fuel oils	Fuel oils
Coal and petroleum products, n.e.c.1 (Note: primarily natural gas, selected coal products, and products of petroleum refining, excluding gasoline, aviation fuel, and fuel oil.)	Coal-n.e.c.1
Basic chemicals	Basic chemicals
Pharmaceutical products	Pharmaceuticals
Fertilizers	Fertilizers
Chemical products and preparations, n.e.c.1	Chemical prods.
Plastics and rubber	Plastics/rubber
Logs and other wood in the rough	Logs
Wood products	Wood prods.
Pulp, newsprint, paper, and paperboard	Newsprint/paper
Paper or paperboard articles	Paper articles
Printed products	Printed prods.
Textiles, leather, and articles of textiles or leather	Textiles/leather
Nonmetallic mineral products	Nonmetal min. prods.
Base metal in primary or semi-finished forms and in finished basic shapes	Base metals
Articles of base metal	Articles-base metal
Machinery	Machinery
Electronic and other electrical equipment and components and office equipment	Electronics
Motorized and other vehicles (including parts)	Motorized vehicles
Transportation equipment, n.e.c.1	Transport equip.
Precision instruments and apparatus	Precision instruments
Furniture, mattresses and mattress supports, lamps, lighting fittings	Furniture
Miscellaneous manufactured products	Misc. mfg. prods.
Waste and scrap	Waste/scrap
Mixed freight	Mixed freight
Commodity unknown	Unknown

Geographic Areas for the Freight Analysis Framework and 2002 Commodity Flow Survey

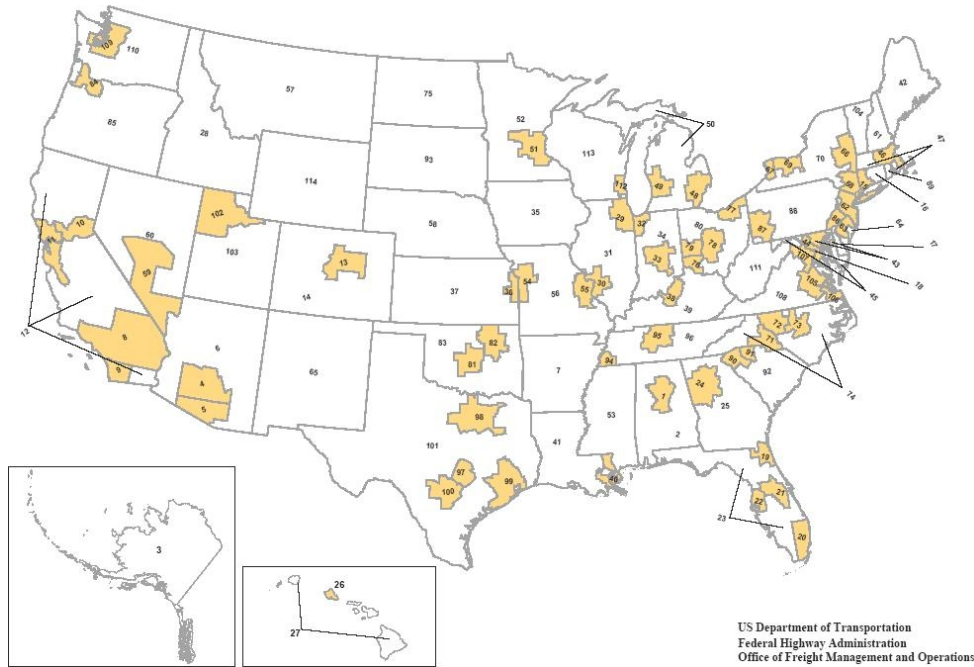


FIGURE 1 Geographic locations for FAF2 data (6).

TABLE 2 Listing of Transportation Modes from FAF2 ( )

Truck. Includes private and for-hire truck. Private trucks are operated by a temporary or permanent employee of an establishment or the buyer/receiver of the shipment. For-hire trucks carry freight for a fee collected from the shipper, recipient of the shipment, or an arranger of the transportation.
Rail. Any common carrier or private railroad.
Water. Includes shallow draft, deep draft and Great Lakes shipments. FAF2 uses definitions by the U.S. Army Corps of Engineers. Shallow draft includes barges, ships, or ferries operating primarily on rivers and canals; in harbors; the Saint Lawrence Seaway; the Intra-coastal Waterway; the Inside Passage to Alaska; major bays and inlets; or in the ocean close to the shoreline. Deep draft includes barges, ships, or ferries operating primarily in the open ocean.
Air (includes truck-air). Includes shipments by air or a combination of truck and air. Commercial or private aircraft, and all air service for shipments that typically weigh more than 100 pounds. Includes air freight and air express.
Truck-Rail Intermodal. Includes shipments by a combination of truck and rail.
Other Multiple Modes. Includes shipments typically weighing less than 100 pounds by Parcel, U.S. Postal Service, or Courier, as well as shipments of all sizes by truck-water, water-rail, and other intermodal combinations.
Pipeline and Unknown. Pipeline is included with unknown because region-to-region flows by pipeline are subject to large uncertainty.

## **METHODOLOGY**

The methodology to develop the external-external table from the FAF2 database is comprised of the following steps:

1. Develop a national travel demand network that includes all 114 zones defined by the FAF2 database.
2. Perform a select link analysis technique in a commonly used travel demand model to determine which origin/destination pairs use roadways in the desired study area or state.
3. Extract the relevant data from the FAF2 database based on the O/D pairs obtained in step 2, either in dollar value of shipment or tons shipped,.
4. Use the O/D pairs and data in a travel forecasting model to determine external-external trips.

The steps listed above are explained in further detail in the following sections.

### **Task 1: Create a National Network**

The national network is designed to provide a basis for using a travel demand software package to determine the external-external traffic flows. The creation of the network involves the development of zones and roadway infrastructure similar to what would be performed to develop a traditional urban planning model. Any travel demand software can be used to create the network and run the model.

The FAF2 data structure defining the 114 zones (see Figure 1) of freight origin and destination should serve as the base zone structure for the travel demand model network. To improve the analysis, a geographic file that contains the 114 regions can be downloaded from the FAF2 website (3). This geographic data is intended to be the starting point for the analysis.

The roadway network developed serves as the connection between the zones. The travel demand network should include roadway distances, travel speeds and capacities. To assist in the analysis, a geographic file containing transportation infrastructure is available for download from the FAF2 website (3).

### **Task 2: Perform Flow Analysis**

After the national infrastructure network has been developed, a flow analysis is performed to determine the travel patterns and identify which O/D pairs utilize the roadways in the area or state of interest. This can be accomplished through various methods based upon the travel demand model being employed for the study. Traffic must be assigned from each zone independently and the path to the other 113 destination zones can be determined. The O/D pairs that use roadways in the area or state of interest can then be identified. The O/D pairs that use the roadways in the study area or state can then be used in the analysis.

### **Task 3: Run Computer Program to Extract Data**

After the O/D pairs that traverse the area or state of interest are determined in task 2, the FAF2 database must be reduced to contain only data for the O/D pairs of interest. To assist this step, researchers at the University of Alabama in Huntsville, Office for Freight, Logistics and Transportation developed a computer program in C++ that allows the user to input the relevant O/D pairs in a text file. The program generates an external-external table for the area or state in either the value of shipment in dollars or tons shipped.

#### **Task 4: Assign Data to National Network**

Once the external-external data is developed, the user must assign the data to the national network. The assignment should be performed using the travel demand model and the user defined assignment procedure. This will allow for the analysis of external-external value of shipment or tons shipped to be assigned to the travel demand network. The assignment must be converted to the number of vehicles to be used for modeling purpose. The conversion factors for turning value of shipments or tons shipped into an accurate number of vehicles for each commodity and mode are critical to the freight planning process, and are of great concern, but is the subject for a future research paper.

The development of the external-external data and assignment can be accomplished by performing the steps of the methodology presented above. Planners can use the process described to create the data for the base level of freight traffic on the transportation facilities in their area of concern, whether local or statewide.

#### **CASE STUDY: ALABAMA**

To demonstrate the application of the methodology, an analysis of the external-external data was performed for the state of Alabama. Included in the case study description is increased detail and documentation of specific steps when using TRANPLAN, which is the travel demand model used in Alabama.

#### **Task 1: Create a National Network**

The first task was the development of the national network. The FAF2 website provides a starting point by providing a national infrastructure. The infrastructure, in ArcGIS format, was downloaded and is shown in Figure 2. From this data, the Interstate routes were highlighted and used to create a national network to connect the zones defined in the FAF2 database (see Figure 3). The national network was developed using CUBE-TRANPLAN, the travel demand model currently being used in Alabama for transportation forecasting. The national network was comprised of 114 zones (as defined by the FAF2 regions), nodes to reflect intersections and links to serve as roadways. The roadway was manually developed and the nodes and links were drawn using a “heads-up” digitizing technique with the ArcGIS file serving as an image layer to ensure the roadways were spatially accurate. Attributes were applied to the network such as roadway distances, speed limits and capacities. However, as the use of the network was to determine shortest path between zones, flows were not constrained by capacity.

#### **Task 2: Perform Flow Analysis**

A variety of CUBE-TRANPLAN modules were used to develop the flow analysis and define the shortest path through the national network between zones. Initially, the network was input to the Highway Selected Summation module to determine the skims, or the shortest path between all 114 zones. Then, the skims were entered into a gravity distribution model, Gravity Model, with a fictitious production and attraction file. The production and attraction file was established with 100,000 productions and attractions for each zone – essentially a large value to ensure some trips would be distributed between each zone pair. Next, a fictitious assignment was performed to utilize the roadway network and place traffic on the roadways utilizing Load Highway Network. The assignment was performed using a shortest path methodology directing all traffic on to the shortest route, regardless of congestion. Finally, the Load Highway Selected Links module was

used to extract specific route information.

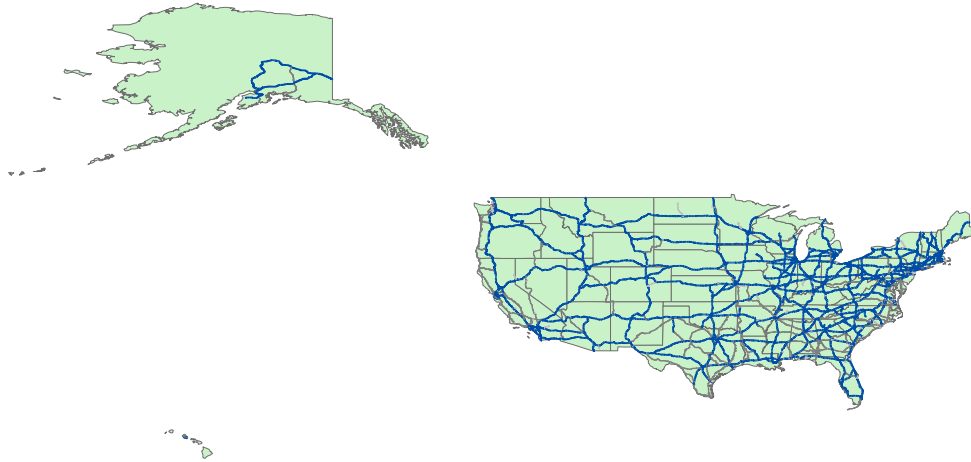


FIGURE 2 Roadway infrastructure from FAF2.

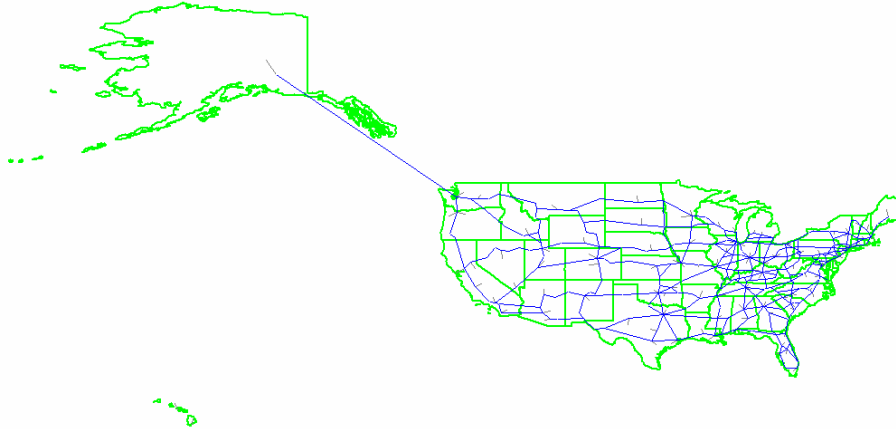


FIGURE 3 National Network in CUBE-TRANPLAN format.

Using the Load Highway Selected Links module, it was possible to identify selected roadways where only the traffic using the selected roadways would be included in the output. It is possible to identify a collection of links where the travelers have to use all the links identified or only one of the links identified. For Alabama, seven roadways that represented interstates crossing state lines were identified as the selected links. The rule was established that the traffic only needed to use one of the links to be included in the results. In addition, the module allows



for the identification of origin locations, destinations locations or a combination of both be identified to limit the amount of traffic stored. In the analysis, as the values external to Alabama were of interest, the origin zones were varied individually from zone 3 – Alaska to zone 114 – Wyoming. Zone 1 and 2 were excluded from the study because they are internal to Alabama. Figure 4 presents the shortest paths from Zone 21 – Orlando, FL to all other zones, if the shortest path crosses through Alabama.

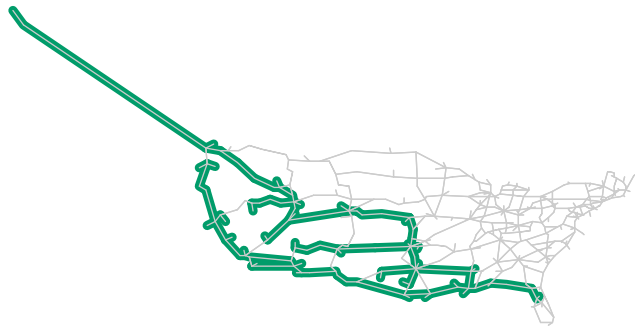


FIGURE 4 Shortest path from Zone 21 through Alabama.

During the process of running the Load Highway Selected Links for each origin, the output network containing the paths that pass through Alabama were exported to ArcGIS for further analysis. A query was developed to show the destination zones that were on the path through Alabama. The main interest in this step was the development of paths from a single origin to multiple destinations. These values were recorded in a spreadsheet and saved as tab delimited text file. The values, formatted to show the origin zone number, destination A zone number, destination B zone number, destination C zone number, etc., were saved for input into the computer program written to extract the FAF2 data.

### **Task 3: Run Computer Program to Extract Data**

After developing the origin destination pairs traffic passing through Alabama would use, the next step was to extract the FAF2 data from its native Microsoft Access Database format into a text file. The FAF2 data for either ‘Kilotons’ or ‘Millions of Dollar Shipped’ could be used by the planner. The two text files serve as input to the computer program written to extract the data. The flowchart for the program developed at UAH is shown in Figure 5. The FAF2 Data Extraction Program creates a text file containing origin, destination and FAF2 value for each commodity listed in the database. In addition, as a parameter input into the program, a search is performed during the operation of the program to extract only data for which “truck” is listed as the mode of transportation. It is important to note, that if the infrastructure were developed for alternative modes, the program could be easily modified to extract rail or water shipment data if the origin destination zones were also adjusted to reflect the alternate mode.

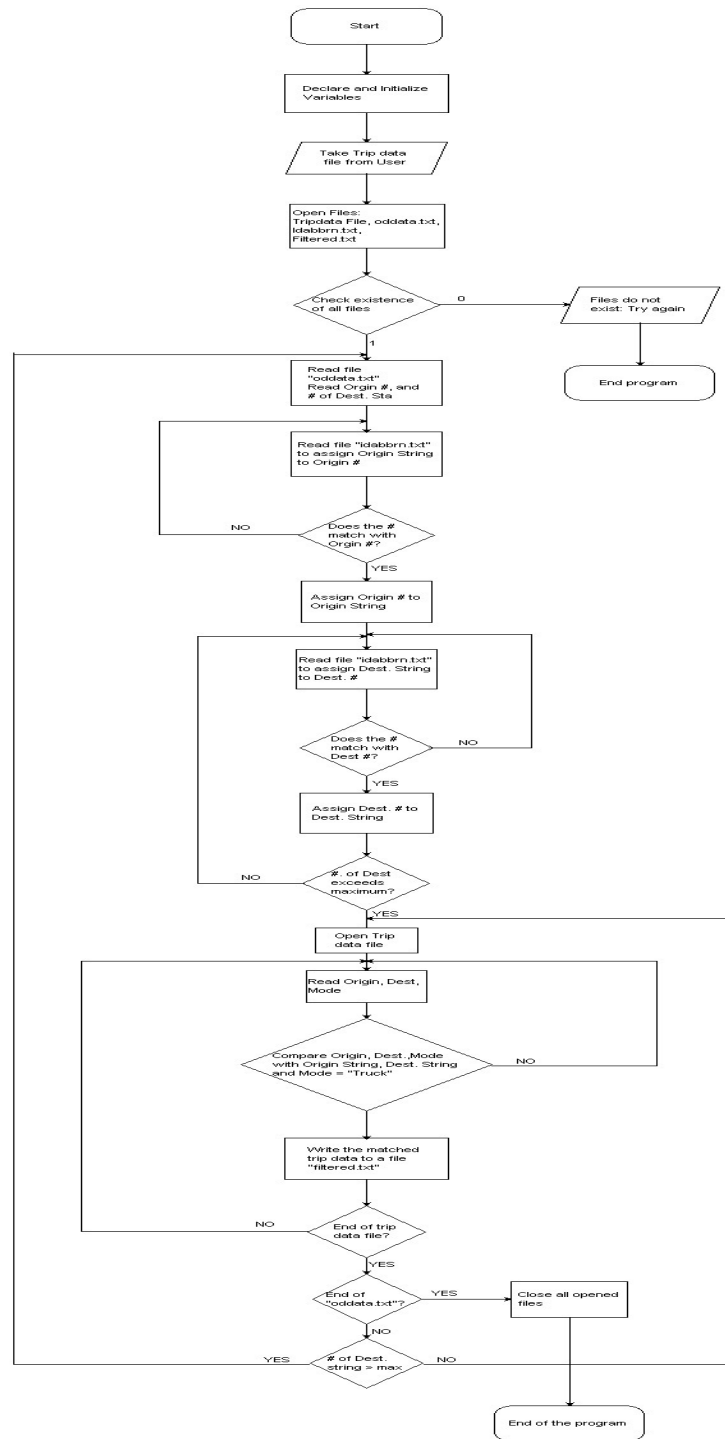


FIGURE 5 Flowchart of the FAF2 Data Extraction Program.

#### Task 4: Assign Data to National Network

The output from the program is a text file that contains origin zone number, destination zone number, and FAF2 data value, either 'Kilotons' or 'Millions of Dollar Shipped', for each

commodity in the FAF2 database. Once developed, a TRANPLAN routine was employed to convert the text file into a trip table for entry into CUBE-TRANPLAN. The trip table file is then input to the Load Highway Network module with the national network, to assign the 'Kilotons' or 'Millions of Dollar Shipped'. Figure 6 illustrates two commodities assigned to the national network that pass through Alabama.

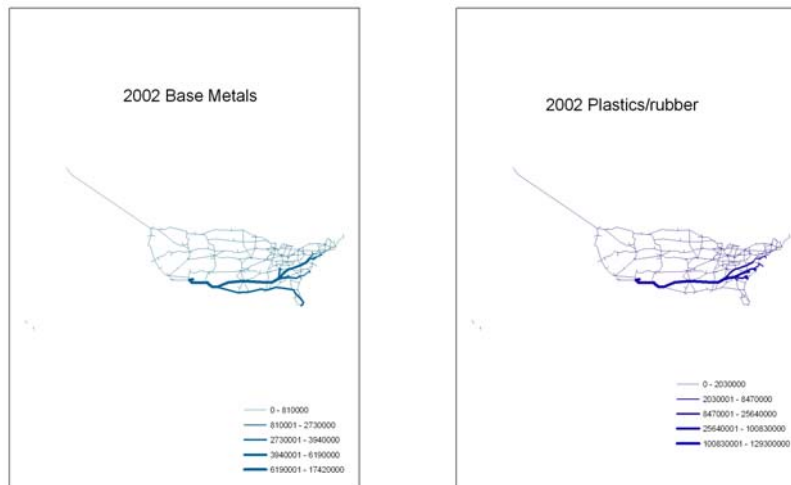


FIGURE 6 Assigned value of kilotons passing through Alabama.

## METHODOLOGY VALIDATION

The validation of the methodology is difficult because the FAF2 data does not contain vehicle traffic. However, it is possible to perform a limited validation of the methodology. The validation technique involves comparing the tons of freight passing in and out of Alabama to the truck traffic crossing the state line to determine if the values violate truck weight laws, or not.

The assignment by commodity of the external kilotons to the national network is intended to provide a measure of the pass through traffic. However, it is still necessary to collect the internal-external and external-internal traffic for Alabama since these trips also pass across the state line. The values of kilotons that have either the origin or destination in Alabama are obtained from a direct export from the FAF2 database. The data exported can be sorted and purged such that only those that have their origin or destination in Zone 1 or Zone 2 (Alabama) and sorted by individual commodities to remove all the values that are not moved by "truck". The TRANPLAN routine can be run to create a trip table for entry into the CUBE-TRANPLAN Load Highway Network module. Figure 7 shows the flow from the FAF2 database of all kilotons moved across the Alabama state lines.

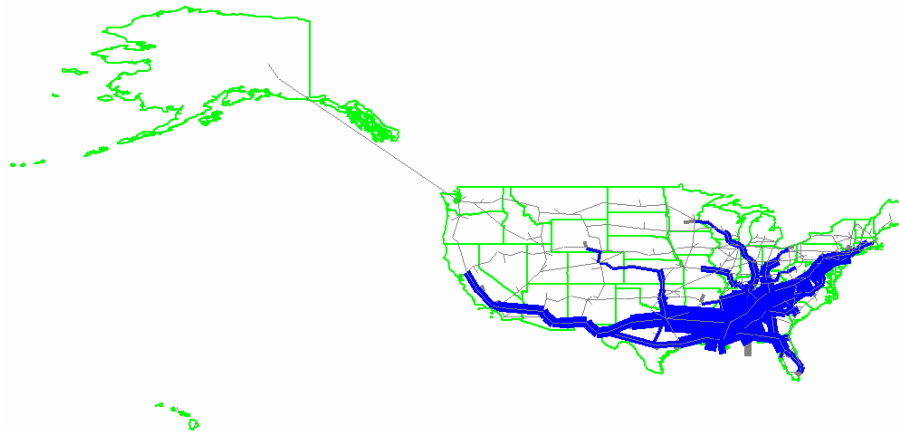


FIGURE 7 Kilotons of freight moved from, destined to, or through Alabama.

A collection of the Kilotons crossing the state lines was then compared to the total truck count at the state line interstate locations. The Alabama Department of Transportation (ALDOT) provided the data related to truck counts. Table 3 presents the number of trucks per day reported by ALDOT crossing the Alabama state line. Table 3 also contains the tons of freight per year obtained from the FAF2 database that the methodology suggests crosses the Alabama state line. A comparison of the results indicates that the values obtained by calculating the weight per truck is realistic. The differences in truck weight are associated with the wide variety of commodities shipped via truck across the state lines and the distribution of destinations for those specific commodities.

TABLE 3 Method Validation.

	Trucks/day (7)	Tons/year model	Tons/day	Tons/truck	Pounds/truck
I65	7,768	52,071,250	142,661	18.37	36,730
I59	4,758	47,408,170	129,885	27.30	54,601
I20	14,531	38,163,040	104,556	7.20	14,390
I85	6,070	42,259,400	115,779	19.07	38,149
I10E	6,334	13,234,480	36,259	5.72	11,450
I10W	9,979	22,101,760	60,553	6.07	12,136
I59W	8,875	107,198,800	293,695	33.09	66,188

## CONCLUSIONS AND RECOMMENDATIONS

The methodology presented in this paper focuses on a means to utilize FAF2 data to estimate statewide external traffic levels. The results of using the methodology produce a reasonable value of weight per truck for each interstate route as it crosses the Alabama state line. Additional use of this methodology would be a forecast of future years freight tonnage provided in the FAF2 database. Then, the application of a reasonable number of trucks to transport the total tonnage of freight could be ascertained to develop a future freight external flow value.

This methodology has been developed to be applicable to any state, or region identified in the FAF2 zone structure. Future improvements of the methodology would include developing truck weight factors for specific commodities and advancements in disaggregating the FAF2 database to a sub-state level. The method presented here improves the ability of transportation planners to quantify the base level of freight traffic in their area of concern. The base level of freight traffic contributes to total roadway congestion, but is difficult to ascertain because traditional sampling techniques are only available within the study area. The methodology presented in this paper can be used to determine the freight movements that occur simply because the study area is along the travel path between unrelated origins and destinations. Overall, this methodology is intended to serve as a starting point for statewide freight flow models interested in using the FAF2 database, but facing the difficulty in understanding the methods to obtain the data and extract the data that is appropriate.

## ACKNOWLEDGEMENT

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