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The University of Texas at Austin

Research Project Summary Report 1838-S
Transportation Control Measure Effectiveness in Ozone Nonattainment Areas
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PROJECT SUMMARY REPORT

Transportation Control Measure Effectiveness In Ozone Nonattainment Areas

Transportation planners, traditionally used to focusing on regional travel forecasting, now have the added responsibility of providing traffic data to state air quality agencies for use in mobile source emissions analysis. Coordinated efforts among land use planners, travel demand planners, and air quality planners are needed to ensure the provision of safe and efficient transportation systems while also addressing environmental concerns. This is particularly so because mobile source emissions constitute a major fraction of total atmospheric emissions. Consequently, many metropolitan areas and states are depending on transportation control measures (TCMs) to reduce mobile source emissions as part of an overall strategy to reduce atmospheric emissions. Within this context, it is important to develop a procedure to determine which TCMs (or combination of TCMs) have the most beneficial impact in terms of mobility, emissions, and cost. It is necessary that such a procedure be methodologically sound yet application friendly, and be capable of analyzing the effects of demographic changes and transport policy actions. The current research contributes toward the development of such an integrated transportation air quality procedure. Specifically, the research has the following objectives: (a) Refine regional travel models to make them more sensitive to sociodemographic changes and TCMs, (b) Develop models for improved supplementary traffic input data needed by the MOBILE emission factor model, and (c) Integrate all relevant models within a Geographic Information System (GIS) architecture. The next section discusses the research conducted in the project to achieve each of the objectives identified above.

What We Did...

Refine Structure and Specification of Travel Models

Several areas of improvement in travel models were undertaken as part of this project. These are discussed below.

How many trips are produced?

Two improvements were made to traditional trip production modeling procedures. First, an ordered-response discrete choice model that accommodates the ordinal but discrete nature of trips was estimated at the household-level. Using such a model structure is theoretically more appropriate than using cross-classification or linear regression approaches, since these latter approaches inappropriately consider number of trips as a continuous variable at the household-level. Second, a variable that captures the composite effect of travel cost, in-vehicle time, and out-of-vehicle time by all available modes to all candidate traffic survey zones was included as an accessibility measure in trip production modeling.

Where are trips concentrated?

The current research estimated an individual-level destination choice model that appropriately combines the travel cost, in-vehicle time, and out-of vehicle time level of service measures by all available modes to develop a composite impedance measure for travel between each zonal pair. The procedure also recognizes differential sensitivities to level of service measures across different demographic groups in the population.

How and when are the trips made?

Many TCMs such as High-Occupancy Vehicle (HOV) lanes, improved transit service during peak hours, peak period pricing, etc. are focused on the peak periods. Such TCMs have a non-uniform (across time-of-day) effect on modal level of service. The primary effect of such TCMs is to shift travel modes and/or shift time-of-day of travel. While the former may be the predominant impact for work trips, both mode and time-of-day may be affected for non-work trips. This research developed mode and time-of-day models to analyze TCM impacts on both these dimensions.

Develop Models for Supplementary Traffic Inputs Needed by MOBILE

As is the case of travel demand models, the development of models for supplementary traffic inputs was pursued along several directions, as discussed below.

VMT Mix Models

The MOBILE model requires several traffic related inputs, one of which is the Vehicle Miles Traveled (VMT) mix ratio. Current procedures determine the VMT mix ratio as a function of two control variables: roadway type (freeways/arterials) and area type (rural/urban). It is quite likely that there is substantial variation in VMT mix even after controlling for roadway functional classification and area type. The research undertaken in this project developed a fractional split model

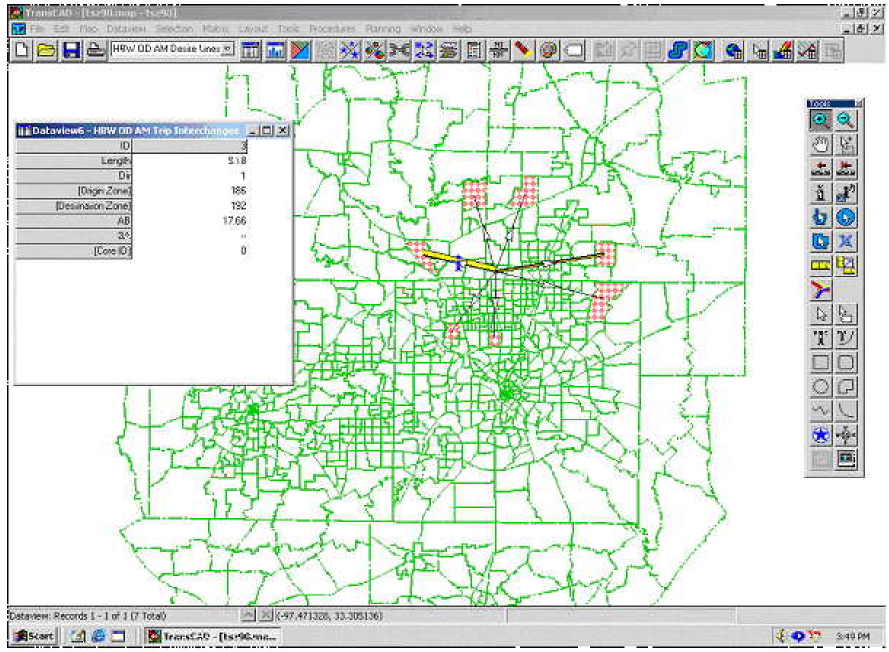

Figure One : Display of Trip Interchanges by Mode and Departure Time for the DFW Metropolitan Area

that determines the VMT mix ratio as a function of several informative variables, including the physical attributes of links (such as number of lanes and whether the link is a divided road or not), the operating characteristics of links (such as link speed), aggregate area-type characterizations of the traffic survey zone in which the link lies (such as urban, suburban, and rural), and the land-use attributes of the zone (such as retail acreage and manufacturing/warehouse acreage in the zone).

Travel Time Duration and Soak Time Models

In addition to VMT, the MOBILE model takes several traffic-related data as inputs, one of which is the distribution of the duration of vehicle trips in the region. The vehicle trip duration distribution is important for several reasons. First, the trip duration distribution provides information for developing trip duration activity parameters used by the MOBILE emissions factor model to estimate running loss emissions. Running loss emissions are evaporative emissions that have escaped from a vehicle while the engine is operating (from spots where the vehicle's evaporative/purge system has become inoperative). Second, operating mode fractions, which are needed by MOBILE5 to estimate emissions rates, can be estimated from the trip duration distribution. Third, the trip duration distribution can be used to predict the vehicle miles of travel (VMT) accumulated on local roads in the region. The current research project formulated and implemented a methodology for modeling trip durations using vehicle trip data from household travel surveys and supplementary zonal demographic/land-use data.

Another traffic input to the MOBILE model is the distribution of the soak-time of vehicle trip starts. The U.S. Environmental Protection Agency (EPA) has defined soak-time as the duration of time in which the vehicle's engine is not operating and which precedes a successful vehicle start. The soak-time for a trip is likely to depend on various factors such as the activity purpose preceding the trip start (i.e., the origin activity purpose), the time-of-day of the trip start, and other land-use and socio-demographic characteristics of the zone of trip start. This research formulated and implemented a methodology for modeling soak-time durations. The methodology involved estimation of models using vehicle trip data from household travel surveys and supplementary zonal demographic/land-use data. The effectiveness of the methodology lies in its easy application at the traffic zonal level within a metropolitan region to obtain zone-specific soak-time distributions by time-of-day and origin activity purpose.

Integrate Relevant Models within a Geographic Information System (GIS) Architecture

In addition to refining the current regional travel models and developing models for improved supplementary traffic inputs to emissions models, this research focused on their integration within TransCAD, a premier GIS for transportation planning. TransCAD is ideally suited for transportation air quality analysis because such an analysis is intrinsically spatial and requires the storage and manipulation of vast amounts of spatial data. The current research developed graphical user interfaces in the TransCAD environment to implement the travel demand and traffic input models described earlier. These user interfaces are easy to use and guide the user through the modeling process using dialog boxes and prompt windows. The research also integrated the outputs from various travel demand models with a comprehensive map display of the DFW region. This will enable the user to visualize the model results.

What We Found...

There are five broad findings from this research.

First, sociodemographic and employment related attributes have a significant impact on travel-related decisions of households and individuals. While this result is not surprising, the state of the practice in travel demand modeling continues to use very limited specifications of sociodemographic variables in the modeling process. Such limited demographic variable specifications can, and in general will, lead to misinformed transportation planning and air quality decisions because of projected changes in demographic and employment-related trends over the next few decades (including aging of the population, a decrease in the number of households with children, and more employed individuals). In addition, our results indicate differential sensitivities of sociodemographic groups to transportation system performance. Accommodating such differential travel sensitivities of demographic groups is important for accurate evaluation of transportation control measure as well as for environmental justice considerations in transport policy analysis.

Second, it is practical and very feasible to apply models in forecasting mode even when they involve several explanatory demographic variables. One of the reasons often provided for the use of a limited specification of demographic variables in estimation is that it renders the forecasting process manageable. However, this research project has developed and applied a forecasting methodology that can be integrated within a GIS-based platform, even if several explanatory variables are used during estimation. The methodology, which is rather simple, entails the generation of a synthetic population of households and individuals based on current or projected aggregate population demographic distributions.

Third, localized transportation control measures (TCMs) such as widening existing lanes, adding new lanes, and traffic signal improvements may not substantially improve mobility and emissions levels. This finding has significant implications for the choice of TCMs for air quality improvements, since it suggests that corridor or area wide TCMs such as HOV lanes, car pooling incentives, and alternative work arrangements may be more effective than localized TCMs in improving mobility and air quality. However, because of the limited nature of the simulation exercises in the current project, we recommend caution in generalizing this finding. Specifically, the results may be a reflection of the relatively low to medium levels of congestion (as opposed to very high levels of congestion) on the arterials used in the simulation exercises. A more comprehensive examination of local TCMs in the context of different roadway types, different vehicle mixes, and different volume levels would be desirable in making any strong and general conclusions. Notwithstanding the caveat above, the results do question the current practice of assuming blanket emissions benefits of localized TCMs.

Fourth, current approaches to VMT mix, local road VMT, soak time distribution, and VMT by trip time duration can be substantially improved by developing models based on local vehicle classification counts and survey data. Since the emissions computations in the MOBILE model are very sensitive to these inputs, it is important that metropolitan planning organizations consider pursuing such efforts.

Fifth, visualization of the intermediate and final traffic output results graphically on the Texas network aids in understanding traffic patterns and provides an effective intuitive means to checking model functionality.

The Researchers Recommend...

Our recommendations are provided under two categories: Implementation and Further Research.

Implementation Recommendations

The models developed as part of the integrated transportation air quality procedure can be implemented for the North Central Texas Council of Governments (NCTCOG) area. The models for travel demand will need additional effort to ensure compatibility with the current framework adopted by NCTCOG; however, the models for supplementary traffic inputs can be used as they are by NCTCOG for planning purposes. Implementation of the travel demand and supplementary traffic model formulations for other metropolitan areas will require model estimations based on data collected locally. It is recommended that TxDOT pursue such implementation-related work for other Texas metropolitan areas.

Research Recommendations

The U.S. Environmental Protection Agency (EPA) is currently developing the MOBILE6 emissions factor model, which should become the required standard for air quality conformity and transportation control measure (TCM) effectiveness analysis by Fall 2001. The structure as well as the input needs for MOBILE6 are quite different from those of its predecessor MOBILE5. The changes in MOBILE6 are valuable and should result in more accurate mobile source emissions estimates. At the same time, the MOBILE6 model offers substantial opportunities and poses important challenges to improve traffic inputs. Among these inputs are (a) fleet characterization data (projections of future vehicle fleet size; and fraction of travel by a multidimensional breakdown based on vehicle age, mileage accumulation rate, and thirty vehicle types), (b) separate traffic-related variables for weekdays and weekends in emissions modeling, and (c) a very high temporal resolution during the day for all traffic indicators. It is recommended that TxDOT place a high priority on the development of models that are capable of accurately providing such traffic inputs to the MOBILE6 model.

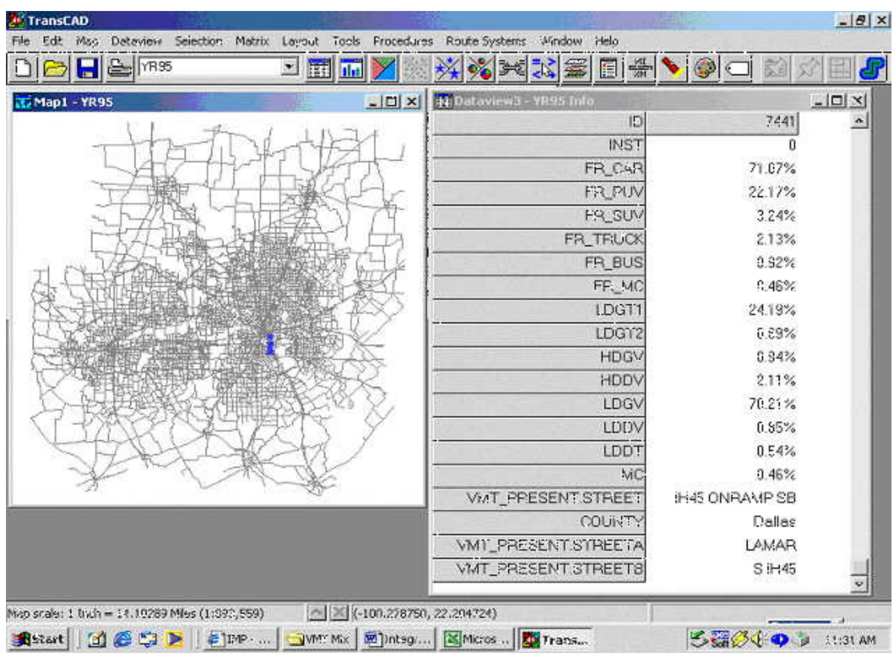

Figure Two: Display of the VMT Mix on an IH-45 SB ramp in Dallas, Texas.

For More Details...

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The research is documented in the following reports:

1838-1 Description of Data Acquisition Efforts, August 1999
1838-2 Review of 1990 Mobile Source Emissions Modeling Procedure for the Dallas-Ft. Worth Non-Attainment Area, August 1999
1838-3 Review of the Current Dallas-Ft. Worth Regional Travel Demand Model, August 1999
1838-4 Presentation Slides for Review Meeting on August 19,1999, September 1999
1838-5 VMT Mix Modeling for Mobile Source Emissions Forecasting: Formulation and Empirical Application, May 2000
1838-6 Modeling Soak-Time Distribution of Trips for Mobile Source Emissions Forecasting: Techniques and Applications, August 2000
1838-7 Modeling Trip Duration for Mobile Source Emissions Forecasting, August 2000
1838-8 Transportation Control Effectiveness in Ozone Non-Attainment Areas, August 2001

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status April 2002

The research resulted in the development of a GIS-based travel demand model that is environmentally policy sensitive and provides improved assessments of Transportation Control Measure (TCM) effectiveness in ozone nonattainment areas. The model is imbedded in TRANSCAD software and is used to estimate mobility and emission changes due to TCM Implementation. The model will be used by Metropolitan Planning Organizations and TxDOT to streamline the transportation conformity process.

For more information please contact Bill Knowles, P.E., RTI Research Engineer at (512) 465-7648 or wknowle@dot.state.tx.us.

Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The content of this report reflects the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Chandra R. Bhat (Texas No. 88971).

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