A Critical Review and Integration of GIS-Based Spatial Databases for Multi-Commodity and Multi-Mode Freight Movement Modeling and Security Analysis in USA

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1.0 Introduction

Freight movement is a critical component of the US economy and world economy. As commerce increases in the US and abroad, the importance of how our transportation networks operate becomes increasingly important. Specifically, the transportation of commodities through container ships is a significant part of the freight transportation network. The importance of freight flows to and throughout the US is underscored by the importance of economic, security, and infrastructure planning and analysis.

The importance in freight transportation security has provided a multidisciplinary environment for studying transportation systems, infrastructure, supply chains, political science, and security innovations toward achieving more efficiency in the global marketplace. A critical component in this process is the flow of freight through transportation networks.

1.1 Oklahoma Containerized Freight Movement Model

The Oklahoma Containerized Freight Movement Model (CFMM) is currently being used in a national supply chain container security freight movement model organized through the Center for Infrastructure Protection and Hardening through Education and Research (CIPHER). The project objective is to determine international container movements between US origins and destinations. The importance of having an accurate network model along with accurate data on freight shipments is essential for developing security initiatives that anticipate changes in the global supply chain. The freight flow objective for this model include flows to, from, within, and through US ports, metropolitan areas, origins, and destinations. This model will be used to construct What-if? Scenarios for policy-making regarding security and risk management situations. Multiple scenarios such as link failure, infrastructure issues, trading partner issues, economic and population changes, and inter-modal facility issues are all possible scenarios which may be constructed from this model. Accurate forecasts for freight flow within the US provide those developing supply chain security programs with data with which to form security processes around. Ensuring an uninterrupted freight supply chain is vital to the international and US economy. The US is a key player in the global supply chain. Anticipating the increase in the amount of freight movement in the near future is an essential aspect of maintaining the US shipping supply chain.

Container security has recently become an important national security issue as awareness has been raised of the potential threat of an attack through the utilization of sea containers (Greenberg et al., 2006). The increased awareness in container security implies the increasing importance of domestic freight flows from the ports where the containers are received. Planning for increased freight flows through accurate flow forecasting can help determine the types of security procedures or the means to implement freight security checks. Freight flow information has economic significance in terms of our ability for economic growth, which depends on the stability in our transportation infrastructure to move goods. Bottlenecks or congested areas in a transportation network cause delays in shipments. This has an impact on the cost of doing business and ultimately affects the US ability to conduct commerce. Freight flows also provide an indication for making decisions on capital projects such as highway maintenance or expansion. Capital projects such as highways, rail roads, river ports, or sea ports require intensive planning schedules for their construction.

The movement of freight requires visual analysis at both the national and international scale. The use of a Geographic Information System (GIS) in freight transportation plays a critical role in monitoring the flow of freight from US ports throughout the US. A software platform which allows the visual display of changes and movement in the roadways or networks is useful for this type of analysis. By implementing an effective analysis tool with a GIS, economic, security, and infrastructure concerns can be identified and alleviated.

1.2 Research Objective and Organization

There are quite a few software platforms that provide the analysis and ability to simulate flow patterns. ArcView, TransCAD, Cube Cargo, TP+, TRIPS, and Tranplan are some of the popular transportation planning and flow forecasting software platforms that can be used for forecasting freight flows. For the purposes of this project the TransCAD software package was utilized for this analysis. In this project datasets and numerous mapping files were integrated to make a US multimodal network map with freight flows displayed through the network. The Freight Analysis Framework dataset was used for flow tonnages, mode use, commodity type, origin, and destination information. Forecasting the future flows and distributing freight shipments through the US transportation network is a necessity for not only capacity improvements, but inland security measures as well. The freight flow database and distribution techniques for this project are used in a regional model for Oklahoma. This model will be used for scenario analysis in Oklahoma and determining future needs of the transportation system.

This discussion is organized in order to provide an understanding of the use of freight movement data with a GIS. First a brief description of individual freight databases will be provided in section 2 followed by a description of the databases with available GIS data for the purpose of visual analysis. Section 3 will review some of the studies that have used freight databases and GIS programs for freight modeling. This section will also provide background on the integration of freight flow information with a GIS for certain analysis. Finally, a description of the database and programs used for the Oklahoma containerized freight movement model will be explained in section 4 with closing remarks and recommendations.

1.3 Overview of Freight Databases

There are numerous databases available which provide shipping information as well as geospatial data which can be utilized for determining the flows of commodities. Interfacing the shipping information provided by private and public agencies with GIS software platforms provides information on flow patterns of goods and the information needed for forecasting and planning for future shipments. Analyzing these databases and determining the usefulness of each database for estimating the flows of commodities is a vital step in providing information for container security decision-making.

The availability and ability to manage data from either public or private sources are challenges when attempting to collect freight data. Often providers of these databases offer their data in a manageable form such as in a spreadsheet or database program format. Other formats available are provided in a bill of lading[1] or shipping receipt.

[1] See Image 1

Clearly, data in this format is more difficult to manage because it must be recorded and placed into a spreadsheet or manageable format. The availability of databases is also a potential difficulty. Many of the freight databases available are offered for a fee or required subscription. Providers of these databases retrieve their data from a variety of sources. The proprietary databases often have offices at individual ports for the purposes of collecting freight data. Public sources may retrieve data from customs agents or other government sources. Accurate freight data is crucial to freight flow analysis. Determining which database is best suited for certain analysis is a strategic step in constructing a model for freight transportation.

2.0 Existing Freight Databases

There are numerous databases that are useful for determining the flow of commodities from international origins to US destinations. Many of these databases are proprietary and are offered on a subscription basis. Other databases are provided through government agencies which monitor freight movements or international trade transactions. The information in each of these databases varies greatly. Commodity codes, geographic level of shipment, origins and destinations of shipments, time series of data, mode of transportation, and other information is available on multiple web databases in various levels of detail. There is ample data available for public use. A chart of the databases and the types and availability of GIS files is presented in the appendix[2]. Managing this data in a way that is usefully integrated with freight flow data through a GIS platform is an essential and difficult aspect of freight flow analysis.

[2] See Table 1

Understanding freight data requires a specific vocabulary for understanding how to interpret the information in databases and what each database has to offer. Commodities are any good that is in exchange for trade. This understanding of commodities requires an extensive coding scheme to assign unique identifiers to every commodity. Commodity codes are numerical codes that can be up to ten digits for some coding types. The types of codes used for commodities are very important as one commodity may have a different code than the same commodity listed under a different coding scheme. Harmonized Schedule (HS), Standard International Trade Classification (SITC), Standard Classification for Transported Goods (SCTG), and prior to 1989 the Tariff Schedule of the United States of America (TSUSA). The US officially adopted the HS system after 1989 and dropped the TSUSA coding system. The types of commodities being transported are of great importance to multiple types of analysis. For some analysis the value of the commodity may be important, whereas for others the weight of the commodities being shipped is chiefly important. Taking codes and bridging them with other codes or code mapping is a process that must be performed in some cases. For instance, employment data is provided through industry codes or North American Industrial Classification System (NAICS). Certain commodities can be linked to industries through mapping those commodities to those industry codes[3]. Furthermore, if one database has needed commodity information, but is only available in a specific code, then mapping must occur between commodity codes. Through code mapping a GIS platform could visually display the link between freight movement and employment. Freight is also transported through multiple modes including air, truck, ship, pipeline, or

[3] See Table 2

inter-modal. Databases often provide the mode used for each specific shipment. Origins and destinations are essential aspects of freight data. The scale at which this data is available is a large part of freight forecasting as freight flows at small geographic levels, such as counties, are often difficult to determine. Each database contains a varying amount of the information described above. Understanding the characteristics of each database is important to deciding on a particular database to use.

2.1 Freight Databases from Federal and State Government

Most of the databases provided by government are free of charge for use. Multiple government agencies including the US Department of Commerce, International Trade Administration, US Customs, Maritime Administration, and the Federal Trade Commission, US Census, and Bureau of Economic Analysis provide or host freight information. The information these agencies have may also be taken from state, county, or city sources. The International Trade Administration hosts Trade Stat Express, which provides useful map and graphing capabilities for the data in their databases. The commodities are aggregated in total imports and exports for each country. Export data is available at the state level for each US state and country exported to. The database does not provide specific commodity description, which makes determining tonnages for shipments and specific flows challenging. USA Trade Online is provided through the Department of Commerce but requires a fee for usage. This database provides a comprehensive shipment database for imports to US port districts from any country. The commodity codes in this database are provided at the 10-digit commodity code level. The US International Trade Commission offers a database for imports to specific US port cities at the 4-digit commodity level. This database lists imports from all countries. The International Trade Administration provides a database for 233 countries listing their top 20 imported and exported commodities. This database provides commodities at the 3-digit level. The US Census Bureau's Foreign Trade Statistics division provides imports for each country at the 5-digit commodity level. The Freight Analysis Framework (FAF) database offers origin and destination information for 43 commodity groups for the year 2002. The geographic level of analysis for this database is helpful because it includes metropolitan areas and the remainder of states. It also contains information on shipments to other continents, but is much more useful for analysis of domestic flows. The US Census Commodity Flow Survey offers origin and destination information for US commodity shipments. This database offers commodity information at the 5-digit level for domestic flows for US metropolitan areas. Finally, the US Maritime Administration provides shipments to US ports by the number off containers received at each port. Information on specific commodities is not available from this dataset; however the shipment amounts from other databases can be used with the number of containers in this database for validation of shipment numbers.

2.2 Freight Databases from Private Firms

Unlike the databases provided by the government, private company databases usually require a fee or subscription purchase to use. PIERS is a trade consulting company that offers proprietary data at the 9-digit commodity level for all US ports and US cities from any country. Their data provides the number of containers for each commodity and the date the shipment was received at the port. Global Insight provides numerous databases including port tracker, which tracks shipments at a 2-digitt commodity level with origin and destination information. Global Insight, which recently acquired Reebie and Associates Transearch system, provides data at the county-level freight movement for shipments in the domestic US. This database is popular because of it is one of the few databases that provides county-level freight movement information. This database is also useful for its level of detail in tracking commodity shipments by the week. WISERTrade Foreign Trade database offers commodity information at the 6-digit level for all US states and countries. Like the PIERS and Global Insight databases, the data is available at a great level of geographic, temporal, and descriptive detail. Also like the previously mentioned databases, access to the WISERTrade database is available on a subscription basis.

2.3 GIS Network Databases for Freight Movement and Modeling

The Bureau of Transportation Statistics provides the North American Transportation Atlas Data (NORTAD). This database is linked to the NORTAD GIS files. This database contains commodity shipment origins and destinations by mode for all US states, Canadian provinces, and Mexico. The commodity information provided through NORTAD is available at the 2-digit commodity level. The map information available is a comprehensive network of transportation networks in the US, Canada, and Mexico. This database also contains points for inter-modal facilities throughout the entire US. Oakridge National Laboratories (ONL) has a number of transportation network files for international shipping networks, inter-modal networks, highways, railways, and waterway networks. Integrating the GIS files from this resource with the data resources found elsewhere is an option for conducting freight flow analysis. The Freight Analysis Framework (FAF) provides freight data but also provides data for displaying these flows visually. The origin and destination areas are available in a GIS format, however the transportation networks are not available through this database and must be obtained from another source. Because the database provides origin and destination information based on metropolitan areas and remainder of states, the files of how these areas are delineated is provided.

3.0 Freight Database Integration and Handling in GIS

Multiple studies have utilized these databases and resources described as well as others. Because of the differences in commodity detail and commodity codes in each dataset, there is little agreement about which database is the best to use for freight analysis. The best data can be obtained for the right of money, but studies with a lack of funding for this type of financial expenditure on data find many of these models data driven. Because of the difficulty with many modeling efforts in obtaining data some have marketed their freight models directly to shippers in hopes that the models can directly utilize company data (Donnelly, 2006). Examples of these types of models are seen in the Netherlands[4] but not practiced in the US. Revealing the shipments of a company is useful information for competitors for purposes of supply chain and market competition. Many companies withhold shipment information for proprietary concerns and release information only on the basis of how the company will benefit from the study or model (Gray, 2006).

[4] See Tavasszy's model for the Netherlands: http://onlinepubs.trb.org/webmedia/trbweb/fdm/tav/index.htm

3.1 Issues with Existing Freight Databases

The freight modeling studies that utilize GIS for analysis purposes vary in their use of data for validating freight flow models, which software platform, and which networks are used in the study. Before describing the methods in each study, it is worth noting some commonalities that exist in each of the different commentaries. For many of the papers the primary source of data for freight flow tonnages, commodities, and origins and destinations is the 1997 Commodity Flow Survey (CFS). As noted before, this database contains detailed information on domestic freight movement between metropolitan statistical areas and select cities. The networks used to simulate this information are used from a variety of sources, since they are not provided in the commodity flow survey. In general a shortcoming of the available data is the level of detail provided. Even for the widespread use of the CFS, there is commodity information missing from much of the database. Most if not all of the freight databases contain missing information on commodities. Tonnages, values, modes, or commodity types are often missing from datasets. Some studies will estimate these values through the total tonnages or values for the commodity using a gravity model or some other variation (Holguin-Veras, 2000; Memmott, 1983; Vilain et al., 1999; Nan Liu and Vilain, 2004). Origins, destinations, and modes are also required to be estimated in similar ways because of the inconsistency in freight datasets. The datasets do provide enough information to form estimates of the missing data such as the totals for certain origins or destinations and methods are available for estimating these missing data types (TRB, 2003). However, without methods of estimating empty data for some commodities, origins, destinations, or modes, much of the provided datasets are useful for only gross analysis (Meyburg, 2006).

3.2 Issues using GIS software and networks with freight databases

The geographic scale of the current GIS datasets is not satisfactory for most analyses. Forecasting freight flows is an area where using certain datasets with network models requires estimating linkages and flows for freight. The origins and destinations for counties or cities are estimated in the Freight Analysis Framework and Oakridge National Laboratory. The FAF relies primarily on survey and matrix estimation techniques. The ONL network model relies on econometric and engineering models to estimate linkages. The nature of the national transportation system and the ever increasing availability of inter-modal shipping make constructing an accurate freight network model more challenging. The software provided also contains shortfalls such as its ease of use or lack of functionality for certain estimation techniques. The planning organizations or transportation authorities that require the use of these programs for their jurisdiction need a software package that is easy to use and understand. Many of the software packages provided require extensive training on how to use them and a high level of knowledge regarding computer programming. Furthermore, some software packages offer limited methods of estimating missing flows or mode use through only a multinomial logit equations or gravity models. Expanding the demand estimating methods to include other techniques may be useful for the technical users.

3.3 Current Freight research using existing Freight databases with GIS

Luo, M. & Grigalunas Ta. used GIS data to develop their own simulation software. Whereas many studies utilize a GIS software platform already developed, this study seeks to design a platform specifically for simulating movements at US container ports (Luo, M. & Grigalunas Ta., 2003). Ham, Kim, and Boyce utilized the NORTAD database in their input-output model for US commodity flows. Their study used the NORTAD database transportation networks to simulate natural disasters and other disruptions to the national transportation network that would affect commodity shipments. The implemented program attempts to simulate the changes in freight movement over different networks when a hazard or disruption causes one network or part of a network to fail (Ham et al., 2005). Juri and Kockelman in their freight flow model used input-output multipliers combined with land use constraints to estimate the influences of network use, production, and land use demand on trade flows in Texas. The study combined the use of the 1997 CFS with Bureau of Transportation Statistics GIS data. TransCAD was used as the software platform to computer the shortest path distance for each of the destinations described in the 1997 CFS. Network problem scenarios and production improvement measurements were simulated to determine how trade flows would change on the network (Juri and Kockelman, 20004). Kockelman et al. applied the same data and used TransCAD for their analysis of land use, work and non-work trips, and industrial production as influences on trade flows (Kockelman et al., 2004). Chanda used GIS for transportation analysis for inter-modal freight networks and the costs associated with a particular route or mode. Her work simulated network flows using ArcView network analyst and 1997 CFS commodity flow information. The network was made available through Oak Ridge National Laboratory. This network, differently from other networks available, shows the inter-modal nodes for container storage and transfer as well as network links. For the purposes of this study the uppermidwest region of the network was used (Chanda, 2004). This paper demonstrates the use of a GIS system in modeling inter-modal freight movements and the cost-effectiveness of a given mode for a given freight shipment. Standier and Walton analyzed the North American Transportation Database using ArcView network analyst. The use of this analysis method could be utilized for policy scenarios, market area analysis, and routing problems (Standier and Walton, 2000). Their paper demonstrated the ability for a GIS software platform to analyze an inter-modal freight network given certain cost and rule attributes for the network. Southworth and Peterson described the process for integrating a digital representation for a multimodal and transcontinental freight transportation network. Their network utilized the 1997 CFS data with Oak Ridge National Laboratory transportation network files. The development of this network relied on GIS technology for the construction and maintenance of the network, along with mode sequences and route selection (Southworth and Peterson, 2000). Their network was developed for the use of multiple freight analysis through a GIS software platform. There are multiple ways to implement a network model using a variety of datasets and GIS software analysis packages. Scenario analysis, routing problems, cost optimization, flow forecasting, capacity limitations, and shortest path distances are all outputs available through a GIS program when analyzing freight or other transportation issues. The dataset, network, or analysis program chosen affects the robustness of the model. Choosing an appropriate dataset and network for a freight analysis scenario is vital component to an effective and accurate model.

4.0 Database management for freight movement and security

For the purposes of this study both a dataset with freight flow tonnages and an accurate network model were needed. TransCAD was the software platform chosen for this project because of its variety of routing, assignment, planning, and distribution techniques available in the program specifically designed for transportation analysis scenarios. For the purposes of simulating the movement of freight flows over a network, the most useful dataset was the freight analysis framework (FAF) database for 2002 shipments. This dataset was compiled using multiple data sources[5]. The FAF attempts to integrate multiple public and private data sources for public dissemination. The freight flows are available for 131 origins and destinations for 43 commodities. This dataset is particularly useful because of the GIS files included on the website which map the origin and destination boundaries in the US (See Map 1). The commodity flows, origins, and destinations are manageable through Microsoft Access. This program is particularly useful for querying large databases for certain data. Because of the amount of data in this dataset, only select port areas were used to display flows and network linkages visually. If it were attempted to show all the network linkages for all origins and destinations, the map would be visually unappealing and lack purpose as a tool for analysis. The network files used are from the 2006 North American Transportation Atlas highway network, rail network, and waterways. TransCAD was used for assigning flows to the network and visually displaying the tonnages shipped to each destination. The shortest path distance was calculated using TransCAD and for this study served as the routing method for shipments. The lines displaying the tonnage amounts are shown in map 2.

[5] Commodity Flow Survey, For-Hire Trucking Survey, GeoGreight Highway Economics Requirements System, Highway Statistics, Maritime Statistics, Motor Carrier Financial and Operating Statistical Program, North American transportation Statistics, Pipeline Statistics, Rail Waybill Data, and Transborder Surface Freight Data, Vehicle Inventory and Use survey, VTRIS W-Table Web site, and Waterborne Commerce of the United States. Some of these data sources are for subscription or require purchase.

Corresponding to these origins and destinations are the network shortest path distances for each destination (see Map 3).

4.1 Issues in database integration

Similarly to previous studies, the dataset, origins and destination files, network files, and commodity information had to be integrated into one workable GIS platform. Integrating these files can be accomplished using TransCAD and some knowledge about the principles of a GIS[6]. For the purposes of making the visual display easy to interpret I chose one commodity from one origin to one destination (Map 3). Electronics equipment is a commodity group that is distributed throughout the US. For the purposes of showing freight movement to a variety of destinations, this commodity was chosen. The New York/New Jersey port receives in the top 5 of US ports in tonnage volume. The port currently confronts multiple capacity and shipping issues because of the increasing tonnages of shipment being received. Since 1991 the port has seen increases in imports on average of 6% per year (Port of NJNY, 2006). China is the ports largest trading partner facilitating 22.6% of the port's volume in 2005 (Port of NJNY, 2006). Furthermore, China is the largest exporter of electronic products in the US as of 2005 (US International Trade Commission, 2006). For these reasons, this commodity and this port are suitable for displaying freight movements for the purposes of freight movement scenario analysis.

4.2 Remarks and Conclusion

[6] Among some of the tasks required to make this model, building centroids for the shipping regions and connecting these to the network along with joining relevant databases was required.

The analysis of freight movement depends on the ability to integrate valuable datasets with visual analysis tools. Monitoring the flow of freight from US ports to inland destinations is an important part of the US economy and US security. Freight analysis and forecasting are important analysis tools for economic, infrastructure, and security decision-making. Many papers and projects have addressed freight transportation issues with use of a GIS, but there are areas for improvement. Understanding the domain of the shipper is an important and difficult aspect of freight transportation to understand (Leachman, 2006). Surveys and logistic information on individual shippers is important to the future of freight transportation studies. Markets are changing more quickly than changes in transportation networks. Understanding the responses of the private sector to market changes should be a priority for future models and research. By developing multiple analysis techniques using a variety of networks, detailed datasets, and software; potential consequences from not addressing the impacts of increased freight movement can be lessened. Devising a way to analyze freight flows through a GIS using an accurate network is an issue of national and international significance.

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Image 1: Bill of Lading Example

TradeIntelligence PIERS.com U.S. Waterborne Import Data

View their sources of supply

Identify your competitors

Uncover the shipment detail

Coffee Bean Import Report

IMPORT BILL OF LADING DETAIL*

SHIPPER	CONSIGNEE
BECAFISA S.A. DE C.V. CARRETERA VERACRUZ-JAMAPA KM 1.5 NO. - 1499 COL. GRANJAS DE LA BOTICARI	BRAUNNER INTL. 66 YORK ST. SUITE #100 JERSEY CITY, NEW JERSEY, 07302, AT'N: LANDIA CHU

NOTIFY PARTY	ALSO NOTIFY
VOLCAFE SWITZERLAND LTD. GERTRUDSTRASSE 1 CH-8400 WINTERTHUR AT'N: BRUNO SURI TEL.-4152 2649 49	ORDER

PACKAGING INFORMATION

Weight:	115,500.00 KG	**Measurements:**	0.00
Quantity:	1,650 BAGS	**TEU's:**	6.00

SHIPMENT DETAIL

Carrier:	ZIM CONTAINER	**Country of Origin:**	MEXICO
SCAC:	ZIMU	**Coastal Region:**	East Coast
Vessel:	ZIM PANAMA	**US Port:**	1001 NEW YORK
Voyage:	8E	**For Port:**	2412 KINGSTON
B/L:	ZIMUMEX19370	**US Dest:**	NEW YORK
Pre Carrier:	VERACRUZ, MEXICO (MX	**For Dest:**	
Lloyd's Code:	9231781	**Mode of Transport:**	10
Inbond Code:	00	**Arrival Date:**	05/19/2004
Estimated Value:	$149,191		

AMS COMMODITIES

Container	Qty	Description
FSCU3685875	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS
GSTU5046720	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS
INBU3323691	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS
TRLU3637957	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS
UESU2262348	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS
ZIMU2422200	275	20' DV: 1.650 BAGS WITH GREEN COFFEE BEAN S WITHOUT PEEL. NET WEIGHT: 113,850 KGS

MARKS & NUMBERS

Container	Marks&Number
FSCU3685875	LOTS-
GSTU5046720	LOTS-
INBU3323691	LOTS-
TRLU3637957	LOTS-
UESU2262348	LOTS-
ZIMU2422200	LOTS-

PIERS COMMODITIES

Qty	Units	Commodity Description	Harm Code	JOC Code
1650	BGS	GREEN COFFEE BEANS	090111	1601020

Note: Bills of lading that contain multiple commodities will list the total weight and TEU's for the entire bill of lading

*For sample purposes only

33 Washington Street, 13th Floor | Newark, NJ 07102-3107 | Tel: +1 800 952 3839 | Fax: +1 973 848 7043 | info@piers.com
To contact your regional office, visit www.piers.com/contactus/

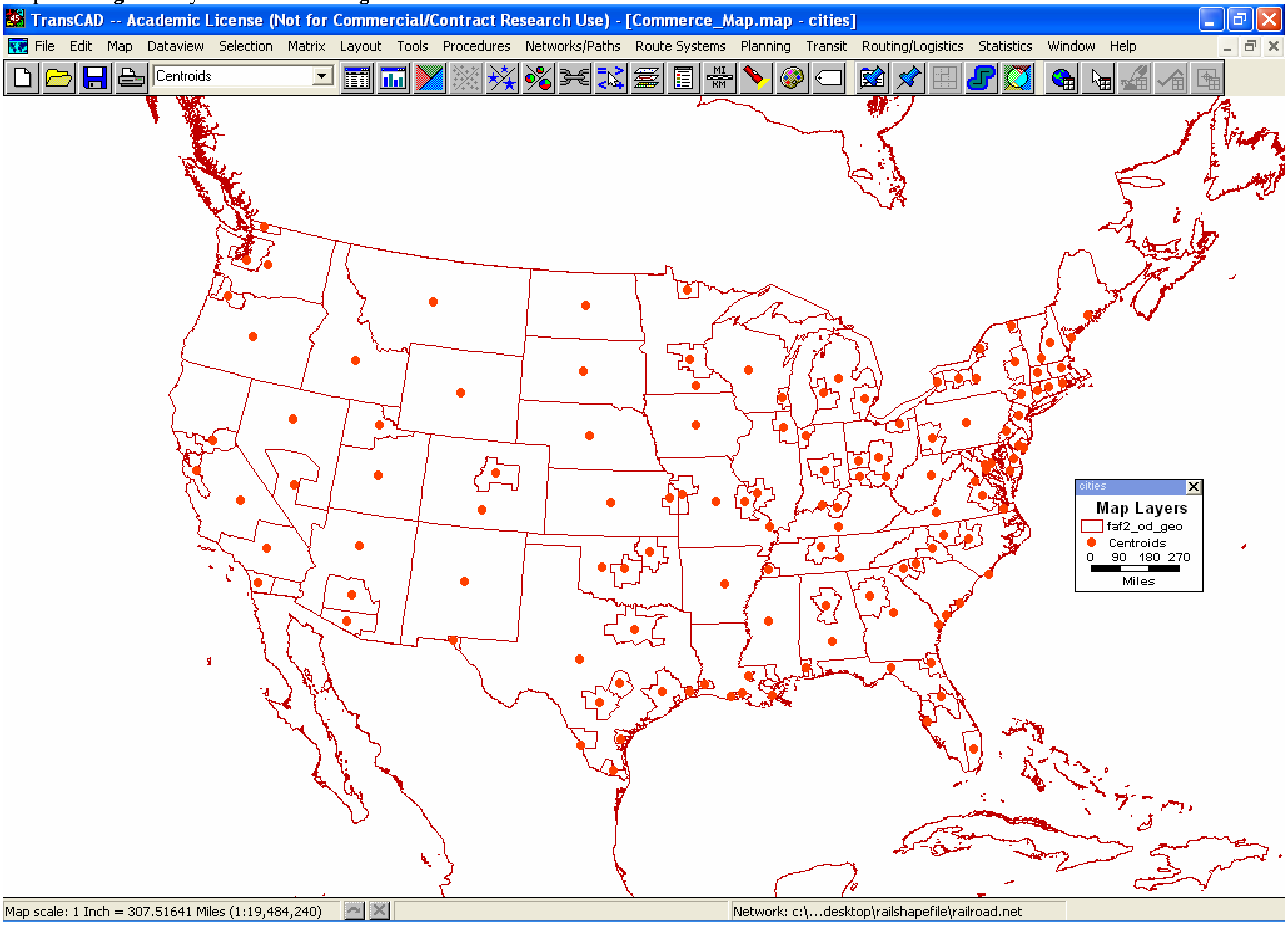
Table 1: Databases and available information

Freight Databases					
Database	**Commodity**	**Geographic Detail**	**Status**	**Code**	**GIS Data**
Trade Stat Express	Aggregated	States and Countries	Free	HS, SITC	No
USA Trade Online	9 digit commodities	US ports and countries	Purchase required	HS	No
United States International Trade Commission	4 digit commodities	US States	Free	HS, SIC, SITC	No
International Trade Administration	3 digit commodities	US States and Metropolitan Areas	Free	SITC	No
PIERS Global Intelligence Solution	9 digit commodities	US Ports and cities, countries	Purchase required	HS	No
US Census Bureau: Foreign Trade Statistics	5 digit commodities	Country Imports	Free	End Use	No
Bureau of Transportation Statistics: NORTAD	2 digit commidities	US States, Canada, Mexico	Free	N/A	Yes: National Transportation Networks, Transborder Freight Data
Global Insight	2 digit commodities	US county level and countries	Purchase required	STCC	No
WISERTrade Foreign Trade Database	6 digit commodities	US states and countries	Purchase required	HS,SITC	No
Freight Analysis Framework	2 digit commodities	US Metropolitan areas and continents	Free		Yes: Metropolitan Areas
US Census Bureau: Commodity Flow Survey	5 digit commodities	US Metropolitan areas	Free	SCTG,STCC	No
Oakridge National Laboratory	N/A	N/A	Free	N/A	Yes: US states, intermodal network, rail, highway, waterway, US cities
US Maritime Administration	Number of containers	US Ports	Free	None	No

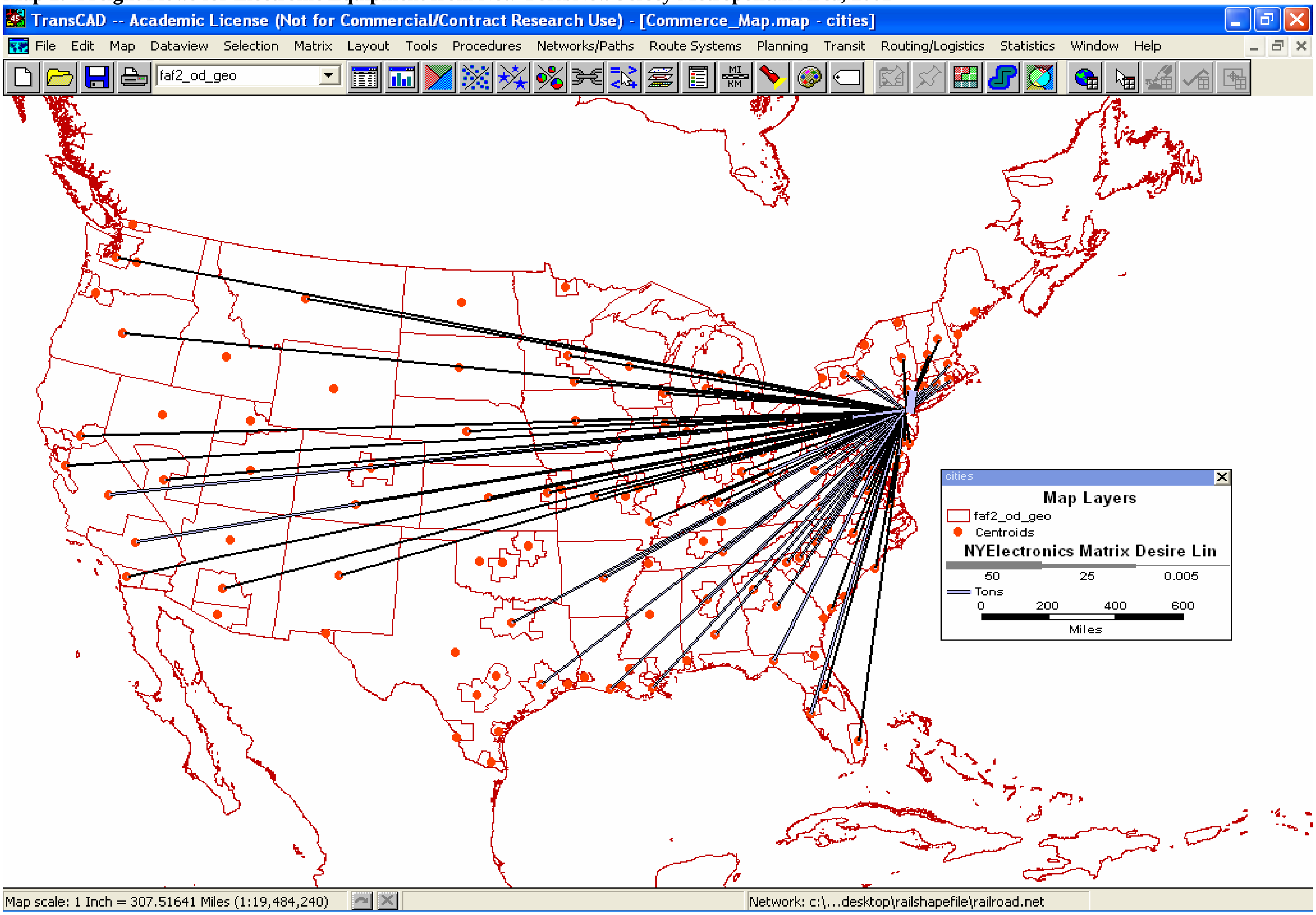
Table 2: Commodity Mapping for SCTG and NAICS codes

SCTG	Commodity type	Constituents	NAICS Code	Industry Constituents
	Live animals and live fish	Live Animals	********	********
1		Live Fish		
1		Live Poultry		
1		Bovine Animals		
1		Swine		
1	Cereal grains	Wheat	42251	Grain Wholesale
1		Corn		Bean Wholesale
2		Barley		Includes: Wheat,
2		Oats etc		Barley, Oats, Corn etc
2	Other agricultural products	Vegetables (Fresh/Chilled)	42291	Farm Dealers
2		Fruits & Nuts		Wholesale Distributors
2		Other Agricultural Products		
2		like soy bean, Cotton etc		
3	Animal feed and products of animal origin, n.e.c.	Straw or Husk	3111	Dog&Cat food mfg
3		Inedible flour, meat, fish etc		Other animal food mfg
3		Dog & Cat Food		
3		Raw Hide, Skin etc		
3		Oil Cake, Eggs etc		
3	Meat, fish, seafood, and their preparations	Meat, Poultry, Fish	3116	Animal Slaugtering &
4		include fresh, chilled & frozen	3117	Processing:
4		Extracts & Juices of fish + Meat		Includes poultry&meat
4				Seafood canning
4				Seafood processing
4	Milled grain products and preparations, and bakery products	Milled grain products like malt,	3118	Bakeries&tortillas mfg
4		wheat, Rice, Flour, cereals etc	31121	
5		Bakery Products like dough,		Flour + Rice milling
5		snack foods, pastries, dry-baked,		Malt mfg
5		frozen baked like pizza etc.		

Map 1: Freight Analysis Framework Regions and Centroids



Map 2: Freight Flows for Electronic Equipment from New York/New Jersey Metropolitan Area, 2002



Map 3: Shortest Path Route from New York/New Jersey Metro Area to Oklahoma City Metro Area