Vermont Statewide Travel Demand Model - A Preliminary Evaluation

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Vermont Agency of Transportation

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Acknowledgements

The Project Team would like to thank the Vermont Agency of Transportation, the Chittenden County MPO, and Stephen Lawe at Resource Systems Group, Inc. for their time and insights during the preparation of this report.

Disclaimer

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Executive Summary

The University of Vermont Transportation Research Center, working with the Vermont Agency of Transportation, is conducting an evaluation of the existing statewide travel demand model and to identify potential improvements and refinements to the model based on planning practices and needs. The model's current software platform, Cube/Voyager, is also explored, with a comparison to two other widely-used modeling software packages. The evaluation also includes a literature review of statewide travel demand modeling practices in other states, including general model structure, uses, and model operation and maintenance, as well as a discussion of emerging trends in travel demand modeling.

The Vermont Agency of Transportation has operated a statewide modeling program for nearly fifteen years, beginning in the mid-1990s using TRANPLAN transportation planning software and GIS methods, to the current model in Cube/Voyager. The statewide model, which covers the entire geographic area of Vermont and thousands of miles of roadway, has served and continues to serve as a valuable tool that provides travel activity data projections for transportation planning studies and analyses throughout the state. The data provided by the model is used by planners and decision makers so that sound transportation policies can be developed.

With the development and management of transportation systems continuing as a vital role of the Vermont Agency of Transportation and other invested state agencies, including the planning of highways, transit, freight and evaluations of their impact on society and the environment, the statewide modeling program will have ongoing utility and is a valuable tool for VTrans. The statewide model does have limitations, however, in functionality and degree of utility and reliability for potential project needs. Importantly, the model is not currently capable of modeling transit or rail networks, since its primary transportation system is limited to highways and other roadways.

Depending on the identified planning and policy needs of the Vermont Agency of Transportation and other participating state agencies that would require use of the statewide model, the model could benefit from the following improvements and refinements in the coming years:

- Development of a transit network (bus, rail, or both) and a freight rail network.
- Development of a new mode choice module to complement a new transit network.
- Algorithms for disaggregation of vehicle miles of travel (by vehicle class, average speed, roadway grade, etc.) for air quality analyses.
- Feedback loop(s) between modeling steps, such as between traffic assignment and trip distribution.
- Updates of input data, inclusion of roadway grade data, and further calibration and validation of model algorithms, assumptions, and outputs.
- Development of an actual year 2030 scenario to cover 20-year forecasts from year 2010.
- A degree of integration with the Chittenden County MPO's regional model.

At a minimum, there is enough cause for the Vermont Statewide Model to be maintained and periodically updated to keep it viable and available for planning needs at VTrans. The overall model could be kept in its current form without substantial improvements, such as transit and rail networks, but should remain available for forecasts of roadway travel and VMT estimates. Most importantly, the success and longevity of the statewide model greatly depends on the clearly-defined procedures and goals of its utility by VTrans and other Vermont agencies. As stated previously, the goals of a statewide modeling program should be defined well in advance of model-specific details, such as data needs, model components, computer software, and budget allocation.

1. Introduction

The University of Vermont Transportation Research Center, working with the Vermont Agency of Transportation (VTrans), is conducting an evaluation of the Vermont statewide travel demand model's utility, components, and current software platform. This report represents the first working draft of the evaluation and its preliminary findings. The goals of the evaluation are to:

- Identify the current and potential uses for the model based on VTrans planning practices and needs.
- Recommend updates to the model to meet future implementation.
- Compare its existing software platform with two other widely-used software packages currently available.

Also provided in this report are a literature review of statewide travel demand modeling practices in other states, including general model structure, operation, and maintenance, and a discussion of emerging trends in travel demand modeling.

2. Background

The Vermont Agency of Transportation is responsible for the planning, construction, maintenance, and policy governing the transportation system in the State of Vermont. The transportation system includes passenger travel by modes such as motor vehicles, transit, air, and non-motorized travel, as well as the mobility of freight. The Policy and Planning Division of VTrans, specifically, develops and oversees the comprehensive transportation planning strategies and policy framework in the state, and works with local municipalities, the eleven regional planning commissions (RPC), the Chittenden County Metropolitan Planning Organization (CCMPO), and other state agencies to ensure that the state's transportation system is part of a responsible and efficient social, economical, and ecological development policy plan.

Part of the VTrans planning responsibilities includes the forecasting of future travel demand and travel patterns on the transportation system. The purpose of the forecasts is to help guide policy and funding decisions, such as the construction of a new roadway, the creation of a new bus transit line, or a land use development scheme to make most efficient use of the in-place transportation infrastructure. In order to perform the forecasts, and also to gain better understanding of the current transportation system, VTrans relies on transportation planning tools for a number of its planning tasks. These transportation tools range from very small-scale, detailed models, ideal for tasks such as roadway capacity analyses and management of traffic operations, to a large-scale, statewide planning model, ideal for determining the travel demand loads on the entire multi-modal transportation system.

For its planning responsibilities, VTrans relies on the statewide model to evaluate the effects of transportation projects and to guide future development policies for sections of the transportation system. The statewide model – identified as a *travel demand model* – covers the entire State of Vermont and incorporates demographic and economic data of Vermont's households, employment estimates, and the characteristics of the transportation system itself, including the travel mode opportunities and the state's roadway network into a structured four-step transportation planning model. Essentially, the passenger travel model estimates demand for use of the transportation system based on characteristics of the transportation network and its potential users, and reports measurable degrees of use, including roadway volumes, miles of travel on roadways, and transit ridership. The statewide model also includes a freight demand model that estimates truck usage of the state's roadway network for the movement of goods.

3. Review of Modeling Practices

3.1 Statewide Modeling at Other Departments of Transportation

Currently, approximately one-half of the states in the United States have functional statewide models (*1*). The structure, utility, and costs of the numerous statewide models vary and greatly depend on the needs of their host departments of transportation. Published documents such as *NCHRP Synthesis 358: Statewide Travel Forecasting Models* (*1*) and *Statewide Travel Demand Modeling: A Peer Exchange* (*2*) provide information about current modeling practices in states throughout the country based on survey responses from state departments of transportation, including Vermont. Table 1, taken from *NCHRP Synthesis* 358, page 14, presents a summary of statewide modeling activity as of 2005.

As cited in *NCHRP Synthesis 358*, states predominantly use traditional four-step procedures at the core of their passenger travel demand models, similar to urban or regional models. Trip generation is generally performed by cross-classification techniques, trip rates and linear equations, or tour-based multinomial logit expressions (*1*). The most commonly used demographic and travel data sources, such as the US Census, the Census Transportation Planning Package (CTPP), the National Household Travel Survey (NHTS), and local MPO information provide readily available data for use by states in their models, and are used solely or supplemented by state-collected data. Furthermore, in most states with functional models, gravity model application is used for trip distribution, while there are some instances of growth factor methods. Mode choice is typically accomplished by logit expressions or fixed percentage shares, and traffic assignment is performed using estimations of equilibrium conditions (*1*).

Moreover, *NCHRP Synthesis 358* finds that state departments of transportation predominantly utilize their models for corridor planning, system planning, bypass studies, regional planning while collaborating with an MPO, and project-level forecasts, such as for environmental impact purposes. Approximately one-third of states with functional models apply their models for air quality analyses, freight planning, and economic development and long-term investment studies.

The report also indicates that states with longer histories of modeling and greater confidence in the validity of the modeling outputs tend to more widely use their models for a broad range of functions.

TABLE 1: STATUS OF STATEWIDE MODELING CAPABILITY - SPRING 2005

State	Model Condition	Cost	Development Time (years)	Comments
Alabama	None			
Alaska	None			
Arizona	None			
Arkansas	None			
California	Operational	$200,000	2.4	
Colorado	None			
Connecticut	Operational	$400,000	1	
Delaware	Operational			
District of Columbia	MPO model			
Florida	Operational	$1,500,000	4	
Georgia	Operational	$65,000	1	
Hawaii	None			Individual island models
Idaho	Dormant			
Illinois	Dormant			
Indiana	Operational	$1,500,000	3	7 more years for various upgrades
Iowa	Developing	$300,000	2	
Kansas	Developing			Has a dormant freight component
Kentucky	Operational	$370,000	2	New model under development
Louisiana	Operational	$500,000		Cost includes some applications
Maine	Operational	$500,000	5	Being revised
Maryland	None			
Massachusetts	Revising	$800,000		
Michigan	Operational	$1,000,000	2	
Minnesota	Partial			
Mississippi	Developing			
Missouri	Operational	$500,000		Revision completion soon
Montana	Operational			Freight only
Nebraska	Dormant			Base year model
Nevada	None			
New Hampshire	Revising	$2,000,000		
New Jersey	Operational	$500,000		Freight only
New Mexico	None			
New York	None			County-level OD assignment
North Carolina	None			
North Dakota	None			
Ohio	Operational	$6,000,000	8	Being revised; $3,500,000 for data
Oklahoma	None			
Oregon	Operational			Being revised
Pennsylvania	Developing			
Rhode Island	MPO model			
South Carolina	Operational	$25,000	0.5	
South Dakota	None			Feasibility study being conducted
Tennessee	Developing			Based on OD table estimation
Texas	Operational	$1,700,000	4	
Utah	None			
Vermont	Operational	$730,000	2.5	
Virginia	Operational	$1,500,000	3	
Washington	None			
West Virginia	None			
Wisconsin	Revising	$850,000	2.5	
Wyoming	None			

Notes: MPO is metropolitan planning organization; OD is origin-destination.
Modified from source: NCHRP Synthesis 358: Statewide Travel Forecasting Models (2006), Table 1, p.14.
[1] Data moved from "Colorado" in the originally published table to "Connecticut" in this version.

Accordingly, the *NCHRP Synthesis 358* reports that the most common measures of effectiveness (MOE) used from models as indicators of system performance include vehicle miles of travel (VMT), vehicle hours of travel (VHT), volume to capacity ratios (v/c), levels of congestion, and traffic growth rates. Additional outputs may be used for more specialized model uses, but VMT and VHT are standard. Some models produce MOEs for certain periods of the day, namely peak hours, while others report daily totals.

The maintenance and resource needs for the range of statewide models are also varied. While many state departments of transportation rely on professional consulting firms to develop their models, many perform routine maintenance themselves (*1*). Staff allocations for modeling programs typically range from one or more personnel with part-time responsibilities – some supplemented by varying levels of consultant support – up to multiple full-time personnel. Moreover, maintenance is performed continuously or at frequent intervals (one to two years), and states typically perform model updates on regular cycles – some coinciding with reissuing of transportation plans (typically every five years), and others using cycles as long as ten years.

Survey feedback reported in *Statewide Travel Demand Modeling: A Peer Exchange* provides insight into some reasons for modeling program failures. According to Rick Donnelly of Parsons Brinckerhoff, whose survey response was quoted in the *Statewide Travel Demand Modeling: A Peer Exchange* for the Oregon statewide model, "vague or poorly defined goals and objectives," "higher than expected maintenance and application costs," and "lack of management support" are some of the causes for model failure and abandonment (p.74). Most importantly, a common and reasonable trend in statewide modeling programs is that states must balance model quality with time and budget constraints (*1*).

In order to ensure that a statewide modeling program is effective and sustainable, both in terms of labor and budget allocation, its objectives must be clearly defined and its utility must be transparent. As stated in "A Critical Review of Statewide Travel Forecasting Practice" (*3*), the goals of a statewide modeling program should be defined well in advance of model-specific details, such as data needs, model components, computer software, and budget allocation. The planning needs of the state department of transportation should steer the modeling program.

3.2 Advances in Travel Demand Modeling

Recent research in the subject of travel demand forecasting has seen a shift from traditional trip-based modeling techniques of the four-step paradigm to activity-based forecasting models. This has been in general response to the limitations of the four-step process, the need for models to be more sensitive and responsive to the effects of system conditions and policies on mobility and lifestyle choices, and the desire to disaggregate travel demand forecasting to the level of micro-simulation modeling techniques, replacing aggregate zonal calculations (*4, 5, 6, 7, 8*). Since activity-based modeling considers the decision processes that dictate travel of individual entities

or "agents," potentially on a continuous temporal basis, its methodology adapts itself better to the dynamic nature and computational characteristics of micro-simulation. There could, therefore, be a shift away from individual "trips" as travel units to "tours" with more advanced activity-based models implemented at regional and statewide levels.

In addition to serving the standard forecasting needs of transportation planning, the new activity-based models have also shown to be valuable tools for evaluating more specific transportation system management policies, including: travel demand management and peak spreading effects, high-occupancy vehicle/facility demand, toll and congestion pricing, and transit fare and parking pricing policies (*5, 7*). They can also be applied to planning issues such as transportation equity and changes in demographics, such as population aging, household compositions, and labor force characteristics (*5, 7*).

The data requirements for development, computational demands, validation processes, variability of results, and costs versus benefits of activity-based modeling, though implemented and evaluated on limited up to regional scales, have yet had widespread application on a statewide scale. Some states with new or recently revised statewide models have implemented varying degrees of activity-based travel demand procedures, including Ohio, Oregon, New Hampshire, Michigan, and Louisiana, with Ohio's (still in development) being the most advanced. Various MPOs nationally, such as the Mid-Ohio Regional Planning Commission (MORPC), the New York Metropolitan Transportation Council (NYMTC), and the San Francisco County Transportation Authority (SFCTA), also have implemented activity-based procedures in their regional models. However, many travel demand practitioners are still skeptical of the accuracy and large-scale applicability of the new modeling techniques, as well as their data and resource needs. Depending on the desired utility and necessary detail for a statewide travel demand model at this time, as well as implementation constraints, activity-based modeling may not yet have a feasible application for all states currently with travel demand models.

3.3 Ongoing Applications of Transportation Modeling

A study panel for the Florida Department of Transportation, as part of its evaluation of transportation models, provided an effective list of "current and emerging issues in transportation planning" that summarizes a broad spectrum of potential applications for travel demand models and other transportation models (*9*). The list includes:

- Capacity deficiencies and congestion
- Interaction between transportation and land use
- Economic development impacts of transportation
- Freight mobility strategies
- Air quality
- System preservation, maintenance, and operations
- Safety
- Security and emergency evacuations

- ▪ Equity
- ▪ Resource allocation and project selection

These planning challenges have universal contexts and are also applicable to Vermont's transportation systems, developed space, and environment. Therefore, it is reasonable to be cognizant of these topics while discussing the current and future functionality and utility of Vermont's statewide model.

4. Statewide Travel Demand Modeling at the Vermont Agency of Transportation

The Vermont Agency of Transportation currently has a functional statewide travel demand forecasting model. In 2007, the model was translated from the original TRANPLAN system into the new Cube/Voyager (Citilabs, Inc.) software platform by VHB, Inc. with updates to the roadway network, freight model, and model calibration procedures and results (for documentation about this process refer to *Vermont Statewide Travel Demand Model Improvements: Updated Passenger and Truck Models in Cube/Voyager*, 2007). Importantly, during this process employment data for trip generation, truck percentages by regional planning commission (RPC) for non home-based trips, and the friction factor functions for trip distribution were all updated (*10*). Although the model has been applied to a number of project-level tasks, such as the Circ-Williston Environmental Impact Statement and currently the Western Corridor Transportation Management Plan, the potential exists for further improvements and broader utility to aid VTrans project work and planning in the Vermont (see *Appendix A: A-1–A-3, A-5*).

4.1 Model Structure and Components

The statewide model is structured as a typical four-step transportation planning model, comprised of: 1) trip generation, 2) trip distribution, 3) mode choice, and 4) traffic assignment (for a description of these four steps in a general transportation planning context refer to *11* and *12*). Briefly, in the trip generation step, the model takes inputs from demographic sources and combined with trip rates, estimates the number of person trips generated per day, categorized into six generalized purposes: *home-based work*, *home-based shopping*, *home-based school*, *home-based other*, *non home-based*, and *truck* (as a percentage of *non home-based*). For example, Figure 1 shows the trip production rates for the four home-based purposes based on the cross-classification of persons per household and autos per household; non home-based trip productions are based on a linear approximation instead of cross-classification, similar to trip attractions. In the trip distribution step, the flows of trips between each origin/destination pair of TAZ are estimated based on the zone-to-zone travel times (impedance). Figure 2 shows the trip length (time) frequencies by purpose, which are one result of the trip distribution process. The mode choice step splits the total number of person trips into those using the roadway network and those using transit; in turn, the roadway person trips are converted to vehicle trips using vehicle occupancy factors by trip purpose. Lastly, the vehicle trips are assigned to the

roadway network, producing traffic volume and VMT estimates on each roadway. Because the statewide model currently does not have a transit network, the person transit trips estimated in the mode choice step are not assigned.

FIGURE 1: DAILY PERSON TRIP RATES PER HOUSEHOLD BY PURPOSE
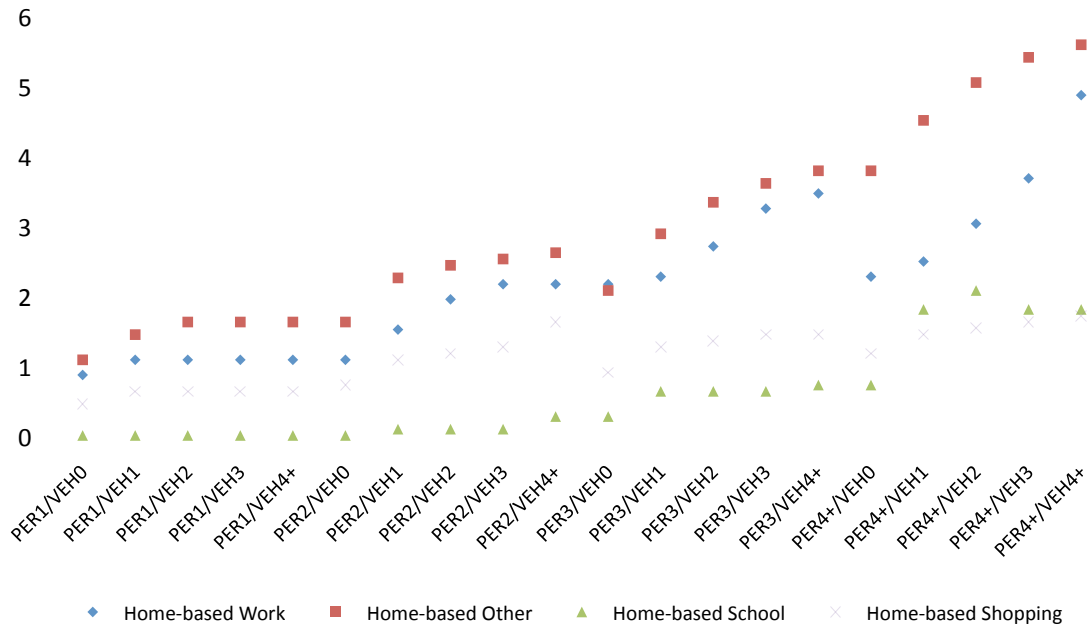
FIGURE 2: TRIP LENGTH FREQUENCY DISTRIBUTION
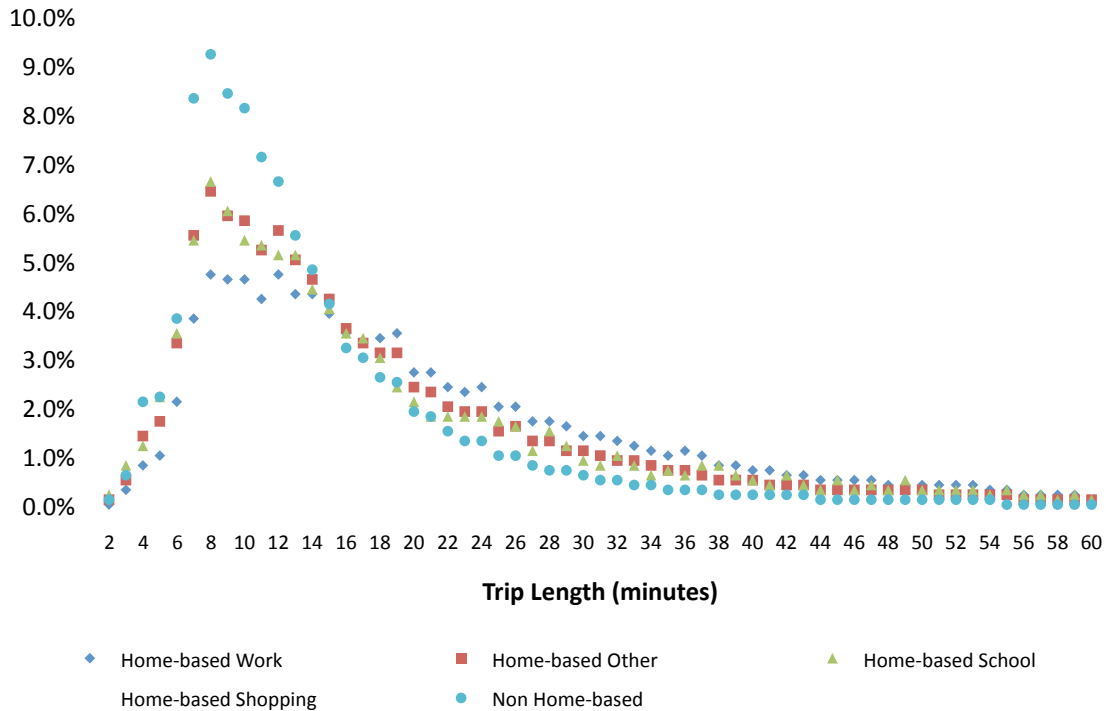
The model has a 2000 base year with a forecast year of 2020 and a ten-year interpolation to 2030. It contains 628 internal and 70 external traffic analysis zones (TAZ) as shown in Figure 3. The external TAZ represent travel to/from and between regions beyond Vermont, including neighboring states (New York, New Hampshire, and Massachusetts), the rest of New England and the northeast, and Canada. Generally, the internal TAZ coincide with Vermont municipality boundaries, except in more densely populated areas where the TAZ are more disaggregate. The TAZ also aggregate to 2000 US Census block group boundaries.

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Vermont Statewide Model
TAZ Boundary
0   10   20   30
Miles

□

□y □□w□□□ p □t□□kp dw0□□dnWkW□dN□r r w□o A □k□9 t□/ U□mm□□9n0W□n□S □ na□nk□w□9□n□□□k□w□9□□□□□ □□nkw□ □□dnn□□kdw□□□ T □□□□nk□□s wk□□n□9□WWM□k dn□□k□adw□W□□

- ,/ V□s w□9□nk□wk□k□□
- ,j V□s w□9t wn □ r □9□k□w□9□
- ,L V□s w□9A ndw□□wk□w□9□
- ,G V□s w□9A □2dw□□d9□□kdw□□
- ,l V□s w□9A ndw□□d9□□kdw□

- ▪ (9) rural local
- ▪ (11) urban interstate
- ▪ (12) urban principal arterial/freeway
- ▪ (14) urban other principal arterial
- ▪ (16) urban minor arterial
- ▪ (17) urban collector
- ▪ (19) urban local
- ▪ (20) internal TAZ centroid connector
- ▪ (21) external TAZ centroid connector

4.2 Application, Improvement and Maintenance of the Model

The VTrans statewide model has had or will have utility for transportation studies throughout the state, including the Circ-Williston Draft Environmental Impact Statement (DEIS) (*13*), the Morrisville Bypass, the Bennington Bypass (*14*), the Western Corridor Transportation Management Plan (*15*), and a state employee commuter study. The model would also have applicability for the Highway System Policy Plan (*16*), Public Transportation Policy Plan (*17*), Rail System & Policy Plan (*18*), the Asset Management Vision and Work Plan (*19*), the Vermont Long Range Transportation Business Plan (LRTBP) (*20, 21*) – the state's overall plan for the multi-modal transportation system – and the Final Report and Recommendations of the Governor's Commission on Climate Change (GCCC) (*22*).

The usefulness of the model for project-level analyses, planning scenario evaluations, and storage and presentation of transportation system data reinforce the need for continued maintenance and application of the tool, as well as outreach and training to inform other VTrans departments and other state agencies of the model's utility. The following sections highlight anticipated modeling needs based on future planning goals and the improvements likely required or recommended for the statewide model in order to meet those specific needs, especially those that are not currently within its capabilities.

Depending on the determination of the long-range modeling objectives of VTrans and the statewide model's future utility, it is possible that the statewide model would need additional refinement and updates. If such refinements and updates were to be implemented, it is expected that their purpose would primarily be to meet some of the planning goals identified in the LRTPB and GCCC, as well as other modeling efforts at VTrans, including transit planning and air quality analyses. As such, some of the continued and future modeling goals discussed could determine the need for a number of potential statewide model improvements.

4.2.1   System Policy and Environmental Policy Planning

A number of applications of the statewide model are likely based on anticipated modeling needs described in state and agency documents, such as the LRTBP and the individual system policy plans. These documents do not explicitly identify the application of the statewide model to meet

their recommendations but from a practical viewpoint, the model is clearly a tool to aid completion of some of the policy components. The LRTBP identifies transportation opportunities, specifically the integration of land use and transportation planning and the evolving focus on corridor management planning, as methods for the state to more effectively meet transportation system challenges. The final report and recommendations of the GCCC cites the need for strengthened state-level planning and decision-making to support managed growth as well as transportation planning to facilitate alternative travel modes, transit priority and the rehabilitation and maintenance of existing infrastructure.

Bus and Rail Transit System Planning

In addition to the planning goals outlined in official agency documents, discussions with VTrans personnel underscore the potential utility of the statewide model to support varied tasks at the agency (see *Appendix A: A-1–A-3, A-5*). At the Policy and Planning Division, there is a recognized need for improved multi-modal planning, as recommended in the LRTBP and more specifically the Highway and Public Transportation System Policy Plans, which would likely include the creation of a transit network in the statewide model. A fully developed transit network would allow planners to estimate ridership loads along existing and proposed transit routes such as intercity bus transit, to evaluate headways and stops, and to identify potential route capacity improvements and extensions. Importantly, any improvement in the capabilities and detail of the model's transit component would require redevelopment of the mode choice module, since the model currently apportions a fixed percentage as a transit share (*10*). A new mode choice module would likely be a logit model, which predicts the selection probability of alternative modes by comparing the costs (monetary cost, time, convenience, etc.) of those modes (*11, 12*).

The development of a transit network in the model would be an intensive but probably worthwhile task considering the importance of transit modeling recognized in long range planning documents. Addition of a transit network would represent a significant improvement to the model's functionality and utility. This transit network would certainly include bus, which would use the model's roadway network, and possibly rail, which would require the development of a new network structure.

Rail Freight System Planning

Development of a rail network as part of the freight model would improve the freight model component as well as the overall model's utility. A growing need or desire to shift more freight from truck to rail could still precipitate a need for a rail component in the statewide model. The Vermont State Rail & Policy Plan identifies a goal to provide competitive freight and passenger service, even though that report also recognizes the uncertainty of the future of Vermont's intercity passenger rail service (*18*). However, with a passenger rail component, if deemed worthwhile, the statewide model could be used to evaluate plans to expand and promote passenger rail service both in Vermont and regionally.

The general rail network topology – links and nodes – of the rail passenger transit component could be transferred from a newly developed rail freight component, if the transit improvements in the model were undertaken first. The rail network structure could then be specifically configured for use in the freight model.

Highway System Planning

The Highway System Policy Plan indicates that for system management and preservation "it is desirable to define different sections of the highway system based on functionality and overall level of importance for which different performance standards and investment policies are developed" (p.ES-5). This idea of sub-networks applies to performance measures, including preservation, safety, mobility, and environment/quality of life as outlined in the Highway System Policy Plan, and to the prioritization of assets. As Vermont develops with growing population centers, the designations of existing and hitherto unbuilt roadways as parts of either the "primary" or "off-primary" sub-networks may need to be revised. Forecasts and analyses with the statewide model could aid in appropriately identifying the evolving level of importance of roadways in the network and evaluate certain performance measures, such as VMT, travel times, average speeds, flows, and volume-to-capacity ratios for roadway links. As an extension of the sub-network definition process, the statewide model could serve to evaluate and determine the critical links in the system, and the possible impacts due to the closure (e.g. bridge maintenance, natural disasters, emergency evacuations, etc.) of a critical link. This would provide data for the planning of management and response strategies.

The statewide model could also serve the Traffic Operations department responsible for the management, analysis, and reporting of VTrans traffic counts throughout the state, by aiding traffic growth projections and helping to identify the potential effects of network disruptions and resulting detours/re-routing (see *Appendix A: A-1)*. However for detailed analyses of roadway sections or corridors using, for example, micro-simulation models with the statewide model's projected volumes as inputs, it would first be advisable to evaluate the accuracy and applicability of the statewide model's traffic volumes for direct use in other modeling analyses before such applications were undertaken.

Environmental Planning

The importance of environmental policies relating to climate change and air quality conditions could drive the need for further statewide travel demand forecast modeling. Although Vermont is currently in attainment, air quality conditions could worsen or more stringent standards could result in non-attainment for certain criteria pollutants such as ozone or particulate matter (*21*). Moreover, potential future limits on green house gases, namely carbon dioxide, as well as VMT performance measures would require VMT forecasts and pollutant inventory estimates for Vermont's transportation system. The statewide model is a valuable tool for such environmental analyses, primarily because it can feed necessary input data – VMT by functional roadway class and average speeds – to mobile emissions models (currently the EPA's MOBILE model and the

newer MOVES model). It is reasonable to expect that air quality modeling and the resulting environmental policies will continue to gain importance for Vermont and nationally, and the need for increasingly detailed and accurate travel data from the statewide model would grow concurrently.

There are methods to improve the statewide model's outputs to better serve mobile emissions modeling, specifically the MOBILE model which is currently used in Vermont. Accurate disaggregation of VMT data by vehicle class could improve emissions estimates, since different types of on-road vehicles, such as light-duty versus heavy duty, have different operating characteristics and emissions profiles. However, a typical four-step travel demand model like the statewide model does not inherently consider vehicle types in this manner. The statewide model does currently define a portion of non home-based trips as truck trips based on a percentage (determined by vehicle classification counts) for each RPC in Vermont, but this does not translate to specific vehicle-type VMT assigned to the highway system as a model output. Therefore, it would be worthwhile to develop a new means to accurately disaggregate highway VMT by vehicle class, at least into general weight classes (e.g. light-duty vehicle, light-duty truck, and heavy-duty truck) within the statewide model. This could involve using 24-hour classification counts and conducting road-side surveys.

Other VMT break-downs that could be explored to improve emissions modeling would include VMT by time of day (hourly) and VMT by average speed. Importantly, the merit of developing these distributions specifically for Vermont instead of using the default values (national averages) supplied with the MOBILE model would need to be investigated. The default values may be "good enough," and it would not be worth the time and cost to develop Vermont-specific distributions that would not serve to improve emissions estimates, or worse, decrease their accuracy.

Greenhouse Gas Emissions Inventories and Standards

The current and future utility of the statewide model should be considered in the context of potential air quality standards changes and potential greenhouse gas standards legislation for Vermont and on a federal level. In April 2009, the Environmental Protection Agency released its finding that greenhouse gases contribute to air pollution that poses a threat to public health and welfare, in response to a 2007 ruling by the Supreme Court of the United States that required the EPA to review the potential impacts of emissions of six greenhouse gases (*24*).

Concurrently, the State of California is taking a lead in greenhouse gas legislation, including new cap standards for light-duty vehicles and rules for GHG reporting/inventories (*25,26*). Vermont, in addition to approximately fifteen other states (*27*), has passed its own legislation to adopt California's GHG standards, expecting that the U.S. EPA will grant California's waiver to the Clean Air Act for the proposed standards. California's waiver request was first rejected by the EPA during the Bush Administration in late 2007, but the EPA has recently been directed by the Obama Administration, in early 2009, to review and reconsider that decision.

Vermont passed its own rule in November 2005, making its GHG emission standards for low emission vehicles to be identical to those of California. In the rule, titled *Air Pollution Control Regulations, Subchapter XI, Low Emission Vehicles – Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, GHG standards for small and large light-duty vehicles would be gradually phased in between model-years 2009 and 2016 (*28*). However, Vermont cannot act until the California waiver is granted.

As Vermont adopts California standards, it is possible that the state will also seek to follow California's lead on GHG reporting rules. Requirements for inventories of GHG emissions for the transportation sector would likely emphasize regular and detailed reporting of VMT estimates for GHG contributions from on-road sources. Also, an evaluation of GHG emission impacts would be desired for planning and policymaking purposes (e.g. the recommendations presented in the *Vermont Comprehensive Energy Plan*, 2008, (*29*) and *Vermont Governor's Commission on Climate Change*, 2007) (22).

In May 2009, the development and debate of *American Clean Energy and Security Act of 2009* (H.R. 2454) has highlighted the proposed bill's multi-faceted approach to reduce consumption of fossil fuels and limit greenhouse gas emissions. Regarding the link between the transportation sector and GHG emissions, a summary of the bill dated May 16, 2009 describes the Transportation Efficiency section of H.R. 2454, which would amend the Clean Air Act to "require states to establish goals for greenhouse gas reductions from the transportation sector and requires submission of transportation plans to meet those goals by Metropolitan Planning Organizations for areas with populations exceeding 200,000 people" (*30*).

The Vermont statewide model would be the most suitable tool to forecast VMT for the estimation process of greenhouse gas emissions from on-road sources in the transportation sector and to evaluate GHG-related impacts of planning alternatives based on the VMT projections. Currently in California, the California Air Resources Board's (CARB) travel activity forecasting approach for transportation sector GHG emission inventories uses VMT estimates from the EMFAC2007 model and regional planning organizations. EMFAC2007 estimates travel activity based on vehicle population and vehicle-age-specific travel accumulations, which are matched to VMT estimates from the regional planning organizations' transportation models (*31*). Similar to California, Vermont should maintain it planning tools and procedures for VMT forecasting, including the statewide model.

4.2.2   Other Model Refinements

Additional refinement tasks could be undertaken to improve the model's functionality. The accuracy of the model's base year and projected volumes should be further assessed. For regional air quality purposes and planning processes, the need for reliable estimates of vehicle miles of travel (VMT) would be paramount, and other uses of the statewide model, such as analysis of a section of its volume outputs using more detailed modeling tools such as traffic simulation, would greatly depend on the accuracy of its estimates. To this end, the task of

assessing and improving the reliability of the model's volume projections could include further refinement of the four planning steps, input data modifications, and additional iterations of calibration and validation.

Four-Step Model Algorithms

Further refinement of the model's outputs could be accomplished by incorporating one or more feedback loops within the model's algorithmic process. Since trip distribution estimations are based on interzonal travel times as are the travel mode utility values (travel time cost, perceived cost, etc.) in the mode choice step, it is common to feed the link travel times estimated in the traffic assignment step back into the trip distribution and mode choice steps. This is especially important if traffic assignment indicates congestion that results in link travel times significantly different from those initially assumed. The resulting feedback would produce an iterative process that would continue until an equilibrium condition had been met.

Input Data Updates and Further Calibration & Validation

During the VHB, Inc. update and migration of the statewide model to Cube/Voyager in 2006-2007, the travel time friction factors for trip distribution, originally based on the 1994 Vermont household survey, were updated using the functions described in the *NCHRP Report 365* (*12*). VHB, Inc. also revised the trip attraction regression equations, but the trip production rates, originally based on the 1994 household survey, were not changed. New demographic, socio-economic, and travel data from upcoming updates in the 2008-2009 National Household Travel Survey (http://nhts.ornl.gov/nhts2008.shtml) and the 2010 US Census would provide a basis to evaluate and possibly revise current trip rates. Furthermore, with the new data, it would also be possible to evaluate the feasibility and merit of applying regional-specific trip rates and friction factors within the model, for example by county or RPC. It is important to note that following VHB, Inc.'s recent work on the model, some additional calibration was done at VTrans for TAZ in western portions of Vermont for the Western Corridor Transportation Management Plan and subsequent to that, Cambridge Systematics, Inc. performed further calibration while running the model for that study.

Roadway Grade Data

The network links in the model with functional roadway classifications (i.e. all of the links except the centroid connectors) currently have a default value of "1" for the "TERRAIN" data field. According to the VHB, Inc. 2007 report, a default value of 1, which indicates level terrain, was assigned to the links due to lack of better, more specific terrain information. Updating the model's network links with accurate terrain information, or potentially more specific data such as grade, could serve as an inventory for Vermont's roads and improve the model's utility in future on-road mobile emissions and air quality estimates using the US Environmental Protection Agency's MOVES emissions model, which considers roadway grade (as part of a vehicle's operating mode for running emissions) in its estimates. The statewide model could provide VMT

totals by grade. However, if defining individual link grades is deemed impractical, categorical information, such as general terrain type, could be defined for the model's network links and used to approximate more detailed grade values as needed. Terrain categories could include level, rolling, and mountainous, similar to the 2000 *Highway Capacity Manual*.

Integration with the Chittenden County MPO Model

Possible integration of the statewide model with the CCMPO's regional model of Chittenden County could further promote analyses using the models jointly, to complement each other. The CCMPO model is continually maintained and has recently undergone a new series of updates (*23*). For certain projects and planning analyses within Chittenden County, the statewide model could be relied upon to evaluate transportation effects beyond the regional boundary of the CCMPO model (see *Appendix A: A-4*). One such example is the Circ-Williston DEIS. Transferability of network and TAZ data from the regional model to the statewide model, or vice versa would have desired utility. Also, by including some of the same travel modes in the statewide model as in the CCMPO – namely auto, carpool, bus, and possibly rail – there could be improved transferability of trip data between the two models. This would also rely on rectifying the temporal resolution of the two models, daily (the statewide model) versus peak hour (the CCMPO model). Also, the models are currently in different software platforms; the statewide model is in Cube/Voyager and the CCMPO model is in TransCAD. If that were to remain the case for the foreseeable future, a means of data transfer (import/export) would be needed, such as with the use of database files or spreadsheets.

4.2.3   Maintenance

Regular maintenance of the model should be done continuously, including minor calibration and validation processes or as needed by specific projects employing the model. More significant updates and revisions to the model including updates to input data such as demographic and employment figures and roadway, transit, and freight network characteristics, and possibly the model's algorithms and logic could be on a scheduled cycle of approximately five to ten years. Update programs could coincide with the release of revised system policy plans or the publication of updated data sources, such as the National Household Travel Survey and the 2010 US Census. Depending on air quality attainment status in Vermont, air quality conformity needs could potentially require acceleration of the model's update schedule.

According to the LRTBP, the Intermodal Surface Transportation Efficiency Act (ISTEA, 1991) stipulated that the statewide transportation plan must cover forecasts for a minimum 20-year horizon. That stipulation has progressed in TEA-21 (1998) and subsequently in SAFETEA-LU (2005). Currently, the statewide model forecasts to 2020 and 2030, though the 2030 forecast is based on extending the growth from 2000 to 2020 by an additional ten years (*10*). With the year 2010 approaching, more accurate forecasts for 2030 would be required and should be developed to maintain compliance with the minimum 20-year horizon rule in the LRTBP.

5. Options for the Statewide Model and Modeling Program

VTrans has a number of options for the future of its statewide model. VTrans must consider the feasibility of continuing its model, given an expected future level of utility of the model compared to the time and budget resources to keep it active and capable of meeting the Agency's needs. Beyond that evaluation, there are long-term decisions concerning the state of the model and how its current functionality does or does not meet the desired planning applications of the model.

The current and envisioned level and extent of model use would largely dictate the specifics of if and how the model is kept active. If the model at its current level of functionality, given periodic updates to input data, would sufficiently and cost-effectively meet the planning needs of VTrans, then it would be beneficial for VTrans to keep the model active with a clear program for its update and application. Going further, if there is a desire within the Agency for increased and more widespread use of the model, perhaps for traffic research applications, roadway asset management, performance measure determinations, and perhaps coordination of planning work with other planning organizations in Vermont such as the CCMPO and RPCs, then there would be cause to develop a program to refine and improve the model to meet those goals.

5.1 Four Options

The following four options give general overviews of the work items, relative time and budget needs, and pros and cons depending on the Agency's decision for the statewide model. Table 2 provides a summary of the options.

5.1.1   Option I – Discontinue the model

This option would have VTrans shelve the model and rely on consultant(s) for fulfilling its forecasting needs on an as-needed basis. It is possible that the consultant(s) would desire access to the model – at whatever condition in which it would be at the time – for the project modeling needs. In this case, VTrans would have the model inactive but available for its consultant(s). If needed, the consultant(s) would then be responsible for any necessary updates to the model in order to use it for the specific analysis.

TABLE 2: OPTIONS SUMMARY

Option	Work Items	Resource Ranking
I	- Discontinuation of the model - No program for periodic updates of the model - VTrans reliance on consultant(s) for forecast modeling needs	4th (least time and budget[1] requirements)
II	- Program for periodic updates of the model - VTrans supervision of model updates and application - Development of program for continued model use by VTrans & DEC/ANR (e.g. travel demand forecasting for planning and air	3rd

	quality analyses)	
III	▪ Program for periodic updates of the model ▪ Formulation of detailed model work plan, including the type/extent of improvements to be made to the model and timeframe ▪ Implementation of improvements/refinements to model components and procedures ▪ VTrans supervision of model updates, improvement program, and application ▪ Outreach within VTrans to raise awareness of model functionality and promote model use	2nd
IV	▪ Program for periodic updates of the model ▪ Formulation of detailed model work plan, including the type/extent of improvements to be made to the model and timeframe ▪ Implementation of improvements/refinements to model components and procedures ▪ VTrans supervision of model updates, improvement program, and application ▪ Outreach within VTrans to raise awareness of model functionality and promote model use ▪ Coordination of modeling procedures and planning goals with other planning organizations in Vermont (CCMPO and RPCs)	1st (most time and budget requirements)

Notes: [1] This determination greatly depends on the amount of work contracted by VTrans to consultant(s); if significant, this option may exceed Option II in budget resource requirements.

As a possible extension of this option, the consultant(s) could provide the model updates and an update summary to VTrans at the end of the project, such that the model would experience selected updates on a project-basis instead of on a defined schedule. However, an important caveat to this process would be that model updates would be on an "ad hoc" basis, potentially performed by more than one consultant, so there could be an issue with the consistency and scope of the model updates. Therefore, VTrans would need to review and verify the updates – a process that may not be attractive considering the general goal of this option, which is for VTrans to significantly reduce its necessary time and resources for the model.

Work type and hours

▪ Work and hours would depend on a per-project basis, with VTrans contracting and supervising a consultant, or consultants.

Pros

▪ *For the most part, a low-cost option since VTrans would not have to allocate time and budget resources for maintenance and updating of the modeling program.*
▪ *On an as-needed basis, VTrans would only pay for what it needs per project (i.e. VTrans would not fund a dormant model).*

- *Point of uncertainty: A pro depending on if the cost to keep model active and run it would be greater than the cost to contract and supervise an outside consultant for forecasting work.*
- *Point of uncertainty: Amount of project work contracted to consultant(s); a low amount of project work would keep costs for VTrans down.*

Cons

- VTrans would have to rely on consultants for project forecasting needs.
- A resurrection of the model in the future for some mandatory analysis need would require signification resources, of both time and budget.
- *Point of uncertainty*: A con depending on if the cost to keep model active and run it would be less than the cost to contract an outside consultant for forecasting work. If this were the case, Option II, below, may be a more cost-effective choice since a high amount of project performed by consultant(s) work could be overly costly for VTrans.

5.1.2   Option II – Maintain the model at its current level of capability, with periodic updates

This option would include periodic updates to the model's input data, such as new US Census, National Household Travel Survey (NHTS), and employment data, yearly AADT counts and newly built roadways for the highway network. The model updates would not include changes to the underlying model procedures and assumptions. It is assumed that VTrans would still utilize the model for relevant project analyses, while the UVM TRC and/or consultant(s) would be contracted to perform the periodic updates and necessary model runs.

The feasibility of this option would depend on the extent to which use of the model in its current form would act as reimbursement for the time and funds put into it. An updated but dormant model would be of no value to VTrans.

Example periodic updates of input data
- For US Census and NHTS data, updates could occur every five to ten years, depending on data availability. US Census is every ten years, but other demographic and household data sources, such as NHTS, may be available on a more frequent basis.
- Employment data can be updated every one to five years, depending on availability of new data.
- New highway data, such as new roadways and/or capacity improvements, can be updated on a five-year interval, or as needed depending on project analysis needs. AADT count data could be updated yearly.
- Significant land use developments can be updated on a five-year interval, or as needed depending on project analysis needs.
- More detailed, less frequent updates could include new household daily person trip rates, which are currently based on a 1994 Vermont household survey. A new survey would likely be needed to determine new the trip rates.

- ▪ *Note*: In general, periodic updates would be needed at least every ten years to make the model's base-year current and ensure forecasting to a 20-year horizon. For example, the model's base year is currently 2000 with a forecast to 2020. During an update process for base year 2010, the forecast year would have to be updated to 2030.
- ▪ *Note*: Updates of input data and model base year would require re-validation of the model and, if needed, new calibration of model parameters.

Work type and hours

- ▪ Work would include 1) model updates and 2) model application. It is possible that the entity responsible for model updates would not perform model application. For example, the UVM TRC could perform model updates regularly while a consultant could run the model on a per-project basis. Or one entity could be responsible for all tasks.
- ▪ Work hours for model updates could be determined based on an update schedule. Hours for model application would be more variable and would be determined on an as-needed basis. For the purposes of this preliminary evaluation, it is assumed that the work hours required for model data updates of this nature and corresponding tasks (checking, re-validation, and calibration, if needed) would be approximately one-tenth of the duration of the update period. For example, to update data on a ten-year interval, it would take approximately 12 months of work time, every ten years. Updates on a one-year interval would take approximately 1–1½ months, every year.

Pros

- ▪ Likely the least expensive option to keep the model active, up-to-date, and available for use by VTrans.
- ▪ Scheduled updates could be performed by the UVM TRC and/or a consultant, with management by VTrans.

Cons

- ▪ The model would not gain further functionality beyond the current level.
- ▪ The model would not be relevant for detailed transit/multi-modal planning efforts.

5.1.3 Option III – Improve the model's capability for VTrans (including DEC/ANR) analytical objectives

This option would include necessary updates to the model as outlined in the Option II, and would also include further improvements and refinements to the model and the VTrans modeling process. Under Option II, the model could be used in its current state to provide VMT estimates to DEC/ANR for greenhouse gas and other on-road pollutant emission analyses. However, Option III provides for further refinement of model outputs when providing VMT data for air quality analyses.

The feasibility of this option would depend on the extent to which use of the improved model would be a form of reimbursement for the time and funds put into it. An improved and updated but dormant model would be of no value to VTrans.

Example improvements and refinements
- Transit network, possibly with a rail component.
- Mode split module.
- Feedback between modeling steps, namely traffic assignment and trip distribution.
- New household daily person trip rates or verification of current rates with updated survey data.
- A program of more frequent updates so that the model can aid in base-year determination of performance measures, AADT estimates by traffic research, and roadway asset management and safety data needs.
- Procedure for determining VMT by vehicle class consistent with on-road emissions model (e.g. EPA MOBILE's 16 vehicle classes); procedure would not necessarily occur within the model and instead could be a post-procedure where the total VMT forecasted by the model could be disaggregated by vehicle fractions (vehicle fractions could be defined for the entire state, or by region, or by roadway functional class, or by some combination of area and roadway class).
- Define roadway grade or terrain data to the model's highway network links
- Develop an intra-agency outreach program for use of the model in VTrans, so that other divisions are aware of the model and its current uses, and to solicit detailed plans for how model can gain broader utility.

Work type and hours
- For more complex improvements to the model, such as a transit network or a mode split module, VTrans would need to contract a consultant to perform the work tasks. Duration of work would greatly depend on the nature of the model improvement/refinement tasks. More basic updates, as outlined in Option II, could be performed independently and as described in Option II.
- A small committee of stakeholders would be needed comprised of VTrans and other relevant state agency staff members, UVM TRC representatives, and involved private consultants, if any, to develop a scope and work plan for the model's updates, improvements, and application.

Pros
- Expands functionality of the model, making it suitable for a broader range of applications.
- Could generate increased "awareness" and utility of the model.
- Could improve accuracy of model forecasts.

Cons
- Costlier than Options I and II.

▪ Improved functionality would not necessarily lead to increased use of the model – increased use of the model may be more reliant on "awareness" of the model by other VTrans departments and state agencies, and may need to precede major model improvements to make those improvements worthwhile and cost-effective.

5.1.4 Option IV – Improve the model's capability for VTrans and coordination with analytical/planning objectives of other organizations such as CCMPO and Regional Planning Commissions

This option would include necessary updates to the model as outlined in Option II, and would likely include some or all of the improvements listed in Option III. Under this option, more specific refinements would likely occur in response to modeling needs of the CCMPO beyond Chittenden County and the individual Regional Planning Commissions.

For example, the upcoming 2060 Metropolitan Transportation Plan, which the CCMPO will prepare, is expected to forecast growth and trip-making trends for the MPO region for the next fifty years and evaluate development and transportation system plans. Due to the anticipated increase of trips between Chittenden County and its neighbors, such as Franklin, Lamoille, and Addison Counties, there is a desire for more detailed travel demand forecasting for those neighboring areas, which are beyond the boundary of the MPO's regional model. Currently, the statewide model, which spatially covers the areas needed for the preparation of the MTP, does not have the required forecasting capability to year-2060. In response, improvements to the statewide model could include more distance horizon year forecasts, such as 2060, and mechanisms for data consistency and transfer with the CCMPO regional model.

Work type and hours
▪ Similar to Option III, but with more required time and budget resources for further improvements and coordination with the CCMPO and the RPCs.
▪ A small committee of stakeholders would be needed comprised of VTrans and other relevant state agency staff members, CCMPO, RPC and UVM TRC representatives, and involved private consultants, if any, to develop a scope and work plan for the model's updates, improvements, and application.

Pros
▪ Creates a defined role for the statewide model in the CCMPO and RPC's planning processes.
▪ Helps to form a more unified planning process for VTrans, the CCMPO, and the RPCs.

Cons
▪ Costliest of the four options, since it requires the greatest extent of model updates and improvements as well as increased coordination with organizations outside of VTrans.

5.2 Options and Model Strengths and Weaknesses

Table 3 highlights general strengths and weakness of the current statewide model, and also lists the option or options that could potentially address each weakness. A number of the weaknesses listed could be considered such only in the context of a desired, more extensive utility of the model. That is, the model is currently capable of performing its presently intended functions, regardless of the weaknesses or deficiencies listed here.

TABLE 3: MODEL STRENGTHS & WEAKNESS WITH RELEVANT OPTIONS

Strengths	Weaknesses	Category of Weakness	Option(s) to Address Weaknesses
Generally up-to-date travel demand model in current software platform (Cube)	Base-year 2010 will soon be needed, with a 2030 forecast year	Input Data and Rates	Option II/III/IV
Four Step model (widely-used and accepted modeling methodology)	Potentially out-dated calibration of trip rates, based on 1994 Vermont household survey	Input Data and Rates	Option III/IV (possibly Option II)
Well-developed and well-organized TAZ and roadway network layers	No roadway grade data in network layer	Input Data and Rates	Option III/IV
Clear and well-documented model structure/procedure	No feedback between model steps	Model Algorithm	Option III/IV
Broad range of trip purposes (HBW, HBSC, HBSH, HBO, NHB)	No transit network/assignment	Model Component	Option III/IV
Recent model application and "awareness" of model at public and private entities throughout the state (e.g. CCMPO, CAMSYS, VHB)	No mode split module (instead, fixed percentage shares based on comparison of highway times and transit times)	Model Component	Option III/IV
--	No freight rail network/assignment	Model Component	Option III/IV
--	Limited intra-agency "awareness" of model function and uses	Modeling Program	Option III/IV

6. Travel Demand Modeling Software Packages

The increasing processing power and utility of personal computers have provided an opportunity for development and marketing of ever-improving travel demand modeling software packages. Coupled with the features of geographic information systems (GIS), these models provide a valuable tool for planners and decision makers. Some commonly used software packages today, both nationally and globally, include Cube and its passenger demand modeling module, Voyager (a new incarnation of TRANPLAN/TP+ software lineage), EMME/2, TransCAD, and VISUM.

Three modeling packages were chosen for a preliminary review. Cube was selected since it is the native platform of the current VTrans model and is a well-established modeling software

package. TransCAD represents a major share of national and global modeling today and is used in Vermont for the Chittenden County MPO regional model. VISUM, though used to a lesser extent than Cube and TransCAD, is a robust model that is part of an integrated software suite, including VISSIM, a premier micro-simulation model. Table 4 summarizes the features and general information about the three software packages, and the following sections discuss the packages in greater detail.

A newer and hitherto unvetted package for potential statewide modeling application is TRANSIMS (TRansportation ANalysis and SIMulation System), an activity-based travel demand model representing individual travelers initially developed at the Los Alamos National Laboratory. It employs the disaggregate modeling techniques of the activity-based paradigm with integrated dynamic microscopic network simulation modeling. TRANSIMS is a new and ongoing programming effort, undergoing iterations and version updates as an open-source application (http://transims-opensource.org). It is excluded from this evaluation due to limited application thus far, especially on a statewide scale.

6.1 Cube/Voyager

The VTrans statewide passenger demand model is currently in the Cube/Voyager platform. Cube is developed by Citilabs, Inc. and is a suite of specific modules to accomplish a broad range of modeling and planning applications running in the Microsoft Windows operating system (*32*). Cube Base is the foundation of the software and houses the integrated ArcGIS (developed by ESRI) interface and the menus with the software's functions. Mapping features and network editing are accomplished using the GIS in Cube Base. Cube Base also makes uses of geodatabases through the Database Manager, allowing quick access to map data for manipulation, display, and use in Voyager model steps. Integrated with Cube Base environment, the primary modeling modules include:

- Voyager – passenger demand modeling
- Cargo – freight demand modeling
- Land – Land use forecasting
- Avenue and Dynasim – traffic analysis and micro-simulation
- Analyst – travel matrix/trip table estimation

Cube allows transportation planning users to develop their planning models using the Scenario and Application Managers. Scenario Planners organizes model runs by category, such as forecast year or planning alternative (e.g., the VTrans model has three scenarios in Cube: base year, year 2020, and year 2030). The Application Manager uses a hierarchical flowchart structure and scripting to define the various steps in the planning model and provides a clear view of each part of the process. The open structure of Application Manager allows for the application of the traditional four-step process, including the various methodologies available to accomplish each step, and other approaches, such as activity-based and discrete choice methods.

Multi-modal passenger demand modeling is possible in Cube/Voyager, including roadway/highway, transit, pedestrians, and bicycles. Cube Cargo includes the freight forecasting procedures. Cube/Avenue provides tools for viewing and analyzing link flows, turning movement volumes at intersections, and traffic operations impacts. Cube/Dynasim is a traffic micro-simulation model for video presentation of traffic conditions.

6.2 TransCAD

Developed by the Caliper Corporation, *TransCAD* is a robust GIS for transportation planning applications and operates in the Microsoft Windows operating system (*33*). TransCAD can perform the four-step forecasting process, either manually using built-in menus or through the use of custom coding in the GIS Developer's Kit (GISDK) interface. TransCAD provides alternate methodologies for each step of the transportation forecasting process. Trip generation can be accomplished using cross-classification techniques with user-defined trip rates or application of established trip rates from the *ITE Trip Generation Manual* and *NCHRP Report 365*. Gravity models, growth factors, or intervening opportunities can be applied for trip distribution. Like the other steps, mode choice methods can be user-defined or performed using logit model application features. Traffic assignment has a number of possible methodologies (equilibrium, all-or-nothing, incremental, system optimal, etc.) and TransCAD also features a number of tools to analyze and display assignment results.

The GIS is used for development, manipulation, and display of model components, including traffic analysis zones, networks, routes, and underlying data structures – tables, matrices, and maps. Numerous passenger transport systems can be modeled, including roadways, transit, freight, and non-motorized modes – pedestrians and bicycles. As a powerful data tool, TransCAD also includes a plethora of the most current US Census data for varying spatial levels and provides tools for accessing and viewing the US Census data. Moreover, routing functionality allows for logistics analyses and system planning.

TABLE 4: SUMMARY OF CUBE, TRANSCAD, AND VISUM FEATURES AND FUNCTIONALITY

		FEATURES/SPECIFICATIONS		
		Cube	**TransCAD**	**VISUM**
FEATURES/SPECIFICATIONS	**Developer**	Citilabs	Caliper	PTV
	Current Version	5	5.0	10
	Vendor Support and Software Services	Technical support, training, existing model conversion, and custom module development	Technical support, training, and custom software development based on user needs	Technical support, training, and custom software development based on user needs
	Vendor Staff Offices	San Francisco, CA / Washington DC / Philadelphia, PA	Boston, MA / Washington DC	(PTV America offices) Portland, OR / Wilmington, DE / Austin, TX
	Micro-simulation Companion	Dynasim 5	TransModeler 2.0	VISSIM 5 (often used as a "stand-alone" model) and HCM compatibility
	PC Platform	Windows	Windows	Windows
	Software Structure	"Base" using ArcGIS with modular extensions, but tightly integrated, Extensions: Voyager (passenger), Cargo (freight), Avenue (traffic analysis), Analyst (trip table estimation), Land (land use forecasting), Dynasim	A GIS with all features are in a single, integrated platform; TransModeler separate	All features are in a single, integrated platform using ArcGIS, VISSIM integrated
	GIS Component	Embedded GIS from ESRI	Integrated native GIS	Embedded GIS from ESRI
	Network Editor	GIS-based (integrated form of ArcGIS)	GIS-based (integrated, native)	GIS-based (integrated form of ArcGIS)
	Ease of Use	Flowchart-based Application Manager for developing modeling process ("wrapper"), Scenario Manager, scripting, toolbars	Menus, scripting, toolbars (no "undo" feature for many tasks), Model/Scenario Manager	Menus, scripting, toolbars
	Data Management Tools	Matrix manipulation, tables	Matrix manipulation, tables, US Census data/geographic data tools included	Matrix manipulation, tables
	Modeling Techniques	four-step Model, Activity-based Demand Model, numerous discrete choice and assignment options	four-step Model, Activity-based Demand Model, numerous discrete choice and assignment options	four-step Model, Activity-based Demand Model, numerous discrete choice and assignment options
	Model Feedback	Methods of feedback for trip distribution/mode choice/traffic assignment, economic and land use feedback, can consider traffic signal data/capacity in assignment process	Methods of feedback for trip distribution/mode choice/traffic assignment, can consider traffic signal data/capacity in assignment process	Feedback for integrated distribution/assignment loops
	Modal Modeling	Passenger, Freight, Transit, Pedestrian, Bicycle	Passenger, Freight, Transit, Pedestrian, Bicycle	Passenger, Freight, Transit, Pedestrian, Bicycle
	Common Practice for Model Implementation	Coding of custom applications/interface, User/developer training and certification	Coding of custom applications/interface, User/developer training and certification	Coding of custom applications/interface
	Current Users	Vermont DOT, Maine DOT, California DOT, Florida DOT, Wisconsin DOT, ARC (GA), etc.	CCMPO (VT), Michigan DOT, Ohio DOT, Indiana DOT, North Carolina DOT, SCAG (CA), NYMTC (NY), etc.	Washington DOT, New York State DOT, Capital District Transportation Committee MPO (NY), etc.

Summary information compiled from sources: *9, 32, 33, 34, 35, 36, 37.*

6.3 VISUM

Developed by PTV, VISUM is used both nationally and globally for travel demand modeling and transportation planning, though to a lesser extent than either Cube or TransCAD. VISUM is offered in a number of package levels, depending on user needs, and includes a version of the micro-simulation model, VISSIM, as part of the PTV Vision Suite (*34*). It is capable of implementing a broad range of planning model methodologies and incorporates all standard modes of transportation – drive-alone auto, carpool, public transit, bicycles, pedestrians, and trucks. VISUM uses an integrated GIS from ESRI (similar to Cube), for display and network editing. Furthermore, it has the advantage of integration with VISSIM, a widely used and respected micro-simulation model.

More advanced functionality includes activity-based modeling, dynamic assignment procedures with link and intersection models, and detailed transit assignment with operational analyses. Activity-based modeling is possible using VISEM, a system that performs travel demand estimates as trip matrices for input into VISUM, thus replacing the traditional steps of trip generation, trip distribution, and mode choice. VISUM offers a number of "post assignment" analysis features including travel time isochrones, node flows, sub area network isolation, traffic signal editor, and intersection modeling. VISUM also readily imports models from other software packages, including Cube, TransCAD, EMME/2, and TModel2.

6.4 Practitioner Experiences

In mid-2003, the Florida Department of Transportation, which at the time was using TRANPLAN as the software engine for the Florida Standard Urban Transportation Model Structure (FSUTMS), reported the findings of its evaluation of numerous modeling software packages and recommendations for the next iteration of its statewide model (*9*). The report considered modeling software packages including VISUM, Cube/Voyager, EMME/2, and TransCAD in the context of each program's robustness, operational strengths and weakness, applicability to modeling in Florida as part of FSUTMS toolbox, and ability to meet the requirements of Florida's future modeling needs. Practitioner surveys provided user opinions and ratings for the software packages, and Cube/Voyager and TransCAD were shortlisted by the study's steering committee for detailed evaluation, including review of software specifications and diagnostics of various model functions. Ultimately, the study's model task force voted in mid-2003 to adopt TransCAD instead of Cube/Voyager as the new software platform for FSUTMS. However, documentation indicates that approximately one year after the recommendation of TransCAD and the start of the transitional process, the model task force decided in October 2004 to negotiate with Citilabs for the implementation of Cube/Voyager for FSUTMS, essentially reversing the 2003 recommendation for TransCAD (*35*). Slow development of the TransCAD engine for FSUTMS and an unsatisfactory business relationship with the developer were cited as reasons for the decision. Currently, the Florida Department of Transportation has implemented and is using Cube/Voyager for FSUTMS.

The City of Irvine Department of Public Works' Advanced Transportation Division also performed a modeling software evaluation, including Cube/Voyager and TransCAD. Recommendations included using Cube/Voyager for short-term upgrades to the existing model in TRANPLAN and implementation of TransCAD for long-term new model development (*36*).

In recent years, the North Carolina Department of Transportation, the Southern California Association of Governments (SCAG), and the North Central Texas Council of Government (NCTCOG) have transitioned their models from TRANPLAN to TransCAD (*37*). The Orange County Transportation Authority (OCTA) uses TransCAD for new model development.

Currently, other users of Cube/Voyager include Departments of Transportation in California, Maine, Florida, and Wisconsin, and the Atlanta Regional Commission (ARC) in Georgia. Other users of TransCAD include Departments of Transportation in Ohio, Massachusetts, Michigan, Iowa, Indiana, and the Chittenden County MPO (CCMPO) in Vermont. Similar to many consulting firms, Resource Systems Group, Inc., based in White River Junction, Vermont, is versed in a broad range of travel demand modeling software packages, including Cube, TransCAD, and VISUM (see *Appendix A: A-6*). This is a brief list of active modeling software users considering the ubiquity of the models, both domestically and internationally.

TransCAD is actively used for planning, studies, and research in Vermont by the CCMPO and the University of Vermont Transportation Research Center. In 2005, Resource Systems Group, Inc. completed a 2000 base year regional TransCAD model of Chittenden County, and continually maintains and updates the model for the CCMPO (*23*). The model performs travel demand forecasts for 2005 to 2030 at five-year intervals , and is used for the Metropolitan Transportation Plan (*38*), as well as other planning studies. Similarly, the Transportation Research Center currently uses TransCAD as an analytical tool for a number of research projects, including the Network Robustness Index: A Comprehensive Spatial-Based Measure for Transportation Infrastructure Management (*39*) and Transportation Impacts of Transit-Oriented Development in Rural Towns (*40*).

7. Summary and Recommendations

The statewide model is a valuable travel demand forecasting and transportation analysis tool for Vermont, and it should be maintained, updated, and refined so that it can continue to serve in that regard. The model has been successfully applied to planning studies in the state and has an apparent role in the Long Range Transportation Business Plan, the Highway System Policy Plan, and in air quality analyses for environmental planning. With new transit and rail components, the model would also be positioned to contribute to the goals listed in the Public Transportation Policy Plan and the State Rail & Policy Plan.

The statewide model has recently undergone a series of updates and a migration to a new software platform in 2007, but further refinements of the model would be beneficial. The model should be continually maintained, including calibration and validation processes, and

improvements to its four-step algorithms should be explored, such as a new mode choice module and the inclusion of a feedback loop between assignment, distribution, and mode choice. The further disaggregation of its VMT and average speed outputs should also be considered to potentially improve emissions modeling for air quality analyses.

The three travel demand modeling software packages reviewed in this report meet the current requirements and potential future uses of the statewide model. Fundamentally, their functionalities are similar, but with unique interfaces and formatting, so the decision to use one instead of others would primarily depend on user preference or conformity with other software (i.e., an ArcGIS user may prefer the GIS interface and options of Cube, and possibly VISUM, instead of TransCAD). An important additional factor to consider is that there is currently a base of practitioners and researchers in Vermont employing TransCAD.

At a minimum, there is enough cause for the Vermont Statewide Model to be maintained and periodically updated to keep it viable and available for planning needs at VTrans. The overall model could be kept in its current form without substantial improvements, such as transit and rail networks, but should remain available for forecasts of roadway travel and VMT estimates. Most importantly, the success and longevity of the statewide model greatly depends on the clearly-defined procedures and goals of its utility by VTrans and other Vermont agencies. As stated previously, the goals of a statewide modeling program should be defined well in advance of model-specific details, such as data needs, model components, computer software, and budget allocation.

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Appendix A

Meeting Summaries and Correspondence

A-1
Meeting Date: November 6, 2008
Location: Vermont Agency of Transportation, Montpelier, VT

Part I
Attendees:
Maureen Carr, VTrans, Traffic Operations   (maureen.carr@state.vt.us, 802-828-3091)
John Blodgett, VTrans, Traffic Operations   (john.blodgett@state.vt.us, 802-828-3972)
Richard Watts, UVM TRC
Andrew Weeks, UVM TRC

Maureen and John explained what their usual tasks are at VTrans, which include management, analysis, and reporting of VTrans counts throughout the state. They also make projections for future year volumes based on historical trends. They provided and explained some of their office's AADT and seasonal volume trends reports.

When asked how the statewide model could aid in their tasks, Maureen indicated that they could make use of the model for the following:
- traffic growth projections for future year projects
- effects of traffic network disruptions, such as detours/re-routing due to a bridge closure, or some other network link loss (this data would then be used for detailed analyses along detour routes using simulation software)
- better volume estimations for "local" roadway classes, which are not routinely counted

The TRC will coordinate with Maureen and John as the statewide model evaluation progresses.

Part II
Attendees:
Costa Pappis, VTrans, Policy and Planning   (costa.pappis@state.vt.us, 802-828-5790)
Richard Watts, UVM TRC
Andrew Weeks, UVM TRC

Costa provided the statewide model files and documentation prepared by the previous modeler, including a development timeline of the model, set-up instructions, lists of the file structure, and contact information of those involved in its development and use.

Costa described some previous uses of the statewide model, including environmental impact statements (e.g. Circ-Williston EIS), the Bennington Bypass, the Morristown Bypass, the Western Corridor Study, and the State Employee Commuting Study. Similar to Maureen's comments, Costa indicated an interest in using the model for detour/re-routing evaluations and ITS.

Costa said that VTrans needs to develop a modeling work plan for the next 3-4 years, likely as part of the Long Range Transportation Business Plan, and would include recommendations from the TRC.

Costa highlighted some needed improvements to the statewide model:
- transit network to analyze multi-modal alternatives

- integration with the CCMPO model should be explored, such as transferability of network and TAZ data; travel modes should match those in the CCMPO model for data coordination with the regional model
- preparation for potential non-attainment in areas of Vermont (the Vermont Department of Environmental Conservation currently oversees air quality work, but VTrans would need to perform analyses for conformity determination and the SIP should non-attainment occur)
- potential freight model changes, including a rail component (this depends on the outcome of VTrans freight plan RFP currently active)

Costa said that since VTrans is in "preservation mode" there would less likely be a great need for model use in major capital improvement studies, but alternatively for transit improvement studies.

After the meeting, we spoke informally to Gina Campoli (gina.campoli@state.vt.us, 802-828-5756) who mentioned the potential model use for the Governor's Climate Change Commission (for transportation-related pollutant and greenhouse gas emissions and energy policies).

The TRC will coordinate primarily with Costa as the statewide model evaluation progresses.

Action items for TRC
- Begin to review VTrans statewide model and documentation
- Prepare draft recommendations for potential use and updates of the VTrans statewide model
- Continue modeling software package evaluation and review of modeling practices at other state departments of transportation

A-2
Meeting Date: December 10, 2008
Location: Vermont Agency of Transportation, Montpelier, VT

Attendees:
Clay Poitras, VTrans, Policy and Planning   (clay.poitras@state.vt.us, 802-828-3968)
Scott Bascom, VTrans, Policy and Planning   (scott.bascom@state.vt.us, 802-828-5748)
Costa Pappis, VTrans, Policy and Planning   (costa.pappis@state.vt.us, 802-828-5790)
Andrew Weeks, UVM TRC

- Scott is managing the Highway System Policy Plan, which is part of the Multi-modal Policy Plan.

- Costa manages corridor planning, public transit and freight planning, with the Public Transportation System Policy Plan and Rail Policy Plan as part of the Multi-modal Policy Plan.

- Clay would like to think outside-the-box about what other agencies could use the model's output. ANR/DEC would use VMT and related information for air quality needs. Note: What about Vermont Association of Planning, Development Agencies (VAPDA) and Agency of Commerce and Community Development, Department of Public Safety?

- Chittenden County is covered by the CCMPO regional model. Note: For other areas of Vermont, would it be more worthwhile to isolate and detail a section of the statewide model for regional use, instead of bringing the *entire* statewide model to that level of detail?

- The Asset Management Plan could potentially make use of the model for identification of roadways for funding/work priority – a performance review of the network to determine investment queuing. Contact: Bart Selle (bart.selle@state.vt.us, 802-828-2757).

- Chuck Gallagher (charles.gallagher@state.vt.us, 802-828-3889) and Alec Portalupi (alec.portalupi@state.vt.us, 802-828-3889) from Operations may also have additional uses for that division.

- Scott showed interested in the idea of identifying a "primary" or "critical" roadway network for the state, similar to TRC's work on the *Network Robustness Index*. Using the statewide model as an analysis tool for determining critical roadways could be beneficial. Note: One example discussed was a possible bridge failure or disaster even along I-89 in the vicinity of Waterbury. What would be the regional impact and how could traffic be diverted? This would also relate to the Highway System Policy and Asset Management Plans. (See also: possible replacement of Crown Point Bridge, NYSDOT.)

- Regarding software packages, Costa indicated that it would be important to consider CCMPO's practices (i.e. TransCAD). Another importation consideration is that VTrans uses ArcGIS exclusively, which is the GIS in CUBE.

A-3
Phone Conversation with Clay Poitras, VTrans
Date: November 20, 2008

<u>Discussion</u>

Clay's general comments about the statewide model:

- He is confident of the long-term need and use of the model.

- There will likely not be much need for the model in the next 12-18 months, but he wants to keep it functional until a long-term plan for use is developed.

- Although the model is current a highway model, there will not be many big highway capacity projects in the future that would require the model. The emphasis would be on existing highway infrastructure improvements.

- Clay refers the model as "macro" and clearly states that it becomes increasingly limited in utility as the spatial resolution and analysis detail increase

- There will be increased emphasis on corridor management and planning, such as for 5 to 10-mile segments of roadways, which would require additional micro-analysis capabilities (simulation/HCM methodologies). The statewide model could potentially feed volumes to the micro-analyses. See Western Corridor Study.

- Clay cited a number of areas that the model could be applied, perhaps not immediately, but at some point in the future:

    - Project development and alternative planning (contact: Kevin Marshia, VTrans)

    - Air quality analyses, possible non-attainment (contact: Gina Campoli, VTrans)

    - Transportation planning assistance for the regional planning commissions (RPC) – specifically the local transportation planners; abridged contact list is included

    - Corridor management studies (contact: Costa Pappis, VTrans); Eleni Churchill, CCMPO, can be contacted regarding the Western Corridor Study

    - Modal policy plan, typically at 5-year iterations (contact: Scott Bascom, VTrans)

    - Possible new interchange capacity improvement – I-89 near Hinesburg Rd./Kennedy Dr. in South Burlington

    - Continued use for EIS work, such as Circ-Williston DEIS

    - Collaboration with CCMPO to supplement spatial limitations of the CCMPO model (contact: Eleni Churchill, CCMPO)

- Clay said it is possible to contact Julie Murphy, VHB, with technical questions about the model; however VHB is not currently under contract with VTrans.

- Clay identified the statewide model's current utility limitations due to no transit network or rail component in the freight model; Costa's freight model RFP may deal with the latter limitation.

- Clay thought it worthwhile to explore current modeling trends, evolution, and likely tools that will primarily be used in the coming years.

- Clay recognized that hiring-out to consultants for statewide modeling tasks (application of the model and/or maintenance on the model) is an option.

- Clay believes that an important question to set a stage for this entire evaluation is: "why should the State of Vermont and VTrans continue with a statewide model?"

- Clay agreed that the evaluation process is moving in the right direction – that we should continue to develop a set of likely uses of the model in the future, identify any deficiencies in the model to address in order to facilitate that set of model uses, and then make an action plan to address those deficiencies.

- Clay said that we can provide updates to him and Costa at any point during the ongoing process, in a manner of our convenience.

Contact Information provided by Clay

VTrans Project Development:
Kevin Marshia, Roadway, Traffic & Safety Manager
Kevin.marshia@state.vt.us
(802) 828-2664

VTrans Policy & Planning:
Scott Bascom, Planning Project Manager (Scott will be managing the update to the statewide highway modal plan.)
Scott.bascom@state.vt.us
(802) 828-5748

Costa Pappis, Planning Project Manager (Costa manages our Corridor Management Studies and will be managing the pending statewide freight study.)

Gina Campoli, AOT Environmental Policy Manager (air quality & other)
Gina.campoli@state.vt.us
(802) 828-5756

Regional Transportation Planners:
Contact information for regional planning commissions and the CCMPO is attached. Suggest consulting Eleni Churchill in addition to Dave Roberts at the CCMPO. Eleni is managing the western corridor study. In addition – as a former member of VTrans and a colleague - she is very well founded in the statewide model, how it works and its limitations.

A-4
Conversation with Eleni Churchill, CCMPO
Date: December 09, 2008 at the TRC

Eleni worked at VTrans for 12 years from about 1994 to 2006, managing the statewide model. During her time at VTrans, she coordinated closely with Julie Murphy at VHB, the on-call consultant, working on the model.

<u>**Discussion**</u>

Eleni's general comments about the statewide model:

- She feels that it is important to keep the model alive with maintenance and upgrades, mainly for transit modeling (model improvements needed, though) and potential air quality needs in the future, in case of nonattainment in Vermont.

- For the Western Corridor Study, which Eleni is managing at CCMPO, the statewide model received additional calibration along the western portion of Vermont, going beyond the updates that were done by VHB when the model was brought into CUBE. Charlie Mark performed some of that additional calibration while he was a modeler at VTrans, and Ed Bromage at Cambridge Systematics, who is running the modeling for the Western Corridor Study, also performed more calibration for western Vermont. Eleni will request the updated model files from Cambridge Systematics for TRC use.

- She recognizes the importance of transit modeling capabilities in the model, and the need for a rail network, for modeling of passenger rail and freight rail. A growing desire to shift more freight from truck to rail could precipitate a need for rail modeling in the statewide model.

- While at VTrans, Eleni was involved in work to identify a "primary network" in Vermont – a set of critical links/infrastructure – that should receive priority in funding and maintenance. Travel time from the statewide model was a key component in identifying the "primary network," and the model could be used similarly in the future.

- Eleni brought a hardcopy of Vermont Statewide Travel Demand Model Improvements, VHB, June 2007 for TRC reference.

- Eleni also suggested getting in touch with Julie Murphy at VHB. When VHB was performing the model update and migration into CUBE, part or all of it was done first in TransCAD. Eleni thinks it would be worthwhile for the TRC to obtain those TransCAD files.

- Also regarding TransCAD versus CUBE, Eleni thinks that it would be nice to have the state and regional model all in one platform. She, of course, recognizes the need for a clear plan for future uses of the statewide model before worrying about details such as software packages.

A-5
Meeting Date: March 12, 2009
Location: Vermont Agency of Transportation, Montpelier, VT

Part I
Attendees:
Bart Selle, VTrans, Policy and Planning (Asset Management)
(bart.selle@state.vt.us, 802-828-2757)
Andrew Weeks, UVM TRC

Bart briefly discussed the general responsibilities of asset management including the systems of pavement, bridges, buildings, aviation, safety and maintenance management.

Asset management has established procedures to meet its planning and policy-making needs. Travel demand forecasting does not play an inherent role in the asset management procedures, since asset management is a means for effective investment for existing transportation infrastructure.

Aside from the travel demand forecasting applications of the statewide model, Bart identified a potential need for establishing a base condition for likely performance measures, including mobility (capacities, v/c and travel speed). The reauthorization of SAFETEA-LU in 2009 may identify a plan for state transportation agencies to establish guiding performance measures for maintenance, investment, safety, and mobility in policy planning.

Increasing emphasis on performance measures and accountability for project approval and funding may require more quantifiable and defensible metrics in the decision-making process. The statewide model could serve as a tool in this regard, providing quantitative measures of mobility.

Part II
Attendees:
Bruce Nyquist, VTrans, Program Development (Roadway, Traffic and Safety)
(bruce.nyquist@state.vt.us, 802-828-2696)
Andrew Weeks, UVM TRC

Bruce discussed plans for VTrans to use FHWA's Safety Analyst program (http://www.safetyanalyst.org/index.htm) to identify probable high crash locations in the state, and the associated data needs. He said that they would focus predominantly on rural roadways, including major and minor collectors and local roads. (In the statewide model, those three types are identified as functional classes 7, 8, and 9, and account for approximately 18,000 links in the model and roughly 6,000 miles of roadway. Traffic volume (AADT) needs for Safety Analyst would spatially exceed the Traffic Research department's current collection capabilities.)

Furthermore, HPMS would not be capable of providing the needed data.

The AADT needs for Safety Analyst would be current-year volumes – the particular year being studied by VTrans – and not necessarily future year forecasts. If the statewide were used to supplement Traffic Research's AADT data with analysis-year estimates, implementation of Safety Analyst may be more feasible, and result in more accurate estimates. Two issues with the statewide model would need to be addressed prior to its implementation in this case:

- The model provides base year volumes and future year forecasts. The current base year is 2000, and the future year is 2020, which would likely be updated to 2010 and 2030, respectively, if the model were kept active. In short, the statewide model's analysis years are not readily adjustable due to its nature as a travel demand forecasting tool. However, it is likely that VTrans would need AADT estimates for Safety Analyst for an analysis year between the statewide model's base year and forecast year. As a solution, a procedure for interpolation between base year volumes and future year volumes would be needed, to arrive at volume estimates for the analysis year being evaluated in Safety Analyst.

- The direct use of volume estimates from the statewide model, instead of a general comparison of forecasted volume estimates to the base conditions, raises the issue of the model's accuracy. This issue was previously raised during the discussion with Traffic Research in November 2008. This was also identified by a former VTrans modeler. Updated calibration and validation of the model would likely be required to ensure the model's accuracy. It is also probable that additional refinement of the model's volume estimates could also be necessary before being used in a program such as Safety Analyst. The question then becomes: is this effort worth the volume estimates from the model for use in Safety Analyst, or would it be more feasible to use a more basic, but more easily estimated and checked, procedure to estimate the needed AADT?

In addition to supplementing volume data collection, also having an inventory of base year conditions for mobility measures, such as capacities, v/c and travel speeds could be helpful for project evaluation. In this regard, the model would not be relied on for forecasted volumes for future years, but instead as a tool to better define base year highway conditions in Vermont. This objective may not be an appropriate application of the current model, since it is meant as a forecasting tool for comparison of future volumes to base year volumes, or comparison of planning alternatives. However, the possibility of employing the model as a data resource for safety analyses and performance measure determinations would benefit VTrans data needs and objectives while keeping the model relevant.

Other uses: the statewide model is generally not applicable for traffic operations and project-level analyses. This is the case for most macroscopic statewide models, not just Vermont's. However, although individual projects are not evaluated using the statewide model, the net effect of development and growth due to numerous projects in an area could be quantified using the model (e.g. St. Albans Route 7 corridor). This procedure could provide guidance in the review process of development projects.

Other uses: there are no major roadway projects planned or under analysis that would require the statewide model. The model has been recently employed for the Circ-Williston EIS, and currently for the Western Corridor Study, but there are no clear uses for major roadway planning in the near future.

Summary Comments – The Statewide Model as a Data Resource

A common thread in the discussions with Bart and Bruce was the need for more traffic data, better traffic data. Certainly the costs and resources required to gather transportation system data in the field are significant. It is simply not practical to gather a broad set of data types (volumes, speeds, delays, geometry and control, etc.) at all locations, and continuously for traffic conditions.

NCHRP Report 446, A Guidebook for Performance-Based Transportation Planning (Transportation Research Board – National Research Council, 2000) identifies urban and statewide travel demand models as useful tools to supplement field-collected data for performance-based evaluations and planning. Importantly, however, the report identifies the need for model calibration with survey/field data on a regular basis in order for the models to provide accurate estimates of current/base year data.

Software employed by VTrans for transportation network/system evaluations that require extensive data inventories include Safety Analyst, as mentioned by Bruce, and Highway Economic Requirements System–State (HERS–ST), which is an asset management tool provided by the FHWA (http://www.fhwa.dot.gov/infrastructure/asstmgmt/hersindex.cfm). The Roadway Asset Management Unit cites such data inventories for Safety Analyst and HER–ST as part of its mission. (http://www.aot.state.vt.us/progdev/Sections/Design/Design.htm). Furthermore, the *Vermont Highway System Policy Plan* (Section 5.0 pages 5-6 and 5-7, and Appendix B) recommends an evaluation of the feasibility of expanding the Highway Performance Monitoring System (HPMS) data set to meet the needs of HERS–ST in Vermont.

The Oregon Department of Transportation and the Texas Transportation Institute have worked jointly to explore the use of HERS–ST in asset management programs, evaluating its data needs and potential for implementation with the ODOT statewide model. Their work has identified the need for more robust data sources, which can be a considerable challenge when applying the HERS-ST model (http://mobility.tamu.edu/resources/odot_op_perf_measures.pdf; http://www.fhwa.dot.gov/infrastructure/asstmgmt/dior09.cfm).

The statewide model could become a valuable tool for Program Development, specifically the Roadway Asset Management and Traffic and Safety groups, to provide data for the determination of performance measures. Importantly, in order for the statewide model to be effective in this manner and to ensure that its volume estimates sufficiently accurate, it would require frequent, regular updates to its base year data and careful calibration and validation.

A-6
Email from Stephen Lawe, RSG Inc.
Date: November 11, 2008

The following is an email from Stephen Lawe, answering questions about his experience and feelings about the travel demand modeling software packages commonly used at RSG:

Which travel demand modeling software packages does RSG frequently use?

- For travel demand models we use most if not all of the currently available packages. The list below includes new software and some older software as well: TransCAD, CUBE, VISUM, QRS, TModel, TRANPLAN, TRANSIMS, EMME/2, as well as a package called ITM (integrated travel model) which I wrote. We also use several micro-simulation packages but I will not bother with those here.

Approximately how many years has RSG used each?

Now I wish I had made a shorter list:

- TransCAD = since the early 1990's. We were a beta tester for one of the very first versions of TransCAD.
- CUBE = since the late 1990's (note that this started with TRIPS, TP+, Voyager – all of which we were using around that time).
- VISUM = around 2005 and we don't have significant experience with VISUM.
- QRS = we have been using this on and off for years when our clients request it. Probably mid 1990's was one of the first uses. We had a recent project in 2004 where we used QRS.
- TModel2 = this is now largely out of service. We used it a reasonable amount starting in the late 1980's
- TRANPLAN = we have a statewide model for Florida running in TRANPLAN right now. We know the developer of this package well so we can modify the code to meet specific needs. We probably first used this in the early 1980's.
- TRANSIMS = we first used this in 2006 – it is still really in development and not to be taken lightly if being considered for implementation.
- EMME/2 = this is another package we used a long time ago for a little while. I know there are still versions out there but I think this is also being phased out. We probably used it in the late 1980's.
- ITM = this is a package I first wrote in 1992 and played with over the years. I wrote it when we were not satisfied with the capabilities of other available packages and we wanted control of the code base. I have not touched this in about 3 years.

Of those packages being used, has there been a shift in software package preference at RSG?

- When our clients allow us to choose we primarily choose either TransCAD or CUBE. I also like VISUM but we have had less opportunity to use it. Keep in mind that many states have already made their choice of software so we are somewhat limited in our ability to choose. I like the GIS capabilities in TransCAD. Its most frustrating feature is how it handles transit networks and also how some of the matrices are exposed to the programming interface (GISDK). CUBE is slightly more utilitarian but is also a good package. I like the interface and the integration with geodatabases. The most frustrating feature to me is the assumed required looping in the programming interface.

Have new/inexperienced modelers at RSG (if any) mastered certain software packages more quickly than others? Or is there no discernible difference in the softwares' learning curves?

- I don't think I have noticed a big difference. Once you understand what the algorithms are doing, picking up a new software package is reasonably trivial. I would certainly not call the packages intuitive to a non-modeler but I always feel that it's the concepts rather than the software itself which is the limiting factor. In fact, the software often gives people a sense that they know more about modeling than they actually do which can be dangerous.

Have you had sufficient support from the software vendors/developers when needed?

- Not really. I think this is because we are not asking trivial questions. Usually, we are exposing a bug in the software or asking how to do something that is rather uncommon. It often takes some time to hear back even though I know most of the tech people reasonably well. Having said this, I don't know that this experience is really applicable to people asking more common questions.

What types of projects/uses have you employed various TDM modeling software packages for?

- Well, there are several ways to answer this. Geographically, we have modeled areas as small as parts of a town and as large as the states of Florida, Georgia and Utah. Substantively, we have modeled roadway infrastructure, transit planning, environmental issues (air quality, global climate change, water quality, etc.), impacts on land use, environmental justice issues, congestion pricing, and MPO and State long range planning exercises just to get the list started.