TRUCK TRIP ESTIMATION BY FACILITIES USING ARC-INFO

Mihalis Golias (corresponding author)
Graduate and Research Assistant
CAIT/Maritime Infrastructure Engineering and Management Program
Department of Civil and Environmental Engineering
Rutgers, The State University of New Jersey
623 Bowser Road, Piscataway, NJ 08854
Tel: 732-445-7979, Fax: 732-445-0577
Email: golias@rci.rutgers.edu

Maria Boile, Ph.D.
Assistant Professor and Director of Research and Education
CAIT/Maritime Infrastructure Engineering and Management Program
Department of Civil and Environmental Engineering
Rutgers, The State University of New Jersey
100 Brett Road, Piscataway, NJ 08854
Tel: 732-445-0357 ext. 129, Fax: 732-445-0577
Email: boile@rci.rutgers.edu

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Abstract: Knowledge of truck volumes is important for highway authorities and government organizations because of their strong influence on the economy of the states and the nation overall. The Federal Highway Administration (FHWA) published a report with truck trip generation data in the form of trip rates. This paper describes a GIS based tool used to compute daily truck trips from/to facilities based on the FHWA truck trip rates. The tool allows for the use of truck trip rates from individual studies, if such studies are available to the user. The tool provides the user with an easy to understand interface for entering the data and executing the Quick Response Freight Manual (QRFM) procedures in an efficient and timely manner, while the GIS environment facilitates data visualization that can help the strategic decision-making. A study where the tool was used is also presented and the benefits of using ArcInfo in such studies are discussed.

INTRODUCTION

Knowledge of truck volumes generated at different establishments that will then move onto local, state and interstate highways to reach their destination is important for highway authorities and government organizations because of their strong influence on the economy of the states and the nation overall, and also because of their impact on traffic, roadway pavement and environmental conditions. It has been found that shipments by truck alone account for more than half (53%) of the total tonnage, more than two-thirds (72%) of the shipments by value and nearly one quarter (24%) of the total ton-miles in the United States (Boile, 2001). Estimates say that more than 375M tons of freight is transported each year in New Jersey. Trucks dominate this transportation, carrying 283M tons. The Commodity Flow Survey reported that about 67 percent of the freight tonnage that originates in New Jersey stays in the state, indicating that the truck traffic is mainly regional or local.

Trucks negatively impact the roadway network, primarily because of their massive weight, poor operating characteristics and large dimensions. These factors result in a stronger need for truck traffic estimation. Such an estimate can be helpful in pavement and bridge design and management, reconditioning and reconstruction of highway pavement, planning for freight movements, environmental impact analysis, and investment policies.

The increased importance of truck activity in both engineering and planning has created a need for truck activity estimation. Several estimation techniques have been developed using data typically available for planning applications. These techniques can provide the authorities with good statistics on the freight transportation system activity, which in turn may be used to facilitate plan development for pavement and bridge designs, prediction and planning for future freight movements, development of weight enforcement strategies, environmental impact analysis and analysis of highway investment policies.

One method of truck trip generation analysis is trip rate analysis. This technique develops truck trip rates for each of the various land-use or facility types in a study area. This paper describes a tool that incorporates one of these estimation techniques, the Quick Response Fright Manual (QRFM) truck trip rate estimation method, within a GIS environment facilitating data analysis and visualization. Using ArcObjects and ArcInfo (Burke, 2003; Ormsby, 2004) the Center for Advanced Infrastructure and Transportation at Rutgers University has developed a tool that enables transportation planners and modelers to apply these trip rates or any other rates that may be available from individual studies, in order to estimate truck trip generation by facility type and allow for the visualization of the number of trucks generated by various facilities throughout the state

LITERATURE REVIEW

The current state of the practice in truck trip activity estimation and freight modeling in general falls short to today's needs. Techniques for freight transportation planning, especially at regional level, have not been as well developed as for passenger transportation planning. To some degree, this can be attributed to the greater complexity of the freight transportation system in terms of the spatial and temporal diversity of

freight generation activities and movement. Literature on freight transportation planning at the national or regional level is sparse. Several states have created or are in the process of creating models that will serve as planning tools[1]. The trend shows a focus on commodity-based models and/or vehicle-based models that use the three-step process (trip generation, distribution and assignment).

Typical vehicle-based approaches develop truck trip estimates using land-use and socio-economic data. Based on the purpose for which a model is used, models are classified into various subgroups. These subgroups include the following; Traffic Count-Based Models, Self-Calibrating Gravity Models, Partial Matrix Techniques, GIS-based Models, Heuristic Models and Facility Forecasting Techniques. Mathematical models are also used to forecast freight traffic over specific network links and nodes (Friesz, 2000).

In vehicle-based truck trip generation models, the most common and established approach to estimating truck trip generation is by the use of trip rates i.e. the relation between the number of truck trips produced in or attracted to an area or facility as function of a socioeconomic factor (employment, square footage by activity, etc). Typically, surveys are conducted and used to determine land use at each trip end. Expanded survey data can then be used to relate trip ends by land use (either by facility, or zone, or for the region as a whole) to the socioeconomic factors.

Trip generation rates for different facility types are available through three different main sources: a) the Institute of Transportation Engineers (ITE) Trip Generation Handbook (TGH) published in 2003, b) the Federal Highway Administration (FHWA) QRFM published in 1996 and c) Individual research studies (French et al. 2000; Lancaster Engineering 1998; DeShazo, Tang & Associates, Inc. 2000).

The ITE Trip Generation Handbook provides guidelines for the preparation and application of trip generation data for a wide range of land-use categories to be used in traffic impact studies and other transportation engineering applications. The Handbook is used in conjunction with another ITE publication, Trip Generation, which provides actual trip generation rate data. In general, the trip generation data provided in Trip Generation are total vehicle rates, including trucks; however, specific truck trip generation rates are only provided for truck terminal and industrial park uses, and these are based on very limited data. Appendix A of the Handbook is intended to provide information, but "not recommended practices, procedures, or guidelines" for engineers to use when estimating truck trip generation rates for particular sites.

The FHWA developed the QRFM so that a simple resource for conducting freight analysis would be available to states and Metropolitan Planning Organizations that were getting involved in freight studies with the advent of the ISTEA. The manual describes methodologies for developing freight models, truck models, and site impact studies. Appendix D of the QRFM provides a comprehensive summary and averages of truck trip generation rates and regression equations based on the SIC classification code. Truck trip generation rates are given per employee, per acre and per 1,000 square feet of office space, summarized according to the following land use types (Standard Industrial Classification (SIC) numbers enclosed in parentheses): Agriculture, Mining and Construction (1-19); Manufacturing, Transportation/Communications/Utilities, and Wholesale Trade (20-51); Retail Trade (52-59); Offices and Services (60-88); and Unclassified (89). Although the rates reported are quite extensive, the sources they are

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[1] http://ops.fhwa.dot.gov/freight/

derived from are limited. Another source of truck trip generation data is mainly from traffic impact studies and permitting required by cities, several of which are summarized in NCHRP-298.

DEVELOPMENT AND DESCRIPTION OF THE GIS TOOL

The tool described herein is an add-on GIS tool that computes daily truck trips from/to facilities based on truck trip rates found in the QRFM. The main desktop tool for this application is ArcInfo 9.0, while VBA was used to create the GIS add-on feature interface. This section presents the application of the tool and describes its functionality with the use of snapshots.

      The procedure of estimating truck trip generation per facility using the tool requires two steps:

- a) *Step 1:* Creation of the 2 Digit SIC Codes from the usual 6 Digit SIC Codes, and
- b) *Step 2:* Estimation of Truck Trips per facility based on truck trip rates (per employment and/or per square foot).

Step 1: Creating the 2 Digit SIC Codes

In the QRFM truck trip generation procedure, the number of commercial vehicle destinations/origins per day in each traffic analysis unit (facility, zone, etc) is calculated by:

- a) Obtaining data on or sometimes estimating (usually by extrapolation) the truck generating variable (employees who work in the traffic analysis unit, total square footage etc) for each of the following employment categories:
    1. Agriculture, Mining and Construction (SIC 1-19)
    2. Manufacturing, Transportation/Communications/Utilities and Wholesale Trade (SIC 20-51)
    3. Retail Trade (SIC 52-59)
    4. Office and Services (SIC 60-88),
- b) Applying the trip generation rates to the data obtained above.

      Truck trip rates reported in the QRFM are given for industry classifications based on the Standard Industrial Classification (SIC) system. Economic data, however, is based on the North American Industry Classification System (NAICS) system. Correspondence tables available through the U.S. Census Bureau can be used to relate the economic data to QRFM classifications. Using these tables NAICS economic data can be transformed into SIC data and used with the QRFM trip rates. This transformation procedure is incorporated within the add-on tool and is described below.

      After the data is obtained and imported into the GIS environment, using typical GIS procedures, the user can open the SIC Conversion Form (UserForm1, Fig. 1) and select the layer that contains the socioeconomic data from the list box *Select Layer* on the left of the window. Then the field that contains the 6 digit SIC Code (*Primary_SI*) in the *Select SIC Field* list box is selected and finally the name of the newly created SIC 2 digit code field is entered in the *SIC 2 Digit Name* box (Fig. 1).
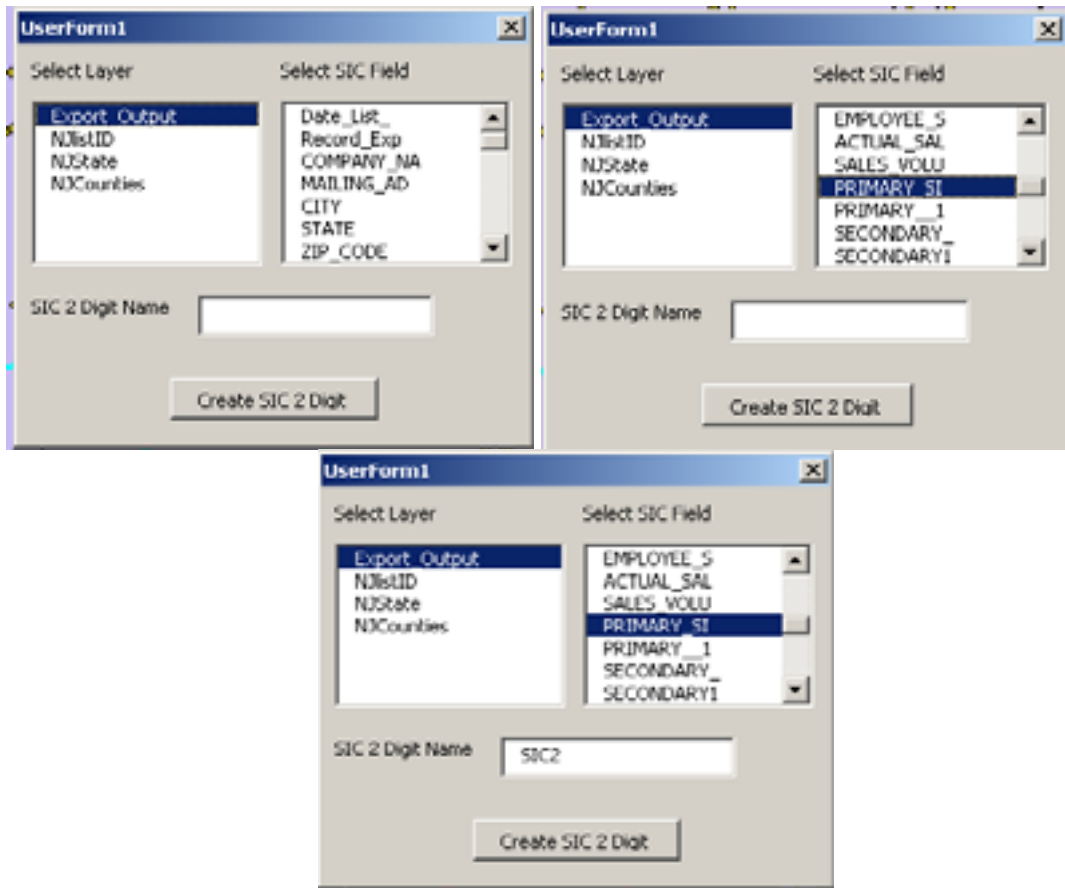
FIGURE 1. Select Layer and 6-Digit SIC Code

This procedure will create the new 2 Digit SIC Codes. A new field (in this example named *SIC2*) is created in the layers database that holds the new SIC codes as shown in fig. 2.

FIGURE 2. New field (SIC2) containing the 2-digit SIC Codes

Step 2: Estimating Truck Trips per facility based on QRFM truck trip rates (per employment and per square footage of establishment)

After the 2-digit SIC codes have been created the user can continue with the estimation of the truck trips per day per facility based on employment and/or facility square footage. The new window that appears, shown in figure 3, contains four lists where the user selects the:

a) Layer that contains the information (*Layer* List Box)
b) Field that contains the SIC 2-digit code (*SIC 2D Field* List Box)
c) Field that contains employment information (*Employment Field* List Box)
d) Field that contains facility square footage information (*Sq Foot Field* List Box)

    In figure 3 the layer *Export_Output* has been selected as the layer containing information of the facilities, the *SIC2* as the field that contains SIC code information, and *ACTUAL_EMP* as the field that contains employment information. The option of calculating truck trips based on the square footage of the establishment could also have been simultaneously selected if the user wanted to compute two different truck trip generation estimates, one based on employment per facility and the other on square footage of the facility.

FIGURE. 3. Selection of Layer and Fields

    At this point the user can select to use the trip rates provided in QRFM, or input trip rates provided by other studies by enabling the *Change Rates* check button (fig. 4).
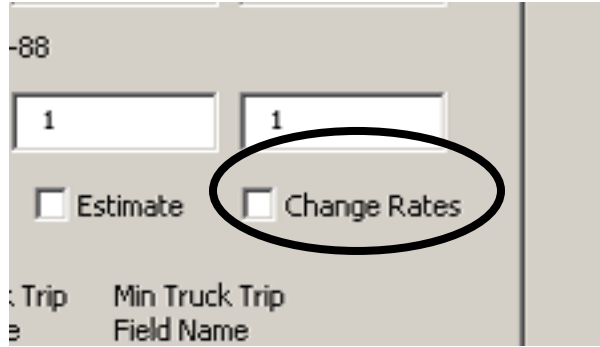
FIGURE 4. Change QRFM Rates Option

The user is given the option of estimating the average, maximum, and/or minimum truck trips per facility (fig. 5).
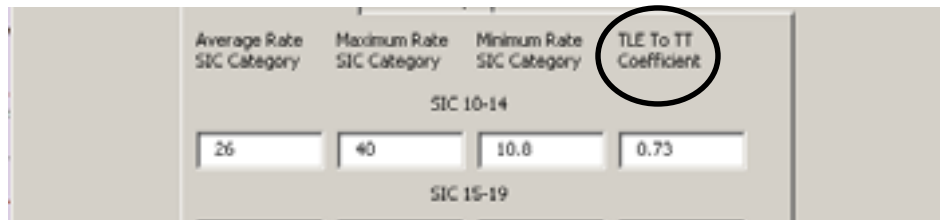

Figure 5. Average, Maximum, and Minimum Trip Rates per SIC 2-digit QRFM Aggregate Category

Some of the trip rates in the QRFM are given as truck-load equivalents (TLE) instead of truck trip rates (SIC category 10-14, and 15-19). For this reason the option of transforming the TLE to truck trips (TT) is given via the *TLE to TT Coefficient* (fig. 5) that contain the coefficients for the transformation from TLE to TT. The default values of these coefficients are taken from the modal split by tonnage for the New Jersey State. The user as with the TT rates is given the option of changing these coefficients.

The last step required is to enter the name for the new field(s), of the average, maximum, and/or minimum for the estimated truck trips (Fig. 6).
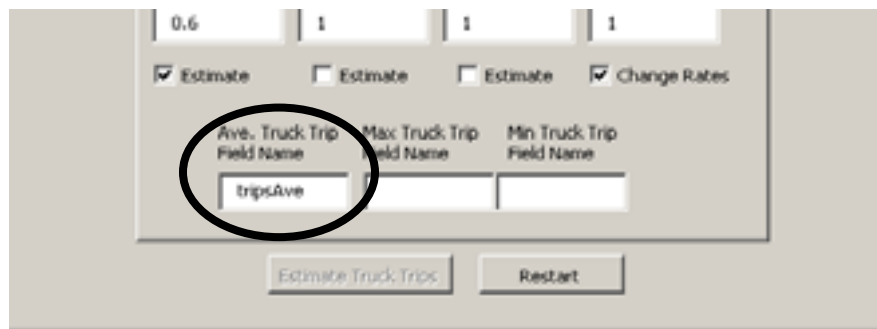

FIGURE 6. Entering Truck Trip Field Names

After the procedure has been executed the user can exit the application or restart it to estimate more truck trips based on different datasets (fig. 7).

FIGURE 7. Restarting the Procedure

Results can be either viewed in the layers attribute table as shown in figure 8, or by utilizing symbology capabilities of ArcInfo and visualize results in the form of a chart (Bar, Pie, or Stacked), as shown in figure 9. One of the advantages of this tool is that truck trip information is now included within a GIS environment and can be viewed simultaneously with all the other elements of the network (highways, railways, warehouse location, city locations etc).

New field with the estimated Truck Trips per Facility

gitude	SIC2	tripsAve
75002210	54	33
75007896	54	25
74812976	80	90
74812976	80	180
74871950	36	14
74834056	50	5
75084597	28	14
75043389	42	5
74842631	17	12
74879625	70	36
75097516	70	90
74816721	90	5
74967387	60	42

FIGURE 8. Attribute Table of Layer With the New Field of Truck Trips Per Facility
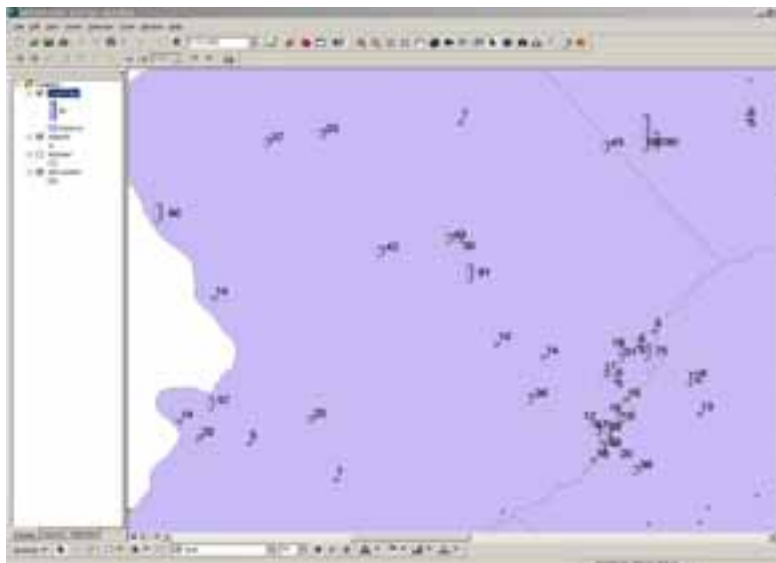

FIGURE 9. Bar Chart of Truck Volume Generation in West New Jersey

In figure 10 truck trips per facility are presented along with municipalities, highway and rail network, business locations, local street network, airports, and major cities (population over 50,000 people), for central New Jersey.
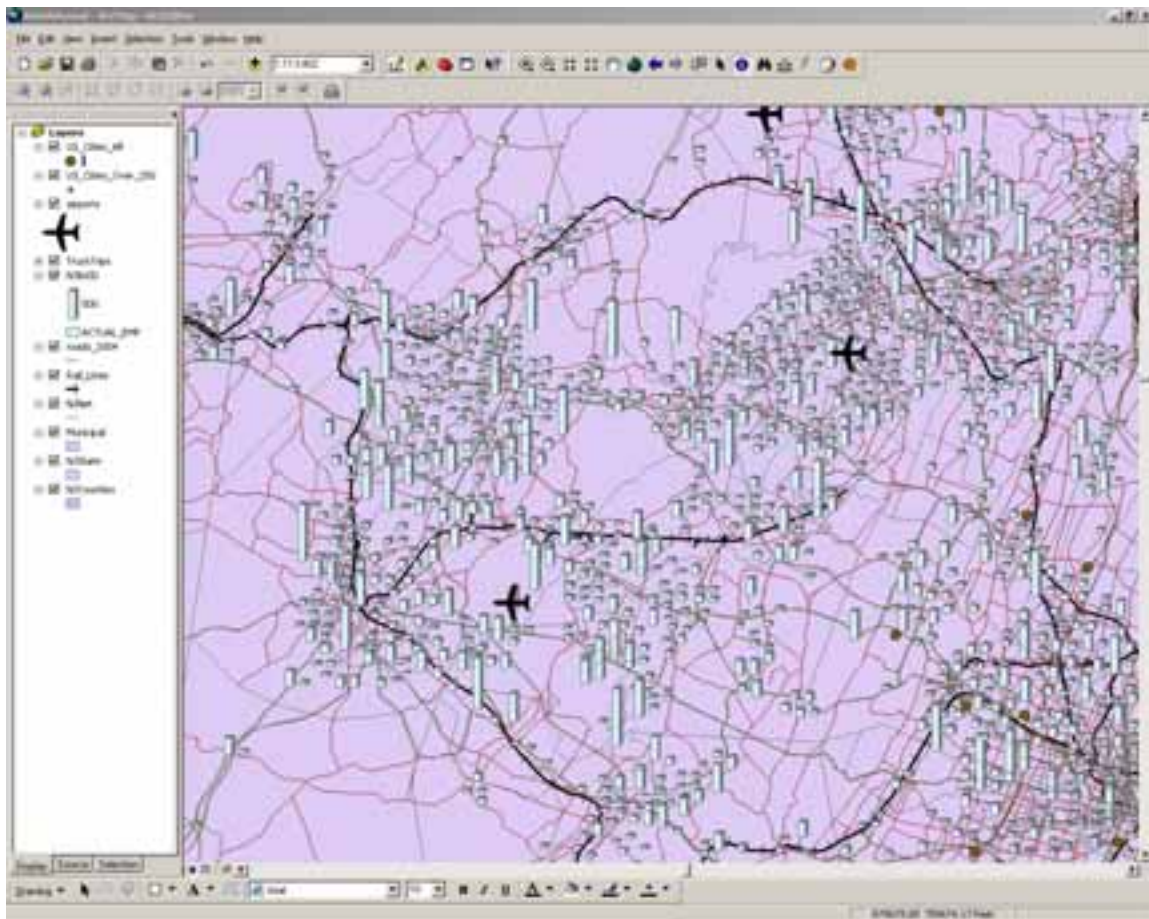

FIGURE 10. Visualizing Truck Trip Generation

CONCLUSIONS

This paper described a tool that incorporates the QRFM truck trip rate estimation approach within a GIS environment facilitating data analysis and visualization. The developed add-on tool was presented and its functionality was discussed via a step-by-step presentation of its use. Having access to a tool with this functionality could be beneficial for a state DOT, DEP, MPOs, or other public or private agencies, since truck volume data availability is required for a big number of applications. The add-on tool is flexible to incorporate more detailed or area-specific data that may be available by the agency. The flexibility of the GIS platform to perform statistical analyses on the resulting truck volumes, cluster locations based on truck activity and prioritize them based on various criteria, and visualize truck activity along with infrastructure availability, proximity to key facilities, and other information (social, economic, environmental) that may be available to the user, facilitates truck volume related planning and decision making and assists in incorporating truck movement related considerations into other planning applications.

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