Local Truck Routing Initiatives Part III

Nashville-Davidson County Truck Routing Study

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INTRODUCTION

With regards to highway safety, changing truck sizes and weights, transportation of hazardous materials and maintenance of our nation's highways and bridges, the importance of conducting truck routing analyses has acquired additional significance in recent months. Transportation researchers at Vanderbilt University have recently completed a truck routing study for Nashville-Davidson County. This paper will highlight several of the innovative analysis techniques used in this study and discuss the importance of certain conclusions. We hope the issues discussed and methodologies presented will provide useful insights for other transportation analysts and local officials.

A primary reason for conducting this truck routing study was to evaluate how various truck routing plans might impact upon the performance of existing and future highway systems, affect accident rates, improve arterial street operations, and minimize harmful environmental impacts in Nashville-Davidson County. More specific operational and environmental reasons for conducting this study related to the already congested truck terminal areas, inner loop truck-automobile congestion, geometric design deficiencies, and better land use planning in locating future new terminals. After completion of this truck routing study, Metropolitan Nashville officials were better able to assess the feasibility of designated truck routes, make more informed truck-automobile planning decisions, and recognize more fully the likely consequences of their decisions.

DATA INVENTORY AND ANALYSIS

Nashville has approximately 550 miles of highways consisting of interstate (86 miles), principal arterials (267 miles), and parkways plus minor arterial and collector streets (estimated 197 miles) that represent the primary Nashville roadway system most suitable for truck utilization. The large interstate mileage is an asset to the mobility of Nashvillians and to the overall economic viability of Nashville-Davidson County. However, frequent interchanges that encourage use of the interstates for local tripmaking and existing geometric design deficiencies, particularly on the inner loop, do present transportation problems.

The first priorities deemed necessary by the transportation research team were to define exactly what constituted a truck and a truck trip. The initial reaction to performing such elementary tasks might suggest that defining these fundamental terms was unnecessary. However, past experiences have proved that careful and succinct definition of the aforementioned terms proves to be highly beneficial and can minimize confusion that often occurs.

Before performing analytical and computerized modeling techniques to evaluate possible truck routes, seven useful data sets and three environmental analysis considerations were identified. The seven initial data sets for possible use in subsequent analyses:

1. Identified truck terminal locations;
2. Classified truck traffic by volumes and percentages on Nashville roadways;
3. Highlighted existing areas of congestion;
4. Specified intersections where high numbers of truck-automobile accidents occurred;
5. Cited highway locations where height restrictions existed; and

6-7. Located Nashville's public schools and hospitals.

The three environmental considerations provided:

1. Vehicle emission rates for various truck types at travel speeds of 40 and 55 mph;
2. A graphic noise prediction model using a nomograph to simplify the Federal Highway Administration's rather tedious highway noise prediction model; and
3. Typical fuel consumption rates for differing truck types and operating conditions.

Identification of truck terminal locations, existing areas of traffic congestion, high accident intersections, and hospital and school locations consisted of placing each of these pertinent data sets on a predetermined base map. Establishing a uniform base map for use throughout the study was extremely useful in subsequent overlay analyses of these data.

Overhead height restrictions and classifying truck traffic by volume and percent traffic were presented in the more conventional form of tables. In addition, the Tennessee Department of Transportation vehicle classification counts for Nashville-Davidson County highways were alphabetized by roadway segment. This has proven to be a useful tool in several subsequent transportation investigations. For example, transportation analysts now have a handy ready-reference if they want to know the truck volume and/or percent trucks by single unit or multiple unit on a specific roadway segment such as Fourteenth Avenue between Church Street and Broadway Avenue. Updating of truck volumes as more current ADT counts become available is also easily accomplished, provided there are no notable significant changes in the percent of trucks per route segment.

From the three environmental considerations studied (i.e., vehicle exhaust emission rates, truck noise, and typical fuel consumption rates), several useful facts emerged. Typical air pollution and fuel consumption rates can and have been used in subsequent transportation analyses and investigations into noise prediction modeling resulted in the discovery of a simplified FHWA noise prediction nomograph developed by the Ontario Ministry of Transportation and Communications. This nomograph has provided local planners with a helpful analytical tool for making noise prediction forecasts for planning purposes and in answering citizen concerns about the noise impacts associated with increased truck traffic.

INTEGRATED DATA SET ANALYSES AND COMPUTER MODELING TECHNIQUES

Two principal techniques were used to analyze several of the data sets presented earlier. The two techniques were:

1. Overlaying and inspecting integrated data visually, and
2. Computerized truck route modeling.

The overlay technique consisted of placing transparencies with respective data on top of one another until particular areas began to darken significantly. The darkened areas thus represented specific trouble areas. Three sets of data from the seven listed earlier were deemed to be the most informative in identifying specific trouble areas to avoid when designating truck routes or areas otherwise needing improvements of some type. The three data sets selected were:

1. Truck terminal locations,
2. Recognized areas of congestion, and
3. High truck-automobile accident locations.

More than three data sets were considered initially, but it became apparent quickly that four or more data sets tended to darken most of Davidson County. This was particularly true if a "busy" data set such as school locations was one of the transparencies used in the overlay analysis.

Seven areas in Davidson County were identified from the overlaying of truck terminal locations, traffic congestion areas, and high accident locations. Thus, these seven areas received particular attention when proposing truck routes or when considering geometric design and other TSM improvements to reduce truck-automobile traffic problems in these areas.

The computer modeling methodology used in this study sought to replicate results from the more detailed models used by the Tennessee Department of Transportation (TDOT) to forecast Nashville-Davidson County truck volumes. The more detailed TDOT models perform the following three transportation planning procedures:

1. Trip generation,
2. Trip distribution, and
3. Traffic assignment.

Each computer run actually consists of a series of sub-model programs (e.g., generation of production and attraction trip ends, formation of trip interchanges through use of the gravity model, and capacity restraint trip assignment). A single computer run requiring these series of sub-model programs costs TDOT or the requesting agency approximately $250 per run in computer costs.

In an attempt to fully utilize the vast capabilities of computer models but less expensively, project researchers proposed the use of similar programs currently available at Vanderbilt University and developed by the Federal Highway Administration. By using a limited number of zones instead of all of Nashville's 248 traffic analysis zones, and by utilizing a less-detailed network (i.e., a limited number of selected road segments or links), several different routing scenarios could be tested less expensively.

The network model Vanderbilt used, TNET for Traffic Network, is constrained to 50 zones, 125 nodes and 450 links per network. After studying the Nashville-Davidson County highway system and plotting truck terminal locations, the researchers decided that five sub-area networks containing the vast majority of truck terminals would be appropriate for testing. The five initially proposed models consisted of the:

1. Interstate system,
2. Downtown street network,
3. Roads between and including I-65 and I-40 to the northeast,
4. Roads between and including I-40 and I-24 to the east, and
5. Roads between and including I-24 and I-65 to the south.

Development of these five networks was begun and initial tests performed. One of the three sub-area networks was completed and tested extensively. Internal-internal trips were distributed rationally and results compared favorably with those from the more extensive TDOT models. Actual external-external (or through) trips were difficult to replicate and successfully link or pass to an adjacent sub-area. The very nature of the distribution model (i.e., the gravity model) that was used probably contributed to the difficulties associated with reproducing longer external-external or through trips. Therefore, the three sub-area networks were not used for further through truck route analyses, but may prove useful in subsequent truck routing analyses investigating specific area routing impacts or the movement of hazardous materials through an area.

Work proceeded with model calibration of the interstate network and the downtown street network. The latest available TDOT ground counts were used to produce daily truck volumes for each network link. The researchers developed production and attraction trip-ends based on these existing truck traffic counts, developed a gravity model to distribute trips proportionately and then used an equilibrium assignment model to assign truck trips to highway links.

A model was considered to be calibrated when there was:

1. Relative agreement between 1982 forecasted model volumes and actual 1982 ground counts (i.e., $\pm 10\%$ error per link), and
2. The overall average error between forecasted and ground count values for all links was approximately equal to or less than a 5.0% average error for all observations.

STUDY FINDINGS AND RESULTS

Trucks have a significant impact upon the overall transportation system performance in Nashville-Davidson County. In the seven-year period between 1976 and 1983, there has been a 70.6% increase in truck terminals in Davidson County. Truck terminal operations apparently evolve through phases which might be termed as:

1. Creation
2. Growth and expansion, and
3. Reorganization.

Of the approximate 86 miles of interstate highway and 267 miles of principal arterials, 1982 truck volumes on different roadway segments varied from an insignificant percentage up to a high of 27% trucks.

Although each of the seven specific areas identified during the overlay analysis could (and probably should) be the focus of site specific operational improvement studies, field observations of these seven areas were performed and a series of possible improvements for each site was presented.

An obvious solution to reducing truck-automobile congestion and improving safety involved the removing of trucks from the traffic mix (e.g., truck routing via other routes). However, it was apparent that two immediate problems would result if trucks were excluded from the identified problem areas.

First, physically prohibiting trucks on these facilities would place substantial economic hardships on trucking operations. The trucks travel these facilities because there is a demand for ingress and egress from these areas. In almost all cases, comparable parallel facilities are not available and considerable inconvenience, additional travel time, and extra vehicle miles of travel and fuel consumption would result from substantial rerouting.

Secondly, existing problems might simply be transferred to other areas, and possibly compounded, if designated truck routes excluded trucks from traveling along the seven identified facilities. Although traffic congestion, high accident rates, and truck terminals exist along these seven facilities, prohibiting truck traffic on them and rerouting trucks to nearby facilities would not deter the possibility of similar problems occurring at other locales. When more convenient and economic routes exist, truckers will use them. Since comparable parallel routes do not exist in most instances, costly construction of new routes or substantial upgrading of existing ones would be required in conjunction with designating truck routes.

As mentioned earlier, the three sub-area computer networks were not used extensively, but were saved because of their possible usefulness in more detailed impact analyses of area truck trip patterns or in a subsequent hazardous materials movement study.

The two additional computer models depicting the interstate network and the downtown street network were used to test several routing scenarios in order that the researchers might obtain a better understanding about:

1. The impacts of route changes, and
2. The appropriateness or sensitivity of selecting certain routes over others.

Once both truck assignments were calibrated against actual ground counts and were within a $\pm 5.0\%$ margin of error, various scenarios were tested. The two most useful interstate scenarios involved:

1. Adding a controlled access circumferential which would divert approximately 5,000 (4,844) truck trips from other routes, and
2. Restricting truck traffic on a portion of Nashville's interstate "inner loop" because of the 14.0' clearances under several structures. (This scenario actually became two separate runs since assignments with and without the addition of the controlled access circumferential were tested.)

Several different scenarios of downtown routes were considered for testing. After running several downtown routing scenarios and realizing the vast number of possible permutations involving over 90 separate downtown links, the researchers decided to test collectively the sensitivity of various east-west and north-south links. For example, by simultaneously increasing all east-west link distances and reducing their travel speeds, truck trip assignments along north-south routes became more attractive and were increased. Then by calculating the percent trip assignment increase per north-south link, analysts obtained an increased sensitivity awareness or intuitive feel for the attractiveness of certain north-south truck routes using individual north-south links.

Similar constraint of north-south links indicated the attractiveness of individual east-west links. Table 1 shows the percent increase or decrease per directional movement for the two scenarios. From the table, one realizes that north-south routes appear to function more efficiently with less overall delay so that, in general, they would be better truck routes in the downtown area. Individual characteristics of each link must be considered, however, before designating truck routes and to ensure the reasonableness of any proposed truck routes.

TABLE 1

SENSITIVITY ANALYSIS OF DOWNTOWN TRUCK ROUTES

North-South Travel Constrained

A.	Increase in Vehicle Miles of Travel (VMT)	10,157 veh-mi
B.	Increase in Travel Times	631,803 min
C.	Total VMT	38,096 veh-mi
D.	Total Travel Time	2.37×10^6 min

Street	***% Change* in Travel Propensity***
Jefferson	+18.0%
James Robertson Parkway	- 45.8
Charlotte	+ 3.8
Church	+54.6
Broadway	+28.7
Demombreun	- 62.5

East-West Travel Constrained

A.	Increase in VMT	3,670 veh-mi
B.	Increase in Travel Times	226,270 min
C.	Total VMT	33,373 veh-mi
D.	Total Travel Time	2.07×10^6 min
E.	Resulting North-South Assignments:	

Street	***% Change* in Travel Propensity***
Thirteenth	+32.7%
Twelfth	- 9.0
Eighth	+ 9.6
Hermitage	+ 9.4
First	+29.0

CONCLUSIONS AND RECOMMENDATIONS

Pertinent study conclusions showed that:

1. A disproportionate percent of the accidents on Nashville-Davidson County highways occur at interstate entrance and exit ramps. Excessive weaving and low design speeds on the inner loop are major contributing causes.
2. Approximately five new or improved facilities scheduled to be

completed in the next few years should significantly improve truck movements and reduce truck-automobile conflicts.

3. In order to segregate truck and automobile traffic, two approaches can be initiated. The two approaches adhere to thou-shall and thou-shall-not philosophies whereby trucks are restricted to or prohibited from operating on certain highways and streets. Designated truck routes represent a selective operational scheme or skeletal network on which trucks can operate. Routes must be selected carefully since the limiting of mobility can have significant financial impacts and detrimental time delays on trucking operations. The prohibitive philosophy allows trucking operations to be more ubiguitous, but prohibit trucks from areas where they do not have to be and/or where their presence is detrimental to the area's quality-of-life.
   The researchers concluded during this study that Nashville, like most developing cities, would have many problems in designating and enforcing routes for trucks only, or diverting trucks to other comparable existing facilities, or building new parallel roadways. Therefore, prohibiting trucks from areas where they are not required to travel and improving existing problem areas where trucks currently travel are the most logical present actions. Removing, or at least reducing, existing problems and evaluating the full impacts of new facilities as they are opened are more appropriate at the present time than designating restrictive truck routes. However, requiring specific routes for trucks transporting hazardous materials is an exception to the preceding argument and should be studied in much greater detail.
4. In addition to foregoing the immediate designation of specific truck routes, defining limited operating times for trucks on certain roads and designating certain lanes in which they must operate (e.g., curb lanes) are two other operational schemes which the researchers considered but concluded were not viable alternatives at the present time. Time restrictions to truck operations would cause economic hardships on trucking operations, increase the prices of goods because of these delays and increased labor costs, and would possibly lead to legal actions by the trucking industry. Designating truck lanes would also restrict truck speeds artificially and create additional safety hazards.
5. Field investigation by the researchers resulted in the conclusion that experimental signing to perhaps startle truckers into greater conscious cautiousness was needed on the interstate inner loop.

6. Speed limit reductions at certain locations were merited.

The more salient study recommendations involved the following:

1. Deferring designated truck routes in favor of system improvements to existing trouble spots and analyzing system operations as scheduled new facilities come on-line in the near future.
2. Improving the seven specifically identified problem areas (specific actions cited in report).
3. Restricting trucks from certain nonessential areas where they presently operate (specific locations cited in report).
4. Reducing two speed limits on the inner loop to 50 mph and 45 mph in different locales.
5. Providing better informational signing on the interstate system.
6. Adding *additional* non-standard signs to supplement existing standard sign.
7. Encouraging north-south truck traffic downtown instead of east-west truck traffic.
8. Recommending that a hazardous materials study be conducted.

CONCLUDING REMARKS

Reformatting existing data, overlay analyses, computer sensitivity analyses, use of non-standard highway signs, and use of a noise analysis nomograph were but a few of the ideas presented in this paper. Although the non-designation of defined truck routes may be slightly contrary to the expected results of a truck-routing study, the inability to define logical and appropriate surrogate truck routes in a developing city is certainly not uncommon. Hopefully through this discussion of the methodologies and resulting conclusions and recommendations, other transportation professionals will be better able to assess the feasibility and impacts of truck routes in subsequent locales.