Development of a Method to Forecast Freight Demand Arising from the Final Demand Sector and Examination of Federal Data to Analyze Transportation Demand for Local Area Through Trips

Final Report for:

Alabama Department of Transportation
Research Project 930-697

Project Advisory Committee
Mr. Bob Jilla – Chair
Mr. Don Vaughn
Dr. Emmanuel Oranika
Ms. Ivy Harris – RAC Liaison
Mr. Clint Andrews – FHWA Liaison

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Principal Investigator:
Michael D. Anderson, Ph.D., P.E.

Co-Investigator:
Gregory A. Harris, Ph.D., P.E.

Office for Freight, Logistics & Transportation
College of Engineering & College of Business Administration Research Centers
UAHuntsville

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Table of Contents

	Executive Summary	**4**
1.	**Introduction**	**5**
2.	**Final Demand/Freight Forecasting and Distribution**	**7**
	2.1 Task 1	8
	2.2 Task 2 & 3	10
	2.3 Task 4	26
	2.4 Task 5	28
	2.5 Future Enhancement Opportunities	30
3.	**Pass Through Freight Modeling**	**30**
	3.1 FAF2 Data	31
	3.2 Statewide Pass Through	34
	3.2.1 Statewide Alabama Pass Through	36
	3.3 Local Pass Through from a Statewide Model	46
	3.3.1 Montgomery MPO Case Study	48
	3.4 Summary	49
4.	**Conclusions**	**50**
	References	51
	Project Staff	51
	Appendix A-D	52

Table of Tables

2.1	Example Table of Circuit City Stores for Alabama	9
2.2	Excerpt of Retail/Wholesale Distribution Centers within Alabama Database	10
2.3	Distribution Center Freight Networks by Sector	27
3.1	Listing of Commodities on FAF2 Database	31
3.2	Listing of Transportation Modes from FAF2	34
3.3	Method Validation	43
3.4	Volume and Expected Number of Pass Through Trucks Statewide	44
3.5	Daily Truck Volumes Expected to Pass-Through Montgomery MPO	49

Development of a Method to Forecast Freight Demand Arising from the Final Demand Sector and Examination of Federal Data to Analyze Transportation Demand for Local Area Through Trips

Table of Figures

1.1	Sample Screenshot of the Freight Analysis Framework Commodity Flow Database	6
2.1	Example of Freight Forward Survey	12
2.2	Beverage Distributor Network	14
2.3	Alabama Beer Distribution Network	14
2.4	Big Box Centers Distribution	15
2.5	Furniture Distribution	16
2.6	Fuel Distribution	17
2.7	Pharmacy Retail Distribution	18
2.8	Automotive Distribution	19
2.9	General Merchandise Distribution	20
2.10	Grocery Chain Retail Distribution	21
2.11	Home Electronics Retail Distribution	22
2.12	Sporting Goods Retail Distribution	23
2.13	Parcel Shippers Inbound Distribution	24
2.14	Parcel Shippers Outbound Distribution	25
2.15	Alabama Income Distribution by County for 2006	29
3.1	Geographic Locations for FAF2 Data	33
3.2	Roadway Infrastructure from FAF2	37
3.3	National Network in CUBE-TRANPLAN format	37
3.4	Shortest Path from Zone 21 through Alabama	39
3.5	Flowchart of the FAF2 Data Extraction Program	40
3.6	Assigned Value of Kilotons Passing Through Alabama	41
3.7	Kilotons of Freight Moved from, Destined To, or Through Alabama	42
3.8	Pass Through Freight for 2010	43
3.9	Pass Through Freight for 2035	44
3.10	Port of Mobile Impact on Pass Through Freight 2010	45
3.11	Port of Mobile Impact of Pass Through Freight 2035	45
3.12	Statewide Roadway Network	47
3.13	Validation of the Statewide Model	48
3.14	Statewide model with FAF2 2035 daily truck volumes	48

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Executive Summary

This report describes the research performed to develop a framework and a research approach to achieve insight into two important components of freight transportation in Alabama, and the U.S. The first objective is to develop the ability to project freight traffic arising from retail sales to households or to the final demand sector of the economy. Normally, this involves shipments from distribution centers and bonded warehouses to retailers located in the state's population centers. The research demonstrates that this final leg of a shipment's journey to the consumer is growing very fast and evolving rapidly.

Major retail centers were identified in all of Alabama's cities with populations of over 25,000. A subset of the retailers in these communities was chosen for a detailed analysis of their distribution network. The researchers conducted interviews to gather information about how each network operates. The information collected from the survey included the geographical region served, the physical and operational characteristics of the network, volume of traffic, and anticipated future traffic volumes. The survey revealed that most distribution networks serving Alabama can either be characterized as hub and spoke or route-based. The survey also uncovered many unique characteristics of each network.

Finally, researchers determined a method to allocate freight traffic arising from the final demand sector to Alabama counties. Several variables were tested including population, employment, payroll and personal income. It was found that total personal income of residents in the county appeared to work best with population coming in second.

The second research objective focuses on the use of federal freight flow data to forecast the amount of pass through freight expected in urbanized areas in the state. The report documents procedures developed to utilize the Freight Analysis Framework Version 2 Database to determine the number of vehicles passing through an urban area in Alabama.

The procedures developed in this research focus on the national level pass through data, trips from one state to another that pass through other states only because of that state's location; pass through from the port of entries, where the urbanized area is located on a major corridor; and statewide level through trip data, trips from one part of the state to another that pass through the urbanized area because of its geographic location.

The need for, and application of, the pass through freight forecasting is evident in the transportation planning models each state is expected to develop and maintain for evaluating transportation projects. The ability to forecast accurately the pass through freight movements will benefit transportation planners in urbanized areas by being able to

identify freight volumes that must be accommodated by the infrastructure, but for which the local area has no direct method to survey.

1. Introduction

This study had two primary objectives. The first objective of this research was to create a method and a database for use in forecasting freight demand arising from the household sector. This demand comes both from households within Alabama and from households in other states when finished goods are transshipped through Alabama. Total truckloads of freight entering Alabama are a function of some variable used to measure final sales to households. This variable could be personal income, household income or total retail sales to the state's residents, but to date, the appropriate factor has not been identified or tested.

The total truckloads of freight entering, moving within or leaving Alabama can be calculated by summing the total truckloads entering the state and the total truckloads leaving the state and the total truckloads shipped within the state. The attraction of freight is a function of final sales to Alabama households plus sales to households outside Alabama. With final demand increasing there will be an associated increase in the attraction of freight due to the new sales in an area. The opposite occurs when final demand is declining.

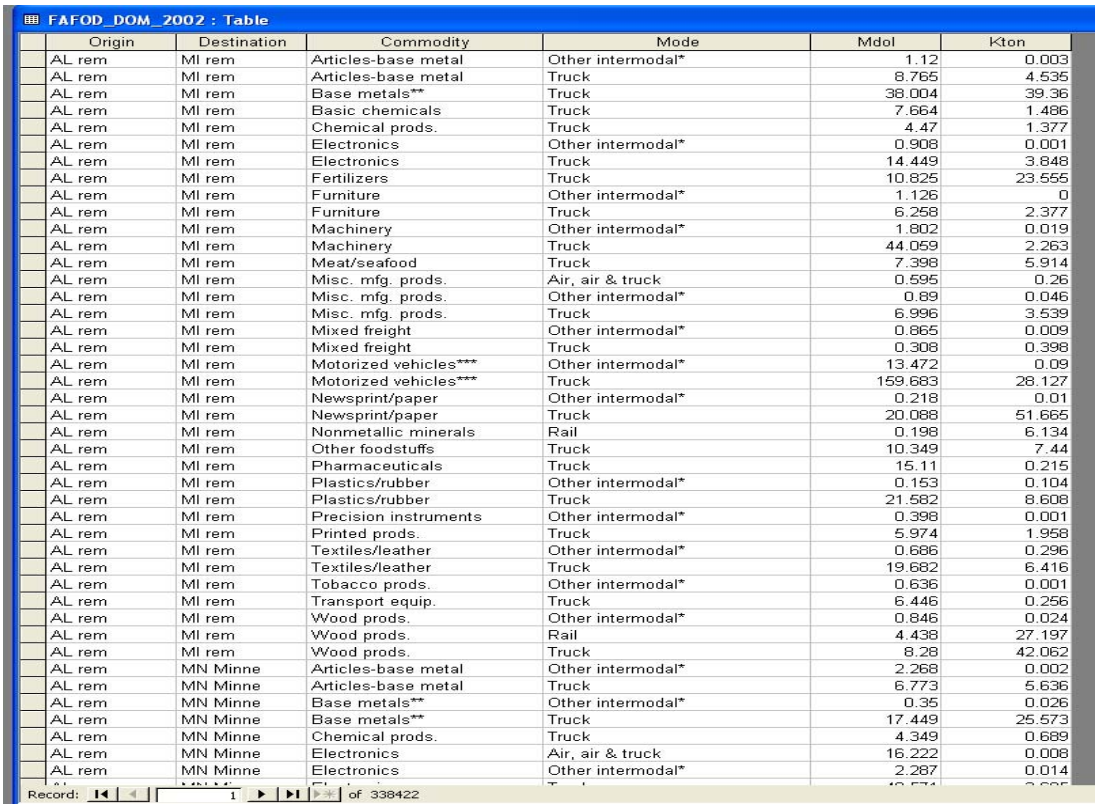
The benefit to the Alabama and the Department of Transportation (ALDOT) as a result of this first research objective is two-fold. First, the freight servicing the retail sector of the state and the nation is growing at an extremely fast rate as more supply chains become international with the growth of global manufacturing capability. This trend will not soon reverse, which indicates that the freight factor on our interstate, highway and state roads is going to become a more significant component of congestion throughout the state, especially in urban areas. As a result, the need to forecast freight accurately becomes more important in the planning activities for transportation infrastructure.

The second benefit of this research is the ability to forecast the total freight in the state with more accuracy. Researchers at UAH have been developing methods for forecasting freight as a result of manufacturing activity in the state which has resulted in the creation of the Freight Planning Framework (FPF) and the Alabama Transportation Infrastructure Model (ATIM) and the ability to simulate transportation system behavior over time. This research adds an important component to the freight demand on that infrastructure due to the fact that household demand ends up in a truck on a road at some point in the supply chain process.

One of the results of this project is the ability to provide more accurate forecasts of freight demand on the roadways of Alabama to the transportation planners at ALDOT and the state MPO's.

The second objective of this research was to use the US Department of Transportation Freight Analysis Framework Version 2 (FAF2) database to provide state and local government's access to transportation information related to freight origin/destinations. This information is produced and intended to support transportation planning activities within the states and local agencies as the data can be mined to determine sub-regional commodity flows and patterns. Unfortunately, the sheer volume of the database has limited its usefulness to state and local agencies as the nearly 1 million entries are often overwhelming to first time users. Some of the purposes of this project were to extract data from the FAF2 Origin-Destination database to support transportation planning activities within Alabama and for the local regions as well as develop a repository for such data to allow for easier access to the information for future use.

The data provided by the Freight FAF2 database identifies origin/destination locations for freight movements, by commodity, mode and amount. A sample from the dataset is shown as Figure 1.1.



FAFOD_DOM_2002 : Table

Origin	Destination	Commodity	Mode	Mdol	Kton
AL rem	MI rem	Articles-base metal	Other intermodal*	1.12	0.003
AL rem	MI rem	Articles-base metal	Truck	8.765	4.535
AL rem	MI rem	Base metals**	Truck	38.004	39.36
AL rem	MI rem	Basic chemicals	Truck	7.664	1.486
AL rem	MI rem	Chemical prods.	Truck	4.47	1.377
AL rem	MI rem	Electronics	Other intermodal*	0.908	0.001
AL rem	MI rem	Electronics	Truck	14.449	3.848
AL rem	MI rem	Fertilizers	Truck	10.825	23.555
AL rem	MI rem	Furniture	Other intermodal*	1.126	0
AL rem	MI rem	Furniture	Truck	6.258	2.377
AL rem	MI rem	Machinery	Other intermodal*	1.802	0.019
AL rem	MI rem	Machinery	Truck	44.059	2.263
AL rem	MI rem	Meat/seafood	Truck	7.398	5.914
AL rem	MI rem	Misc. mfg. prods.	Air, air & truck	0.595	0.26
AL rem	MI rem	Misc. mfg. prods.	Other intermodal*	0.89	0.046
AL rem	MI rem	Misc. mfg. prods.	Truck	6.996	3.539
AL rem	MI rem	Mixed freight	Other intermodal*	0.865	0.009
AL rem	MI rem	Mixed freight	Truck	0.308	0.398
AL rem	MI rem	Motorized vehicles***	Other intermodal*	13.472	0.09
AL rem	MI rem	Motorized vehicles***	Truck	159.683	28.127
AL rem	MI rem	Newsprint/paper	Other intermodal*	0.218	0.01
AL rem	MI rem	Newsprint/paper	Truck	20.088	51.665
AL rem	MI rem	Nonmetallic minerals	Rail	0.198	6.134
AL rem	MI rem	Other foodstuffs	Truck	10.349	7.44
AL rem	MI rem	Pharmaceuticals	Truck	15.11	0.215
AL rem	MI rem	Plastics/rubber	Other intermodal*	0.153	0.104
AL rem	MI rem	Plastics/rubber	Truck	21.582	8.608
AL rem	MI rem	Precision instruments	Other intermodal*	0.398	0.001
AL rem	MI rem	Printed prods.	Truck	5.974	1.958
AL rem	MI rem	Textiles/leather	Other intermodal*	0.686	0.296
AL rem	MI rem	Textiles/leather	Truck	19.682	6.416
AL rem	MI rem	Tobacco prods.	Other intermodal*	0.636	0.001
AL rem	MI rem	Transport equip.	Truck	6.446	0.256
AL rem	MI rem	Wood prods.	Other intermodal*	0.846	0.024
AL rem	MI rem	Wood prods.	Rail	4.438	27.197
AL rem	MI rem	Wood prods.	Truck	8.28	42.062
AL rem	MN Minne	Articles-base metal	Other intermodal*	2.268	0.002
AL rem	MN Minne	Articles-base metal	Truck	6.773	5.636
AL rem	MN Minne	Base metals**	Other intermodal*	0.35	0.026
AL rem	MN Minne	Base metals**	Truck	17.449	25.573
AL rem	MN Minne	Chemical prods.	Truck	4.349	0.689
AL rem	MN Minne	Electronics	Air, air & truck	16.222	0.008
AL rem	MN Minne	Electronics	Other intermodal*	2.287	0.014

Record: 1 of 338422

Figure 1.1. Sample screen shot from the Freight Analysis Framework Commodity Flow Database

The research involved disaggregating the extracted freight data to focus on the impact of through freight trips on the local communities. These through freight trips are becoming an increasing matter of concern in the local communities as freight transportation has a large impact on the performance and quality of the transportation system in a local area, both with respect to roadway congestion and infrastructure needs.

A direct benefit of this research to both ALDOT and the Metropolitan Planning Organization (MPOs) within the state is realized through the development of the methodology to sort the massive database into useable information and, through analysis, to assimilate the filtered data into the transportation planning process. This can be done at both the state and local level. This project is intended to contribute to the FPF and a new freight modeling environment being develop at UAH which is intended to improve the status of freight and traffic estimation.

This report documents the completion of each task and the method that was developed to forecast freight demand originating from the household sector and the pass-through freight. The report is divided into four distinct sections. This first section provides a general introduction. The second section contains the work performed related to the final demand aspects of this project. The third section contains work performed on the pass-through freight. The report provides a conclusion section and identifies area for potential future research.

2. Final Demand Freight Forecasting and Distribution

Project Scope

The purpose of this portion of the research project was to develop a methodology for forecasting final demand arising from the household sector considering the global supply chains of major retailers. A better understanding of the distribution networks for major retail industry sectors in Alabama should improve infrastructure planning to support growing freight volumes.

Project Components

The Final Demand Freight research on distribution networks and forecasting is composed of five tasks. These tasks are:

1. Identification of major distribution centers of finished goods serving Alabama
2. Identification of Shipping Areas (Networks) for distribution centers
3. Capture information regarding the size and number of shipments at distribution centers
4. Create a methodology to identify destinations for distribution centers using an industry database
5. Create a methodology to project final demand in Alabama by destinations (67 counties)

The research approach, analysis, findings, and/or results for each task are described below.

2.1 Identification of major distribution centers of finished goods serving Alabama – Task 1

David Berkowtiz, Ph.D. served as the lead for this task which was to identify major distribution centers of finished goods serving Alabama in the following sectors:

- Big Box Supply Stores
- Furniture
- Fuel Distributors
- Pharmacies
- Autos
- General Merchandise
- Grocery Chains
- Home Electronics
- Sporting Goods
- Parcel Services

Secondary research on the locations of distribution centers and retail stores in Alabama was gathered by a student research team under the guidance of Dr. Berkowtiz. For each sector, students examined industry databases to identify locations, contacts, and facility characteristics. The objective was to provide a detailed spatial analysis of retail shopping in the state's major population centers. Initial data gathered suggested differences in the number and types of retail centers based on population size. After examining the data, the team defined the major population centers as cities with population over 25,000 people. With this focus, data refinements to ensure that all data were being reported consistently became much more manageable.

Alabama retail store locations were identified for each company within the selected industry sectors utilizing a national internet research database, *Reference USA*. This database was selected because the desired data elements appeared to be most accurate and complete of the potential data sources reviewed. Telephone directory listings were used to verify locations. Location data by zip code was gathered to ensure appropriate geographic coverage at the county level. Data collection of retail store locations includes sales volume, number of employees, and contact information.

The location analysis included the following tasks:

- Detailed retail and spatial analysis of the all cities with a population of over 25,000 concentrating on identifying the highest-potential areas for retailing. This was accomplished by investigating the highest spending in the target business categories.
- For those areas identified as having the highest overall potential to support retail, a detailed site-by-site evaluation analysis of locations and numbers of residents in the targeted area was conducted.

- The resulting information provided insight necessary to develop a data gathering survey for both on-site and phone interviews. The survey and analysis of firms in each high-potential area were conducted to determine the specific characteristics about their service operation.

By combining the spatial analysis with the survey analysis, a better assessment of the freight transportation volumes for specific locations was possible and met the objective of finding the highest potential traffic volumes across the industry sectors.

Data on retail stores within a variety of industries were collected and organized by retailer. For each industry, the largest volume producers were selected. The analysis of the retail sales data from *Reference USA* allowed appropriate comparisons. Cities with a population size of at least 25,000 were used to narrow the choices for data collection. This resulted in data on retailers in seventeen cities. Table 2.1 below outlines a sample of the data collected for one of the major electronics retailers, Circuit City.

Table 2.1. Example Table of Circuit City Stores for Alabama

Example Table of Circuit City Stores for Alabama							
Store Name	**Address**	**City**	**St**	**Zip**	**Phone**	**Volume**	**# of Employees**
Circuit City	704 S Quintard Ave	Anniston	AL	36201	(256)238-9709	$10 to $20 Million	60
Circuit City	2000 Riverchase Galleria	Birmingham	AL	35244	(205)823-5566	$2.5 to $5 Million	9
Circuit City	4351 Creekside Ave	Birmingham	AL	35244	(205)989-9321	$10 to $20 Million	60
Circuit City	7720 Ludington Ln	Birmingham	AL	35210	(205)956-8493	$1 to $2.5 Million	5
Circuit City	2821 Montgomery Hwy	Dothan	AL	36303	(334)673-8807		
Circuit City	5900 University Dr NW	Huntsville	AL	35806	(256)722-9425	$20 to $50 Million	100
Circuit City	3725 Airport Blvd	Mobile	AL	36608	(251)460-0421	$20 to $50 Million	70
Circuit City	3987 Eastern Blvd	Montgomery	AL	36116	(334)284-8306	$10 to $20 Million	55
Circuit City	2600 Mcfarland Blvd E	Tuscaloosa	AL	35405	(205)343-9540	$10 to $20 Million	45

In Table 2.2, an excerpt from the distribution center database provides information regarding industry sector, company or distributor, city and county.

Table 2.2. Excerpt from Retail/Wholesale Distribution Centers within Alabama Database

Retail/Wholesale Distribution Centers within Alabama			
Sector Name	Company/Distribution	City	County
Apparel	Dillards	Mobile	Mobile
Apparel	Vanity Fair Brands LP	Monroeville	Monroe
Apparel	Simply Fashions Stores Ltd	Birmingham	Jefferson
Apparel	Children's Place		DeKalb
Apparel	VP Jeanswear LP - Lee Apparel Co.	Holly Pond	Cullman
Apparel	Gerber Childrens Wear	Evergreen	Conecuh
Apparel	Russell Corporation	Montgomery	Montgomery
Auto Parts	Herzog Automotive Parts		Jefferson
Auto Parts	OReilly's	Saraland	Mobile
Auto Parts	Motion Industries -subsidiary of Genuine Parts Company	Birmingham	Jefferson
Auto Parts	CarQuest	Montgomery	Montgomery
Auto Parts	Napa Auto Parts -subsidiary of Genuine Parts Company	Birmingham	Jefferson
Auto Parts	Ace Hardware	Loxley	Baldwin
Magazine/Book Distribution	CR Gibson Company	Florence	Lauderdale
Magazine/Book Distribution	Great News Inc	Phenix City	Russell
Magazine/Book Distribution	American Wholesale Book Co	Florence	Lauderdale
Drugstore	Qualitest Pharmaceuticals - Apax Partners	Huntsville	Madison
Drugstore	UniCare Inc	Prattville	Autagua
Drugstore	Respiratory Distributors	Foley	Baldwin
Drugstore	McKesson Pharmaceuticals	McCalla	Jefferson
Drugstore	Rite Aid	Tuscaloosa	Tuscaloosa
Drugstore	CVS Caremark	Bessemer	Jefferson
Furniture	Badcock WS Corp	Cullman	Cullman
Wholesale Grocery	Osborn Brothers Inc	Gadsden	Etowah
Wholesale Grocery	Merchants Company	Clanton	Chilton
Wholesale Grocery	Alabama Food Group	Alexander City	Tallapoosa
Wholesale Grocery	Petrey Wholesale	Montgomery	Montgomery
Wholesale Grocery	MBM Corporation	Montgomery	Montgomery
Wholesale Grocery	Andalusia Distributing Company	Andalusia	Covington
Wholesale Grocery	Halsey Food Service	Huntsville	Alabama

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2.2 Identification of Shipping Areas (Networks) for distribution centers and Capture Information regarding the size and number of shipments at distribution centers - Tasks 2 & 3

Jeff Thompson served as the lead on these tasks which entailed the identification of Shipping Areas (Networks) for distribution centers and the capture of information regarding the size and number of shipments at distribution centers.

Data gathered from Task 1 was used to design a questionnaire to gather freight transportation data from distribution centers as well as retail store locations. Several of the industry segments supply Alabama retail stores from out-of-state distribution centers.

In this case, phone interviews with local store managers were used to collect transportation network information.

A survey questionnaire was developed to gather the following information about the industry freight transportation networks. (See Figure 2.1 for Sample Survey Questionnaire, complete survey questionnaire available as Appendix A.)

- Address and contact data for store location interviewed or distribution center surveyed
- Whether the center identified ships freight to retail stores
- The geographic region served by the distribution location
- How the company manages their freight transportation function
- Size of the distribution facility in square feet
- Utilization factor on current capacity
- Network visibility from the location
- Expansion plans in the next 5 years
- Value of goods handled in the previous year at this location
- Annual volume change over the past 5 years
- Annual volume change expected 5 years into the future
- The source of inbound shipments (manufacturer, distributor, wholesaler, etc.)
- Seasonality of the operations
- Peak times of day for receipts and shipments
- Inventory turn rate expressed in days
- Percentage of cross docking of inbound freight
- Percentage of volume transported by company owned/leased, common carrier, or a combination
- Number of employees at the location
- Current transportation issues for the company

ID Code: _____

Freight Forward Transportation Survey **UAH – Office for Freight, Logistics and Transportation**

	FILL IN BEFORE VISIT:	**DATE OF SURVEY:** ____/____/_____
1	Company Name:	
2	Street Address:	
3	City	
4	State	
5	Zip	
6	Phone:	
	COMPLETE AT INTERVIEW:	
7	Contact Name:	
8	Contact Title/Position:	
9	Email Address:	
	BEGIN SURVEY QUESTIONS:	

10 Does your company at this location:
Ship products to retail locations within the State of Alabama? YES NO

11 What is the number of stores served from this location: Total Stores: _____
Alabama Stores: _____

12 What geographic region (by state or within AL - by county) does this location/warehouse serve?
All States Served: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
All AL counties served: 1._____ 2._____ 3._____ 4._____ 5._____ 6._____
(Ask for a list of Stores Served)

Note: _____

13 From what other location(s) does your company ship retail goods into State of Alabama?
#1 Location Name/City : _____
#1 Location Contact Name: _____
#1 Location Phone Number: _____

#2 Location of Warehouse # 2: _____
#2 Location Contact Name: _____
#2 Location Phone Number: _____

14 Does your company control the transportation of freight in and out of this facility?
YES NO

15 What is the total square footage at this location?
Square footage: _____

16 What percentage of capacity of this location is being used?
Today (circle one) 1-25% 26-50% 51-75% 76-100%
In Five Years (circle one) 1-25% 26-50% 51-75% 76-100%

Note: _____

Figure 2.1. Example of Freight Forward Survey
Complete Freight Forward Survey – Appendix A

Companies from each industry sector were selected as targets for interviews. The target companies were ranked based on the number of stores, sales volume, and footprint of their stores in Alabama. It was often difficult to reach the distribution center manager. Familiarity with university research by the operation manager increased the chance of securing an interview. Freight transportation data is considered very proprietary by most companies. However, all companies interviewed shared at least some information. The most sensitive data to acquire was the value of shipments and the question was often not answered.

Data gathered from both interviews and secondary research was utilized to draw representative freight transportation networks for:

- Beverage Distributors
- Big Box Centers
- Furniture
- Fuel Distributors
- Pharmacies
- Automobiles
- General Merchandise
- Grocery Chains
- Home Electronics
- Sporting Goods
- Parcel Services

The freight distribution network for each of these sectors has unique characteristics. Individual companies within a sector may have a radically different distribution strategy from their competitors. In fact, freight transportation system design and strategy are often considered competitive advantages. All of the industry sectors have a similar goal of placing merchandise in the retail stores just in time for the consumer selection. Pressure to reduce investments in inventory continues to increase. Therefore, there is no typical or "model" design that can be followed by transportation planners.

Sector Summaries

<u>Beverage Distributors</u>

The beverage distributor industry sector in Alabama is shaped by state law on alcoholic beverages and territory designations for non-alcoholic beverages. However, both types of distributors use a hub and spoke type of network where the finished product is either received from out of state (alcoholic) or bottled (non-alcoholic) at regional locations. A central location receives out of state shipments of raw materials or finished product from manufacturers, distributors, or port container facilities for imports. Then after processing (bottling or repackaging), ship the product to retail stores on trucks with regular, established routes.

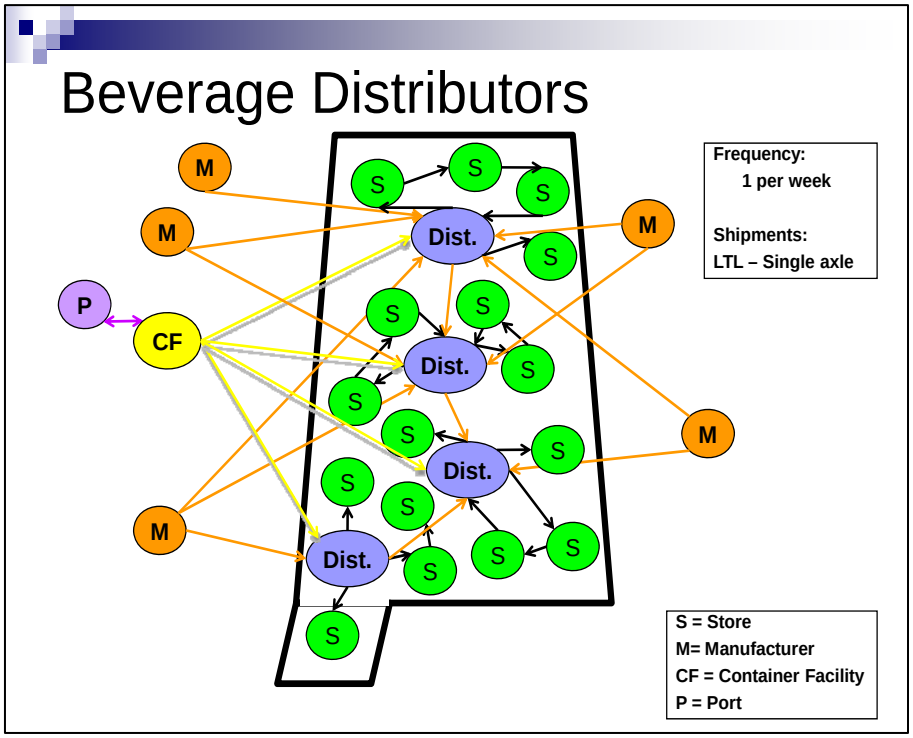

Figure 2.2. Beverage Distributor Network

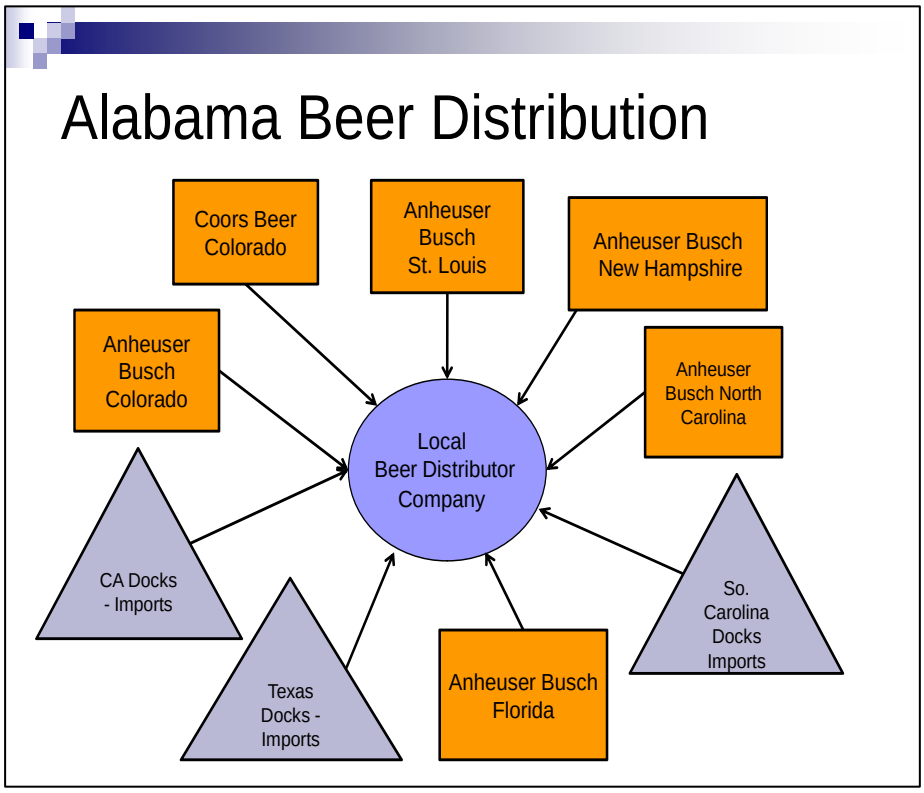

Figure 2.3. Alabama Beer Distribution Network

Big Box Centers

The big box or super center sector in Alabama is configured based on store size and locations which are selected with consideration for population size and density. These centers use a combination of hub and spoke as well as manufacturer delivery to stock their stores. Distribution centers are established where transportation infrastructure will easily support inbound and outbound freight shipments relative to their retail super store locations. Large, bulky items as well as perishable items may be delivered by the manufacturer directly to the retail store. For the majority of the product items, the distribution receives regular shipments from manufacturers, distributors, import container facilities and intermodal facilities. Then outbound truck loads are built for each store on the route. Large centers will receive multiple trucks per day while smaller stores may receive a pallet every few days. Outbound equipment (trailers) may be company owned or leased. Common carriers may be used for less than trailer load shipments across larger geographic areas.

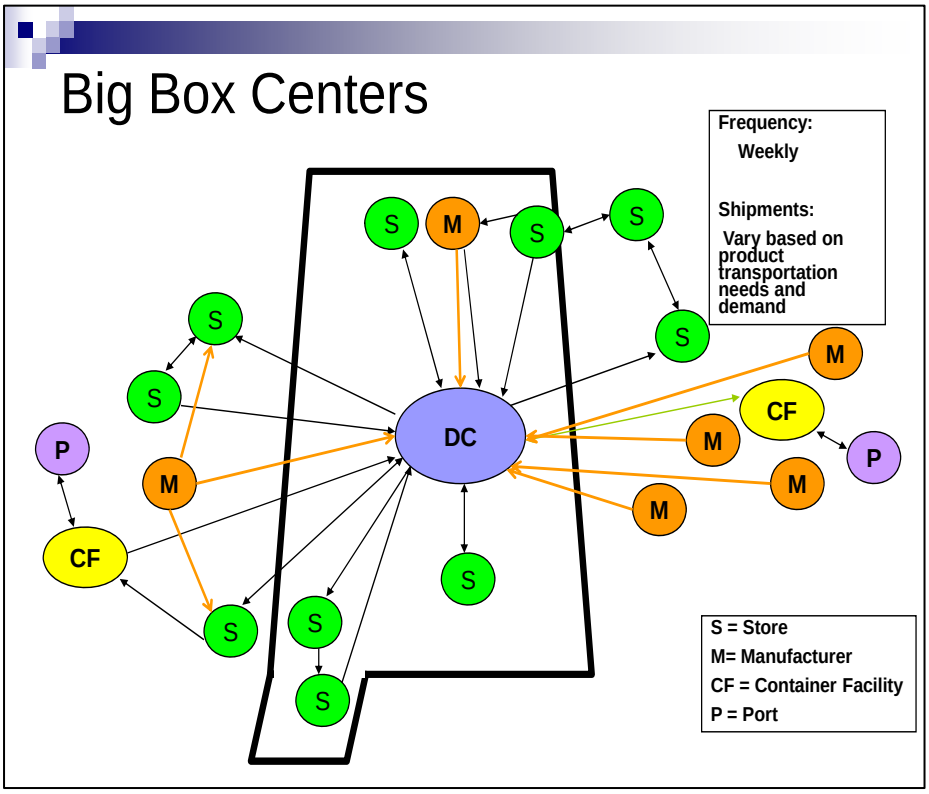

Figure 2.4. Big Box Centers Distribution

Furniture

The furniture industry supply chain has been changing over the past decade. Manufacturing centers in the United States have given way to other parts of North America which are now losing the manufacturing operations to off-shore locations. Although distribution centers and warehouses still exist, their roles in the final demand transportation network are changing from a supplier of retail stores to the delivery of goods to residences and office locations. Furniture stores that carry an inventory are becoming less common as furniture "showrooms" become more popular. The showrooms allow customers to make their selections which are then ordered for delivery to the customer's home. The distribution centers/warehouses are regionally located to serve large geographic areas which may span parts of several states. Manufacturers, distributors, and container facilities ship products to the distribution center. The distribution center takes the products and builds truckloads to be delivered to customers in a geographic region. Of course, product is still delivered to the showrooms from the distribution center as needed for display.

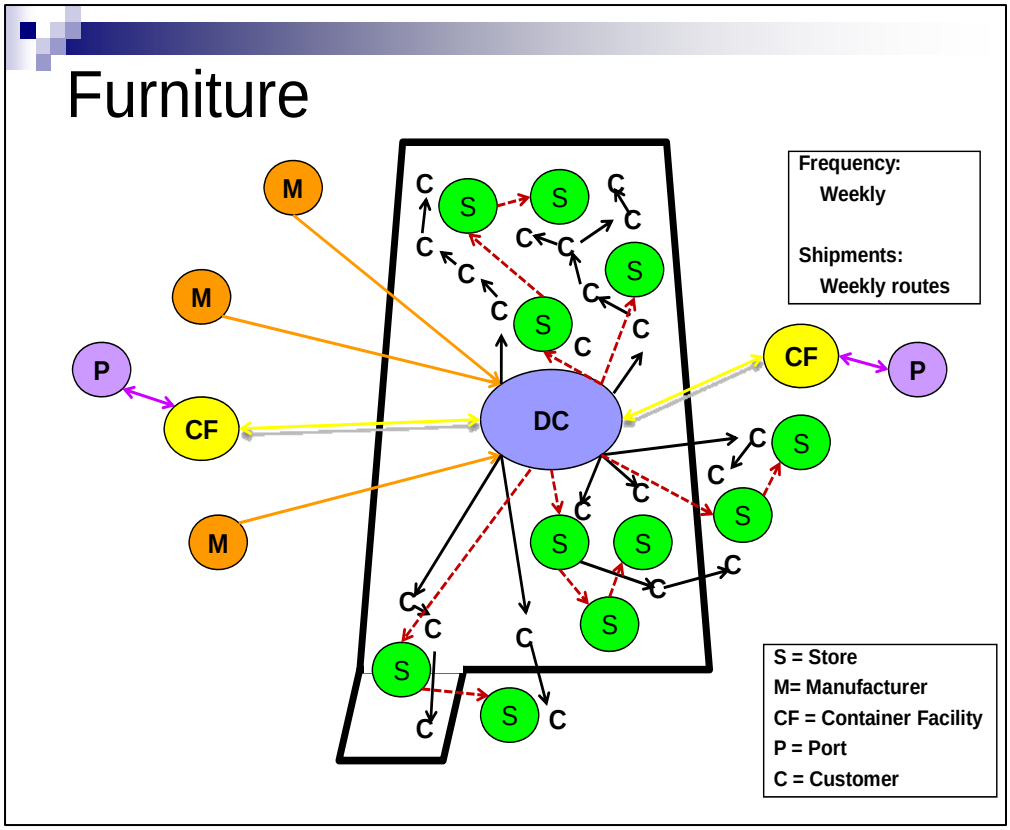

Figure 2.5. Furniture Distribution

Fuel Distributors

Fuel products move through the same hub and spoke design distribution network used for decades. Changes in demand levels have required tweaks to the networks in Alabama but few supply chain links have switched modes since the territorial-based final demand network was established. The supply chain for fuel products (gasoline, diesel, jet fuel, etc.) starts at either a water port or refinery. The product then travels to terminals or tank farms by pipeline. From there, the fuel is trucked to retail stores or customer tanks (e.g., airport) by regional oil companies. Each regional oil company may use a combination of their company trucks or leased carriers, especially in periods of high demand. Much like the furniture supply chain, fuel distributors hold as little fuel in inventory as possible. Instead, customer tanks receive shipments directly from the terminal/tank farms. During times of peak demand, safety stock may be maintained by the oil company. Multiple shipments travel to larger cities and to larger retailers each day.

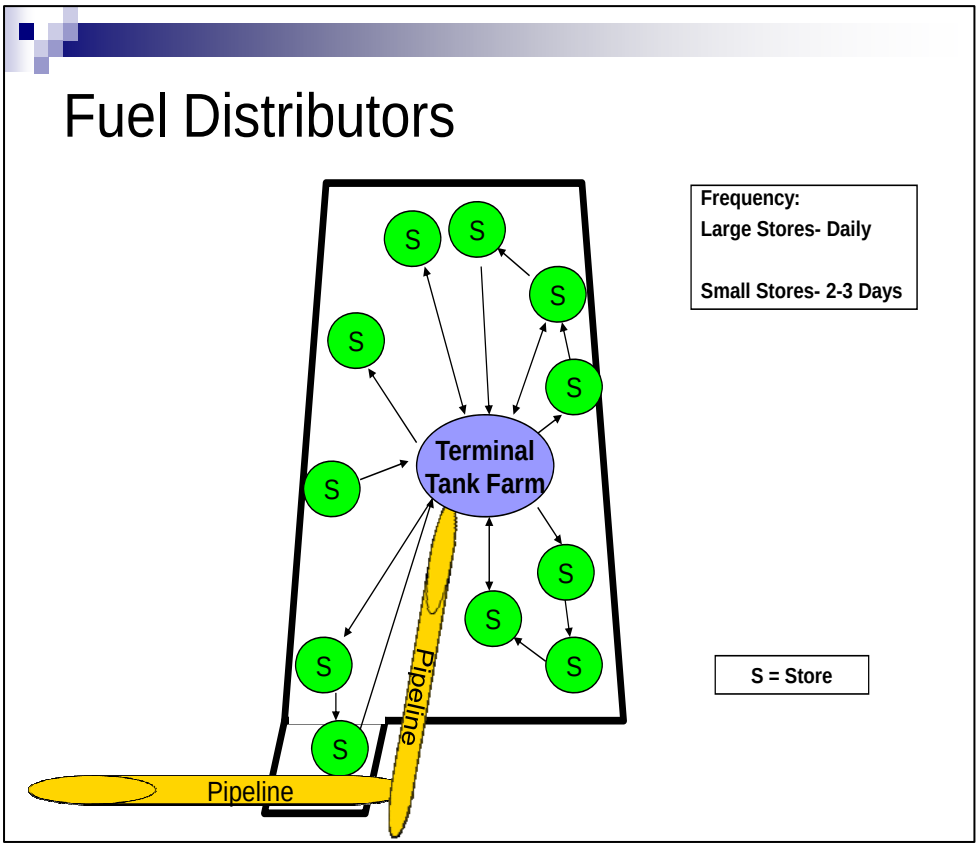

Figure 2.6. Fuel Distribution

Pharmacies

The opening of drug stores continues at a rapid pace. The battle for market share of the drug store chains, grocery chains with pharmacies, and big box retailers with pharmacies has created what seems like pharmacies on every corner. The drug store merchandising plan may cover a very large number of items from food products to hardware to drugs. The transportation plan is segmented by inventory type such as perishable (drugs or food) and staple items. Daily deliveries are made to each store for drugs as well as staple items in most chains. One of the most interesting findings is that one of the companies surveyed uses a third party logistics provider to deliver drugs to each store within a narrow delivery window each day. Parcel services or common carriers may be used to deliver staple products from the distribution centers to the stores on a less than daily schedule. For chains that mostly use their own fleet of trucks or vans, merchandise can be moved between stores or backhauled to the distribution center for return or redistribution. One of the surveyed distribution centers of non-perishable items serves a large geographic area spanning several states and makes direct deliveries to multiple stores several times each week.

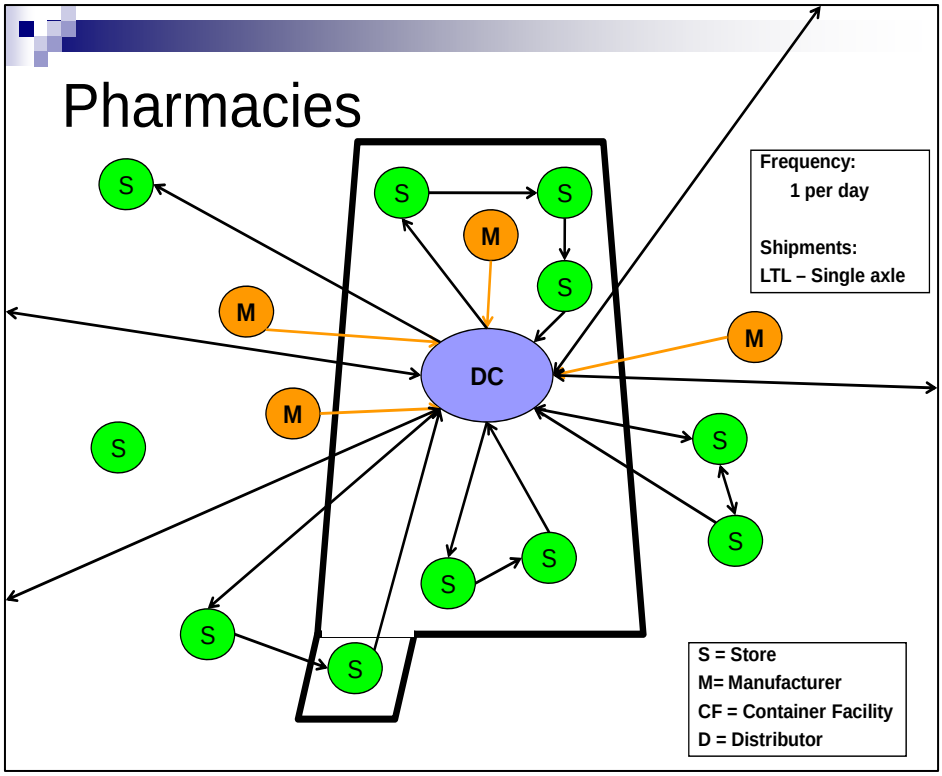

Figure 2.7. Pharmacy Retail Distribution

Autos

The automobile industry sector is one of only a few which use a mode other than trucking to move freight to distribution points. One auto dealer can carry models assembled in the local region, across the country, in Canada, in Mexico and off-shore. Because the origins are so different, regional intermodal yards for autos are created to facilitate shipments to retail dealers. These regional intermodal yards supply multiple states. In Alabama, the supply chain is similar even though there are three assembly plants located in the state. For example, one company assembles two models in Alabama then ships them directly to dealers by truck. Other models by the same manufacturer are shipped from other parts of the country or from water ports. Autos are delivered from the intermodal distribution yard and the assembly plants by truck to Alabama dealers. Specialized common carriers are used by the auto companies to deliver autos. New and used automobiles may be moved between dealers or to auction yards as backhaul freight by the same common carrier delivering new vehicles.

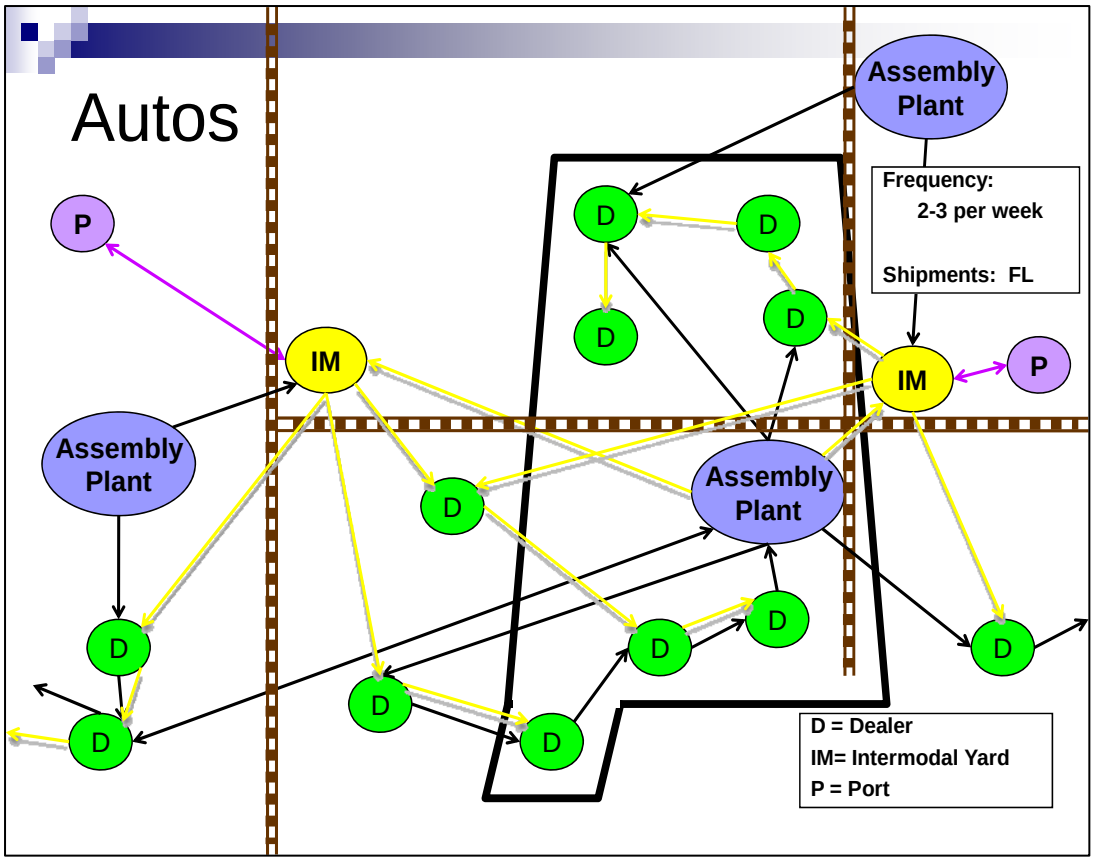

Figure 2.8. Automotive Distribution

General Merchandise

The general merchandise sector includes exclusive department stores to deep discount stores. These stores receive merchandise by company-owned/leased trucks, common carriers, and manufacturer trucks. The marketing strategy of each company significantly influences their transportation network design. Larger chains such as clothing stores that stock a large percentage of their stores with seasonal merchandise are striving to minimize the time required to get products to their stores from the off-shore manufacturers. The result has been the regionalization of distribution centers closer to ports of entry. By eliminating local distribution centers, retail stores can actually receive merchandise several weeks sooner. This reduction in the length of the supply chain allows retailers to enjoy longer periods of premium pricing. Deliveries from the distribution centers are often weekly but daily shipments from manufacturers, distributors, etc., may be received by the store throughout the week. Peak season (Christmas) freight demands are met by using more common carriers or leased trucks. Chains with many stores in geographic regions use a route design to load merchandise at manufacturers, distribution centers, and container processing facilities locations close to the regular routes. In some cases, a fully loaded truck leaves the distribution center once per week to their regular route of stores several states away and does not return to the distribution center until the next week. The truck moves freight between stores as well as picks up freight at manufacturers, ports, etc. to deliver to the distribution center on their return.

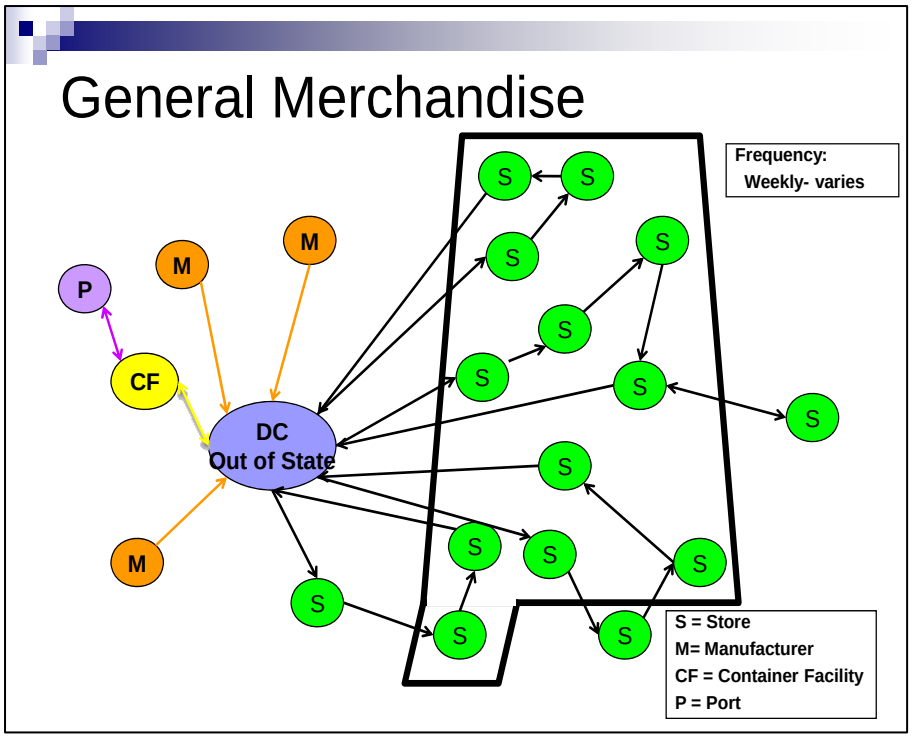

Figure 2.9. General Merchandise Distribution

Grocery Chains

Grocery store chains handle their freight similar to the super centers and drug stores. In fact, some may argue that the grocery store industry designed the transportation networks which have been adapted by the super centers, general merchandisers, drug stores and others. Grocery store chains have more segments of inventory as well as inventory managed by vendors. In broad terms, the sectors may be perishables, staples, and vendor managed inventory. The demand cycles and shopping habits of customers drive the delivery schedule for all of these items. The more frequently sold items like bread and milk, are delivered at least once each day while other perishable items like produce may be delivered one or two times per week. Vendor managed inventory such as soft drinks, beer, and snack food are delivered several times per week by a vendor representative. Additionally, local producers and growers may deliver items directly to the store. Grocery chain distribution centers are utilized to assemble products into shipments of the staple items not managed by vendors or delivered directly by manufacturers for each store. However, manufacturers that directly deliver to stores also deliver products to distribution centers which then ships small quantities to stores in their service region. The goals of maximizing freshness while minimizing transportation costs require a sophisticated logistics capability for grocery chains to be successful.

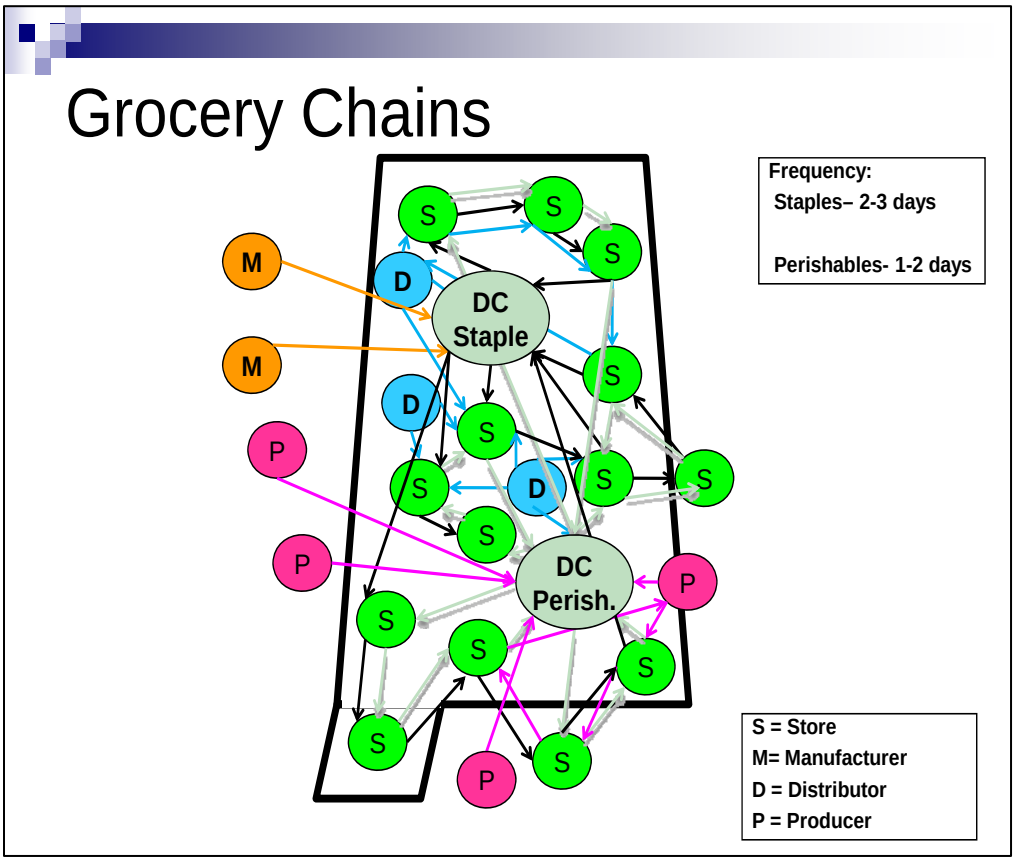

Figure 2.10. Grocery Chain Retail Distribution

Home Electronics

Home electronics and entertainment stores have also changed over the past couple of decades. The distribution strategy by major retailers of these products has shifted from the department stores to "big box" stores which specialize in home electronics and/or entertainment, especially in larger cities. With the emergence of these big box stores, regional distribution centers now supply stores in multiple states. The distribution centers supplying Alabama stores may be located two or three states away but shipments are delivered at each store several times each week, especially during peak (Christmas) season. Companies frequently own or lease the trucks on regular routes. Of course, manufacturers may deliver to both distribution centers and retail stores but the largest volume of these items come from offshore through a water or air port of entry. Container processing facilities can supply both the distribution center as well as retail stores. As with the fashion-based retailers, home electronics chains compete to be the "first" to offer or to have the "most" new products in order to capture market share. While inventory is carried at distribution centers, it is turned as frequently as possible. Build-up of inventory for peak season (Christmas) is sometimes necessary to meet anticipated seasonal demand. Freight is also moved between stores or backhauled to the distribution centers most often in company owned vehicles. Stores exclusively using common carriers or parcel services to ship freight to stores often will drastically mark down merchandise rather than pay to ship it to another store or the distribution warehouse.

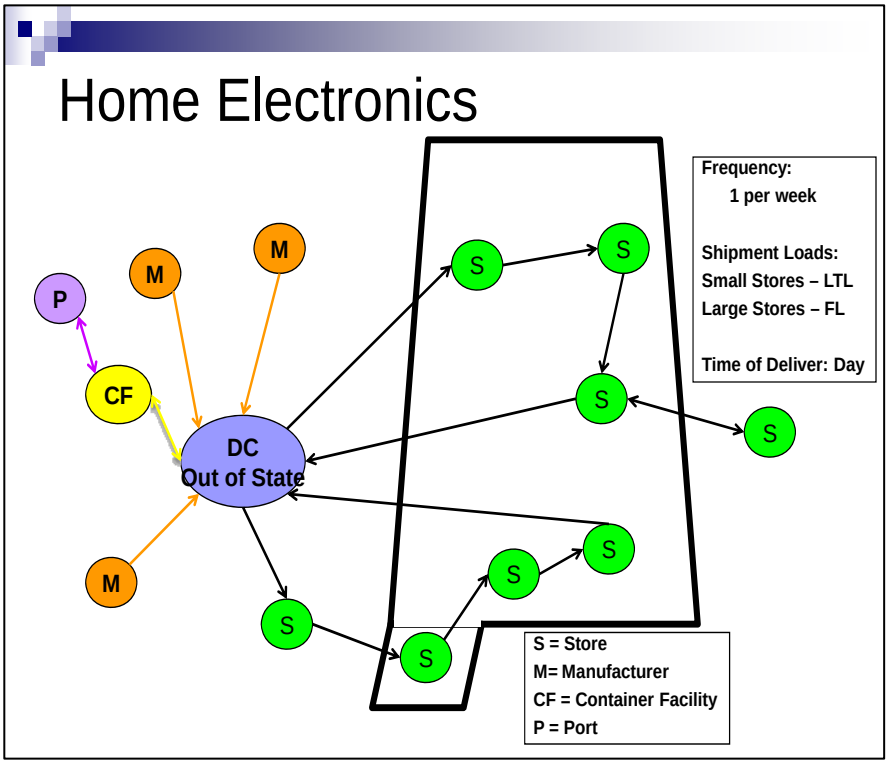

Figure 2.11. Home Electronics Retail Distribution

Sporting Goods

The sporting goods industry is similar to the home electronics industry sector in transportation network design except there is significantly more regional and seasonal adaptation of product lines in the retail stores. Seasonality is largely influenced by the seasons of major sports like football, baseball, basketball, soccer, etc. rather than simply a Christmas rush. However, sporting goods chains rely heavily on their distribution center(s) to serve very large regions of or the entire continental United States. Manufacturers deliver truckloads of product while common carriers deliver less than truck loads to the distribution center. Much of the inventory is imported through container ports with the transportation to the distribution center managed by the manufacturer. Product is then redistributed onto pallets or tubs which will be delivered to each store. Inventory usually remains in the distribution centers for no more than one week as weekly deliveries are made to each retail store. Seasonal peaks may require additional inventory but because of the geographic differences in sport seasons and products, i.e. hockey equipment is sold mostly in the colder climates, sporting goods stores are able to use smaller distribution centers to serve very large geographic areas.

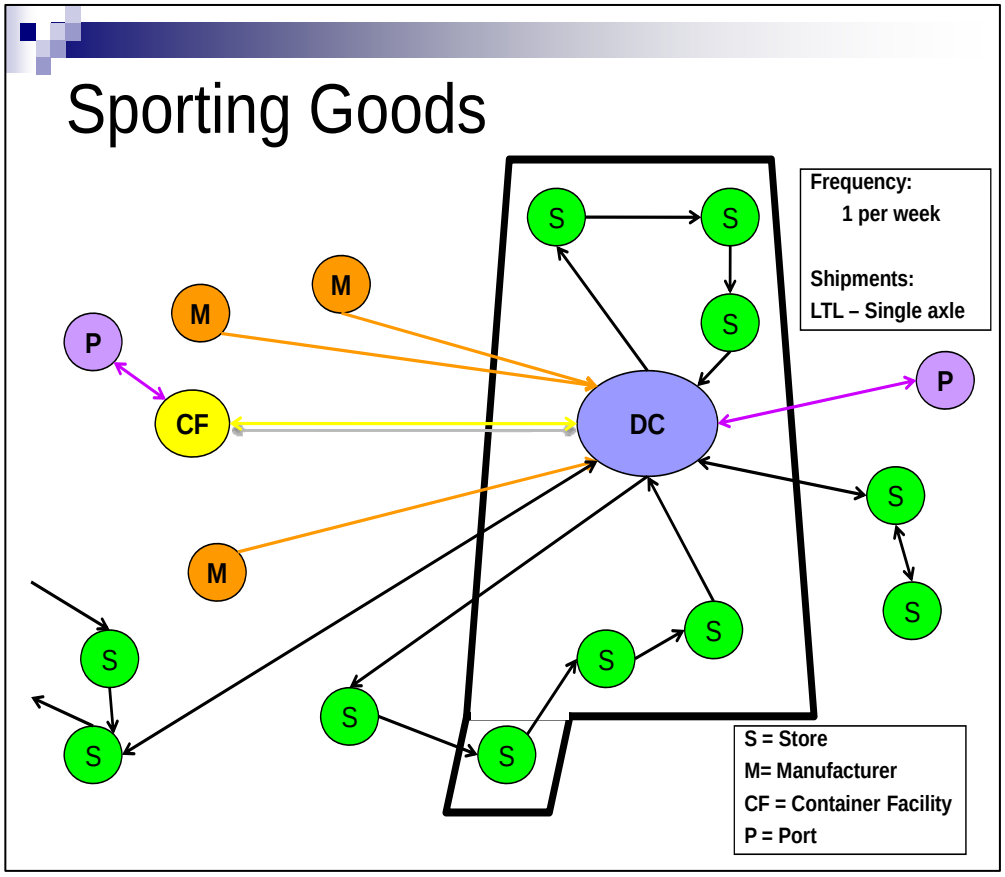

Figure 2.12. Sporting Goods Retail Distribution

Parcel Services

The parcel shipping services industry was redefined by Federal Express many years ago. Services have expanded from next day delivery specialization to ground freight to third party logistics. The parcel service companies consider their freight handling network to be a major competitive strategy that is to be protected and managed constantly. Because of the competitive nature of these companies, detailed information about their transportation network is very difficult to obtain. However by using secondary research coupled with telephone interviews, this very complex transportation network can be approximated to understand better an extremely important sector in the movement of final demand freight. By separating the inbound and outbound shipments to/from Alabama, it is easier to see how freight moves from source to destination.

Inbound freight can come into Alabama from many directions. Regional logistics hubs across the country provide links to local centers which send delivery trucks to businesses and residences. These logistics hubs may do routing of freight destined for areas within their regions without going through a major processing center. Shipments arrive at the logistics hubs from the processing center and other logistics hubs. For inbound freight, logistics hubs serve as connection points to the company's transportation network. From these connections, freight is loaded onto trucks running regular daily routes for delivery to the logistics hub and/or processing centers. Companies own and lease equipment (trucks, trailers, planes, etc.) as well as hire other carriers to move less than full load freight such as on international cargo flights. Local vans deliver the packages to customer locations (business and residence) on at least daily routes. Some routes may be run two or more times per day depending on volume and business density.

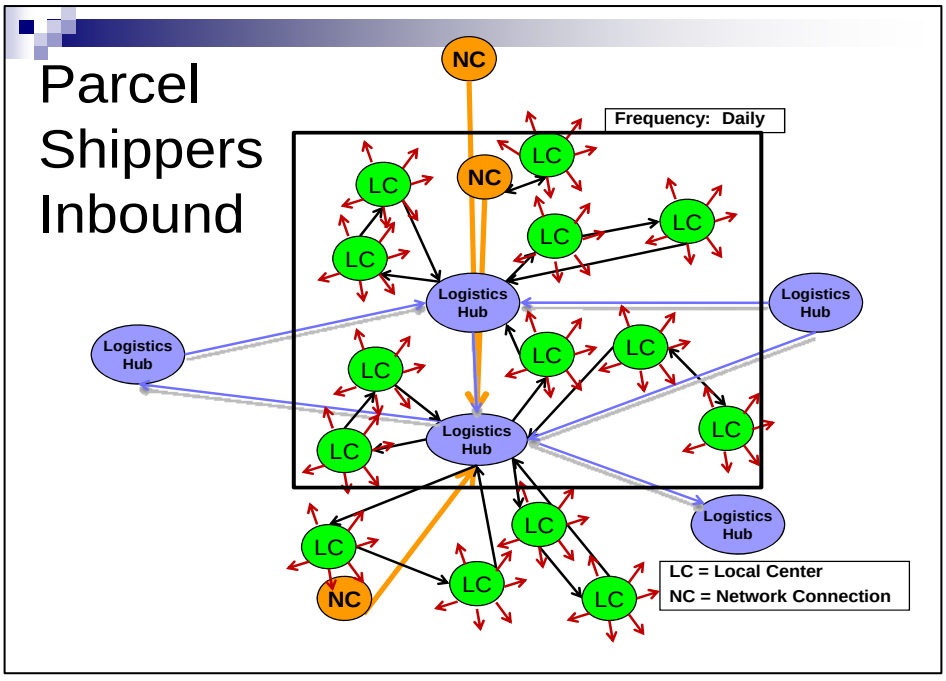

Figure 2.13. Parcel Shippers Inbound Distribution

Outbound freight leaves Alabama in a manner somewhat different than a simple reversal of the inbound network. For outbound freight, pickups are scheduled by the company or customers bring their shipments to the local center throughout the business day. The outbound freight is then sent to logistics hubs which become network collection points. These logistics hubs then separate freight into local zones and non-local zones as well as by package size/weight. Freight that is destined for zones in the local region is sent to the appropriate logistics hub by truck. Freight that exceeds size or weight limits for normal processing is handled through established truck routes between logistics hubs and/or the processing center(s). The overnight and normal size packages are collected at an airport serving the region (one state, multiple states, or partial states) and flown to the designated processing center each night. Network connections used for inbound freight may not be on the outbound freight network at all. This process repeats every business day around the world for major parcel shippers.

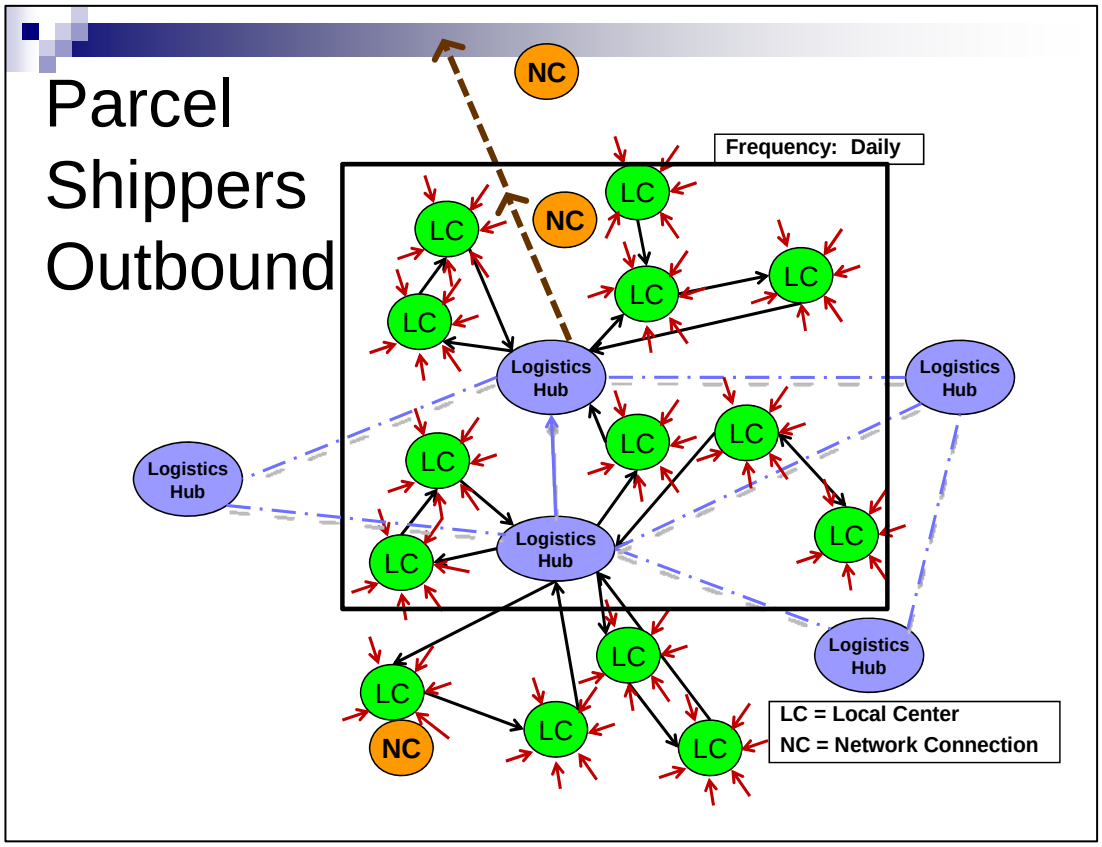

Figure 2.14. Parcel Shippers Outbound Distribution

In summary, each industry sector may have multiple transportation network designs built or adapted by individual companies. In almost all cases, transportation efficiency is measured in terms of total cost as well as elapsed-time. Companies that manage their freight transportation and logistics operations best usually have a competitive advantage over other companies. The growing global supply chain is changing the role of distribution centers and in many cases changing the routing of goods to their retail stores.

2.3 Create a methodology to identify destinations for distribution centers using an industry database - Task 4

Jeff Thompson served as the lead for this task which was to create a methodology to identify destinations for distribution centers using an industry database. The original intent of this task was to use input from distribution center surveys conducted in Task 2 & 3 to build a database by type of industry sector. This information would then be used to improve projections of freight transportation volumes. As the surveys were conducted, it became very clear that there were few, if any common, characteristics for distribution centers even within industry sectors. In other situations, obtaining information from the distribution centers serving Alabama was not possible due to either proprietary issues by the companies or due to their distant location. However, seven characteristics emerged which may be helpful in better representing final demand freight in transportation forecasting models. The characteristics are identified in the listings below:

- Type of Network
- Primary Mode Choice
- Type of Management the Transportation Network
- Origin of Distribution Center Freight
- Destination of Final Demand Freight
- How Freight Shipments are Built
- Whether Back Haul of Freight is Common
- Frequency of Shipment Delivery to the Retail Stores

Network type typically fell into one of two categories: hub and spoke or route-based. There were, however, some sectors that employed a combination of the two. In these cases, the type used most in their network design is identified in the Distribution Center Freight Networks summary table below. Five of the sectors predominately used a hub and spoke design with their distribution center being the hub. Six of the sectors sampled largely used a route-based network to move freight from one or more points of origin.

The primary transportation mode of choice for all final demand freight is by truck. A few sectors rely heavily on rail or air to move freight to or from their distribution centers. The final leg of the shipment to retail stores is always by truck or van. One surprising observation was that tractor trailers are now being frequently used to make deliveries to retail stores even for very small stores that always received less than trailer loads.

The type of management strategy used by companies varies for many reasons such as industry custom, proximity to shipment origins, growing product imports, and time efficiency. Companies may own or lease a fleet of trucks, rely on common carriers, insist on manufacturer delivery to their dock, or hire third party logistics providers to handle freight. Intermodal container processing centers are important links in retail supply chains as more products are imported.

Table 2.3. Distribution Center Freight Networks by Sector

Distribution Center Freight Networks

Industry Sector	Network Type	Primary Mode Choice	Manage-ment Type	Dist. Ctr. Freight Origin *	Freight Destination	Shipment Build	Back Haul	Frequency
Beverage Distributors	Hub	Truck	Manufac.	M,D,CF	Retail Store	Product Group	n/a	Weekly
Big Box Centers	Hub	Truck	Own/ Lease	M,D,CF, IM	Retail Store	Product Group	n/a	Weekly
Furniture	Hub	Truck	Own/ Lease	M,D,CF	Residence	Geography	n/a	Weekly
Fuel Distributors	Hub	Truck	Multi	Terminal	Retail Store	Product Group	n/a	1-2 Days
Pharmacies	Hub	Truck	CC, 3PL	M,D	Retail Store	Product Group	Stock	Daily
Automobiles	Route	Truck/Rail	Carrier	M,IM	Retail Dealer	Product Group	Stock	2-3 Weekly
General Merchandise	Route	Truck	Own/ Lease	M,D,CF	Retail Store	By Store	Stock	Weekly
Grocery Chains	Route	Truck	Manufac.	M,D,W	Retail Store	Product Group	n/a	1-3 Days
Home Electronics	Route	Truck	Own/ Lease	M,D,CF	Retail Store	By Store	Stock	Weekly
Sporting Goods	Route	Truck	Own/ Lease	M,D,CF	Retail Store	By Store	Stock	1-2 Weekly
Parcel Services	Route	Truck/Air	Own/ Lease	n/a	Residence	Route	Outbound	Daily

*M=Manufacturer D=Distributor, CF=Container Facility, IM=Intermodal, W=Warehouse

Inbound freight to distribution centers can originate at manufacturers, distributors, container processing centers and intermodal facilities. Geographic location expressed in units of time rather than distance greatly influences how shipments arrive at distribution centers. Additionally, the goal of shortening the supply chain to the retail store as well as reducing inventory levels significantly influence the scheduling of receipts and outbound shipments at distribution centers.

Freight destination was an unexpected characteristic in that the distribution centers are no longer only supplying retail stores but increasingly fill orders delivered directly to the customer. The furniture sector appears to be a leader in using this model outside of the parcel services companies.

Shipments from distribution centers are built by store or by product group. The products handled at some distribution centers are segmented based on the product handling requirements as well as regional territories. These roles may be defined differently by each company even within the same sector.

The type of freight moved in distribution center backhaul legs was found to include not only company inventory but also inbound freight from manufacturers/distributors. Each company or freight transportation provider seeks to minimize unused trailer capacity on each leg of their routes. Empties are seen as very costly as well as opportunities to expand the capacity of a network.

Deliveries to retail stores appear to be increasingly more frequently with smaller less-than- trailer loads even as routes are growing longer. Restrictions on the time of day that deliveries can be made to retail stores are even more important as larger trucks are used for relatively small shipments. However, frequency of delivery is more uniform across industry sectors with a few shipments from the distribution center each week being the norm. This frequency appears to be a requirement in the design of distribution networks by most transportation network managers.

2.4 Create a methodology to project final demand in Alabama by destinations - Task 5

Niles Schoening, Ph.D., served as the lead for this task which entails the creation of a methodology to project final demand in Alabama by county. A basic assumption was made which is that final demand freight is a function of local consumer demand. The challenge became one of identifying one or more factors that could represent consumer demand at the county level that were collected often and originated from a reliable source.

Demand variables of population size, personal income and a combination of population & personal income were analyzed through the transportation forecasting model. The population size alone skewed the freight too heavily to major cities while somewhat ignoring consumer demand in the rural parts of the state. Population & personal income together likewise appeared to centralize freight too heavily in high density areas of the state. Personal income alone, while not perfect, correlated better with expected final demand freight distribution across the state. Regional differences in personal income exist but to a lesser degree than population differences.

Using the industry sector distribution center surveys as representative of the entire sector was not feasible due the wide variation of freight transportation networks within industry sectors. Instead, Alabama data was extracted from the FAF2 database and then allocated to freight analysis zones, determined by cluster analysis approach by the research team. The freight in each zone was allocated to each of the counties in the zone based on its personal income level.

In Figure 2.15 below, a map of Alabama highlights the distribution level of personal income by county in 2006.

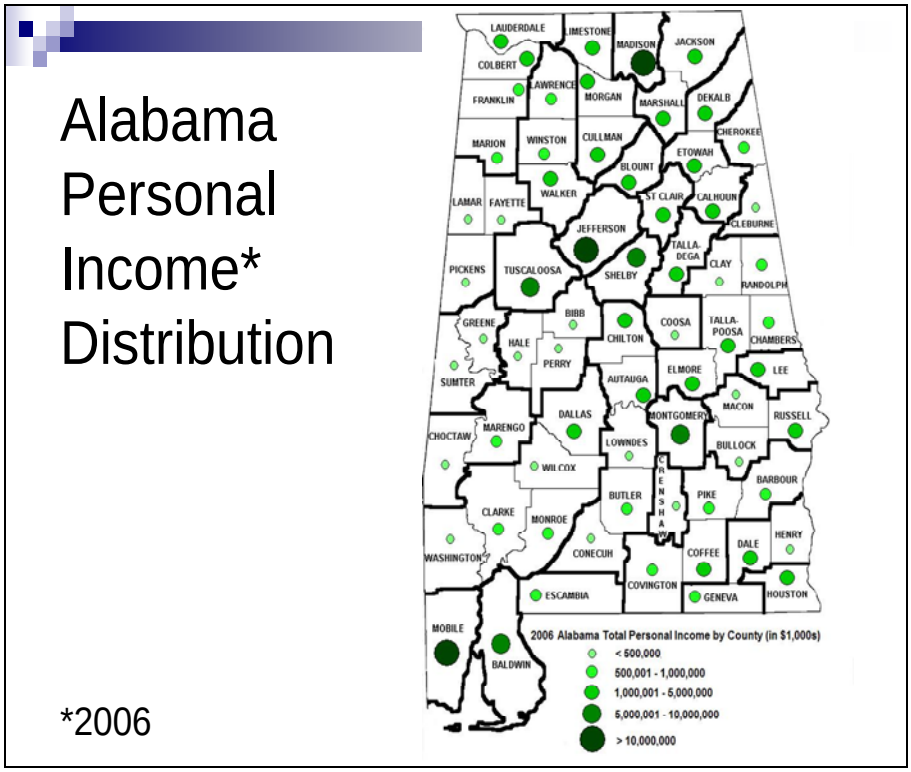

Figure 2.15. Alabama Income Distribution by County for 2006

The multi-step process of allocating shipments first to freight zones and then to counties produced reasonable results that can be repeated as final demand freight volumes change and/or personal income levels change. Personal Income is estimated and projected in a number of third party economic forecasts models each year.

A major challenge with this approach is that retail centers for multiple county regions may not get a larger share of the freight shipments than the surrounding counties where there are relatively fewer retail stores but higher personal income. Examples of this can be seen in the relationship between Jefferson and Shelby counties as well as between Baldwin and Mobile counties. Since the personal income is calculated based on place of residence, refinements to the personal income factors need to be evaluated.

2.5 Future Enhancement Opportunities

There are a number of alternatives and/or enhancements to the approach developed which may improve forecasting of final demand freight at the local level. These include: (1) more localized (e.g., metropolitan statistical area or county level) economic forecasting instead of relying on state-level economic forecasts for growth, (2) using a larger sample size for the industry sectors, (3) estimating economic impacts of new and future economic development announcements, and (4) better understanding the impact of improved commuter transportation infrastructure on retail shopping behavior. These and other enhancements should be analyzed in future research on forecasting final demand freight.

3. Pass-through Freight Modeling

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 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).

This section of the report focuses on the development of tools and procedures to utilize the Federal Highway Administrations (FHWA) Freight Analysis Framework, Version 2 (FAF2) database to forecast and model pass-through freight. The tools and procedures will be designed and built using national, statewide and local levels for analysis. This chapter first presents work performed to determine pass-through freight for the entire state using a national level approach. The chapter then focuses on the development of a statewide freight flow model for Alabama that can then bring the pass-through to the local level. Finally, this chapter concludes with an analysis of pass-through freight at the MPO level.

3.1 FAF2 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 (Table 3.1) and mode of transportation (Table 3.2) 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 3.1. Listing of commodities on FAF2 database (5)

BTS/Census Full Commodity Name	FAF Abbreviation
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

Table 3.1. Listing of commodities on FAF2 database (5) - Continued

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.

Table 3.1. Listing of commodities on FAF2 database (5) - Continued

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

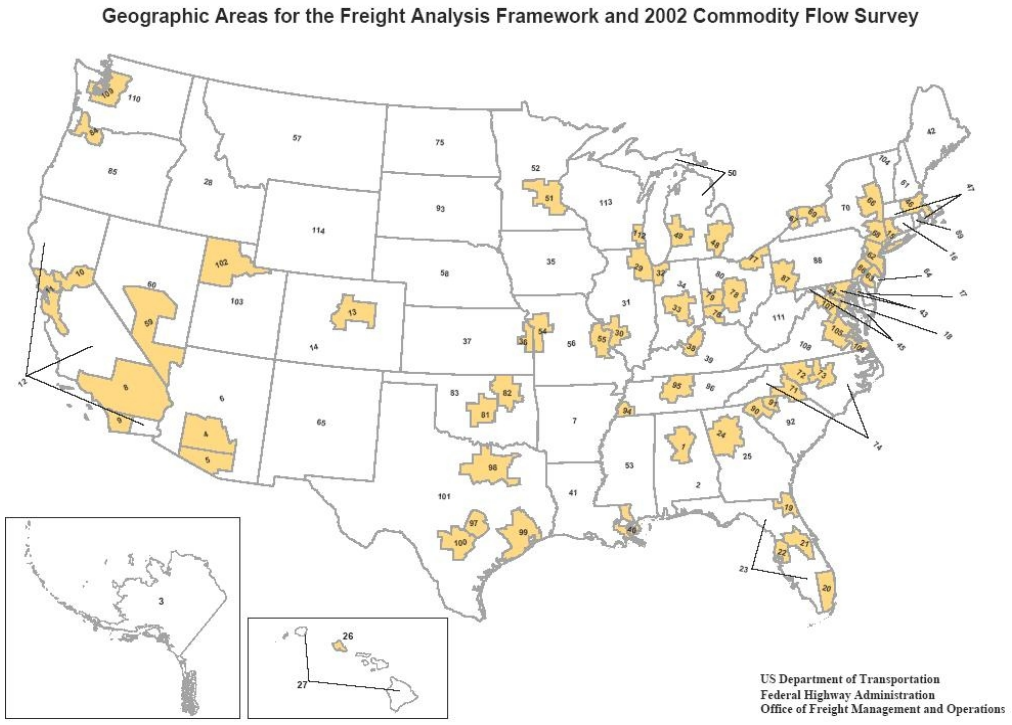

Figure 3.1. Geographic locations for FAF2 data (6)

Table 3.2. Listing of Transportation Modes from FAF2 (6)

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.

3.2 Statewide Pass-Through

The initial level of analysis undertaken in this work was to focus on the statewide level of national pass through freight. This freight was essentially comprised of those movements where Alabama was in the unfortunate position of being between origin-destination locations, but the freight activity in no way was primary to Alabama. An example of this freight pass-trough would be freight traveling from South Carolina to Louisiana. Alabama in not primary to this freight movement, however, this freight movement would impact travelers in Alabama and consume roadway capacity within the state and MPOs.

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.

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 (Figure 3.1) 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).

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.

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.

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. Data from the National Model is located in Appendix B.

3.2.1 Statewide Alabama Pass-through

To demonstrate the application of the methodology, an analysis of the external-external (pass through) 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.

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 3.2. From this data, the Interstate routes were highlighted and used to create a national network to connect the zones defined in the FAF2 database (Figure 3.3). 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.

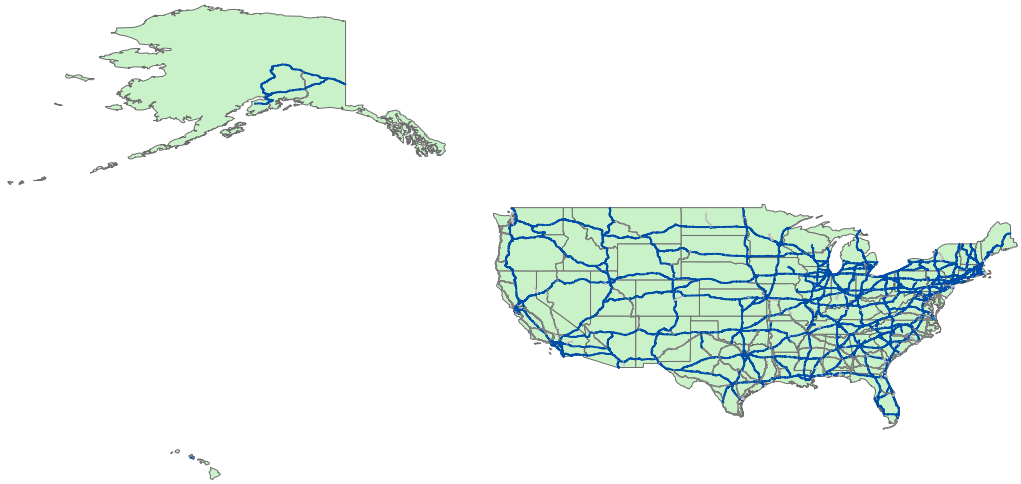

Figure 3.2. Roadway infrastructure from FAF2

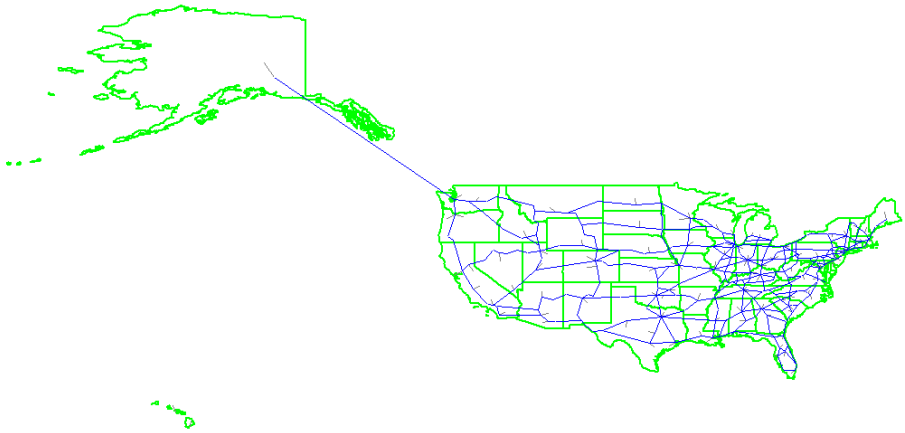

Figure 3.3. National Network in CUBE-TRANPLAN format

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.

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 3.4 presents the shortest paths from Zone 21 – Orlando, FL to all other zones, if the shortest path crosses through Alabama.

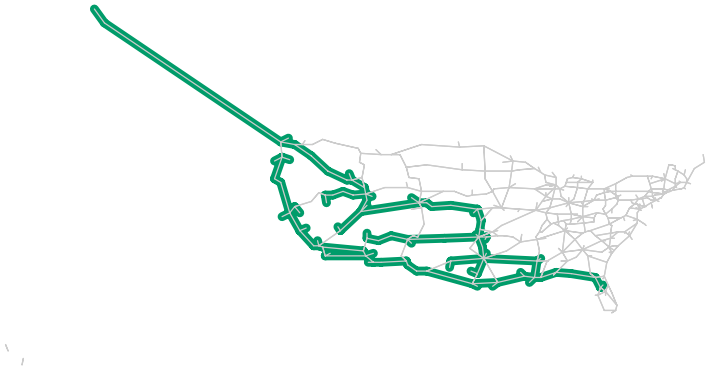

Figure 3.4. Shortest path from Zone 21 through Alabama

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.

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 planner could use the FAF2 data for either 'Kilotons' or 'Millions of Dollar Shipped'. 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 3.5.

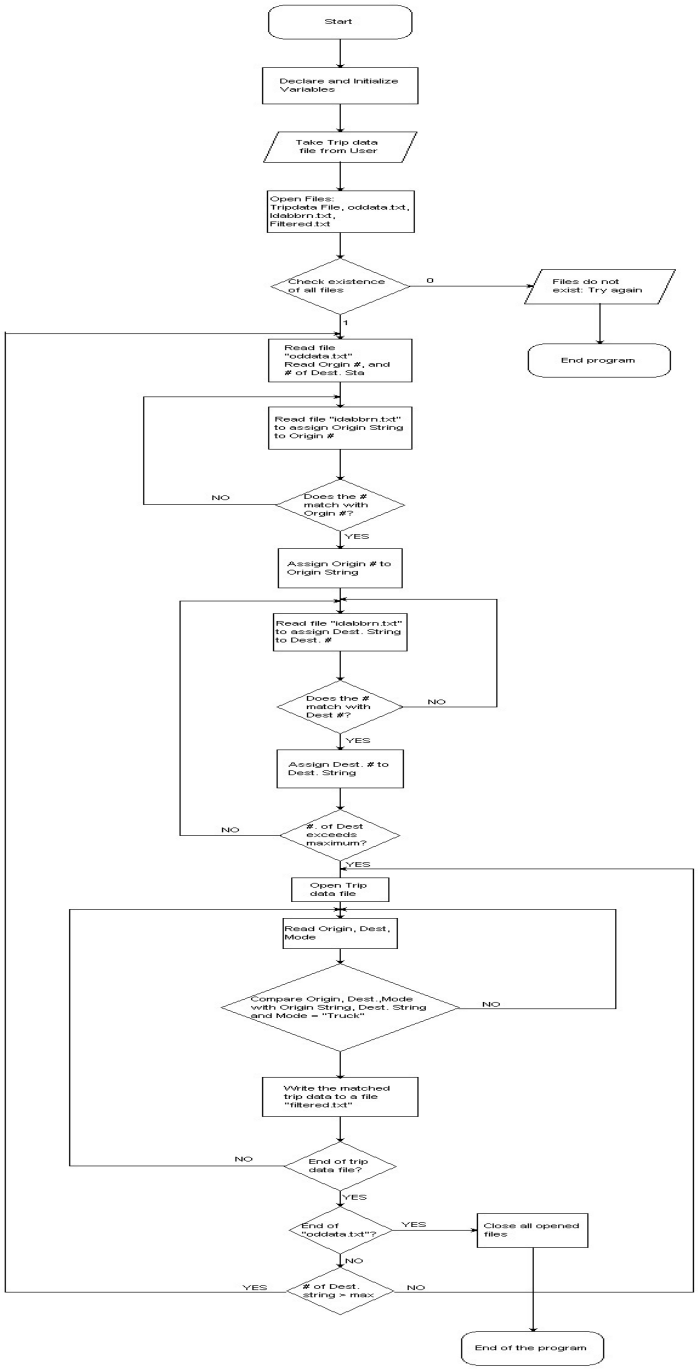

Figure 3.5. Flowchart of the FAF2 Data Extraction Program
Enlarged copy of Flowchart located in Appendix C

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.

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 3.6 illustrates two commodities assigned to the national network that pass through Alabama.

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.

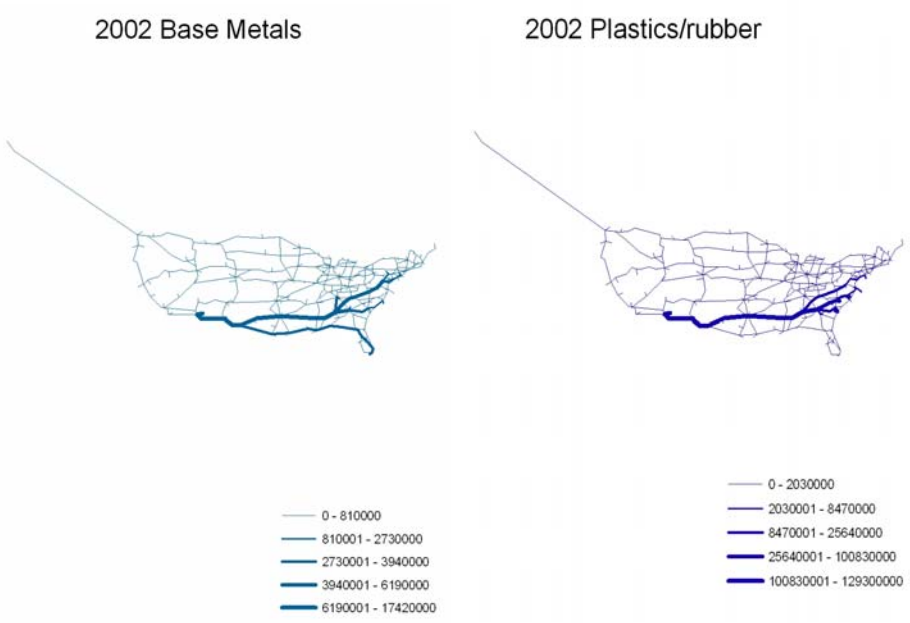

Figure 3.6. Assigned value of kilotons passing through Alabama

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 3.7 shows the flow from the FAF2 database of all kilotons moved across the Alabama state lines.

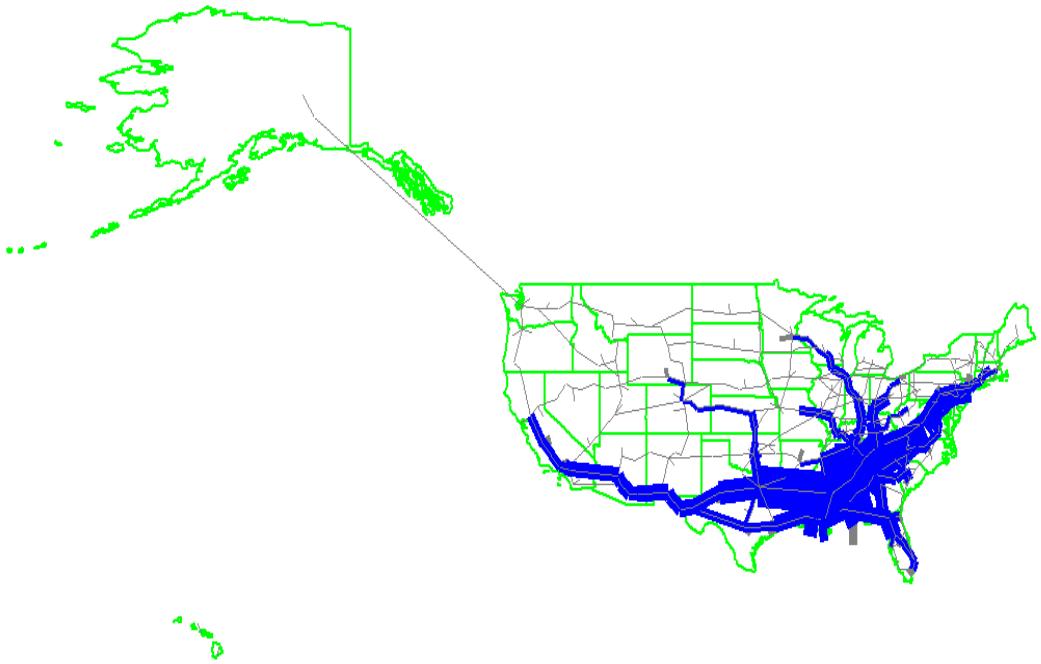

Figure 3.7. Kilotons of freight moved from, destine to, or through Alabama

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 3.3 presents the number of trucks per day reported by ALDOT crossing the Alabama state line. Table 3.3 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 are 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 3.3. 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

The application of the methodology for statewide modeling of pass-through freight is evident thought the use of the forecasted volumes from the FAF2 database. Using the forecasts included with the database and the national networks developed as part of this research, it was possible to obtain a level of pass through freight expected on each major interstate roadway in Alabama for any year in the FAF2 database, year 2010 and 2035 are shown. Additionally, the volume of pass-through freight can be shown for each year, assuming a value of 16 tons per truck. It is important to note at this point that the successive values for increases in pass-through freight are adjusted for the addition of Interstate 22, scheduled to be completed between the 2010 and 2015 forecast.

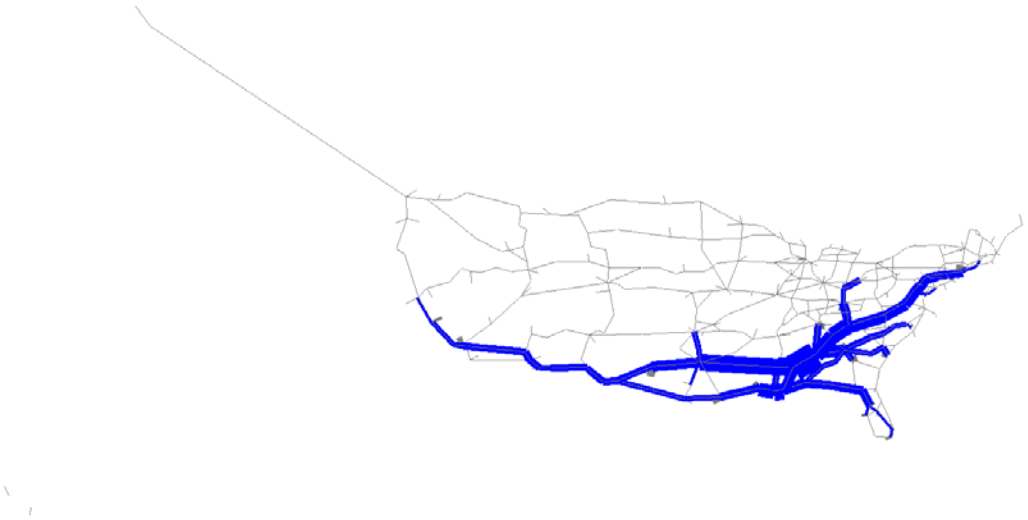

Figure 3.8. Pass-through freight for 2010

Figure 3.9. Pass-through freight for 2035

The number of trucks can be determined for specific MPOs, located on interstate facilities, from this analysis. For example, the Montgomery MPO will have to plan for almost 1,650 trucks passing through the study area between Interstate 85 to Interstate 65 in downtown Montgomery. This is not including the amount of trucks that will be on the interstate associated with trips that originate/terminate within Alabama.

Table 3.4. Volume and expected number of pass-through trucks statewide

Year	Trucks
2010	18,258
2015	20,071
2020	22,485
2025	25,799
2030	30,151
2035	35,554

Additionally, the FAF2 data can be used to evaluate the pass-through truck volumes resulting from the port of Mobile on the state and MPOs within the state. Through modeling the port facility separately, it can be seen that there is significant volume of freight moving by truck that is destine for locations outside Alabama and freight is generated outside Alabama destine for the Port of Mobile. The following Figure 3.10 outlines this freight.

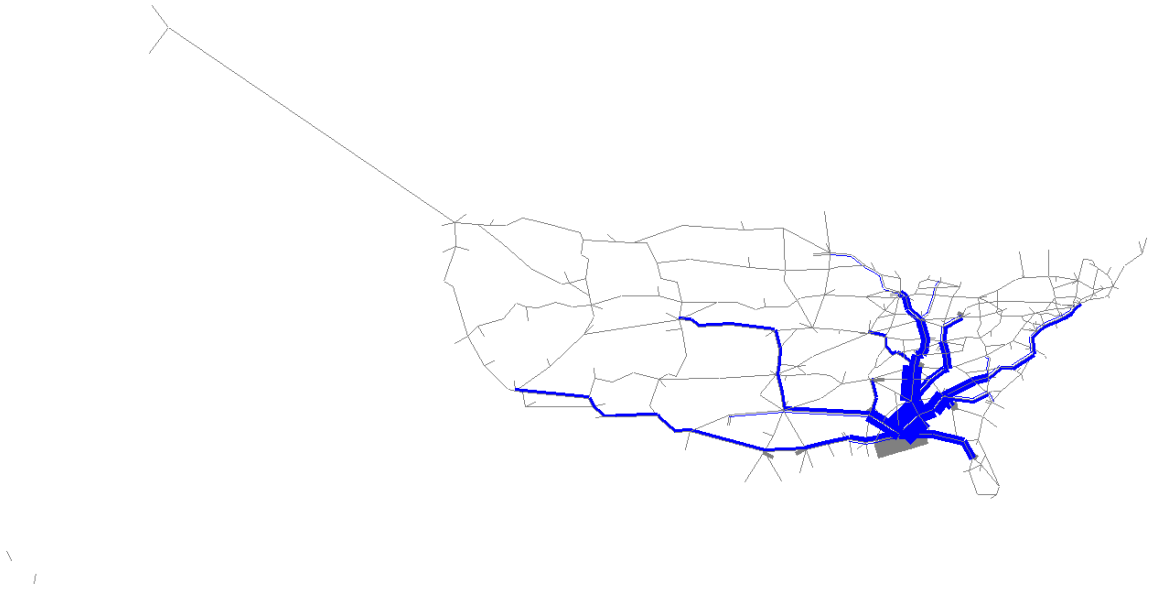

Figure 3.10. Port of Mobile impact on pass-through freight 2010

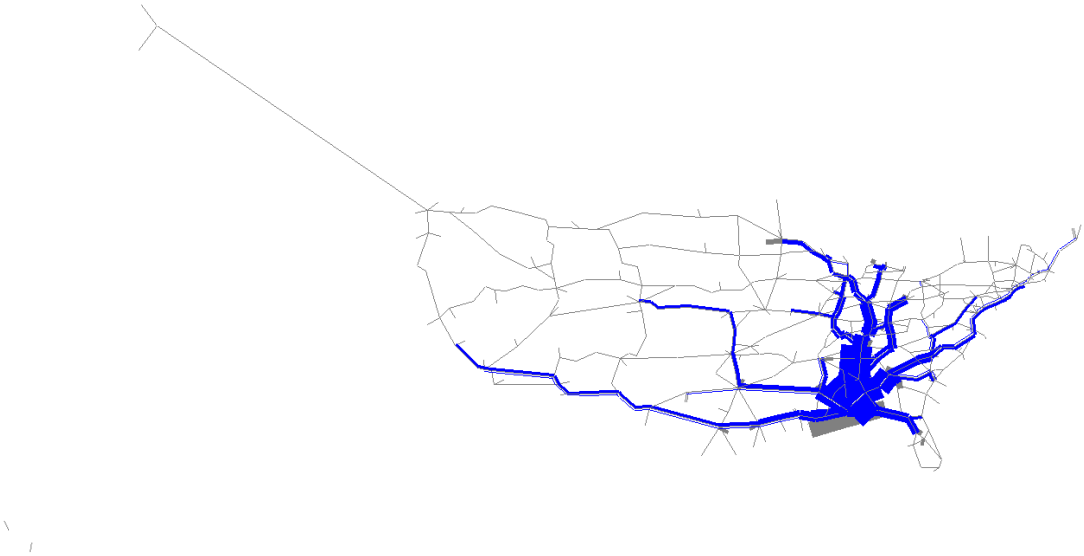

Figure 3.11. Port of Mobile impact on pass-through freight 2035

Examining the volumes passing-through the Montgomery MPO from the Port of Mobile, in 2010 the number of daily truck passing through Montgomery on Interstate 65 is 168 trucks per day and the number of daily trucks passing through Montgomery using Interstate 85 and Interstate 65 is 118 trucks per day. In 2035, the number of truck per day on Interstate 65 passing through Montgomery increases to 304 and the number of trucks

per day on Interstate 85 and Interstate 65 is 190. Again, these trucks need to be accommodated in the planning process, but are not under the control of the local MPO.

The methodology presented in this section of chapter 3 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.

3.3 Local Pass-through from a Statewide Model

After looking at the national model for determining the amount of pass-through trucks that would be present simply because Alabama on the shortest path between origin/destination, the next items was to disaggregate the FAF2 to the county level and include the amount of freight traffic that originated/terminated within Alabama. This involved the development of a statewide freight flow model and method to disaggregate the FAF2 data from the two counties provided in the FAF2 database to the 67 counties in Alabama. Then, the modeling environment needed to be adjusted to allow for the freight volumes to be assigned to all possible combinations. Finally, the modeling structure was modified to account for the pass-through that was generated within the state, terminated within the state, or both. Data is provided from the State-wide Model in Appendix D.

The model that was developed was created in CUBE/TRANPLAN and contains all interstate and US highways in Alabama. Additionally, some state highways were included to provide continuity of the roadway network and make counties accessible. The modeling network developed is shown in Figure 3.12.

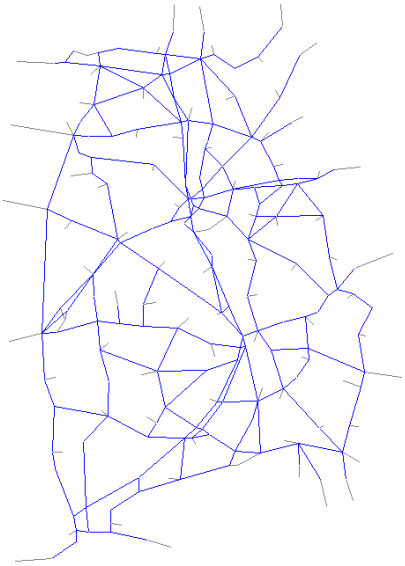

Figure 3.12. Statewide roadway network

The model used to disaggregate the FAF2 data to the counties used the personal income and value of shipment for the counties. This disaggregation is outlined in the FAF2 report submitted to ALDOT, therefore it not presented here. Additionally, the trip purposes used in the assignment are in the FAF2 report and are not presented here.
The modeling effort from the statewide freight model has been validated to 2002 counts obtained from ALDOT. The validation chart is shown in Figure 3.13.

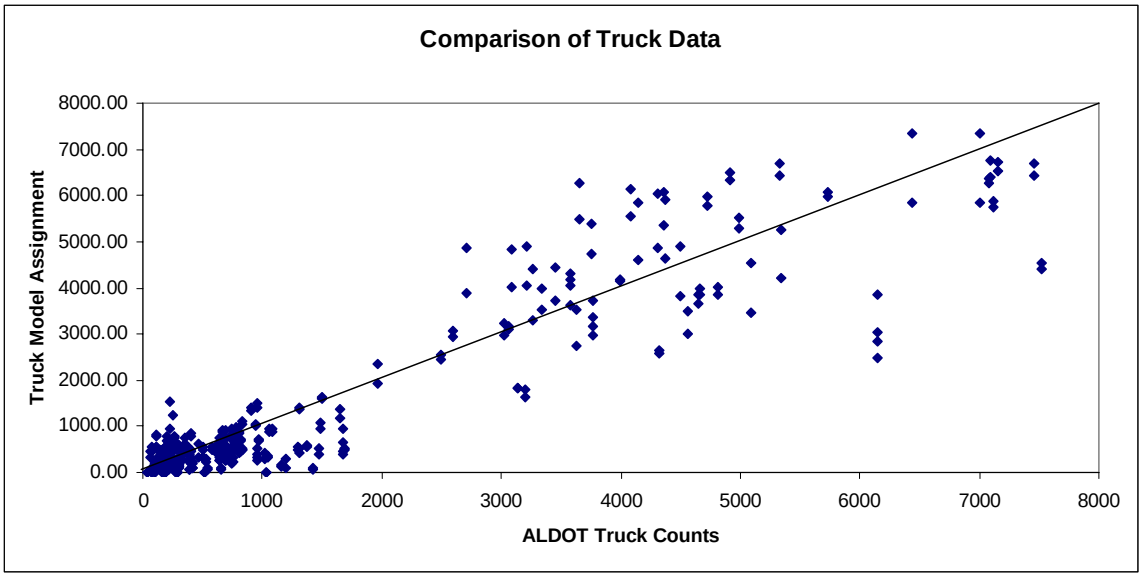

Figure 3.13 Validation of the Statewide Model

The statewide model was also assigned with the FAF2 2035 freight flow data. The same disaggregation procedure and trip purposes were used in the process. The output from the 2035 was used in the Statewide Travel Demand Model developed for ALDOT by Carter Burgess. The 2035 model output with roadway thickness proportional to daily truck volume is shown in the following figure.

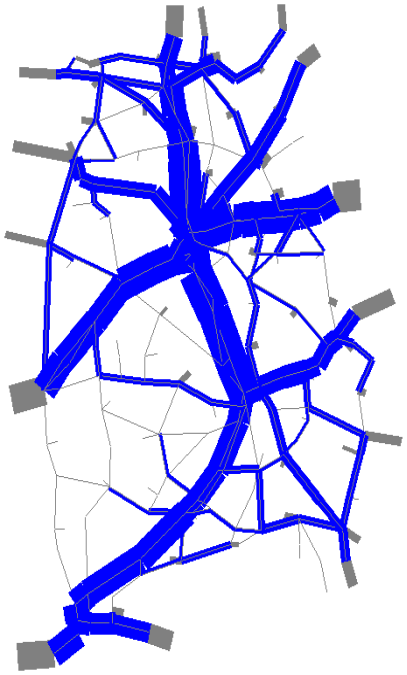

Figure 3.14 Statewide Model with FAF2 2035 daily truck volumes

3.3.1 Montgomery MPO Case Study

To demonstrate the applicability of using the FAF2 data for local pass-through modeling, a study was conducted to highlight the truck traffic passing through the Montgomery MPO. For the analysis, the statewide model was used and the CUBE/TRANPLAN control files used to operate the model were adjusted to assign all trips, with the exception of those that originated or terminated within the Montgomery MPO boundary. For the study, the counties that were excluded from the assignment were Montgomery, Autauga and Elmore. It is understood that the Montgomery MPO boundary does not include all of these three counties; however, the majority of activity in these three counties is included in these three counties.

The process of removing the trips from the trip table prior to assigning to the roadway network is performed through a MATRIX UPDATE module in CUBE/TRANPLAN. Additionally, a series of post-processing modules have been developed to identify specific volume of pass-through truck for the MPO. Examining the data for the

Montgomery MPO, the pass-through daily truck volumes are shown in the following table.

Table 3.5. Daily Truck Volumes Expected to Pass-through Montgomery MPO

	Daily Truck Volumes		
Origin Road	Interstate 65 South of Montgomery	Interstate 65 North of Montgomery	Interstate 85 North of Montgomery
Interstate 65 South of Montgomery	4,900 trucks entering study area	4,300 trucks	500 trucks
Interstate 65 North of Montgomery	4,580 trucks (140 to West US 80)	6,200 trucks entering study area	1,540 trucks (1,290 to South US 231)
Interstate 85 North of Montgomery	1,820 trucks (1,050 to West US 80)	300 trucks	2,140 trucks entering study area

As can be seen from the table, the daily truck volumes expected to pass-through the Montgomery MPO are significant, especially when considering these identified roadways serve as the main commuter roads for residents of the study area.

3.4 Summary

The development of the procedure to forecast pass-through freight within Alabama at the local level involved several steps. Initially, the Freight Analysis Framework, Version 2 Database required study to understand the complexity of the database. Then, the national pass-through freight volumes were researched to understand the implication of freight originating/terminating outside the state and the impact of this freight on roadways within Alabama. Using the statewide model, tools and procedures were developed to examine the impact of Alabama's freight to local areas.

It is important to note that the work presented focuses on Montgomery and the Montgomery MPO. However, this work is easily transferable to all other MPOs within the state and the models and tools developed are maintained at UAH to provide pass-through freight volumes for other MPOs.

4. Conclusions

Although this was a combined project, the research had two distinct focuses, the determination of final demand goods distribution and the development of local pass through freight traffic for modeling purposes.

The understanding of the final demand goods distribution is an undertaking that previously had not been attempted and the knowledge of industry supply chains will be beneficial in understanding freight needs to allow for this consideration in transportation planning and network investment.

Industry sectors may have multiple transportation network designs built or adapted by individual companies with efficiency measured in terms of total cost and elapsed-time. Approximately 7% of companies today are effectively managing their supply chain; however, these companies are 73% more profitable than other manufacturers (8). Companies that manage their freight transportation and logistics operations best do possess a competitive advantage over other companies. Transportation infrastructure in Alabama should be seen as an advantage in attracting these highly competitive companies to provide jobs and opportunities in the state.

Interesting knowledge was gained in understanding freight and the purpose and function of distribution centers in the 21st century supply chain. Freight destination was an unexpected characteristic in that the distribution centers are no longer only supplying retail stores but increasingly fill orders delivered directly to the customer. The furniture sector appears to be a leader in using this model outside of the parcel services companies.

The methods developed in data analysis, including the multi-step process of allocating shipments first to freight zones and then to counties produced reasonable results that can be repeated. Personal Income seems to have some merit as a predictor of final consumer demand.

The discovery and revelation of the pass through freight in a local area is vital to the transportation planner in performing required planning activities, especially since these pass through freight trips cannot be surveyed using traditional methods.

Further research into the appropriate factors to determine final demand, and the use of pass through data for planning and modeling activities at the MPO level is needed. The research performed in this project has provided researchers with indications that we are on the right track and that refinement of the methods and tools use here is warranted.

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5. FAF2 Internet Page. http://www.ops.fhwa.dot.gov/freight/freight_analysis/faf/faf2userguide/index.htm
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Project Team

- Michael D. Anderson, Ph.D., P.E. – Principle Investigator
- Gregory A. Harris, Ph.D., P.E. – Co-Principle Investigator
- David Berkowtiz, Ph.D.
- Niles Schoening, Ph.D.
- Jeff Thompson
- Karen Yarbrough
- Sharla Anselm
- Lynsey Delane

APPENDIX

A	Freight Forward Survey
B	National Model -- Data
C	Flowchart of the FAF2 Data Extraction Program
D	Alabama Model – Data

Appendix A

ID Code: _____

Freight Forward Transportation Survey UAH – Office for Freight, Logistics and Transportation

	FILL IN BEFORE VISIT:	**DATE OF SURVEY:** _____/____/_____
1	Company Name:	
2	Street Address:	
3	City	
4	State	
5	Zip	
6	Phone:	
	COMPLETE AT INTERVIEW:	
7	Contact Name:	
8	Contact Title/Position:	
9	Email Address:	
	BEGIN SURVEY QUESTIONS:	

10 Does your company at this location: Ship products to retail locations within the State of Alabama? YES NO

11 What is the number of stores served from this location: Total Stores:
Alabama Stores:

12 What geographic region (by state or within AL - by county) does this location/warehouse serve?

All States Served: 1._____ 2._____3._____4._____ 5._____ 6._____

All AL counties served: 1._____ 2._____3._____4._____ 5._____ 6._____

(Ask for a list of Stores Served)

Note: _____

13 From what other location(s) does your company ship retail goods into State of Alabama?

#1 Location Name/City : _____

#1 Location Contact Name: _____

#1 Location Phone Number: _____

#2 Location of Warehouse # 2: _____

#2 Location Contact Name: _____

#2 Location Phone Number: _____

14 Does your company control the transportation of freight in and out of this facility?

YES NO

15 What is the total square footage at this location?

Square footage: _____

16 What percentage of capacity of this location is being used?

Today (circle one) 1-25% 26-50% 51-75% 76-100%

In Five Years (circle one) 1-25% 26-50% 51-75% 76-100%

Note: _____

FILL IN BEFORE VISIT: **DATE OF SURVEY:** _____/____/_____

1 Company Name:

17 Do you anticipate an expansion within 5 years (2012) at this location? (Cycle one) No Expansion expected Double Current Size or Increase of _____ sq ft or %

Note: _____

18 Does this location monitor inbound/outbound truck weight?

Inbound YES NO Avg truckload weight ? _____lbs Outbound YES NO Avg truckload weight ? _____lbs

19 What is the total value of goods handled last year (2006) at this location?

(round to nearest $1000): $_____ (=) value of goods - Retail or Wholesale Value?

20 What was the annual INBOUND volume at this location:

last year - 2006?	Number	Avg $ Value/Load	Primary Product	Primary Origin	Product Categories
Full Truck loads from Alabama					Apparel
Full Truck loads from outside Alabama					Auto Parts
LTL Trucks from Alabama					Books
LTL Trucks from outside Alabama					Electronics
Common Carrirers (UPS, FEDEX)					Furniture
Rail CARS or CONTAINERS					Mixed

Note: _____

Avg $ five years ago - 2001?	Number	Value/Load	Primary Product	Primary Origin	Product Categories
Full Truck loads from Alabama					Apparel
Full Truck loads from outside Alabama					Auto Parts
LTL Trucks from Alabama					Books
LTL Trucks from outside Alabama					Electronics
Common Carriers (UPS, FEDEX)					Furniture
Rail CARS or CONTAINERS					Mixed

Note: _____

21 What do you expect the annual volume to be 5 years (2012) from now?

(in # of inbound shipments) #_____

Note: _____

FILL IN BEFORE VISIT:		DATE OF SURVEY:	_____/___/_____
1	Company Name:		

22 What is the source of inbound shipments to your facility?

Manufacturer _____%

Distributor/Freight handler _____%

→ Your Distribution Center → Retail

Total = 100%

23 Please rank each quarter's volume level of goods moving in/out of this location.
(By calendar year - 1 being least amount of activity & 4 being the most amount of activity) Jan-Mar _____
Apr-Jun _____ Jul-Sept _____ Oct-Dec _____

24 Please rank the busiest time of day for your location?
(1 being least amount of activity & 3 being the most amount of activity)

8 a.m. to 4 p.m. _____ 4 p.m. to midnight _____ Midnight to 8 a.m. _____

25 Average length of time of goods stay at this location?
Crossdocked goods _____ unit _____ (hrs, days, etc.)
Inventoried goods _____ unit _____ (hrs, days, etc.)

Note: _____

26 What percentage of inbound shipments are cross-docked?
_____% inbound shipments

27 What percentage of current volume is transported by company-vehicle ?
Inbound _____% of current volume Outbound _____% of current volume

Note: _____

28 What percentage of current volume is transported by common carrier ?
Inbound _____% of current volume Outbound _____% of current volume

Note: _____

29 How many employees work at this location?
Full-time employees: _____
Part-time employees: _____

	FILL IN BEFORE VISIT:	DATE OF SURVEY:	_____/____/_____
1	Company Name:		

30 What transportation related problems are you currently experiencing in shipping or receiving your products from this location/warehouse?

31 What transportation infrastructure improvements are needed in Alabama to better serve your current and future needs?

THANK YOU

Appendix B
National Model
Data

National Network

N	1	92605	33936
N	2	92968	32305
N	3	33798	64291
N	4	69137	33212
N	5	68412	32124
N	6	68321	35930
N	7	87984	35658
N	8	62069	34933
N	9	63700	33302
N	10	59713	38467
N	11	57448	37923
N	12	60529	36564
N	13	73939	40279
N	14	73939	38920
N	15	106735	41312
N	16	107572	41636
N	17	104466	39098
N	18	102981	38719
N	19	98201	30050
N	20	99308	25782
N	21	98444	27970
N	22	97174	27916
N	23	98146	29213
N	24	95797	34290
N	25	96715	33021
N	26	22406	21688
N	27	24584	19148
N	28	66040	43459
N	29	91440	41736
N	30	89898	39649
N	31	90955	40978
N	32	93254	41282
N	33	93889	40375
N	34	93527	39196
N	35	87086	42099
N	36	84364	39468
N	37	81734	38470
N	38	94978	38289
N	39	95069	37382
N	40	88900	29671
N	41	87812	30941
N	42	110944	45818
N	43	103728	39290
N	44	102921	39171
N	45	102850	39599
N	46	109235	42162
N	47	107906	42423
N	48	96987	42661
N	49	94542	43207
N	50	95420	43017
N	51	86495	45652
N	52	85427	44916
N	53	90364	32644
N	54	85712	38744
N	55	89106	38673
N	56	87492	38649
N	57	69366	46380
N	58	81607	41364
N	59	64627	36670
N	60	63154	39708
N	61	108665	43849
N	62	105351	40812
N	63	105351	39846
N	64	105444	40352
N	65	73876	34508
N	66	105858	43389
N	67	101762	43205
N	68	106042	41226
N	69	104385	42791

Appendix B
National Model
Data

National Network

N	70	105674	42515
N	71	99691	35244
N	72	101808	35014
N	73	100888	35842
N	74	101624	35980
N	75	79858	47438
N	76	96194	39155
N	77	99001	41548
N	78	97667	40260
N	79	95458	39661
N	80	96700	40214
N	81	82067	35750
N	82	84828	36164
N	83	83264	35060
N	84	56482	45045
N	85	58507	45183
N	86	104753	40352
N	87	100520	40628
N	88	102314	40674
N	89	108573	41456
N	90	98495	34876
N	91	99461	33771
N	92	98955	33495
N	93	80410	44631
N	94	90948	35198
N	95	93709	36440
N	96	93893	35842
N	97	81515	30964
N	98	83448	33357
N	99	84184	29170
N	100	82297	29078
N	101	78708	31517
N	102	68952	40582
N	103	68262	39339
N	104	107054	44079
N	105	102038	37453
N	106	103649	36762
N	107	102360	39017
N	108	100934	37453
N	109	58276	47944
N	110	60439	47576
N	111	99323	38465
N	112	91823	43573
N	113	89982	44217
N	114	73278	42330
N	1001	93111	33403
N	1002	93709	32345
N	1003	68170	32943
N	1004	69044	32207
N	1005	68354	35198
N	1006	87681	34738
N	1007	62188	34186
N	1008	62970	32943
N	1009	59197	39247
N	1010	58461	38465
N	1011	59749	36210
N	1012	74935	39754
N	1013	75165	39017
N	1014	106754	41154
N	1015	107315	41743
N	1016	104345	39676
N	1017	102880	38855
N	1018	98336	30354
N	1019	99759	26083
N	1020	98527	28479
N	1021	97610	27972
N	1022	97884	28930
N	1023	95612	33762
N	1024	96255	32927
N	1025	22860	20872
N	1026	24674	19964

Appendix B
National Model
Data

National Network

N	1027	66403	42643
N	1028	92220	41871
N	1029	89724	38672
N	1030	91031	40466
N	1031	92708	41559
N	1032	93820	39784
N	1033	86349	41676
N	1034	85394	39140
N	1035	82351	38867
N	1036	94229	38243
N	1037	95556	38009
N	1038	89509	30168
N	1039	88222	30382
N	1040	111125	44911
N	1041	103476	39300
N	1042	102852	39367
N	1043	108849	42310
N	1044	108091	42198
N	1045	96878	42310
N	1046	94381	42911
N	1047	95407	42688
N	1048	86735	44962
N	1049	89856	32301
N	1050	87516	38966
N	1051	70032	45818
N	1052	81643	40738
N	1053	64861	36112
N	1054	63047	40738
N	1055	108408	43246
N	1056	105924	40762
N	1057	104981	39969
N	1058	105564	40358
N	1059	73388	35114
N	1060	106148	42812
N	1061	101868	43037
N	1062	106268	41016
N	1063	104397	43096
N	1064	99100	35285
N	1065	101659	35510
N	1066	101000	36048
N	1067	101359	35689
N	1068	80010	46725
N	1069	95584	39208
N	1070	98349	41461
N	1071	97021	39975
N	1072	95694	39561
N	1073	82530	35433
N	1074	84149	36078
N	1075	83346	35396
N	1076	57513	45455
N	1077	100185	40461
N	1078	102742	40227
N	1079	108512	41706
N	1080	97983	34935
N	1081	99017	34046
N	1082	99395	33334
N	1083	80425	43841
N	1084	89886	35087
N	1085	93338	36106
N	1086	82317	30700
N	1087	83108	32696
N	1088	84896	29619
N	1089	81631	29494
N	1090	78887	32322
N	1091	68054	40909
N	1092	67513	38601
N	1093	107421	43939
N	1094	102544	37566
N	1095	103542	36993
N	1096	100826	37954
N	1097	57422	47360

Appendix B
National Model
Data

National Network

N	1098	60144	47088
N	1099	99332	38924
N	1100	92257	43006
N	1101	90352	43550
N	1102	73388	41645
N	1103	35087	62531
N	1104	91909	30629
N	1105	92197	30904
N	1106	90313	30305
N	1107	90232	33685
N	1108	91125	32279
N	1109	91287	32333
N	1110	94613	35118
N	1111	94856	32766
N	1112	96587	30738
N	1113	97209	30251
N	1114	94180	30765
N	1115	98885	29196
N	1116	99264	28358
N	1117	99940	26763
N	1118	98291	26114
N	1119	98696	32144
N	1120	97993	33469
N	1121	100102	34199
N	1122	99480	34199
N	1123	97317	35578
N	1124	96533	36092
N	1125	95992	35956
N	1126	95695	35902
N	1127	92504	36741
N	1128	91990	37092
N	1129	91584	36957
N	1130	90449	36038
N	1131	90232	36038
N	1132	89691	35416
N	1133	91071	37606
N	1134	90449	36795
N	1135	91043	38390
N	1136	91476	39120
N	1137	92450	38201
N	1138	92531	37227
N	1139	93234	37390
N	1140	93504	36930
N	1141	90476	39877
N	1142	91828	40148
N	1143	89502	41527
N	1144	91860	41446
N	1145	92123	41446
N	1146	90773	43231
N	1147	89556	43988
N	1148	88448	44853
N	1149	87555	43934
N	1150	86663	43663
N	1151	91043	42257
N	1152	90962	41960
N	1153	92882	40581
N	1154	92774	40148
N	1155	94180	37552
N	1156	93964	37011
N	1157	95857	37119
N	1158	97101	37309
N	1159	97155	37741
N	1160	97425	38363
N	1161	95776	39823
N	1162	96344	41554
N	1163	94991	41662
N	1164	93369	41743
N	1165	94478	40175
N	1166	95019	42257
N	1167	93721	42690
N	1168	93585	42203

Appendix B
National Model
Data

National Network

N	1169	98426	41040
N	1170	97398	40716
N	1171	98480	39959
N	1172	98534	39418
N	1173	98236	38931
N	1174	98453	38336
N	1175	100021	39526
N	1176	99183	41094
N	1177	99832	41148
N	1178	99832	42068
N	1179	99832	40684
N	1180	99778	40341
N	1181	100117	40071
N	1182	101725	40013
N	1183	103564	40445
N	1184	104023	41094
N	1185	104402	41067
N	1186	104213	42149
N	1187	103834	43122
N	1188	101238	42933
N	1189	98967	36930
N	1190	98885	37714
N	1191	100508	37795
N	1192	101022	38120
N	1193	99291	36741
N	1194	99129	35821
N	1195	100075	36011
N	1196	102590	37119
N	1197	102509	38390
N	1198	101658	39044
N	1199	102199	39600
N	1200	101843	39657
N	1201	103224	40184
N	1202	102521	39485
N	1203	107070	41295
N	1204	108167	41437
N	1205	109748	44001
N	1206	108737	42833
N	1207	107724	43726
N	1208	107383	42705
N	1209	107341	42135
N	1210	106344	41309
N	1211	105945	41523
N	1212	105788	41081
N	1213	105861	40910
N	1214	104848	40924
N	1215	104337	41440
N	1216	106529	44471
N	1217	106842	44471
N	1218	107355	44314
N	1219	104805	40640
N	1220	104463	40583
N	1221	103766	40269
N	1222	104321	40056
N	1223	104734	40098
N	1224	86765	35377
N	1225	85646	35501
N	1226	82911	34133
N	1227	86050	33574
N	1228	81264	33916
N	1229	75825	31026
N	1230	84898	35467
N	1231	85366	36900
N	1232	84185	39044
N	1233	82725	37459
N	1234	82662	36340
N	1235	83098	46938
N	1236	75266	47093
N	1237	71412	45726
N	1238	67434	45944
N	1239	67247	46565

Appendix B
National Model
Data

National Network

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N 1240      64295      47342
N 1241      62710      47715
N 1242      61466      47125
N 1243      59204      47182
N 1244      61156      45695
N 1245      63393      43768
N 1246      65693      42556
N 1247      67962      41624
N 1248      67651      42960
N 1249      67900      44483
N 1250      67278      44794
N 1251      72469      45726
N 1252      73245      44203
N 1253      73556      42991
N 1254      74831      42711
N 1255      75141      41126
N 1256      70479      41624
N 1257      79461      41095
N 1258      80953      40567
N 1259      83439      40784
N 1260      84185      41220
N 1261      84434      41499
N 1262      83191      42773
N 1263      83222      43644
N 1264      75825      44452
N 1265      78933      39355
N 1266      76478      39168
N 1267      75856      39666
N 1268      77955      41106
N 1269      75514      36931
N 1270      74706      35346
N 1271      74085      35532
N 1272      78063      35190
N 1273      72655      33015
N 1274      73463      31927
N 1275      74613      30994
N 1276      73210      32267
N 1277      70013      32175
N 1278      67838      33605
N 1279      69702      34879
N 1280      71350      35594
N 1281      62710      34102
N 1282      61560      34289
N 1283      61218      39821
N 1284      62243      41033
N 1285      63953      40660
N 1286      65289      41095
N 1287      66563      40722
N 1288      68304      39945
N 1289      57271      42338
N 1290      56587      42773
    1 10010 735T  50   0 1 0 0 0 99999     02
    2 10020 742T  50   0 1 0 0 0 99999     02
    3 110302182T  50   0 1 0 0 0 99999     02
    4 100301004T  50   0 1 0 0 0 99999     02
    5 10040 637T  50   0 1 0 0 0 99999     02
    6 10050 733T  50   0 1 0 0 0 99999     02
    7 10060 969T  50   0 1 0 0 0 99999     02
    8 10070 756T  50   0 1 0 0 0 99999     02
    9 10080 814T  50   0 1 0 0 0 99999     02
   10 10090 935T  50   0 1 0 0 0 99999     02
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   12 10110 857T  50   0 1 0 0 0 99999     02
   13 101201126T  50   0 1 0 0 0 99999     02
   14 101301230T  50   0 1 0 0 0 99999     02
   15 10140 159T  50   0 1 0 0 0 99999     02
   16 10150 278T  50   0 1 0 0 0 99999     02
   17 10160 591T  50   0 1 0 0 0 99999     02
   18 10170 169T  50   0 1 0 0 0 99999     02
   19 10180 333T  50   0 1 0 0 0 99999     02
   20 10190 542T  50   0 1 0 0 0 99999     02
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Appendix B
National Model
Data

National Network

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  24 10230 560T  50   0 1 0 0 0 99999     02
  25 10240 470T  50   0 1 0 0 0 99999     02
  26 10250 934T  50   0 1 0 0 0 99999     02
  27 10260 821T  50   0 1 0 0 0 99999     02
  28 10270 893T  50   0 1 0 0 0 99999     02
  29 10280 792T  50   0 1 0 0 0 99999     02
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  32 10310 612T  50   0 1 0 0 0 99999     02
  33 10320 595T  50   0 1 0 0 0 99999     02
  34 10320 657T  50   0 1 0 0 0 99999     02
  35 10330 850T  50   0 1 0 0 0 99999     02
  36 103401081T  50   0 1 0 0 0 99999     02
  37 10350 734T  50   0 1 0 0 0 99999     02
  38 10360 750T  50   0 1 0 0 0 99999     02
  39 10370 794T  50   0 1 0 0 0 99999     02
  40 10380 786T  50   0 1 0 0 0 99999     02
  41 10390 693T  50   0 1 0 0 0 99999     02
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  44 10170 319T  50   0 1 0 0 0 99999     02
  45 10420 232T  50   0 1 0 0 0 99999     02
  46 10430 413T  50   0 1 0 0 0 99999     02
  47 10440 291T  50   0 1 0 0 0 99999     02
  48 10450 368T  50   0 1 0 0 0 99999     02
  49 10460 337T  50   0 1 0 0 0 99999     02
  50 10470 329T  50   0 1 0 0 0 99999     02
  51 10480 731T  50   0 1 0 0 0 99999     02
  52 104801309T  50   0 1 0 0 0 99999     02
  53 10490 613T  50   0 1 0 0 0 99999     02
  54 10340 508T  50   0 1 0 0 0 99999     02
  55 10290 618T  50   0 1 0 0 0 99999     02
  56 10500 318T  50   0 1 0 0 0 99999     02
  57 10510 872T  50   0 1 0 0 0 99999     02
  58 10520 627T  50   0 1 0 0 0 99999     02
  59 10530 605T  50   0 1 0 0 0 99999     02
  60 105401036T  50   0 1 0 0 0 99999     02
  61 10550 656T  50   0 1 0 0 0 99999     02
  62 10560 575T  50   0 1 0 0 0 99999     02
  63 10570 390T  50   0 1 0 0 0 99999     02
  64 10580 120T  50   0 1 0 0 0 99999     02
  65 10590 778T  50   0 1 0 0 0 99999     02
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  69 10630 305T  50   0 1 0 0 0 99999     02
  70 10600 559T  50   0 1 0 0 0 99999     02
  71 10640 592T  50   0 1 0 0 0 99999     02
  72 10650 518T  50   0 1 0 0 0 99999     02
  73 10660 235T  50   0 1 0 0 0 99999     02
  74 10670 394T  50   0 1 0 0 0 99999     02
  75 10680 729T  50   0 1 0 0 0 99999     02
  76 10690 612T  50   0 1 0 0 0 99999     02
  77 10700 658T  50   0 1 0 0 0 99999     02
  78 10710 706T  50   0 1 0 0 0 99999     02
  79 10720 256T  50   0 1 0 0 0 99999     02
  80 10710 400T  50   0 1 0 0 0 99999     02
  81 10730 561T  50   0 1 0 0 0 99999     02
  82 10740 684T  50   0 1 0 0 0 99999     02
  83 10750 346T  50   0 1 0 0 0 99999     02
  84 107601110T  50   0 1 0 0 0 99999     02
  85 107601031T  50   0 1 0 0 0 99999     02
  86 10570 446T  50   0 1 0 0 0 99999     02
  87 10770 374T  50   0 1 0 0 0 99999     02
  88 10780 619T  50   0 1 0 0 0 99999     02
  89 10790 257T  50   0 1 0 0 0 99999     02
  90 10800 515T  50   0 1 0 0 0 99999     02
  91 10810 522T  50   0 1 0 0 0 99999     02
```

Appendix B
National Model
Data

National Network

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   95 10850 499T  50   0 1 0 0 0 99999     02
   96 10850 615T  50   0 1 0 0 0 99999     02
   97 10860 844T  50   0 1 0 0 0 99999     02
   98 10870 743T  50   0 1 0 0 0 99999     02
   99 10880 842T  50   0 1 0 0 0 99999     02
  100 10890 785T  50   0 1 0 0 0 99999     02
  101 10900 825T  50   0 1 0 0 0 99999     02
  102 10910 956T  50   0 1 0 0 0 99999     02
  103 109201052T  50   0 1 0 0 0 99999     02
  104 10930 393T  50   0 1 0 0 0 99999     02
  105 10940 519T  50   0 1 0 0 0 99999     02
  106 10950 255T  50   0 1 0 0 0 99999     02
  107 10170 545T  50   0 1 0 0 0 99999     02
  108 10960 513T  50   0 1 0 0 0 99999     02
  109 109701035T  50   0 1 0 0 0 99999     02
  110 10980 570T  50   0 1 0 0 0 99999     02
  111 10990 459T  50   0 1 0 0 0 99999     02
  112 11000 714T  50   0 1 0 0 0 99999     02
  113 11010 763T  50   0 1 0 0 0 99999     02
  114 11020 694T  50   0 1 0 0 0 99999     02
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 1001 102302527T3032   0 1 0 0 0 99999     02
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 1001 111002280T2736   0 1 0 0 0 99999     02
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 1004 12770 970T1164   0 1 0 0 0 99999     02
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 1005 127901386T1663   0 1 0 0 0 99999     02
 1006 108402233T2679   0 1 0 0 0 99999     02
 1006 122401117T1340   0 1 0 0 0 99999     02
 1006 122702004T2405   0 1 0 0 0 99999     02
 1007 105303295T3954   0 1 0 0 0 99999     02
 1007 12810 528T 634   0 1 0 0 0 99999     02
 1007 12820 637T 764   0 1 0 0 0 99999     02
 1008 128101188T1426   0 1 0 0 0 99999     02
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 1009 128302101T2521   0 1 0 0 0 99999     02
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 1012 125501388T1665   0 1 0 0 0 99999     02
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 1014 12030 346T 415   0 1 0 0 0 99999     02
 1015 10440 900T1080   0 1 0 0 0 99999     02
 1015 12030 511T 613   0 1 0 0 0 99999     02
 1015 12090 393T 472   0 1 0 0 0 99999     02
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 1016 10410 947T1136   0 1 0 0 0 99999     02
 1016 10570 700T 840   0 1 0 0 0 99999     02
 1017 10410 744T 893   0 1 0 0 0 99999     02
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 1017 119801237T1485   0 1 0 0 0 99999     02
 1017 12020 725T 870   0 1 0 0 0 99999     02
 1018 111301132T1358   0 1 0 0 0 99999     02
 1018 111501282T1538   0 1 0 0 0 99999     02
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Appendix B
National Model
Data

National Network

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1020 111702223T2668   0 1 0 0 0 99999     02
1021 10220 997T1196   0 1 0 0 0 99999     02
1021 111801979T2375   0 1 0 0 0 99999     02
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1023 102401054T1265   0 1 0 0 0 99999     02
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1023 111001685T2022   0 1 0 0 0 99999     02
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Appendix B
National Model
Data

National Network

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1052 125901797T2157   0 1 0 0 0 99999     02
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1073 127204095T4095   0 1 0 0 0 99999     02
```

Appendix B
National Model
Data

National Network

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1112 11130 790T 948   0 1 0 0 0 99999     02
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Appendix B
National Model
Data

National Network

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Appendix B
National Model
Data

National Network

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Appendix B
National Model
Data

National Network

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1285 128601406T1687    0 1 0 0 0 99999      02
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1289 12900 811T 973    0 1 0 0 0 99999      02
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National Data: External-Internal/Internal-External

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8	266150	29760	236390	0	0	0	0	0	0	0	0	0	0	0	0
9	4090	930	3160	0	0	0	0	0	0	0	0	0	0	0	0
10	10520	2960	7560	0	0	0	0	0	0	0	0	0	0	0	0
11	73270	31570	41700	0	0	0	0	0	0	0	0	0	0	0	0
12	84900	59900	25000	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	176330	29920	146410	0	0	0	0	0	0	0	0	0	0	0	0
15	29300	1950	27350	0	0	0	0	0	0	0	0	0	0	0	0
16	8630	800	7830	0	0	0	0	0	0	0	0	0	0	0	0
17	27930	6750	21180	0	0	0	0	0	0	0	0	0	0	0	0
18	3010	790	2220	0	0	0	0	0	0	0	0	0	0	0	0
19	523240	251990	271250	0	0	0	0	0	0	0	0	0	0	0	0
20	147490	72060	75430	0	0	0	0	0	0	0	0	0	0	0	0
21	70790	23730	47060	0	0	0	0	0	0	0	0	0	0	0	0
22	106860	38460	68400	0	0	0	0	0	0	0	0	0	0	0	0
23	3587870	496200	3091670	0	0	0	0	0	0	0	0	0	0	0	0
24	7149580	3113840	4035740	0	0	0	0	0	0	0	0	0	0	0	0
25	5692610	1510190	4182420	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	100630	80820	19810	0	0	0	0	0	0	0	0	0	0	0	0
29	830090	431580	398510	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	300460	244210	56250	0	0	0	0	0	0	0	0	0	0	0	0
32	162470	56550	105920	0	0	0	0	0	0	0	0	0	0	0	0
33	98970	26760	72210	0	0	0	0	0	0	0	0	0	0	0	0
34	358770	97930	260840	0	0	0	0	0	0	0	0	0	0	0	0

Appendix B
National Model
Data

National Network

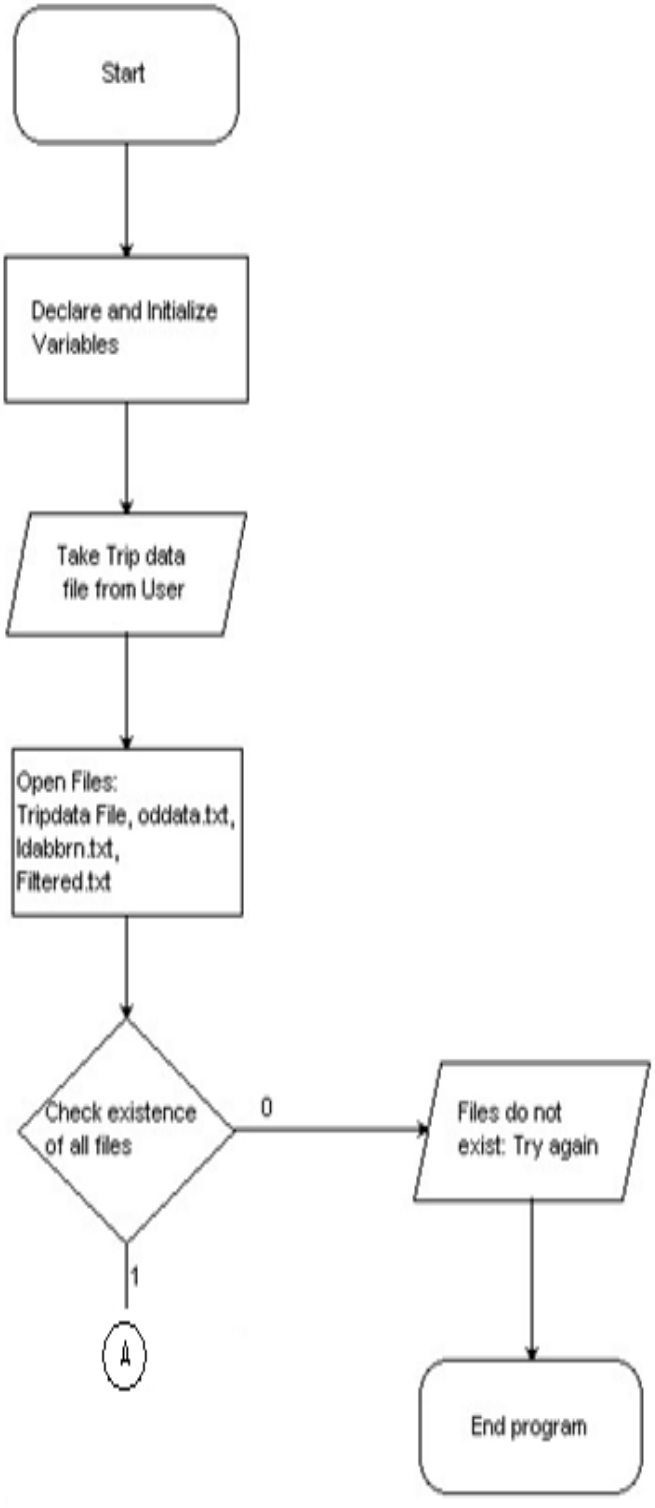
National Data: External-External

*1

	Sum	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	93818280	0	0	36850	1011700	104340	74090	0	3332330	275880	104430	709170	995950	0	25140
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	212400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	49420	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	17760	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1819980	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	146300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	78450	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	669840	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	1088260	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	82080	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	62220	0	0	0	0	450	0	0	0	0	0	0	0	0	0
16	41680	0	0	0	0	460	0	0	0	0	0	0	0	0	0
17	231180	0	0	0	7990	550	0	0	0	4520	0	0	0	0	0
18	11270	0	0	0	1010	230	0	0	0	0	0	0	0	0	0
19	672120	0	0	1850	8320	920	250	0	103720	1420	0	20010	6390	0	6050
20	1222050	0	0	1290	19150	2590	3620	0	190040	3200	4380	23820	106560	0	10360
21	286160	0	0	90	11450	410	320	0	23950	1840	5140	24480	2240	0	6400
22	571510	0	0	15020	12170	870	660	0	100690	2110	1820	36780	18060	0	2330
23	2889750	0	0	18600	62810	5150	12980	0	533130	21190	2250	97820	143700	0	0
24	3858020	0	0	0	30770	0	940	0	295510	7150	0	68140	152990	0	0
25	4696570	0	0	0	67180	32710	41830	0	594860	42230	0	131260	114760	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	252960	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
33	16570	0	0	0	0	0	0	0	0	0	0	0	0	0	0
34	122560	0	0	0	0	0	0	0	0	0	0	0	0	0	0

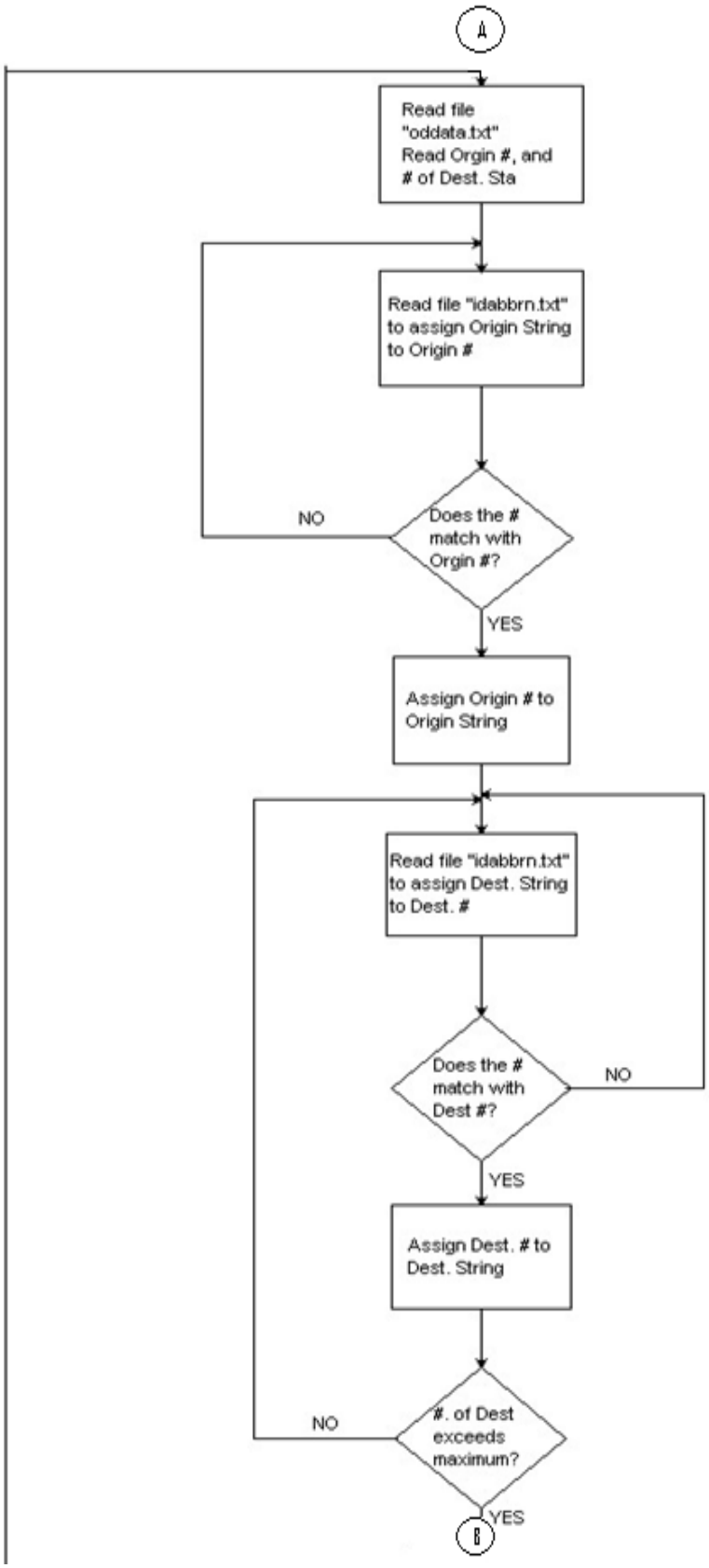
Appendix C

Flowchart of the FAF2 Data Extraction Program



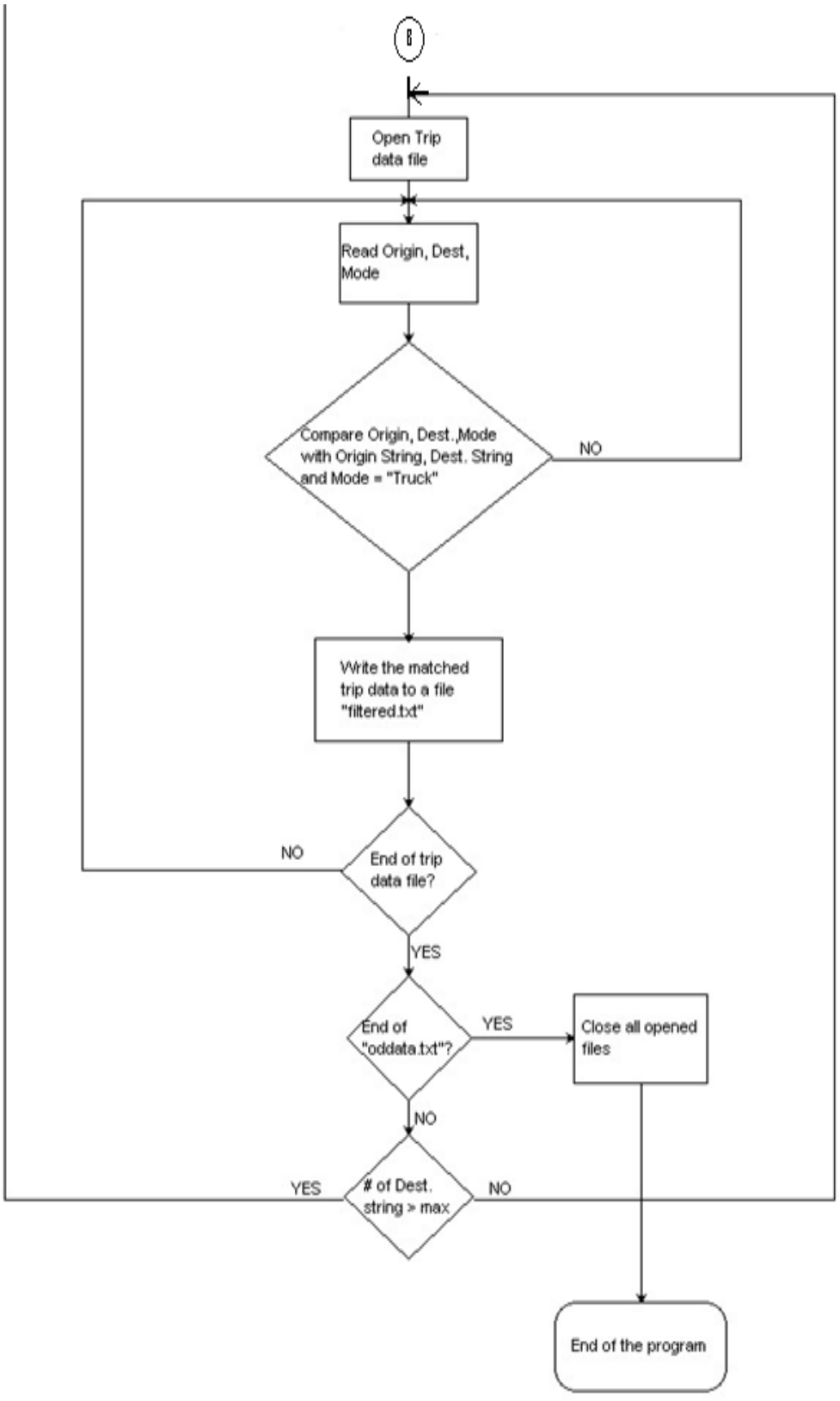
Appendix C

Flowchart of the FAF2 Data Extraction Program



Appendix C

Flowchart of the FAF2 Data Extraction Program



Appendix D

Alabama Model
Data

ALABAMA Network

```
N     1    1101898    3615497
N     2    1008846    3411048
N     3    1224040    3550950
N     4    1050742    3665149
N     5    1095952    3775953
N     6    1184032    3573148
N     7    1094768    3532993
N     8    1164931    3760140
N     9    1216765    3667942
N    10    1184674    3805809
N    11    1088133    3655433
N    12     945650    3553666
N    13     990385    3521831
N    14    1159999    3700817
N    15    1200902    3753074
N    16    1166886    3492645
N    17     980351    3847363
N    18    1080546    3489744
N    19    1131566    3668324
N    20    1121560    3468894
N    21    1145487    3543418
N    22    1059499    3786175
N    23    1204040    3507003
N    24    1073750    3610884
N    25    1157650    3831665
N    26    1140613    3633775
N    27    1055251    3456134
N    28    1151036    3790366
N    29     987101    3738068
N    30     969000    3819654
N    31    1181355    3458018
N    32     973461    3661114
N    33    1003520    3637177
N    34    1238147    3506535
N    35    1238856    3471952
N    36    1145639    3859744
N    37    1061050    3721752
N    38     960206    3749163
N    39     975515    3865764
N    40    1030509    3824094
N    41    1227466    3630682
N    42    1045417    3873059
N    43    1099241    3574010
N    44    1195012    3605098
N    45    1096866    3874576
N    46     996036    3586972
N    47     955898    3800473
N    48    1110790    3823362
N    49     958943    3401266
N    50    1033612    3515236
N    51    1137309    3589224
N    52    1077263    3814240
N    53    1042152    3626256
N    54     954779    3698069
N    55    1161944    3533704
N    56    1197571    3705719
N    57    1245043    3593924
N    58    1118806    3743427
N    59    1093538    3697089
N    60     954355    3609387
N    61    1132724    3711467
N    62    1173164    3657482
N    63    1015251    3694313
N    64    1039534    3753895
N    65     952482    3481930
N    66    1028488    3556228
N    67    1023715    3786378
N    68    1056376    3390040
N    69     906616    3376034
N    70     900673    3589035
N    71     895172    3724798
N    72     908324    3859697
N    73    1060051    3914139
N    74    1085002    3912326
N    75    1163309    3914909
```

Appendix D

Alabama Model Data

ALABAMA Network

```
N    76    1198311    3877227
N    77    1240007    3757737
N    78    1270896    3674322
N    79    1279657    3553907
N    80    1232703    3435195
N    81    1207501    3429520
N    82     902950    3797911
N  1001     963528    3869671
N  1002     955029    3858905
N  1003     944263    3857772
N  1004     988458    3854939
N  1005     986758    3867971
N  1006    1006589    3872504
N  1007    1043418    3867404
N  1008    1051917    3866271
N  1009    1085913    3861738
N  1010    1088746    3888935
N  1011    1059283    3888368
N  1012    1098378    3866271
N  1013    1118776    3852673
N  1014    1140873    3864005
N  1015    1165237    3893468
N  1016    1056114    3848078
N  1017    1048517    3846440
N  1018    1030386    3833975
N  1019    1059849    3823776
N  1020    1066649    3801112
N  1021    1068348    3785814
N  1022    1024154    3794313
N  1023    1000357    3786947
N  1024     982792    3818110
N  1025     963528    3788080
N  1026     977693    3787514
N  1027     969194    3800546
N  1028     968060    3771083
N  1029     979959    3767116
N  1030     981092    3751252
N  1031     995257    3741619
N  1032    1005430    3687745
N  1033    1007992    3684329
N  1034     961261    3705357
N  1035     937464    3716689
N  1036     981659    3653797
N  1037     950496    3621501
N  1038     932365    3596570
N  1039     986192    3608469
N  1040    1007156    3606202
N  1041    1030386    3603369
N  1042    1044551    3659463
N  1043    1096678    3661162
N  1044    1079114    3694592
N  1045    1076417    3709341
N  1046    1056450    3704791
N  1047    1065515    3718389
N  1048    1073448    3726888
N  1049    1040585    3760317
N  1050    1084780    3747285
N  1051    1089879    3775049
N  1052    1097812    3798846
N  1053    1087613    3735953
N  1054    1089313    3727454
N  1055    1084213    3717256
N  1056    1111410    3709323
N  1057    1117076    3735953
N  1058    1123875    3736520
N  1059    1164670    3739920
N  1060    1156171    3758051
N  1061    1143248    3782094
N  1062    1134788    3786323
N  1063    1106872    3758407
N  1064    1092146    3782414
N  1065    1118776    3826609
N  1066    1162404    3824909
N  1067    1182235    3866271
N  1068    1214531    3754651
N  1069    1198666    3746719
```

Appendix D

Alabama Model Data

ALABAMA Network

```
N 1070    1179402    3741619
N 1071    1203766    3710456
N 1072    1209998    3670795
N 1073    1217931    3639065
N 1074    1209432    3633399
N 1075    1178269    3663429
N 1076    1131807    3687793
N 1077    1139173    3666828
N 1078    1139173    3709323
N 1079    1142573    3721788
N 1080    1138040    3738220
N 1081    1234928    3659463
N 1082    1232662    3634532
N 1083    1251360    3620934
N 1084    1237762    3596004
N 1085    1243994    3559175
N 1086    1186768    3613002
N 1087    1198666    3616968
N 1088    1189601    3581839
N 1089    1190167    3571073
N 1090    1153905    3580139
N 1091    1140873    3599403
N 1092    1165803    3607336
N 1093    1131241    3632266
N 1094    1126708    3594304
N 1095    1118209    3611302
N 1096    1113110    3622634
N 1097    1093279    3625467
N 1098    1106310    3616401
N 1099     989025    3580139
N 1100     996390    3528578
N 1101     996390    3516680
N 1102     944263    3525745
N 1103     947096    3597703
N 1104     945397    3465119
N 1105     962961    3419225
N 1106     974860    3427724
N 1107     972593    3491750
N 1108    1034919    3495716
N 1109     997524    3549543
N 1110    1051350    3525179
N 1111    1081455    3505432
N 1112    1101778    3530278
N 1113    1121042    3571073
N 1114    1096112    3586371
N 1115    1063249    3601670
N 1116    1240595    3545010
N 1117    1229829    3507048
N 1118    1222463    3481551
N 1119    1226429    3455487
N 1120    1201499    3454921
N 1121    1180535    3490050
N 1122    1165803    3543310
N 1123    1178793    3553666
N 1124    1140873    3530845
N 1125    1136340    3512714
N 1126    1143706    3480984
N 1127    1118776    3482684
N 1128    1113676    3469086
N 1129    1066082    3454921
N 1130    1087414    3503729
N 1131    1070048    3495149
N 1132    1026420    3443589
N 1133    1026420    3456620
N 1134     999223    3425458
N 1135     998598    3404216
N 1136    1034919    3396561
N 1137     965597    3405643
N 1138     965794    3394861
N 1139     941430    3378996
N 1140    1071341    3739796
N 1141    1039195    3697498
N 1142     977440    3403951
N 1143    1161859    3744872
N 1145    1174548    3800705
N 1146    1073879    3802397
```

Appendix D

Alabama Model Data

ALABAMA Network

```
N 1147    1078955    3720339
N 1148    1076217    3726876
N 1149    1069649    3702574
N 1150     982516    3632359
N 1151     957137    3618824
N 1152    1096720    3672119
N 1153    1124021    3582901
N 1154    1129128    3583752
N 1155    1106994    3530120
N 1157    1077434    3495247
N 1158    1094591    3498710
N 1159    1200997    3504749
N 1160     998598    3412756
N 1161    1180501    3746671
N 1162    1159151    3709949
N 1163    1030196    3624548
N 1164    1005430    3623694
N 1165    1091685    3560498
N 1166    1043006    3510112
N 1167    1181355    3469120
N 1168     943088    3481930
N 1169     935402    3551104
N 1170    1043860    3559644
    1 10980 278T 334   0 1 0 0 0  1000     02
    2 11600 644T 773   0 1 0 0 0  1000     02
    3 111601085T1302   0 1 0 0 0  1000     02
    4 10420 520T 624   0 1 0 0 0  1000     02
    5 10510 379T 455   0 1 0 0 0  1000     02
    6 10890 400T 480   0 1 0 0 0  1000     02
    7 111201500T1800   0 1 0 0 0  1000     02
    8 10600 556T 667   0 1 0 0 0  1000     02
    9 10720 453T 544   0 1 0 0 0  1000     02
   10 11450 700T 840   0 1 0 0 0  1000     02
   11 10430 636T 763   0 1 0 0 0  1000     02
   12 11690 655T 786   0 1 0 0 0  1000     02
   13 110101500T1800   0 1 0 0 0  1000     02
   14 11620 568T 682   0 1 0 0 0  1000     02
   15 10690 417T 500   0 1 0 0 0  1000     02
   16 11210 857T1028   0 1 0 0 0  1000     02
   17 10040 688T 826   0 1 0 0 0  1000     02
   18 11570 392T 470   0 1 0 0 0  1000     02
   19 10770 479T 575   0 1 0 0 0  1000     02
   20 112601559T1871   0 1 0 0 0  1000     02
   20 11280 487T 584   0 1 0 0 0  1000     02
   21 11240 828T 994   0 1 0 0 0  1000     02
   22 10210 547T 656   0 1 0 0 0  1000     02
   23 11590 235T 282   0 1 0 0 0  1000     02
   24 11150 866T1039   0 1 0 0 0  1000     02
   25 10660 511T 613   0 1 0 0 0  1000     02
   26 10930 586T 703   0 1 0 0 0  1000     02
   27 11290 674T 809   0 1 0 0 0  1000     02
   28 10610 703T 844   0 1 0 0 0  1000     02
   29 10310 550T 660   0 1 0 0 0  1000     0T 6602074 1 0 0 0  1000     0
   30 10240 858T1030   0 1 0 0 0  1000     02
   31 11670 688T 826   0 1 0 0 0  1000     02
   32 10360 681T 817   0 1 0 0 0  1000     02
   33 11640 846T1015   0 1 0 0 0  1000     02
   34 11170 514T 617   0 1 0 0 0  1000     02
   35 111801173T1408   0 1 0 0 0  1000     02
   36 10140 395T 474   0 1 0 0 0  1000     02
   37 104701500T1800   0 1 0 0 0  1000     02
   38 103001298T1558   0 1 0 0 0  1000     02
   39 10010 780T 936   0 1 0 0 0  1000     02
   39 10050 709T 851   0 1 0 0 0  1000     02
   40 10180 614T 737   0 1 0 0 0  1000     02
   41 10820 399T 479   0 1 0 0 0  1000     02
   42 10070 372T 446   0 1 0 0 0  1000     02
   43 11140 791T 949   0 1 0 0 0  1000     02
   44 10860 706T 847   0 1 0 0 0  1000     02
   45 10120 524T 629   0 1 0 0 0  1000     02
   46 10990 605T 726   0 1 0 0 0  1000     02
   47 10250 902T1082   0 1 0 0 0  1000     02
   48 10650 532T 638   0 1 0 0 0  1000     02
   49 11370 493T 592   0 1 0 0 0  1000     02
   50 11660 663T 796   0 1 0 0 0  1000     02
   51 10910 669T 803   0 1 0 0 0  1000     02
```

Appendix D
Alabama Model
Data

ALABAMA Network

```
   52 11460 763T 916   0 1 0 0 0  1000     02
   53 11630 748T 898   0 1 0 0 0  1000     02
   54 10340 605T 726   0 1 0 0 0  1000     02
   55 11220 641T 769   0 1 0 0 0  1000     02
   56 10710 482T 578   0 1 0 0 0  1000     02
   57 10840 467T 560   0 1 0 0 0  1000     02
   58 10570 476T 571   0 1 0 0 0  1000     02
   59 10440 904T1085   0 1 0 0 0  1000     02
   59 105601339T1607   0 1 0 0 0  1000     02
   60 10370 790T 948   0 1 0 0 0  1000     02
   60 11030 854T1025   0 1 0 0 0  1000     02
   60 11510 610T 732   0 1 0 0 0  1000     02
   61 10780 420T 504   0 1 0 0 0  1000     02
   62 10750 485T 582   0 1 0 0 0  1000     02
   63 10320 731T 877   0 1 0 0 0  1000     02
   64 10490 404T 485   0 1 0 0 0  1000     02
   65 11680 582T 698   0 1 0 0 0  1000     02
   66 11700 976T1171   0 1 0 0 0  1000     02
   67 10220 494T 593   0 1 0 0 0  1000     02
   68 113601387T1664   0 1 0 0 0  1000     02
   69 113902163T2596   0 1 0 0 0  1000     02
   70 103802017T2420   0 1 0 0 0  1000     02
   71 103502666T3199   0 1 0 0 0  1000     02
   72 100302227T2672   0 1 0 0 0  1000     02
   73 101101600T1920   0 1 0 0 0  1000     02
   74 101001470T1764   0 1 0 0 0  1000     02
   75 101501334T1601   0 1 0 0 0  1000     02
   76 106701201T1441   0 1 0 0 0  1000     02
   77 106801581T1897   0 1 0 0 0  1000     02
   78 108102398T2878   0 1 0 0 0  1000     02
   79 108502221T2665   0 1 0 0 0  1000     02
   80 111901315T1578   0 1 0 0 0  1000     02
   81 112001617T1940   0 1 0 0 0  1000     02
   82 102503803T4095   0 1 0 0 0  1000     02
 1001 10020 851T1021   0 1 0 0 0  1000     02
 1002 10030 670T 804   0 1 0 0 0  1000  1307T 8041307 1 0 0 0  1000  1307
 1002 100402082T2498   0 1 0 0 0  1000   9122
 1004 10050 816T 979   0 1 0 0 0  1000   818T 9791599 1 0 0 0  1000   818
 1004 101703750T4095   0 1 0 0 0  1000  10562
 1004 101802905T3486   0 1 0 0 0  1000   742T34863020 1 0 0 0  1000   742
 1004 102402315T2778   0 1 0 0 0  1000   662T27784095 1 0 0 0  1000   662
 1005 100601258T1510   0 1 0 0 0  1000     02
 1006 100702299T2759   0 1 0 0 0  1000   6452
 1007 10080 530T 636   0 1 0 0 0  1000     02
 1008 100902119T2543   0 1 0 0 0  1000   668T25434095 1 0 0 0  1000   668
 1008 101101445T12392857 1 1 0 0 20000  3994T1239   0 1 0 0 0 20000  3994
 1008 101601158T 9932286 1 1 0 0 20000  4650T 993   0 1 0 0 0 20000  4650
 1008 101701249T1499   0 1 0 0 0  1000   3832
 1009 101001696T2035   0 1 0 0 0  1000   677T20353360 1 0 0 0  1000   677
 1009 10120 819T 983   0 1 0 0 0  1000     02
 1009 101602026T2431   0 1 0 0 0  1000  1968T24314011 1 0 0 0  1000  1968
 1009 105203971T4095   0 1 0 0 0  1000   403T40954095 1 0 0 0  1000   403
 1009 106502979T3575   0 1 0 0 0  1000   6862
 1012 101301516T1819   0 1 0 0 0  1000   9632
 1013 101401534T1841   0 1 0 0 0  1000     02
 1014 101502365T2838   0 1 0 0 0  1000   9502
 1016 10170 480T 576   0 1 0 0 0  1000  1368T 576 943 1 0 0 0  1000  1368
 1016 101901526T1308   0 1 1 0 0 20000     0T1308   0 1 0 0 0 20000     0
 1017 101801361T1633   0 1 0 0 0  1000   470T16332689 1 0 0 0  1000   470
 1017 101901572T1886   0 1 0 0 0  1000   3232
 1018 102003032T3638   0 1 0 0 0  1000   786T36383020 1 0 0 0  1000   786
 1018 102403109T3731   0 1 0 0 0  1000   3342
 1019 102001468T1258   0 1 1 0 0 20000  4994T12582903 1 0 0 0 20000  4994
 1019 114601585T1902   0 1 0 0 0  1000     02
 1020 10210 955T 8191877 1 1 0 0 20000     0T 819   0 1 0 0 0 20000     0
 1020 102202660T3192   0 1 0 0 0  1000   353T31924095 1 0 0 0  1000   353
 1020 11460 455T 546   0 1 0 0 0  1000     0T 5461729 1 0 0 0  1000     0
 1021 114002860T24513190 1 1 0 0 20000  4908T2451   0 1 0 0 0 20000  4908
 1022 102301541T1849   0 1 0 0 0  1000   291T18493049 1 0 0 0  1000   291
 1023 102402220T2664   0 1 0 0 0  1000     0T26644095 1 0 0 0  1000     0
 1023 102601402T1682   0 1 0 0 0  1000   6462
 1024 102701378T1654   0 1 0 0 0  1000   775T16542723 1 0 0 0  1000   775
 1025 10260 877T1052   0 1 0 0 0  1000     0T10521721 1 0 0 0  1000     0
 1025 10270 850T1020   0 1 0 0 0  1000     02
 1025 102801093T1312   0 1 0 0 0  1000     0T13122261 1 0 0 0  1000     0
 1025 103504095T4095   0 1 0 0 0  1000   2562
```

Appendix D
Alabama Model
Data

ALABAMA Network

```
1028 10290 776T 931    0 1 0 0 0  1000      0T 9311606 1 0 0 0  1000      0
1029 10300 988T1186    0 1 0 0 0  1000      0T11862044 1 0 0 0  1000      0
1029 104903774T4095    0 1 0 0 0  1000   1305T40954095 1 0 0 0  1000   1305
1030 10310 900T1080    0 1 0 0 0  1000    163T10803470 1 0 0 0  1000    163
1031 103203307T3968    0 1 0 0 0  1000    392T39684095 1 0 0 0  1000    392
1032 10330 265T 318    0 1 0 0 0  1000      02
1032 103402942T3530    0 1 0 0 0  1000   1016T35304095 1 0 0 0  1000   1016
1032 103602568T3082    0 1 0 0 0  1000    400T30821541 1 0 0 0  1000    400
1033 103602500T21433923 1 1 0 0 20000   4314T2143    0 1 0 0 0 20000   4314
1033 104202738T3286    0 1 0 0 0  1000    7462
1033 114102095T1796    0 1 1 0 0 20000   6438T17962761 1 0 0 0 20000   6438
1034 103501633T1960    0 1 0 0 0  1000    750T19603233 1 0 0 0  1000    750
1035 103804095T4095    0 1 0 0 0  1000    2312
1036 103702783T23854095 1 1 0 0 20000   4369T2385    0 1 0 0 0 20000   4369
1036 115001331T1597    0 1 0 0 0  1000    164T15971926 1 0 0 0  1000    164
1036 115102647T3176    0 1 0 0 0  1000     75T31763829 1 0 0 0  1000     75
1037 103801913T16403793 1 1 0 0 20000   4144T1640    0 1 0 0 0 20000   4144
1038 11030 914T1097    0 1 0 0 0  1000    7382
1038 115102063T2476    0 1 0 0 0  1000     98T24764095 1 0 0 0  1000     98
1038 116902824T3389    0 1 0 0 0  1000      02
1039 104001304T1565    0 1 0 0 0  1000      02
1039 109901769T2123    0 1 0 0 0  1000    172T21233505 1 0 0 0  1000    172
1039 110302509T3011    0 1 0 0 0  1000    807T30114095 1 0 0 0  1000    807
1039 115001500T1800    0 1 0 0 0  1000    3032
1040 104101447T1736    0 1 0 0 0  1000    6952
1040 116401092T1310    0 1 0 0 0  1000    135T13102307 1 0 0 0  1000    135
1041 111502034T2441    0 1 0 0 0  1000    6412
1041 116301312T1574    0 1 0 0 0  1000    216T15743009 1 0 0 0  1000    216
1042 109703678T4095    0 1 0 0 0  1000    4162
1042 116302339T2807    0 1 0 0 0  1000    3852
1043 104402342T20074015 1 1 0 0 20000   4080T2007    0 1 0 0 0 20000   4080
1043 109602598T2227    0 1 1 0 0 20000   3652T22274095 1 0 0 0 20000   3652
1043 109802827T3392    0 1 0 0 0  1000    165T33924090 1 0 0 0  1000    165
1043 11520 677T 812    0 1 0 0 0  1000      02
1044 10450 930T 7971826 1 1 0 0 20000   4728T 797    0 1 0 0 0 20000   4728
1044 11490 767T 920    0 1 0 0 0  1000   1033T 9201521 1 0 0 0  1000   1033
1044 115201769T2123    0 1 0 0 0  1000    287T21232559 1 0 0 0  1000    287
1045 104601265T1084    0 1 1 0 0 20000   4557T10842498 1 0 0 0 20000   4557
1045 104801105T 9472177 1 1 0 0 20000   6147T 947    0 1 0 0 0 20000   6147
1045 10550 687T 5891342 1 1 0 0 20000   4660T 589    0 1 0 0 0 20000   4660
1045 11470 673T 808    0 1 0 0 0  1000    521T 8081333 1 0 0 0  1000    521
1045 11490 570T 684    0 1 0 0 0  1000      02
1046 104701013T 868    0 1 1 0 0 20000   6147T 8681993 1 0 0 0 20000   6147
1046 114101158T 9931527 1 1 0 0 20000   7004T 993    0 1 0 0 0 20000   7004
1047 10480 720T 617    0 1 1 0 0 20000      0T 6171408 1 0 0 0 20000      0
1048 104902685T3222    0 1 0 0 0  1000   16802
1048 11400 811T 695    0 1 1 0 0 20000   5328T 695 905 1 0 0 0 20000   5328
1048 11480 171T 147    0 1 1 0 0 20000   7520T 147 336 1 0 0 0 20000   7520
1050 105101751T2101    0 1 0 0 0  1000      02
1050 10530 725T 870    0 1 0 0 0  1000      0T 8701417 1 0 0 0  1000      0
1051 106301474T1769    0 1 0 0 0  1000    3862
1051 10640 478T 574    0 1 0 0 0  1000      02
1052 106202419T2903    0 1 0 0 0  1000    787T29033339 1 0 0 0  1000    787
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1052 114601499T1799    0 1 0 0 0  1000    5852
1053 10540 538T 461    0 1 1 0 0 20000   3138T 4611044 1 0 0 0 20000   3138
1053 106301831T1569    0 1 1 0 0 20000   3761T15692700 1 0 0 0 20000   3761
1053 11480 903T 7741777 1 1 0 0 20000   3200T 774    0 1 0 0 0 20000   3200
1054 10550 707T 606    0 1 1 0 0 20000   4815T 6061381 1 0 0 0 20000   4815
1054 105701793T15373553 1 1 0 0 20000   7158T1537    0 1 0 0 0 20000   7158
1054 11480 810T 6941593 1 1 0 0 20000   4315T 694    0 1 0 0 0 20000   4315
1055 105601750T2100    0 1 0 0 0  1000   1676T21003466 1 0 0 0  1000   1676
1055 11470 378T 454    0 1 0 0 0  1000   1153T 4541435 1 0 0 0  1000   1153
1056 105701687T2024    0 1 0 0 0  1000    3022
1056 107601836T2203    0 1 0 0 0  1000   1470T22033639 1 0 0 0  1000   1470
1057 10580 421T 361    0 1 0 0 0 20000      02
1057 106301529T1835    0 1 0 0 0  1000    3042
1057 114302829T3395    0 1 0 0 0  1000    400T33953020 1 0 0 0  1000    400
1058 10800 881T 7551729 1 1 0 0 20000   7080T 755    0 1 0 0 0 20000   7080
1059 10700 915T 7841797 1 1 0 0 20000      0T 784    0 1 0 0 0 20000      0
1059 107901767T2120    0 1 0 0 0  1000    527T21203501 1 0 0 0  1000    527
1059 108001647T1412    0 1 1 0 0 20000   7115T14123261 1 0 0 0 20000   7115
1059 11430 352T 422    0 1 0 0 0  1000      02
1060 106101691T2029    0 1 0 0 0  1000    8332
1060 11430 888T1066    0 1 0 0 0  1000      0T10661752 1 0 0 0  1000      0
1061 10620 585T 702    0 1 0 0 0  1000    833T 7021141 1 0 0 0  1000    833
```

Appendix D
Alabama Model
Data

ALABAMA Network

```
1061 114502248T2698    0 1 0 0 0  1000    411T26983103 1 0 0 0  1000    411
1062 106302443T20944095 1 1 0 0 20000  3018T2094    0 1 0 0 0 20000  3018
1062 106502687T3224    0 1 0 0 0  1000    801T32244095 1 0 0 0  1000    801
1062 106602936T25174095 1 1 0 0 20000  2599T2517    0 1 0 0 0 20000  2599
1066 106702839T24334095 1 1 0 0 20000  2498T2433    0 1 0 0 0 20000  2498
1068 106901094T 938    0 1 1 0 0 20000  7459T 9382155 1 0 0 0 20000  7459
1069 107001229T1053    0 1 1 0 0 20000  7088T10532425 1 0 0 0 20000  7088
1069 116101126T1351    0 1 0 0 0  1000  1426T13512182 1 0 0 0  1000  1426
1070 107102447T2936    0 1 0 0 0  1000    234T29364095 1 0 0 0  1000    234
1070 116202329T2795    0 1 0 0 0  1000    171T27954095 1 0 0 0  1000    171
1071 107202487T2984    0 1 0 0 0  1000    266T29844095 1 0 0 0  1000    266
1071 116202765T3318    0 1 0 0 0  1000    105T33181659 1 0 0 0  1000    105
1072 107302025T2430    0 1 0 0 0  1000    266T24304017 1 0 0 0  1000    266
1073 10740 630T 540    0 1 1 0 0 20000      0T 5401228 1 0 0 0 20000      0
1073 108101640T1406    0 1 1 0 0 20000  3064T14063248 1 0 0 0 20000  3064
1073 10820 951T1141    0 1 0 0 0  1000      02
1074 107502676T3211    0 1 0 0 0  1000    6152
1074 108701215T1041    0 1 1 0 0 20000  3765T10412397 1 0 0 0 20000  3765
1075 107603241T3889    0 1 0 0 0  1000    8142
1076 107701377T1652    0 1 0 0 0  1000    2922
1076 107801410T1692    0 1 0 0 0  1000    1542
1076 116202181T2617    0 1 0 0 0  1000     62T26174094 1 0 0 0  1000     62
1077 109302198T2638    0 1 0 0 0  1000    8342
1078 10790 801T 961    0 1 0 0 0  1000      02
1078 116201238T1486    0 1 0 0 0  1000    1052
1079 108001057T1268    0 1 0 0 0  1000    321T12682081 1 0 0 0  1000    321
1082 108301427T1712    0 1 0 0 0  1000  12942
1083 108401756T2107    0 1 0 0 0  1000    5082
1084 108502313T2776    0 1 0 0 0  1000    5082
1085 108803636T4095    0 1 0 0 0  1000    2062
1085 11160 902T1082    0 1 0 0 0  1000      02
1086 10870 774T 6631515 1 1 0 0 20000      0T 663    0 1 0 0 0 20000      0
1086 108801939T2327    0 1 0 0 0  1000    116T23273845 1 0 0 0  1000    116
1086 109201340T11492647 1 1 0 0 20000      0T1149    0 1 0 0 0 20000      0
1088 10890 668T 802    0 1 0 0 0  1000      02
1088 109002205T2646    0 1 0 0 0  1000    194T26464095 1 0 0 0  1000    194
1089 112301288T1546    0 1 0 0 0  1000     722
1090 109101441T1729    0 1 0 0 0  1000    9652
1090 112202399T2879    0 1 0 0 0  1000  1692T28794095 1 0 0 0  1000  1692
1091 109201615T1384    0 1 1 0 0 20000  3626T13843197 1 0 0 0 20000  3626
1091 109302123T2548    0 1 0 0 0  1000    762T25484095 1 0 0 0  1000    762
1091 10940 930T 797    0 1 1 0 0 20000  5340T 7971827 1 0 0 0 20000  5340
1094 109501178T1010    0 1 1 0 0 20000  4354T10102323 1 0 0 0 20000  4354
1094 109801864T2237    0 1 0 0 0  1000     0T22373651 1 0 0 0  1000     0
1094 11530 727T 6232933 1 1 0 0 20000  3576T 623    0 1 0 0 0 20000  3576
1094 11540 671T 805    0 1 0 0 0  1000     0T 8054095 1 0 0 0  1000     0
1095 10960 770T 6601507 1 1 0 0 20000      0T 660    0 1 0 0 0 20000      0
1096 10980 572T 686    0 1 0 0 0  1000      02
1097 10980 982T1178    0 1 0 0 0  1000      02
1099 110901973T2368    0 1 0 0 0  1000     0T23683913 1 0 0 0  1000     0
1099 117003627T4095    0 1 0 0 0  1000     0T40954095 1 0 0 0  1000     0
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1100 110901305T1566    0 1 0 0 0  1000    3012
1101 110203274T3929    0 1 0 0 0  1000    2072
1101 110702137T2564    0 1 0 0 0  1000    955T25644095 1 0 0 0  1000    955
1101 110802716T3259    0 1 0 0 0  1000    5462
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1104 110503054T3665    0 1 0 0 0  1000     0T36654095 1 0 0 0  1000     0
1104 116801051T1261    0 1 0 0 0  1000     0T12612965 1 0 0 0  1000     0
1105 11060 906T 777    0 1 1 0 0 20000  3216T 7771779 1 0 0 0 20000  3216
1105 11370 859T 736    0 1 1 0 0 20000  3753T 7361689 1 0 0 0 20000  3753
1106 110703983T4095    0 1 0 0 0  1000    7102
1106 113303659T31364095 1 1 0 0 20000  2703T3136    0 1 0 0 0 20000  2703
1106 114201482T1778    0 1 0 0 0  1000  1051T17782928 1 0 0 0  1000  1051
1108 113102171T2605    0 1 0 0 0  1000    3062
1108 116601023T1228    0 1 0 0 0  1000     0T12282162 1 0 0 0  1000     0
1110 111102225T2670    0 1 0 0 0  1000      02
1110 116503322T3986    0 1 0 0 0  1000     0T39864095 1 0 0 0  1000     0
1110 116601067T1280    0 1 0 0 0  1000      02
1110 117002185T2622    0 1 0 0 0  1000      02
1111 111201986T1702    0 1 1 0 0 20000     0T17022347 1 0 0 0 20000     0
1111 11300 384T 461    0 1 0 0 0  1000      02
1111 11310 951T 8152987 1 1 0 0 20000  3450T 815    0 1 0 0 0 20000  3450
1112 111302796T2397    0 1 1 0 0 20000  3336T23974095 1 0 0 0 20000  3336
1112 11550 323T 388    0 1 0 0 0  1000      02
```

Appendix D
Alabama Model
Data

ALABAMA Network

```
1113 11530 756T 648    0 1 1 0 0 20000   3576T 6482932 1 0 0 0 20000   3576
1113 116501934T2321    0 1 0 0 0  1000    1102
1114 111502242T2690    0 1 0 0 0  1000    962T26904095 1 0 0 0  1000    962
1114 115301743T2092    0 1 0 0 0  1000    6412
1115 117002868T3442    0 1 0 0 0  1000      0T34423383 1 0 0 0  1000      0
1116 111702387T2864    0 1 0 0 0  1000    7382
1117 111802500T3000    0 1 0 0 0  1000    6872
1118 111901633T1960    0 1 0 0 0  1000   1499T19603233 1 0 0 0  1000   1499
1118 112102639T3167    0 1 0 0 0  1000    761T31674095 1 0 0 0  1000    761
1118 11590 808T 970    0 1 0 0 0  1000   14922
1120 112102533T3040    0 1 0 0 0  1000      02
1121 112602341T2809    0 1 0 0 0  1000      0T28094095 1 0 0 0  1000      0
1121 116701298T1558    0 1 0 0 0  1000    196T15582483 1 0 0 0  1000    196
1122 112301025T1230    0 1 0 0 0  1000      0T12302863 1 0 0 0  1000      0
1122 112401721T2065    0 1 0 0 0  1000    2462
1122 115901334T1601    0 1 0 0 0  1000   1645T16014094 1 0 0 0  1000   1645
1124 112501159T1391    0 1 0 0 0  1000      0T13912285 1 0 0 0  1000      0
1124 112603098T3718    0 1 0 0 0  1000    1782
1124 115403362T4034    0 1 0 0 0  1000    1932
1124 115502100T2520    0 1 0 0 0  1000    134T25204095 1 0 0 0  1000    134
1125 112702155T2586    0 1 0 0 0  1000     79T25864094 1 0 0 0  1000     79
1126 112701543T1852    0 1 0 0 0  1000      02
1127 11280 900T1080    0 1 0 0 0  1000      0T10801767 1 0 0 0  1000      0
1127 115801793T2152    0 1 0 0 0  1000    1102
1128 112903068T3682    0 1 0 0 0  1000    115T36824095 1 0 0 0  1000    115
1129 113102510T3012    0 1 0 0 0  1000    2882
1129 113202550T3060    0 1 0 0 0  1000    299T30604095 1 0 0 0  1000    299
1130 115502036T2443    0 1 0 0 0  1000    190T24434095 1 0 0 0  1000    190
1130 11570 812T 974    0 1 0 0 0  1000     40T 9742693 1 0 0 0  1000     40
1130 11580 541T 649    0 1 0 0 0  1000      0T 6493916 1 0 0 0  1000      0
1131 113303604T30894095 1 1 0 0 20000   3086T3089    0 1 0 0 0 20000   3086
1131 11570 458T 550    0 1 0 0 0  1000      02
1132 11330 810T 972    0 1 0 0 0  1000      0T 9721587 1 0 0 0  1000      0
1132 113402024T2429    0 1 0 0 0  1000      02
1134 11600 790T 948    0 1 0 0 0  1000      02
1135 113602296T19684095 1 1 0 0 20000   3262T1968    0 1 0 0 0 20000   3262
1135 114201309T11222468 1 1 0 0 20000   4496T1122    0 1 0 0 0 20000   4496
1135 11600 531T 637    0 1 0 0 0  1000   1084T 6372863 1 0 0 0  1000   1084
1137 11380 670T 5741312 1 1 0 0 20000      0T 574    0 1 0 0 0 20000      0
1137 11420 740T 634    0 1 1 0 0 20000   5084T 6341465 1 0 0 0 20000   5084
1138 113901801T15443087 1 1 0 0 20000   5729T1544    0 1 0 0 0 20000   5729
1140 114603883T4095    0 1 0 0 0  1000    131T40954095 1 0 0 0  1000    131
1140 11480 856T1027    0 1 0 0 0  1000    2802
1143 116101160T1392    0 1 0 0 0  1000    650T13922182 1 0 0 0  1000    650
1147 11480 439T 527    0 1 0 0 0  1000    280T 5271669 1 0 0 0  1000    280
1153 11540 321T 385    0 1 0 0 0  1000   1200T 3854095 1 0 0 0  1000   1200
1154 115503595T4095    0 1 0 0 0  1000    174T40954095 1 0 0 0  1000    174
1157 115801085T1302    0 1 0 0 0  1000    2422
1165 117002964T3557    0 1 0 0 0  1000      02
```

Appendix D

Alabama Model Data

ALABAMA Network

Alabama Trip Generation Data

GP	1	1	258	27	0	0	123	0	0	0	0
GP	2	1	840	89	0	0	400	0	0	0	0
GP	3	1	164	17	0	0	78	0	0	0	0
GP	4	1	0	13	0	12	57	58	0	0	0
GP	5	1	0	32	0	29	143	146	0	0	0
GP	6	1	64	7	0	0	31	0	0	0	0
GP	7	1	118	13	0	0	56	0	0	0	0
GP	8	1	631	67	0	0	301	0	0	0	0
GP	9	1	205	22	0	0	98	0	0	0	0
GP	10	1	138	15	0	0	66	0	0	0	0
GP	11	1	0	24	0	22	0	112	0	0	0
GP	12	1	88	9	0	0	42	0	0	0	0
GP	13	1	156	17	0	0	74	0	0	0	0
GP	14	1	81	9	0	0	38	0	0	0	0
GP	15	1	82	9	0	0	39	0	0	0	0
GP	16	1	249	27	0	0	119	0	0	0	0
GP	17	1	310	33	0	0	148	0	0	0	0
GP	18	1	78	8	0	0	37	0	0	0	0
GP	19	1	66	7	0	0	31	0	0	0	0
GP	20	1	209	22	0	0	100	0	0	0	0
GP	21	1	77	8	0	0	37	0	0	0	0
GP	22	1	0	47	0	43	0	215	0	0	0
GP	23	1	279	30	0	0	133	0	0	0	0
GP	24	1	256	27	0	0	122	0	0	0	0
GP	25	1	372	40	0	0	178	0	0	0	0
GP	26	1	391	42	0	0	186	0	0	0	0
GP	27	1	218	23	0	0	104	0	0	0	0
GP	28	1	583	62	0	0	278	0	0	0	0
GP	29	1	104	11	0	0	49	0	0	0	0
GP	30	1	175	19	0	0	83	0	0	0	0
GP	31	1	144	15	0	0	69	0	0	0	0
GP	32	1	56	6	0	0	27	0	0	0	0
GP	33	1	103	11	0	0	49	0	0	0	0
GP	34	1	93	10	0	0	44	0	0	0	0
GP	35	1	510	54	0	0	243	0	0	0	0
GP	36	1	305	33	0	0	146	0	0	0	0
GP	37	1	0	398	0	362	0	1816	0	0	0
GP	38	1	87	9	0	0	42	0	0	0	0
GP	39	1	493	53	0	0	235	0	0	0	0
GP	40	1	197	21	0	0	94	0	0	0	0
GP	41	1	666	71	0	0	318	0	0	0	0
GP	42	1	382	41	0	0	182	0	0	0	0
GP	43	1	76	8	0	0	36	0	0	0	0
GP	44	1	134	14	0	0	64	0	0	0	0
GP	45	1	1619	172	0	0	772	0	0	0	0
GP	46	1	127	13	0	0	60	0	0	0	0
GP	47	1	172	18	0	0	82	0	0	0	0
GP	48	1	472	50	0	0	225	0	0	0	0
GP	49	1	2261	241	0	0	1079	0	0	0	0
GP	50	1	136	14	0	0	65	0	0	0	0
GP	51	1	1261	134	0	0	602	0	0	0	0
GP	52	1	633	67	0	0	302	0	0	0	0
GP	53	1	66	7	0	0	32	0	0	0	0
GP	54	1	118	13	0	0	56	0	0	0	0
GP	55	1	165	18	0	0	79	0	0	0	0
GP	56	1	127	14	0	0	61	0	0	0	0
GP	57	1	279	30	0	0	133	0	0	0	0
GP	58	1	0	41	0	37	0	186	0	0	0
GP	59	1	0	93	0	84	0	424	0	0	0
GP	60	1	81	9	0	0	38	0	0	0	0
GP	61	1	455	48	0	0	217	0	0	0	0
GP	62	1	232	25	0	0	111	0	0	0	0
GP	63	1	937	100	0	0	447	0	0	0	0
GP	64	1	0	43	0	39	0	194	0	0	0
GP	65	1	101	11	0	0	48	0	0	0	0
GP	66	1	74	8	0	0	35	0	0	0	0
GP	67	1	140	15	0	0	67	0	0	0	0
GP	68	1	0	4	0	0	0	0	651	345	2582
GP	69	1	0	7	0	0	0	0	1142	606	4534
GP	70	1	0	8	0	0	0	0	1328	705	5271
GP	71	1	0	1	0	0	0	0	150	79	594
GP	72	1	0	2	0	0	0	0	261	138	1035

Appendix D
Alabama Model
Data

ALABAMA Network

GP	73	1	0	5	0	0	0	0	796	422	3161
GP	74	1	0	1	0	0	0	0	135	72	536
GP	75	1	0	1	0	0	0	0	198	105	787
GP	76	1	0	3	0	0	0	0	498	264	1977
GP	77	1	0	9	0	0	0	0	1487	789	5902
GP	78	1	0	4	0	0	0	0	611	324	2424
GP	79	1	0	1	0	0	0	0	185	98	734
GP	80	1	0	2	0	0	0	0	299	159	1186
GP	81	1	0	0	0	0	0	0	30	16	118
GP	82	1	0	2	0	0	0	0	335	178	1329
GA	1	1	258	0	40	0	0	0	111	0	0
GA	2	1	840	0	129	0	0	0	360	0	0
GA	3	1	164	0	25	0	0	0	70	0	0
GA	4	1	0	37	0	12	0	0	0	79	0
GA	5	1	0	93	0	29	0	0	0	200	0
GA	6	1	64	0	10	0	0	0	27	0	0
GA	7	1	118	0	18	0	0	0	50	0	0
GA	8	1	631	0	97	0	0	0	271	0	0
GA	9	1	205	0	31	0	0	0	88	0	0
GA	10	1	138	0	21	0	0	0	59	0	0
GA	11	1	0	71	0	22	0	0	0	152	0
GA	12	1	88	0	13	0	0	0	38	0	0
GA	13	1	156	0	24	0	0	0	67	0	0
GA	14	1	81	0	12	0	0	0	35	0	0
GA	15	1	82	0	13	0	0	0	35	0	0
GA	16	1	249	0	38	0	0	0	107	0	0
GA	17	1	310	0	47	0	0	0	133	0	0
GA	18	1	78	0	12	0	0	0	33	0	0
GA	19	1	66	0	10	0	0	0	28	0	0
GA	20	1	209	0	32	0	0	0	90	0	0
GA	21	1	77	0	12	0	0	0	33	0	0
GA	22	1	0	137	0	43	0	0	0	293	0
GA	23	1	279	0	43	0	0	0	120	0	0
GA	24	1	256	0	39	0	0	0	110	0	0
GA	25	1	372	0	57	0	0	0	160	0	0
GA	26	1	391	0	60	0	0	0	168	0	0
GA	27	1	218	0	33	0	0	0	94	0	0
GA	28	1	583	0	89	0	0	0	250	0	0
GA	29	1	104	0	16	0	0	0	45	0	0
GA	30	1	175	0	27	0	0	0	75	0	0
GA	31	1	144	0	22	0	0	0	62	0	0
GA	32	1	56	6	9	0	0	0	24	0	0
GA	33	1	103	0	16	0	0	0	44	0	0
GA	34	1	93	0	14	0	0	0	40	0	0
GA	35	1	510	0	78	0	0	0	219	0	0
GA	36	1	305	0	47	0	0	0	131	0	0
GA	37	1	0	1160	0	362	0	0	0	2478	0
GA	38	1	87	0	13	0	0	0	37	0	0
GA	39	1	493	0	76	0	0	0	212	0	0
GA	40	1	197	0	30	0	0	0	84	0	0
GA	41	1	666	0	102	0	0	0	286	0	0
GA	42	1	382	0	59	0	0	0	164	0	0
GA	43	1	76	0	12	0	0	0	33	0	0
GA	44	1	134	0	21	0	0	0	58	0	0
GA	45	1	1619	0	248	0	0	0	695	0	0
GA	46	1	127	0	9	0	0	0	54	0	0
GA	47	1	172	0	26	0	0	0	74	0	0
GA	48	1	472	0	72	0	0	0	203	0	0
GA	49	1	2261	0	347	0	0	0	970	0	0
GA	50	1	136	0	21	0	0	0	58	0	0
GA	51	1	1261	0	193	0	0	0	541	0	0
GA	52	1	633	0	97	0	0	0	272	0	0
GA	53	1	66	0	10	0	0	0	28	0	0
GA	54	1	118	0	18	0	0	0	51	0	0
GA	55	1	165	0	25	0	0	0	71	0	0
GA	56	1	127	0	20	0	0	0	55	0	0
GA	57	1	279	0	43	0	0	0	120	0	0
GA	58	1	0	119	0	37	0	0	0	253	0
GA	59	1	0	271	0	84	0	0	0	578	0
GA	60	1	81	0	12	0	0	0	35	0	0
GA	61	1	455	0	70	0	0	0	195	0	0
GA	62	1	232	0	36	0	0	0	100	0	0
GA	63	1	937	0	144	0	0	0	402	0	0
GA	64	1	0	124	0	39	0	0	0	265	0
GA	65	1	101	0	16	0	0	0	44	0	0
GA	66	1	74	0	11	0	0	0	32	0	0

Appendix D

Alabama Model

Data

ALABAMA Network

GA	67	1	140	0	21	0	0	0	60	0	0
GA	68	1	0	0	0	0	723	253	0	0	2582
GA	69	1	0	0	0	0	1270	444	0	0	4534
GA	70	1	0	0	0	0	1476	516	0	0	5271
GA	71	1	0	0	0	0	166	58	0	0	594
GA	72	1	0	0	0	0	290	101	0	0	1035
GA	73	1	0	0	0	0	885	310	0	0	3161
GA	74	1	0	0	0	0	150	53	0	0	536
GA	75	1	0	0	0	0	221	77	0	0	787
GA	76	1	0	0	0	0	554	194	0	0	1977
GA	77	1	0	0	0	0	1653	578	0	0	5902
GA	78	1	0	0	0	0	679	237	0	0	2424
GA	79	1	0	0	0	0	206	72	0	0	734
GA	80	1	0	0	0	0	332	116	0	0	1186
GA	81	1	0	0	0	0	33	12	0	0	118
GA	82	1	0	0	0	0	372	130	0	0	1329