Vermont Agency of Transportation (VTrans) Statewide Travel Model Peer Review Report

SEPTEMBER 2013

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U.S. Department of Transportation
Federal Highway Administration

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1.0 Introduction

1.1 Disclaimer

The views expressed in this document do not represent the opinions of the Federal Highway Administration (FHWA) and do not constitute an endorsement, recommendation, or specification by FHWA. The document is based solely on the discussions that took place during the peer review meeting sessions and supporting technical documentation provided by Vermont Agency of Transportation (VTrans).

1.2 Acknowledgements

FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review of the VTrans statewide travel model and for sharing their valuable experience.

The following list includes each peer review panel member and the agency with which they are currently associated:

- Keith Killough, Director of Transportation Analysis at Arizona DOT;
- Judy Raymond, Transportation Supervising Planner at Connecticut DOT;
- Chad Baker, Statewide Model Branch Chief at Caltrans;
- Becky Knudson, Senior Transportation Economist in the Transportation Planning Analysis Unit at the Oregon DOT; and
- Kevin Hooper, Principal at Kevin Hooper and Associates.

Brief biographies for each of the peer review panel members are presented in Appendix C.

1.3 Report Purpose

This report summarizes the results of a peer review of the VTrans statewide travel model with a focus on recommendations for future model enhancements. The peer review was supported by the Travel Model Improvement Program (TMIP), which is sponsored by FHWA. The peer review of a travel model can serve multiple purposes, including identification of model areas for improvement, recommendations for model enhancements, and guidance on model applications. Given the increasing complexities of travel demand forecasting practice and the growing demands by decision-makers for information about policy alternatives, it is essential that travel forecasting practitioners have the opportunity to share experiences and insights. The TMIP peer review program provides a forum for this knowledge exchange.

VTrans's overall goal for model improvement and motivation for seeking a TMIP peer review was to continuously maintain and apply a model representative of the state of the practice in travel forecasting that equips the agency with the support needed for informed decision making throughout the state. The peer review was conducted in four two-hour phone/web-based meetings: two technical background meetings including TMIP moderators, VTrans and associated staff, and peer review panelists; one meeting between the panelists and TMIP moderators to discuss potential recommendations; and one final meeting involving all parties to present these recommendations to VTrans. The results of each of these discussions and recommendations from the panel are presented in this report.

1.4 Report Organization

This report is organized into the following sections:

- *Vermont Agency of Transportation Overview* – an introduction to the planning responsibilities of the agency, regional characteristics of the state, and the agency goals for peer review.
- *Development of the Vermont Statewide Model* – a historical context of travel modeling at VTrans, including previous model development efforts and current model improvement efforts.
- *Model Improvement Plan* – a brief summary of the plans to update the statewide model with regard to modeling priorities and necessary considerations.
- *Technical Questions Provided by the Vermont Agency of Transportation* – descriptions of highlighted topics for the peer review panel's review.
- *Peer Review Panel Response to Technical Questions* – a detailed synopsis of the panel's analysis and recommendations.
- *Panel Discussion and Recommendations* – a general summary of the peer review panel's recommendations to VTrans, including prioritized next steps.

In addition, the report includes six appendices:

- *Appendix A* – List of Peer Review Panel Participants
- *Appendix B* – Peer Review Session Agendas
- *Appendix C* – Peer Review Panelist Biographies
- *Appendix D* – Overview of the Vermont Statewide Model
- *Appendix E* – VTrans Peer Review Application
- *Appendix F* – Slides from Peer Review Sessions #1, #2, & #4

2.0 Vermont Agency of Transportation Overview

This section provides an overview of VTrans, including transportation policy and planning issues and demographic characteristics of the state of Vermont to provide context for the peer review discussion.

2.1 Vermont Agency of Transportation Responsibilities

The Vermont Agency of Transportation (VTrans) was created in 1979 as the Vermont State Legislature combined four different but related agencies: Highway, Motor Vehicles, Aeronautics, and Public Transit. VTrans provides planning and financial support for the integrated transportation network throughout the state, including highway, rail, public transit, airports, and bicycle/pedestrian modes. The agency's mission is to provide for the safe and efficient movement of people and goods. Although a majority of VTrans's resources are directed toward maintaining and improving the state's network of roads and bridges, the Agency's vision is a safe, efficient and multimodal transportation system that promotes Vermonters' quality of life and economic wellbeing.

Vermont contains fourteen counties and has a population over 626,000, according to the 2012 US Census estimate. The Chittenden County Regional Planning Commission is the only Metropolitan Planning Organization (MPO) in the state. Regional transportation planning in the rest of the state is conducted by the ten other regional planning commissions with cooperation and funding support from VTrans.

2.2 Statewide Characteristics

Vermont contains twenty distinct Census urban areas, but Vermont's fourteen counties are predominantly rural with the exception of Chittenden County, which accounts for approximately 24% of households, 30% of employment, 39% of internal TAZs, and the largest urban area in the state, Burlington.

After experiencing mild growth in the 1980s and 1990s, the state has experienced minimal growth over the past decade. Between 2000 and 2010, the US Census Bureau reports a population growth of 2.7 percent. Population growth over each decade is provided in Table 1.

Table 1: Vermont State Population Growth: 1980 - 2012[1]

Year	Population	Growth from Previous Year Listed
1980	511,456	N/A
1990	562,758	9.1%
2000	608,827	7.6%
2010	625,741	2.7%
2012 (Estimate)	626,011	0.0%

According to the 2007-2011 American Community Survey (ACS) Five-Year Estimates Vermont has a civilian labor force of 351,086 with a median state household income of $53,422. Table 2 summarizes the commute-to-work mode distribution, as reported by the ACS.

[1] United States Census Bureau. http://www.census.gov/

Table 2: Commute-to-Work Mode Distribution for the State of Vermont[2]

Mode	Percent
Car, Truck, or Van – Drive Alone	74.1%
Car, Truck, or Van – Carpool	10.3%
Public Transportation (Excluding Taxi)	1.1%
Walk	6.0%
Other Means	1.7%
Work at Home	6.9%

VTrans operates ten local airports which do not comprise a significant number of national enplanements. The agency does not manage Burlington International Airport, which accounts for the greatest number of enplanements in the state at 636,019[3] for the 2011 fiscal year.

[2] 2007-2011 American Community Survey 5-Year Estimates. American Fact Finder. http://factfinder2.census.gov

[3] Federal Aviation Administration Calendar Year 2011 Enplanement Data. http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/media/cy11_cargo.pdf

3.0 The Vermont Statewide Model

This section of the report provides an overview of the Vermont statewide travel model, including a history of the model, a description of the model's components and functionality prior to the peer review, and a list of items to be accomplished through the peer review.

3.1 History of the Vermont Statewide Travel Model

The statewide model is an objective, analytical tool developed to assist in transportation policy making and infrastructure investment decisions, as well as aid in long-range planning. Efforts to develop the initial model for the state of Vermont began in the 1990s with processes run in the SAS Model Manager 2000 platform and the road network maintained in the TRANPLAN software format. The base-year 2000 model was improved in 2007 by transitioning to a GIS-based model framework using the CUBE software package. Further enhancements were then made to improve the correlation between model outputs and validation data.

The TRC, under contract with the Division of Policy, Planning, and Intermodal Development at VTrans, has hosted, improved, and applied the statewide model since 2008. In the fall of 2008, when the TRC transitioned to host the model, the following enhancements were made:

- Alignment of statewide TAZs and road-network characteristics with those of the Chittenden County MPO Regional Model (A TransCAD-based regional travel model developed and maintained by the Chittenden County MPO);
- Improved estimation of commercial truck trips;
- Enhanced estimation of the gravity model for trip distribution using calibrated impedance functions;
- Increased road-network representation to include critical minor and local roads; and
- Advanced regression factors for trip production and attraction equations.

In addition to these enhancements, the TRC updated the statewide model to a 2009-2010 base year. This effort included updating employment and housing totals for TAZs and housing characteristics by town. Characteristics from roadway improvements made between 2000 and 2010 were incorporated into the highway network, as well as truck percentages for traffic counts by TAZ and cross-border traffic counts for external trips. Trip rates and regression equations for HBW, HBO, HBSHOP, and NHB trips were updated along with vehicle-occupancy rates and external trip-fractions by trip purpose. Trip-distribution impedance functions for the gravity model were also updated.

Being one of the smallest states in terms of population and home to only one MPO, Vermont's travel model is a useful tool for statewide travel estimation. The statewide model is designed for application in a variety of transportation planning studies and projects. It has been used for scenario planning in the 2009 Long Range Transportation Business Plan to evaluate traffic changes from proposed limited access roads in Morristown and Bennington and to evaluate the implications beyond the limits of the Chittenden County MPO's model.

3.2 Current Vermont Statewide Travel Model

The model, in its current state, can be used to aid in the following activities, as defined by VTrans staff:

- Perform system and intercity-corridor studies;
- Create reliable and timely travel estimates and forecasts;

- Conduct scenario testing or "What If" assessments;
- Provide link-specific traffic breakdown by trip purpose, origin, and destination;
- Create estimates and forecasts of pass-through travel;
- Perform travel analyses in non-MPO regions of the state;
- Create sub-area models in local towns as needed;
- Estimate passenger rail and transit demand from trip tables;
- Accurately estimate traffic flows on inter-urban segments of major roadways;
- Estimate rural trip-making activity;
- Estimate travel characteristics at borders with other states and Canada; and
- Estimate long-distance travel.

The Base-Year 2009-2010 statewide model is comprised of 866 internal and 70 external Traffic Analysis Zones (TAZs). Residential information from both the 2006-2010 American Community Survey (ACS) and the 2010 US Census were used to input household distributions and characteristics in the state. Data from the 2009 Bureau of Economic Analysis (BEA) and the 2009 Vermont Department of Labor QCEW were used to disaggregate employment characteristics among the internal TAZs. Total employment figures used in the statewide model are categorized into five user-specific industry groups: Retail, Manufacturing, Non-manufacturing, Education, and Government.

The statewide model network includes Interstate, State Roads, US Routes, Urban Collectors, and some major rural collectors. The highway network consists of 5,250 miles of roadway, of which about 2,800 are on the state system. A total of 7.4 billion annual vehicle-miles of travel (VMT) were estimated for the 2010 base year network.

The statewide model employs a three-module process, including trip generation, trip distribution, and traffic assignment, to estimate travel demand and link flow throughout the state and across its borders using statewide demographic and employment data. The model estimates daily passenger-vehicle flow between TAZs for four trip types: home-based work (HBW), home-based other (HBO), home-based shopping (HBSHOP), and non-home based (NHB). Commercial truck (TRUCK) traffic is estimated directly from traffic counts as a fifth trip type. There is no currently existing freight model in the statewide model to disaggregate truck travel by medium- and heavy-commercial trucks or to investigate average daily commodity movement.

The model applies rates and coefficients derived primarily from 2009 National Household Travel Survey (NHTS) data. Previous NHTS sampling in Vermont had not been robust enough to use for an effective model update, as compared with sampling from larger states. With this in mind, VTrans purchased an add-on to the 2009 NHTS dataset, which resulted in approximately 1,700 Vermont households and over 3,800 individuals surveyed. The resulting per capita 2009 NHTS sample representation was among the best in the nation. The resulting tabulation of travel behaviors from this dataset forms the basis of the sub-modules used in the model.

The model estimates link flows from the TAZ-based population and employment information. The trip generation sub-module combines these TAZ-based characteristics with the town-based fractions of cross-classified number of household members and workers to calculate home-based trips produced by each internal TAZ. Trip attractions for all purposes and trip-productions for the NHB purpose are generated for each TAZ using purpose-specific regression equations, each of which utilizes a different set of employment and/or population characteristic. TRUCK productions and attractions are taken as a fraction of the NHB trip totals corresponding to the fraction of trucks in traffic counts in the TAZ. Total non-TRUCK external person trips are then subdivided by the other four trip types using an external trip-fractions table estimated from the

NHTS data. The trip production output is held constant while attractions are adjusted by TAZ to create a balanced trip table.

The passenger trip distribution sub-module applies the balanced productions and attractions table, a matrix of free-flow travel times between TAZs (based on travel at five miles per hour over the speed limit, with terminal times from one to four minutes for origin and destination), and a set of impedance functions to generate a Production-Attraction matrix between all TAZs using the gravity model.

Because the statewide model is a daily model, all trips are assumed to return to their origin, rendering the final matrix diagonally symmetric. Therefore, the set of trip-specific matrices resulting from the gravity model application are transposed and averaged with their originals to create symmetrical matrices with trip totals identical to the balanced trip table.

Prior to the assignment sub-module, the symmetrical person-trip matrices resulting from the trip distribution step are converted to vehicle-trip matrices by applying vehicle-occupancy rates by trip type for internal and external travel (from the NHTS). The assignment sub-module employs a user-equilibrium optimization to distribute trips in the network, resulting in statewide vehicle flows and congested travel speeds by link.

Appendix D provides further detail regarding the development, functionality, and validation of the Vermont statewide model. Figure 1 provides an illustration of the TAZs and highway network in the model.

3.1 Vermont Agency of Transportation Goals for Peer Review

After the 2009-2010 base year update, VTrans is now considering a host of potential improvements. VTrans's continued commitment to travel modeling is evidenced by its partnership with the University of Vermont Transportation Research Center (TRC), the current developer and host of the Vermont statewide model, in improving the model's capabilities. The TRC and VTrans felt the TMIP peer review process would be useful to identify model enhancements.

VTrans sought a peer review geared toward statewide model specifications, design, and plan for future improvement. VTrans anticipated that the recommendations of the panel would be innovative, state-of-the-practice ideas and hoped to include the peer review recommended tasks in its work program to enhance model development and refinement. The panel was asked to outline any weaknesses of the existing model and assist in determining whether application of current or more advanced models could inform issues specifically faced by the State of Vermont, as deemed necessary by VTrans. It was anticipated that considerable discussion regarding the merits of moving towards more advanced sub-modules and determining which approaches are capable of providing the greatest benefits for VTrans would be the primary topics of the peer review sessions.

3.2 Previous Peer Reviews

The peer review convened in June and July of 2013 was the first peer review session conducted for VTrans regarding their statewide travel model.

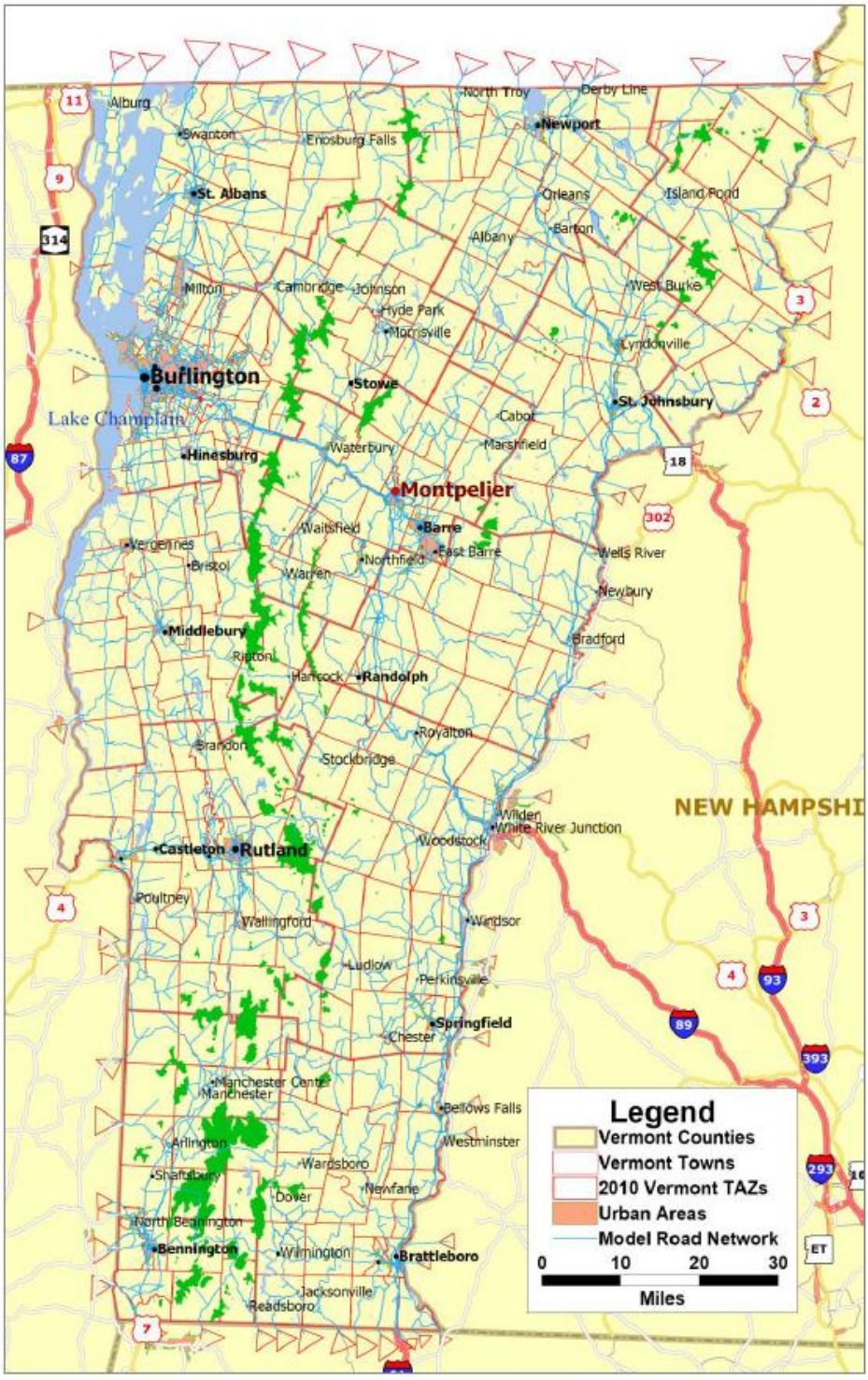

Figure 1: TAZs and Network in the Vermont Statewide Model

4.0 Model Improvement Plan

VTrans is in the process of planning and prioritizing updates for statewide model enhancement. This section summarizes the preliminary stages including identification of agency needs and subsequent model development needs.

4.1 Vermont Agency of Transportation Visioning for Model Improvements

Priorities for implementation are particularly sought by VTrans, as well as a path and process for continued improvement over the next several years. Some of the specific improvements that VTrans and the TRC are considering, as defined in their peer review application and initial model background presentations, include:

- Investigating the potential use of the results of the 2010 Vermont Trip Generation Manual for calibrating or updating the trip-generation sub-module;
- Investigating the need for calibrating or updating the traffic assignment sub-module with speed/density curves derived from speed data logged by weigh-in-motion (WIM) stations and road-weather information system (RWIS) stations;
- Exploring the need for a seasonal component including, at a minimum, an average winter day, an average summer day, and an annual average day;
- Developing a freight module based on the method and guidance provided by Sorrantini and Smith (2000) consisting of commodity flows between counties, out of the state, and into the state, with a coordination of these flows and the truck volumes which are currently in the model at the TAZ level;
- Improving road-network level of detail to get more refined estimates of travel speeds, vehicle-miles of travel, and emissions;
- Refining in the temporal resolution of the model to include a peak hour along with the current daily travel estimates;
- Incorporating of a tourist-travel component to the model to better estimate the trends in visitor travel to Vermont;
- Development and tracking of parking supply in the state for improved estimation of travel on major corridors;
- Improvements in the multi-modal aspects of the model to include passenger rail, bus transit, and airline travel, as is typical for a statewide model;
- Feedback between modeling steps, specifically traffic assignment and trip distribution;
- Roadway grade and pavement type for the model's highway network links to help in speed and emissions modeling;
- Applying a square-footage base for trip-generation; and
- Disaggregating NHB trips into 'Non-Home Based Business' and 'Non-Home Based Personal.'

4.2 Strategic Challenges in Desired Planning Outcomes

In addition to the modeling visions described in the section above, VTrans is interested in how the model can be advanced to inform specific desired planning outcomes, particularly in areas

where obstacles exist with respect to desired outcomes. The strategic challenges described in the agency's considerations in model development include:

- Aging and damaged infrastructure;
- Changing demographics and economy;
- Land use;
- Stagnant and declining transportation fund revenues;
- Energy constraints;
- Climate change, extreme weather events and associated impacts to infrastructure and the environment;
- Freight movement and trade globalization;
- Security needs and issues; and
- Resiliency to a changing world.

5.0 Technical Questions Provided by the Vermont Agency of Transportation

The first peer review meeting was held virtually on June 5, 2013. At this meeting, VTrans and the TRC provided background information on the Vermont statewide model, further articulated their ideas for potential model improvement components from the initial vision described in Section 4.1, and presented questions to the panelists regarding the following areas of interest to lead the initial peer review meeting's discussion:

- Response to FHWA Identified Issues;
- Resiliency Planning;
- Evaluation of Energy/Emission Goals;
- System Preservation and Disinvestment;
- Performance Measurements and Asset Management;
- Fair-Share Methodology; and
- Corridor Prioritization: Transit, Biking, and Walking.

VTrans also noted their desire for the panelists to identify additional areas for improvement or specific areas for attention regarding the model's structure and functionality that would be beneficial to the agency in the development of an enhanced model. This section outlines each of VTrans's technical topics for discussion, as they were presented in the peer review.

5.1 Response to FHWA Identified Issues

In a review conducted by FHWA staff, various issues regarding the structure and operations of the current model were identified as priority areas for VTrans to address in their model enhancement efforts. FHWA's comments included the following:

- Homogenization of the model platform used by VTrans and that used by the consultants from the University of Vermont;
- Review and validation of the highway network coding on a detailed level;
- Reduction of average trip impedances as a result of zone refinements made in Chittenden County;
- Differentiation of short- and long-distance travel;
- Rectification of the discrepancy between the default speed/capacity tables and the future year assignments;
- Adjustment of flows for model fit; and
- Development of a comprehensive user's manual.

VTrans provided FHWA's detailed comments to the peer review panelists for review prior to Session #2 so they could assess the recommendations and elaborate on specific topics as appropriate.

5.2 Resiliency Planning

As a response to Hurricane Irene and its significant damage to the state's transportation infrastructure, resiliency planning has become a major focus at VTrans, with an emphasis on infrastructure design. VTrans would like to utilize the statewide model as a means for resiliency

planning and requested more information from the panelists as to potential related performance measures that can be estimated by the model for this purpose.

5.3 Evaluation of Energy/Emission Goals

In their long-term planning effort, Vermont established statewide energy use and emission reduction goals, which include the following:

- Maintaining the VMT annual growth rate to 1.5% (half of the national average) or less for the portion controlled by the state;
- Increasing public transit ridership by 110%, to a total of 8.7 million annual trips by 2030;
- Quadrupling passenger rail trips to 400,000 Vermont-based trips by 2030;
- Reducing the share of SOV commute trips by 20% by 2030;
- Doubling the bicycle and pedestrian share of commute trips, to 15.6%, by 2030; and
- Doubling ride share commute trips to 21.4% of all commute trips, by 2030.

VTrans would like advice from the expert panel as to how the statewide model can be applied as a tool for the monitoring and evaluation of the state's progress towards these energy and emissions targets from now until 2030.

5.4 System Preservation and Disinvestment

Highway system preservation is becoming an increasingly dominant force driving operations and studies at VTrans. Highway capacity projects will remain critical to the agency's workload, but this large shift to maintenance projects calls for new methods of highway facility assessment. Through the peer review sessions, VTrans would like to obtain insight regarding the potential for the statewide model to measure system preservation performance and possible disinvestment strategies.

5.5 Performance Measurements and Asset Management

Performance-based planning and programming are a core component of the MAP-21 requirements signed into law in July of 2012. In response to this legislation, VTrans would like to know how application of the statewide model can aid in the development and monitoring of performance measures for future year planning. Specifically, VTrans was interested in determining the model's ability to play a role in the development of an asset management system.

5.6 Fair-Share Methodology

VTrans is in the process of developing a fair-share methodology aimed at ensuring that developers pay for the proportional impact triggered by their development. VTrans would like to learn more regarding the potential of the statewide model to contribute to the development and implementation of a fair-share methodology.

5.7 Corridor Prioritization: Transit, Biking, and Walking

Bicycling, walking, transit, and rail are important components of Vermont's transportation system. However, some of these modes, particularly bicycling and walking, are inherently local modes of travel. VTrans requested that the panel identify the appropriate modeling scale for corridor improvement prioritization for each of these modes.

5.8 Model Areas for Improvement

Through the discussion of the model's structure and the analysis of the topics provided above, VTrans anticipated additional identification of potential improvements for the statewide model, both on a general level as well as from a more detail-oriented view. These topics were highlighted in the initial peer review meeting and then used at points for discussion in Session #2. These areas for improvement included the following:

Non-Home Based Travel: VTrans suggested further examination and assessment of the assumptions regarding non-home based travel.

Land Use Forecasting: VTrans currently does not have a standard source for growth forecasts and requested further information with regard to information sources for both population and household growth. VTrans also requested feedback regarding the practice of capping minimum household growth rate at 0.0% rather than allowing for negative growth.

Transit Inclusion Feasibility: The current statewide model does not support transit modes. Therefore, VTrans would like to assess the feasibility of including transit fully in the statewide model. The agency would like to determine the reasonability of including only certain types of regional transit or recognize if it would be more logical to exclude transit. VTrans also questioned the possibility of reflecting hourly variations in transit ridership using the statewide model, which only includes daily temporal resolution in its existing form.

Short-Distance and Long-Distance Travel: The current statewide model does not have the ability to effectively disaggregate the short and long distance trips. VTrans indicated a need for more information and resources regarding which trip purposes and modes are critical in the separation of distance categories and the best methodologies for this distinction.

Vehicle-Ownership Models: VTrans asked the panelists about the effects of vehicle-ownership models on VMT estimation and household-level travel forecasting. VTrans cited that the *Travel Model Validation and Reasonableness Checking Manual* provides guidelines for using vehicle ownership/availability as a validation process. The agency asked the panel if these guidelines would be a logical starting point for the development of a vehicle-ownership model, as well as the quality of household level income data required for application in the vehicle-ownership model.

Economic Modeling: VTrans noted that the incorporation of an economic model would help the model to yield more effective assessments of economic impacts. The agency questioned the variation in aptitude between an economic model with a travel component versus a travel model with an economic component. VTrans also cited NCHRP 735, which states that small samples and economic models are unable to provide significant statistical representation to prioritize capital investments or gain a deeper understanding of travel decision price breakpoints.

Long-Distance and Rural Trip Generation: VTrans identified several issues regarding best practice for generating long-distance and rural trips in a statewide model. These issues included the following:

- Determining whether urban/rural trips be treated separately for all trip purposes in the trip generation module or only for non-home based trips;
- Establishing the difference between a trip-based model with "stops" for long-distance trips and a tour-based model;
- Determining whether to require trip-distances over 300-miles in the model, which only includes passenger-car and commercial truck travel;

- Comparing “rural” trip-making, which is greatest on weekdays, with “long-distance” trip-making, which is greatest around weekend-days;
- Establishing a new set of purposes, including business, pleasure, and personal-business;
- Defining specific TAZ characteristics for the generation of rural and long-distance trips, including population density, road density, land-use mixture, and variation in population density, and applying these characteristics as regression-equation factors instead of households and employment;
- Evaluating exact locations of the most significant tourist destinations to create a “distance-to-tourist-area” factor for the support of long-distance trip rates; and
- Assessing the transferability of parameters found in similar statewide models.

VTrans expressed interest in identifying short-term needs that could be addressed in the near term given existing resources. VTrans also expressed a desire to develop subsequent recommendations for mid- and long-term modeling needs in order to maintain a continuous and on-going model improvement effort.

6.0 Peer Review Panel Response to Technical Questions

When VTrans presented the questions above to the peer review panel in Sessions #1 and #2, the panel was able to ask questions to gain further detail with respect to each question and provide initial feedback. The panel then convened without VTrans staff present in Session #3 to further assess the appropriate responses to each question based on the experiences of each expert panelist. The following section details the responses provided by the panelists as presented to VTrans in Session #4.

6.1 Response to FHWA Identified Issues

The panelists recommended that VTrans address each of the fundamental model development considerations provided from FHWA. Particularly, the panelists agreed that the development of both a users' guide for staff training purposes and a detailed technical reference document containing codes, parameters, assumptions, and other intricate model specifics would be helpful for communication purposes.

The panelists also stressed the importance of defining short-, mid-, and long-term priorities based on the status of the existing statewide model. The panelists noted the ambitiousness of VTrans in their exploration of a wide myriad of application possibilities for the statewide model; however, given logistics, schedule, and budget, prioritization of these enhancements will be critical to creating an effective model development plan.

For example, the panel suggested that in the short-term, it would be valuable for VTrans to develop one comprehensive statewide model package, assess the consistency between sub-models, and establish the appropriateness of model to meet agency needs. In the mid-term, the panelists recommended that VTrans identify a second phase of model enhancement based on the agency's next strongest priorities. These model enhancements could then occur while the model package developed in the short-term enhancement phase is in application. Finally, considering long-term model enhancement the panel recommended that VTrans compile a "wish list" of features that are lacking from the short- and mid-term enhancements, prioritize these features, and work towards them incrementally based on agency needs once the second phase of model improvements is complete.

6.2 Resiliency Planning

The panelists derived a variety of potential options for the assessment of infrastructure design. One panelist initially noted that a travel model will establish a state of equilibrium in which long-term travel decisions are reported, rendering the model insensitive to disaster response. The assessment of infrastructure design and ability to withstand extreme weather or environmental circumstances will require structural design specification evaluation combined with spatial analysis of environmental factors, studies for which a travel model is not applicable.

The panel also noted that emergency contingency planning is associated with links damaged by an emergency event, not general facility design. In this sense, emergency contingency planning for road closures is an appropriate use of the statewide model for particular analyses. It was suggested that VTrans consider the use of a dynamic traffic assignment methodology to assess traffic patterns in emergency response situations or structural failures.

In the event that VTrans would like to apply the statewide model for emergency scenario planning, the panelists recommended that VTrans staff identify the criteria for use in the comparison and evaluation of alternative scenarios. These established performance measures could then guide the development of model features.

To apply the statewide model for emergency scenario planning, VTrans would need to develop an at-risk location inventory in the highway network through the addition of link attributes, marking links with a potential for failure. For example, the model network could be set up to incorporate geo-coded bridge inventory data in order to "fail" bridges and mimic emergency situations. The model could be run with and without failures, and the impacts to traffic flows could be compared between scenarios. Additionally, it would be helpful to design the network to include references that enable the incorporation of agency data into the model network in an automated manner.

6.3 Evaluation of Energy/Emission Goals

The panelists initially identified the necessity for a mode choice component in the statewide model in response to VTrans's interest in using the statewide model for energy use and emissions evaluation. The model will require the design, estimation, calibration, and integration of SOV, HOV2, HOV3, air, rail, bus transit, bike, and walk mode choice models. Additionally, sufficient travel survey information will be required to accurately develop these mode choice models. Furthermore, the model network and TAZ structure will necessitate further resolution to accommodate for bicycle and walk trips, while the model network will need to be expanded to represent rail and air service. The model's sensitivity with regard to parking pricing, transit pricing, toll pricing, and other types of operational costs will also need to be refined to allow for mode shifts based on deltas in price, travel times, land use inputs, and other factors of travel choice significance.

When the model has the desired modes represented and is appropriately sensitive to mode choice factors, it can be used to produce trips by mode, trip length by purpose and mode, and VMT by vehicle classification. Emissions can then be estimated by applying this output in combination with the Motor Vehicle Emission Simulator (MOVES).

While the incorporation of mode choice, specifically rail and transit, in the statewide model would be beneficial, the panel highlighted the difficulty in addressing the performance measures needed for emissions assessment given the scale and resolution of the statewide model. The panel noted that energy use and emissions analysis may be more appropriately conducted using MOVES coupled with a regional model that has an existing detailed TAZ and network structure, particularly for non-motorized travel estimation. Ultimately, an activity/tour-based model would be required to yield meaningful results for emissions assessment rather than application of derived or assumed trip tables.

Another strategy for emissions analysis suggested by the panel was the development of a separate aggregate model that combines information from the statewide model and the Chittenden County MPO model to evaluate VMT, transit/rail trips, auto occupancy, and non-motorized trips. Specialized tools, such as an aggregate model, often entail fewer resources, yet can provide required elements for agency reporting while taking advantage of model improvements made to either the MPO model or the statewide model.

The panel came to a general consensus that staging the model's enhancements should be primarily premised on basic functionality. The qualities listed above that are required for energy and emissions scenario evaluation could be incorporated in the long-term, while model enhancements to improve basic functionality should be prioritized in the short-term.

6.4 System Preservation and Disinvestment

The panel's recommendation in response to VTrans's ambition to conduct system preservation and disinvestment analyses using the statewide model was to first identify the performance measures desired for project prioritization before proposing enhancements or adjustments to

the model. These performance measures will be used to evaluate different scenarios and test various combinations of projects over time to reveal the outcomes of each set of projects; therefore, the performance measures selected by VTrans will be imperative in determining the staging of model enhancements. The panel suggested that VTrans consider using the statewide model to evaluate volumes and road wear as performance measures for project prioritization

For an example of an existing methodology with a successful record in optimizing transportation investments, the panelists suggested that VTrans review Oregon's use of the HERS-ST model. Growth rates from the statewide model can be applied to the HERS-ST model applies to evaluate forecast needs and options for transportation investment optimization. It was also noted that Caltrans conducted a study to evaluate the effect of road conditions on truck speeds, maintenance costs, and costs associate with damaged goods, which could be further referenced.

The panel noted that because Vermont's Highway Performance Monitoring System (HPMS) currently reports pavement conditions and the State Highway Operation and Protection Program (SHOPP) prioritizes system preservation projects, it was recommended that these groups along with VTrans pavement program staff are contacted prior to model enhancement for system preservation and disinvestment evaluation purposes. These agencies may have sufficient evaluation methodologies in place or find minimal need for this level of effort.

6.5 Performance Measurements and Asset Management

In the discussion of model application for performance-based planning and asset management, the panelists again placed an emphasis on the importance of (1) determining which performance metrics are critical with regard to agency needs, (2) establishing the model improvements needed in order to calculate these improvements, and (3) creating a prioritized list of these metrics and associated improvements to guide the model development plan. Given the model development plan design, the timing at which specific measures can be reported will depend on the model development phase, reiterating the importance that the phasing of model development features be dependent on agency priorities.

The panel acknowledged that the statewide model is the only tool available to VTrans to forecast MAP-21 criteria associated with vehicular delay and system reliability. Credible system utilization forecasts, as they relate to factors that affect system conditions (e.g., volumes, classifications, etc.), can provide valuable information to decision-makers to help anticipate facility life-cycle impacts. Additionally, economic assessment software (i.e. - STEAM, T-PICS, TREDIS, REMI Transight) may be applied to the travel model output to evaluate performance measures such as job creation and gross state product (GSP).

Additionally, the panel suggested that a separate post processing methodology could be developed to determine the economic impacts and GSP values of individual links. This component could be developed in the mid- to long-term.

As an alternative to separate economic assessment software or application of a post processor, the panel recommended that VTrans consider employing a separate project-specific benefit/cost model. One panelist noted that Caltrans is in the process of evaluating model performance measures for the next California Transportation Plan and MAP-21 efforts. There are the "standard" outputs of VMT, mode split, trip length distribution, emissions, vehicle hours of delay/travel, and congested speed that can each be used as part of the MAP-21 related efforts; however, the agency does not anticipate performing model upgrades as a specific response to MAP-21. Caltrans uses a separate benefit/cost model (Cal B/C) that is project specific. This specific methodology should be reviewed by VTrans.

6.6 Fair-Share Methodology

The panel sited that impact fee policy scenarios could be assessed using the statewide model to develop estimates of VMT for new development by land use type and trip purpose and determine change over time. The panel, however, suggested that statewide model resolution is not adequate for the post processing methodology that would be necessary to determine long-range growth rates for background traffic. The resources required for this type of spatial accuracy would far exceed the analytical gain from this level of detail. Therefore, it was recommended that VTrans consider using a micro-simulation model, which applies future volumes and growth rates from the regional model, for analysis of specific improvements to meet demand associated with new developments.

It was also recommended that VTrans explore the possibility of using off-model techniques for development impact assessments. For example, the ITE Trip Generation Manual details data available for various off-model methodologies that can be applied in these types of studies separately or in conjunction with the travel model.

6.7 Corridor Prioritization: Transit, Biking, and Walking

The panelists found it important that VTrans recognize that the statewide model may not be the appropriate resolution for evaluating non-motorized transportation improvements. A parcel level TAZ structure and additional travel survey data regarding current travel by mode and future preferences would be required for this type of analysis. The panel noted that a statewide model can effectively handle air, rail, and bus transit, truck, and car modes properly granted the scale of the improvement is significant enough, the TAZ structure is small enough, and the road network is detailed enough so that all travel is not deemed intra-zonal and travel times are not significantly skewed.

The panel recommended that VTrans develop a tool separate from the statewide model for application in the estimation of non-motorized transportation. While not conjoined with the model, this tool should still be compatible and consistent with the statewide model. The panel suggested that VTrans consider the implementation of a micro-simulation model for local area analysis. It was recommended that VTrans also consider a survey effort to further the agency's understanding of current travel by mode within the state.

The panel noted that regional models that perform well in evaluating non-motorized alternatives typically require advanced techniques, such as activity-based modeling, to better address non-motorized alternatives. If VTrans envisions non-motorized travel modeling as a major priority for the statewide model, it is possible that the agency could transition to an activity/tour based model to increase sensitivity to the drivers for bike and walk mode. For this transition to occur, it was recommended that VTrans consider a tiered approach to activity-based model development for non-motorized travel to gradually increase model resolution as a long-term priority.

6.8 Model Areas for Improvement

Based on the background information presented by VTrans and the discussions in the first two peer review sessions, the panel identified issues in the existing model. These were primarily based in the model network. Other potential issues hinging on the model's structure were also identified.

The panelists advised that the network model area be extended beyond the political boundary of the state with, at a minimum, a halo region around the state to represent activity related to Vermont's adjacent states. Because Vermont is such a small state, a significant amount of Vermont's travel crosses the state line, making the development of a robust external model for

this state critical. The panelists also identified the reassessment of network coding as a necessity for the model. Centroid connectors, link attributes, and potential missing roads should all be comprehensively checked for quality assurance.

Other structural elements of the statewide model requiring attention that were identified in the panelist discussion were:

- the extension of the model's horizon year,
- the inclusion of seasonal trip tables,
- the distinction between short- and long-distance trips, and
- the incorporation of a truck model.

7.0 Panel Discussion and Recommendations

After reviewing VTrans's application for peer review, participating in the three initial peer review sessions, and providing individual comments based on previous experiences, the panelists' recommendations were aggregated and presented to VTrans and their associated staff.

The following summarizes the panel's comments and recommendations on the topics of interest to VTrans, as well as general guidance for the future of the statewide model. This summary follows the panel's final presentation to VTrans at the concluding Session #4 of the peer review held on July 31, 2013.

7.1 General Comments and Recommendations

First and foremost, the panelists emphasized the importance of defining one consistent model platform, either CUBE or TransCAD, and maintaining all data and processes in the specified format. This consistent platform would allow for simplicity in validation and calibration efforts and increase the reliability of the modeling outputs.

Next, the panelists highly recommended that VTrans internally strengthen their agency's understanding of the model, specifically with regard to its sensitivities and appropriate uses for model application at the statewide level. The panel recommended that the model developer, whether in-house or external, provide features in support of desired analysis by the agency. Furthermore, a VTrans staff person should have a strong understanding of the application side of the model in order to conduct defendable analyses. The panel also noted it critical that agency staff are able to illustrate the value of the model as a planning tool to gain financial support from agency management.

Another overarching issue discussed in the peer review sessions was the need for VTrans to minimize dependence on the statewide model by developing tools in addition to the statewide model that have the ability to meet agency needs while managing resources and effort. Particularly, the panelists noted that one model cannot provide the analytical power required for different levels of spatial acuity. Therefore, VTrans would benefit from maintaining a variety of tools to meet analytical needs. The tools should be consistent and compatible with each other and use data collected by the agency in a streamlined and automated manner.

Finally, the panel underscored the importance of identifying project types and metrics desired for project prioritization prior to the redesign of model features. Panelists lauded the ambitious nature of VTrans's model enhancement goals; however, noted that it will be imperative to first achieve basic functionality and incorporate comments from FHWA before any mid- to long-term goals that require extensive model development efforts are realized.

7.2 Phased Recommendations

The following subsections partition panelist comments by potential timeframe for implementation: short-, mid-, and long-term.

7.2.1 Recommended Shorter-Term Priorities

The panel feels that VTrans should focus on the following priorities in the next year:

- Address the comments from FHWA's review of the current model:
    - Undertake the list of fundamental model development considerations from FHWA provided in Section 5.1.
    - Develop a statewide model users' guide and technical reference.

    - Define short/mid/long term priorities based on the current model to create a detailed model development plan.
- Include new tools or model metrics for resiliency planning in the model:
    - Recognize that emergency contingency planning is associated with links damaged by an emergency event not general facility design; therefore, the consideration of dynamic traffic assignment to assess traffic patterns in emergency response may be a preferable method.
    - Identify metrics for emergency scenario comparison to guide model development if the agency selects the model as the tool for resiliency planning.
    - Develop an at-risk location inventory in the model network via link attributes and automate their incorporation into the network if the agency selects the model as the tool for resiliency planning.
- Incorporate various model improvements to address model network and structure issues identified by the peer review panelists:
    - Enlarge the external model area by including a halo over the state line.
    - Ensure that the roadway network includes all interstates, major arterials, and collectors with accurate speeds, lengths, and classifications.
    - Reassess centroid connectors.
    - Consider seasonal trip tables.
    - Differentiate between short- and long-distance trips.
    - Expand to a future year beyond 2030.
    - Decide on one freight model component based on either commodity flows or truck/rail vehicles.
- Review the following references for additional ideas for statewide modeling best practices:
    - Special Report 288 “Metropolitan Travel Forecasting”
    - TCRP Report 95 “ Traveler Response to Transportation System Changes Handbook”
    - NCHRP Project 836-B Task 91 “Final Report: Validation and Sensitivity Considerations for Statewide Models”
    - NCHRP Report 735 “Long-Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models”
    - NCHRP Synthesis 406 “Advanced Practices in Travel Forecasting”
    - A Transportation Modeling Primer, Edward A. Beimborn Center for Urban Transportation Studies University of Wisconsin-Milwaukee, May 1995, Updated June 2006

7.2.2 Recommended Mid-Term Improvements

Over the next two to three years, the panel recommended VTrans consider the following:

- Establish a methodology for evaluating system preservation and disinvestment:

    - Coordinate with pavement program staff to determine need for this type of effort.
    - Identify the performance measures desired for project prioritization prior to adjusting the model.
    - Consider evaluating volumes and road wear for project prioritization.
    - Review Oregon's use of HERS-ST as a working example of transportation investment optimization.
- Include model components for the evaluation of performance measures to address MAP-21 and asset management:
    - Identify and prioritize model design features for each performance metric desired based on agency needs.
    - Apply economic assessment software to model output to assess economic impacts of transportation features.
    - Develop post processing methodology to determine economic impact/GSP value of individual links.
    - Consider use of a separate project-specific benefit/cost model.
    - Implement the determined freight model component based on either commodity flows or truck/rail vehicles

7.2.3 Recommended Longer-Term Improvements

The panel also identified potential improvements for VTrans to consider over the longer term (beyond the next three years):

- Apply the model to incorporate the assessment of fair-share methodologies:
    - Develop VMT estimates for new development by land use type and trip purpose to determine change over time and assess impact fees.
    - Recognize that statewide model resolution is not adequate for a post processing methodology to determine long-range growth rates for background traffic.
    - Consider a micro-simulation model, which applies future volumes and growth rates from the regional model.
    - Review off-model techniques that can be used as separate/compatible tool for development impact assessment, such as the *ITE Trip Generation Manual.*
- Develop methodologies to assess transit and non-motorized for corridor prioritization:
    - Recognize that statewide model may not be appropriate resolution for evaluating non-motorized transportation improvements.
    - Develop separate/compatible tool for non-motorized transportation.
    - Consider micro-simulation models for local area analysis.
    - Consider survey efforts to understand current travel by mode.
    - Consider a tiered approach to activity-based model development for non-motorized travel as a long-term priority if the agency envisions the statewide model as the preferred tool for non-motorized transportation assessment.
- Determine the best methodology for assessing energy use and emissions:
    - Include a mode choice model component.
    - Use MOVES in conjunction with model output once the model includes a mode choice component to estimate emissions.

- Identify and test sensitivities in energy/emission performance measures.
- Recognize the difficulty in addressing performance measures given the scale and resolution of the statewide model.
- Consider a separate aggregate model to apply data from both the statewide model and the MPO model to evaluate energy and emissions data.
- Consider scenario testing in the long-term.

List of Peer Review Panel Participants

This section contains a list of the peer review participants, including the panel members, local agency staff, and TMIP documentation support staff.

Peer Review Panel Members

Panel Member	Affiliation
Keith Killough	Director of Transportation Analysis at Arizona DOT
Judy Raymond	Transportation Supervising Planner at Connecticut DOT
Chad Baker	Statewide Model Branch Chief at Caltrans
Becky Knudson	Senior Transportation Economist in the Transportation Planning Analysis Unit at the Oregon DOT
Kevin Hooper	Principal at Kevin Hooper and Associates

Local Agency and Partner Agency Staff

Name	Affiliation
Joe Segale	VTrans
Costa Pappis	VTrans
Jason Charest	Chittendon County Regional Planning Commission
Jason Ramussen	Southern Windsor County Regional Planning Commission

Consultant Staff

Name	Affiliation
Jim Sullivan	University of Vermont
Matt Conger	University of Vermont

TMIP Peer Review Support Staff

Name	Affiliation
Brian Grady	TMIP, Resource Systems Group, Inc.
Christine Sherman	TMIP, Resource Systems Group, Inc.

Peer Review Session Agendas

Below are the agendas for the pre-peer review meeting and the peer review meeting.

Session #1

Wednesday, June 5, 2013, 2:00 to 4:00PM EST

Participants: TMIP Moderator, VTrans and Associated Staff, Peer Review Panelists

Agenda:

- Introductions
- Vermont Travel Model History
- Review of Model Form and Function
- Model Update to 2009-2010 Base Year
- New 2035 Forecast Year
- Summary of Model Uses
- Potential Specific Improvements
- Open Question and Answer Forum between Panel and VTrans

Session #2

Wednesday, June 19, 2013, 2:00PM to 4:00PM EST

Participants: TMIP Moderator, VTrans and Associated Staff, Peer Review Panelists

Agenda:

- Introduction of VTrans Questions for the Peer Review Panel
- Comments from FHWA Review
- Model Limitations Discussed in Session #1
- Addressing limitations with NCHRP 735
- Other Resources for Model Improvements
- Peer Review Schedule
- Open Question and Answer Forum between Panel and VTrans

Session #3

Wednesday, July 10, 2013, 2:00PM to 4:00PM EST

Participants: TMIP Moderator, Peer Review Panelists

Agenda:

- Discussion of Key Issues and Questions
- Areas for Improvement
- Open Discussion between Panelists

Session #4

Wednesday, July 31, 2013, 2:00PM to 4:00PM EST

Participants: TMIP Moderator, VTrans and Associated Staff, Peer Review Panelists

Agenda:

- Discussion of Specific Recommendations from Peer Review Panelists
- Open Question and Answer Forum between VTrans and Panelists
- Closing Comments and Discussion Forum

Peer Review Panelist Biographies

This section contains a brief bio of each of the peer review panel members.

Keith Killough, Director of Transportation Analysis at Arizona DOT

Keith Killough is the Director of Transportation Analysis at Arizona DOT where he is responsible for travel demand modeling, GIS, traffic data collection, HPMS, and air quality analysis. Keith holds a degree in Urban Planning from MIT and certification as an AICP. During his career, Keith has held positions with public agencies in Boston, Detroit, and Los Angeles, and in consulting firms in Washington, D.C. and Los Angeles. He has also been a member on both the Passenger Travel Demand Forecasting and Transportation Planning Applications Committees of TRB.

Judy Raymond, Transportation Supervising Planner at Connecticut DOT

Judy Raymond is a Transportation Supervising Planner at Connecticut DOT where she is responsible for maintaining, updating and running the Connecticut Statewide Travel Demand Model (TDM) and responsible for Air Quality Transportation Conformity compliance at both the regional and project level. Currently, she is the primary lead for the Department's recent initiative to investigate, develop and implement a new and revised statewide TDM. Judy Raymond has an Urban Studies Degree from Fordham University and has held various positions within CT-DOT, the Houston Metropolitan Transit Authority and Texas DOT over her career.

Chad Baker, Statewide Model Branch Chief at Caltrans

Chad Baker is the Statewide Model Branch Chief at Caltrans where he is responsible for all aspects of the model including quality control, operation, scenario development, post-processing and reporting. He provides technical reviews and reports for various planning efforts such as travel surveys, regional demand modeling, freight modeling and passenger rail modeling. Chad graduated from the University of California at Davis with both a Bachelors and a Master's degree in Civil Engineering. Chad is an active participant with the TRB as well as other panels and as a member of the technical expert panel for the SHRP2 C10B Project.

Becky Knudson, Senior Transportation Economist in the Transportation Planning Analysis Unit at the Oregon DOT

Becky Knudson is a Senior Transportation Planning Economist in the Transportation Planning Analysis Unit at the Oregon DOT where she covers a broad set of responsibilities ranging from program management to technical analysis. Becky develops and applies economic, land use and transportation forecast models for use in long range planning and policy analysis. She is the program manager for the Oregon Modeling Improvement Program. Her primary area of focus includes the Oregon Statewide Integrated Model (SWIM). Becky earned a bachelor's degree in economics from the University of Minnesota – Moorhead and a master's degree in economics from Oregon State University.

Kevin Hooper, Principal at Kevin Hooper and Associates

Kevin Hooper is the principal at Kevin Hooper and Associates. His work experience includes positions with public agencies in Ohio, Connecticut, and Georgia and with consulting firms in

Virginia and Maine. He assisted in the development of the Maine statewide travel demand model and has developed and maintains several regional models in the state. He taught the NHI course “Using the Urban Transportation Planning Process for Project Development and Design” over 30 times throughout the U.S.

Overview of the Vermont Statewide Model

The following appendix summarizes the version of the VTrans model at the time of the peer review, along with the data sources used in the development of the model.

Model Components

The following sections summarize models components from the model documentation current to the timing of the model review. The model is made up of two models, freight and passenger, which are each comprised of four primary modules that are shown in the figure below:

4.0.1 Trip Generation

The trip-generation module combines TAZ-based land-use characteristics with town-based fractions of number of workers divided by number of workers cross-classifications to calculate home-based trips produced by each internal TAZ. The module then calculates trip attractions for each internal TAZ by purpose and trip-productions for the non-home-based (NHB) purpose using purpose-specific regression equations, each of which utilizes a different set of employment and/or population field(s) from the TAZ characteristics table. For example, the equation for home-based work (HBW) trips attracted is based on all of the employment fields in the TAZ characteristics table, but the equation for home-based shopping (HBSHOP) trips is based solely on the retail employment field. Truck (TRUCK) productions and attractions are calculated simply by multiplying the truck percentages from the TAZ characteristics table by the production and attraction totals for the other four trip purposes.

Productions and attractions for zones external to Vermont are calculated by first applying external TRUCK trips as the ADT for the external zones listed in the TAZ characteristics table (presumably taken from traffic counts) multiplied by the truck percentages from the TAZ characteristics table. These values are split evenly as productions and attractions. The total for other external vehicle-trips is taken as the remaining fraction of the ADT for each external zone listed in the TAZ characteristics table. The external vehicle occupancy rate (as an input) is applied to this total to derive non-TRUCK external person-trips. Total non-TRUCK external person-trips are then subdivided by the other trip purposes using the fractions in the external trip-fractions table.

Ultimately, this process outputs a table of productions and attractions for each of the five trip purposes in the model (HBW, HBO, HBSHOP, NHB, TRUCK) for each of the 936 internal and external zones. However, because the production and attraction estimates for the internal TAZs came from different sources for each of the four home-based trip purposes, they do not match. This mismatch is typical for most demand-forecasting models where separate regression models are estimated for production and attraction across a full study area with unique predictor variables. Balance factors are calculated as the ratio of trip productions destined for internal zones to the corresponding trip attractions in internal zones by trip purpose. Balancing is accomplished by zone by multiplying the balancing factors to the internal trip attractions only so that they match total productions (internal and external) by trip purpose. The end result is a table of balanced productions and attractions for each of the five trip purposes in the model for each zone. Figure D1 provides a visual summary of the trip generation process.

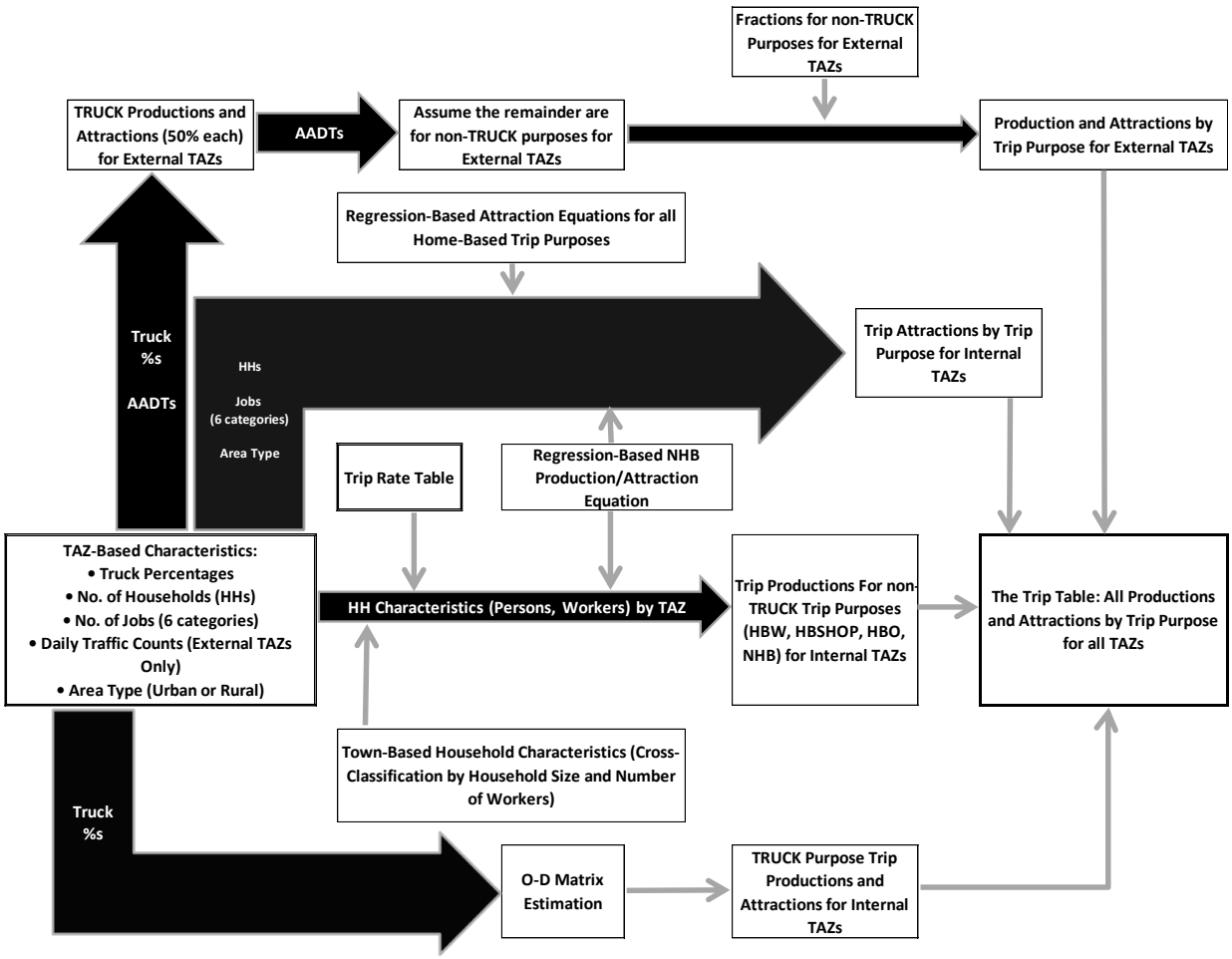

Figure D1: Trip Generation Process

4.0.2 Trip Distribution

The trip-distribution sub-module takes the balanced trip table, a matrix of free-flow travel times between TAZs and a set of impedance functions to develop a matrix of productions and attractions between all zones. The result of this step is a matrix of productions and attractions between all zones. The final step in the trip-distribution application is to convert this matrix into a matrix of origin-destination (O-D)-based trips. Since the model is a daily model, all trips are assumed to return, indicating that all trips originating in one zone and destined for another must also originate in the destination zone and terminate in the origin zone. This assumption requires that the final matrix be diagonally symmetric. To accomplish this, the matrix is transposed, added to the original, and then all cells are halved. The result is a diagonally-symmetric O-D matrix of person-trips. Figure D2 provides an illustration of the tip distribution process.

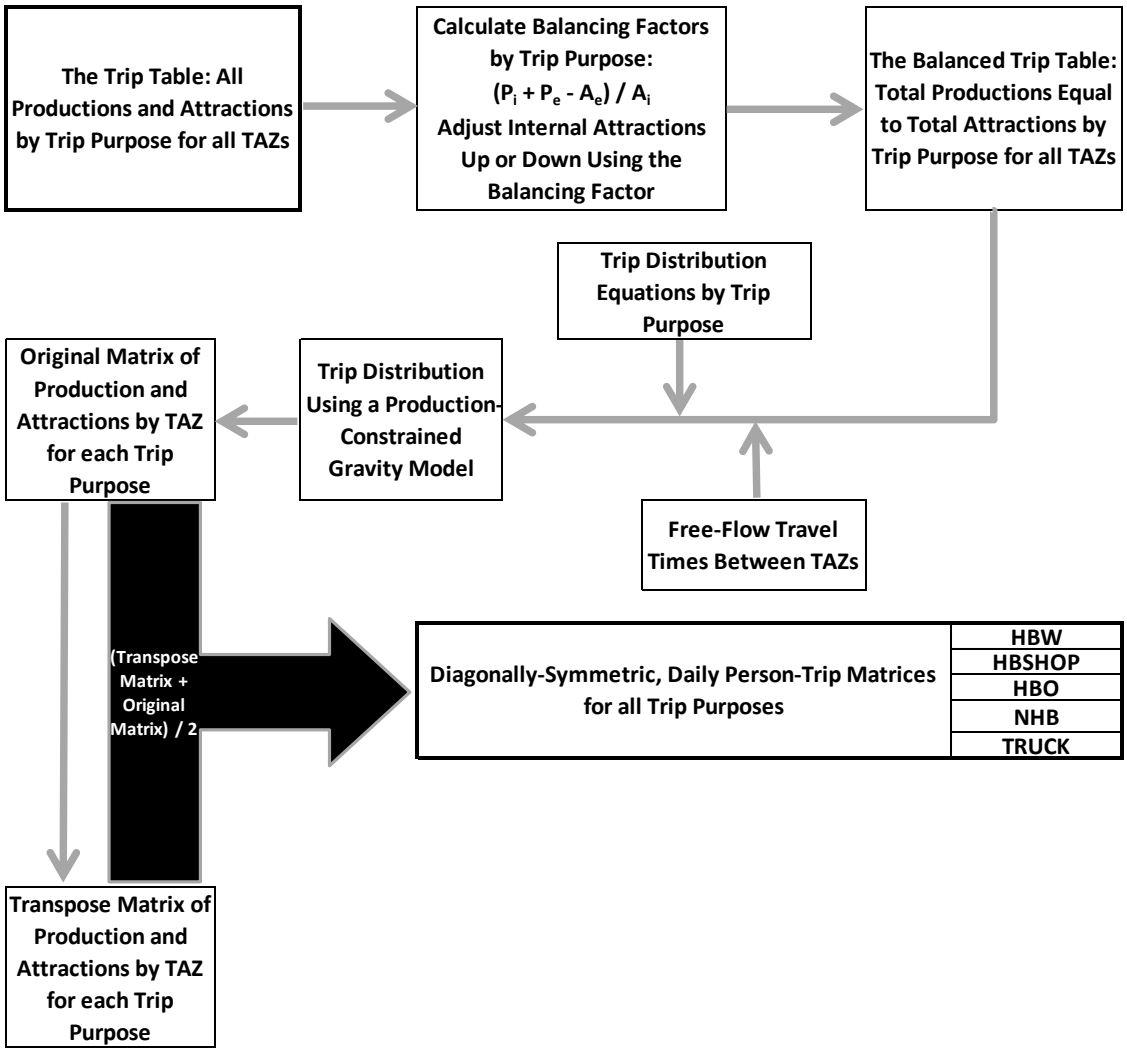

Figure D2: Trip Distribution Process

4.0.3 Mode Choice

In the past, the O-D matrix of person-trips was reduced by the expected transit demand before allocating the remaining trips to passenger vehicles. However, the existing matrix of transit demand may date back as far as 1997, and no definable data source for the transit demand could be located, and the 2009 NHTS does not support the development of full O-D matrix of transit demand statewide. Therefore, transit demand is no longer considered directly in the Model. Instead, the full O-D matrices resulting from the trip-distribution step are divided by a vehicle-occupancy to convert them from person-trips to passenger vehicle-trips.

4.0.4 Trip Assignment

The final matrix, including all external vehicle-trips, is assigned to the road network in the traffic assignment sub-module. Free-flow travel speed on each link is assumed to be the five miles per hour over the speed limit, and the user-equilibrium traffic assignment is used.

Model Comparison Summaries

Table D1: Comparison of the Classification of Vermont Households by Size

No. of People in Household	NHTS	Model
1	28%	28%
2	38%	38%
3	15%	15%
4	13%	19%
5	5%	
6	1%	

Table D2: Comparison of the Classification of Vermont Household by Number of Workers

No. of Workers in Household	NHTS	Model
0	25%	25%
1	40%	36%
2	30%	33%
3	4%	6%
4	1%	

Table D3: Comparison of the Relationship Between Link Volumes and Traffic Counts

Roadway Category	Model Result for Volume/Count	Acceptable Standard for Volume/Count
Freeway	- 15.2%	+/- 7%
Divided Arterial	+ 1.0%	+/- 15%
Undivided Arterial	- 13.7%	+/- 15%
Collector	- 3.0%	+/- 25%

Model Data Sources

The following section provides brief descriptions of the sources of data used in the model.

4.2.1 Demographic Data

US Census – 2010 Population and Household Data

Bureau of Economic Analysis/Vermont Department of Labor – 2009 Employment Estimates

American Community Survey – 2006 to 2010 Number of Workers and Number of Household Members by Town

National Household Travel Survey – 2009 Household Travel Information (Person Trip Table)

4.2.2 Highway Network/Traffic Volume Data

Vermont Center for Geographic Information – Speed Zone Layer along Interstates and State and Federal Highways in Vermont

VTrans Project Information – Preliminary List of Major Roadway Projects whose Construction Began Prior to 2011

VTrans – 2009 Statewide Traffic Counts - Average Annual Daily Traffic (AADT)

VTrans Peer Review Application

Request for TMIP Peer Review

Contact Person

Jim Sullivan, Research Analyst

University of Vermont Transportation Research Center james.sullivan@uvm.edu

802-656-9679

1. Purpose of TMIP Review

The Vermont Agency of Transportation maintains a statewide travel demand model which has recently been updated to a 2009 -2010 base year. Vermont is one of about 2/3 of the states in the US with a statewide travel model. Being one of the smallest states in terms of population and home to only one metropolitan planning organization, Vermont's travel model is a critical tool for travel estimation and forecasting statewide and in its non-MPO regions. The Agency of Transportation has demonstrated its commitment to travel modeling at the statewide level by funding an add-on to the 2009 National Household Travel Survey (NHTS) so that its model could be effectively updated to its current base year.

The University of Vermont Transportation Research Center (TRC), under contract with the Division of Policy, Planning, and Intermodal Development at the Vermont Agency of Transportation (VTrans) , has hosted, improved, and applied the Vermont Travel Model ("the Model") since 2008. The purpose of the Model is to estimate travel demand and link flow throughout the state and across its borders using Vermont's generalized spatial demographics and employment. The model estimates daily passenger-vehicle flow between 866 internal and 70 external traffic analysis zones (TAZs) for four trip types. Commercial truck traffic is estimated directly from traffic counts as a fifth trip type in the Model.

The Model employs a traditional four-step process, using rates and coefficients derived primarily from the 2009 NHTS. Previous NHTS sampling in Vermont had not been robust enough to use for an effective Model update, as compared with sampling from larger states. With this in mind, the TRC and VTrans purchased an add-on to the 2009 NHTS dataset, which resulted in approximately 1,700 Vermont households and over 3,800 individuals surveyed.

The resulting per capita sample representation was among the best in the US for the 2009 NHTS. The resulting tabulation of travel behaviors from this dataset forms the basis of the sub-modules used in the Model. Residential information from both the 2006-2010 American Community Survey (ACS) and the 2010 US Census is used to input household distributions and characteristics in the state. Data from the 2009 Bureau of Economic Analysis (BEA) and the 2009 Vermont Department of Labor QCEW were used to disaggregate employment characteristics among the internal TAZs.

The TRC recently completed the Model update to its current 2009-2010 base year, and VTrans is now considering a host of potential improvements moving forward to better suit its expected uses of the Model. Given the lack of any previous peer review and the advancements made in the travel modeling field in the last 10 years, TRC and VTrans staff feel that a peer review is

timely. It is critical at this time for the state to move forward with a model that suits their needs and makes the best use of the funds available for improving the model to accommodate future planning requests like energy efficiency evaluations or air- quality assessments.

2. The State

866 internal and 70 external TAZs form the geographic basis of the Base –Year 2009-2010 Vermont STM. Vermont in 2010 contained approximately 621,000 residents and 256,000 households. The state contains 20 distinct Census urban areas but Vermont's 14 counties are predominantly rural, with the exception of Chittenden County, which accounts for approximately 24% of households, 30% of statewide employment 39% of the internal TAZs, and its largest urban area, Burlington. Chittenden County is also home to the state's only metropolitan planning organization, which uses its own, more finely-resolved travel-demand model. Total employment figures for the state (403,311) are categorized into five user-specific industry groups: Retail (46,116), Manufacturing (32,813), Non-manufacturing (241,912), Education (30,787) and Government (51,683). The highway network maintained by the state consists of 5,250 miles of roadway, and in 2010 an estimated 7.4 billion annual vehicle- miles of travel (VMT).

3. History of the Model

Efforts to develop the first travel model for the state of Vermont began in the 1990's with processes run in the SAS Model Manager 2000 platform and the road network maintained in the TRANPLAN software format. The base-year 2000 Model was improved in 2007 by transitioning to a GIS -based model framework using the CUBE software package. Further enhancements were made to improve the correlation between model outputs and validation data. In the fall of 2008, the TRC began to host the Model, where further enhancements have included :

- Alignment of TAZs and road -network characteristics with those of the Chittenden County Metropolitan Planning Organization Regional Model
- Improved estimation of commercial truck trips
- Improved estimation of the Gravity Model for trip distribution using calibrated impedance functions
- Improved road-network representation to include critical minor and local roads
- Improved regression factors for trip production and attraction equations

In addition to these enhancements, the TRC updated the Model to a 2009 - 2010 base year by updating:

- Employment and housing totals for TAZs
- Housing characteristics by town
- Roadway characteristics from improvements between 2000 and 2010
- Truck percentages for traffic counts by TAZ
- Cross-border traffic counts for external trips
- Trip rates and regression equations for four trip types:
    - Home based Work (HBW)
    - Home based Other (HBO)
    - Home-based Shopping (HBSHOP)
    - Non-home based (NHB)
- Vehicle-occupancy rates by trip purpose

- External trip-fractions by trip-purpose
- Trip-distribution impedance functions for the gravity model

The Model uses a traditional four-step process to estimate link flows from TAZ-based population and employment. The trip generation sub-module combines these TAZ-based characteristics with the town-based fractions of cross-classified number of household members and workers to calculate home-based trips produced by each internal TAZ. Trip attractions for all purposes and trip-productions for the non-home-based (NHB) purpose are generated for each TAZ using purpose-specific regression equations, each of which utilizes a different set of employment and/or population characteristic. Truck (TRUCK) productions and attractions are taken as a fraction of the NHB trip totals corresponding to the fraction of trucks in traffic counts in the TAZ.. Total non-TRUCK external person trips (PTs) are then subdivided by the other four trip types using an external trip-fractions table estimated from the NHTS data. The trip production- output is held constant while attractions are adjusted by TAZ to create a balanced trip table.

The passenger trip distribution sub-module takes the balanced productions and attractions table, a matrix of free-flow travel times between TAZs (based on travel at 5 mph over the speed limit, with terminal times of between 1 and 4 minutes for origin and destination) and a set of impedance functions to generate a P-A matrix between all TAZs using the Gravity Model. Since the STM is a daily model, all trips are assumed to return to their origin, necessitating that the final matrix be diagonally symmetric. So the set of trip-specific matrices resulting from the Gravity Model application are transposed, then average with their originals, creating symmetrical matrices with same trip totals as the balanced trip table.

Prior to the network assignment sub-module, the symmetrical person-trip matrices resulting from the trip distribution step are converted to vehicle-trip matrices by applying vehicle-occupancy rates by trip type for internal and external travel (from the NHTS). The assignment sub-module employs a user-equilibrium optimization to distribute trips onto the network, resulting in vehicle flows and congested travel speeds by link for the entire state.

With these improvements, the Model provides the state of Vermont with a useful cost-effective tool to:

- Perform system and intercity-corridor studies
- Create reliable and timely travel estimates and forecasts
- Conduct scenario testing or “What If’s?”
- Provide link-specific traffic breakdown by trip purpose, origin, and destination
- Create estimates and forecasts of pass -through travel
- Perform travel analyses in non-MPO regions of the state
- Create sub-area models in local towns as needed
- Estimate passenger rail and transit demand from trip tables
- Accurately estimate traffic flows on inter-urban segments of major roadways
- Estimate rural trip-making activity
- Estimate travel characteristics at borders with other states and Canada
- Estimate long-distance travel

4. Assistance in Model Specification and Design

At this time, VTrans seeks a peer review of its Model specifications, design, and plan for future improvement. VTrans trusts that the recommendations of the panel will be innovative, state-of-

the-practice ideas and looks forward to including recommended tasks in its work program to enhance Model development and refinement. The panel will also be asked to outline the strengths and weaknesses of the existing Model, and to assist in determining whether application of current or more advanced Models can inform issues specifically faced by the State of Vermont, as deemed necessary by VTrans. VTrans continued commitment to travel modeling is evidenced by its partnership with the TRC in hosting and improving the Model's capabilities. It is anticipated that considerable discussion will take place about the merits of moving towards more advanced sub-modules, and which approach(es) are capable of providing the greatest benefits for VTrans.

How the Models can inform the VTrans's specific desired planning outcomes will be an important topic. The strategic challenges that came out of the Agency's strategic planning work are listed below:

- Aging and damaged infrastructure
- Changing demographics and economy
- Land use
- Stagnant and declining transportation fund revenues
- Energy constraints
- Climate change, extreme weather events and associated impacts to infrastructure and the environment
- Freight movement and trade globalization
- Security needs and issues
- Resiliency to a changing world

A path and process for continued improvement over the next five years, and priorities for implementation, are particularly sought. Some of the specific improvements that VTrans and the TRC are considering include:

- Investigation of the potential use of the results of the 2010 Vermont Trip Generation Manual for calibrating or updating the trip - generation sub-module of the Model
- Investigating the need for calibrating or updating the traffic assignment sub-module of the Model with speed/density curves derived from speed data logged by weigh -in-motion (WIM) stations and road - weather information system (RWIS) stations
- Exploring the need for a seasonal component to the Model including, at a minimum, an average winter day, an average summer day, and an annual average day
- Developing a freight module for the Model based on the method and guidance provided by Sorrantini and Smith (2000) consisting of commodity flows between Counties, out of the state, and into the state, with a coordination of these flows and the truck volumes which are currently in the Model at the TAZ level.
- Improvements in road-network level of detail to get more refined estimates of travel speed s, vehicle-miles of travel, and emissions.
- Improvements in the temporal resolution of the Model, to include a peak hour along with the current daily travel estimates
- Development of a tourist-travel component to the Model to better estimate the trends in visitor travel to Vermont

- Development and tracking of parking supply in the state for improved estimation of travel on major corridors
- Improvements in the multi -modal aspects of the Model to include passenger rail, bus transit, and airline travel, as is typical for a statewide model
- Feedback between modeling steps, namely traffic assignment and trip distribution
- Roadway grade and pavement type for the model's highway network links to help in speed and emissions modeling

5. Proposed Panel and Availability

Due to VTrans and TRC staff's time constraints with ongoing work, we request the assistance of TMIP staff to put together the members of the peer review panel. The make-up of this panel will hopefully consist of individuals with experience in the issues faced by statewide modelers in the US. TRC staff members have made use of resource materials produced in conjunction with statewide modelers in Connecticut, Florida, Ohio, and Oregon, so it would be ideal if one or more of those DOTs could be represented. In addition, it would be useful to include the following local stakeholders in the Vermont travel modeling community:

- Jason Charest – Chittenden County Regional Planning Commission (CCRPC)
- Dave Roberts – formerly of the CCMPO, now with the Vermont Energy Investment Corporation
- Chris Jolly – Planning & Program Engineer for FHWA, Vermont Division

The TRC staff contact will be responsible for contacting the local stakeholders. Both TRC staff and VTrans Policy, Planning & Intermodal Development staff will participate in the TMIP review.

6. Schedule and Cost

VTrans would like to conduct the TMIP peer review using video- and telephone-conferencing to avoid the need for travel by panelists. VTrans's responsibilities will be carried out by the TRC staff contact person. Therefore, the only expected commitment from peer review panelists will be time to participate in the review meeting, time to review documents and provide comments, and time to present the recommendations of the review committee.

The TRC staff contact for this peer review has time dedicated to the process in an existing contractual relationship with VTrans. Therefore, we are seeking to implement the process and host a review meeting as soon as possible. Our expectation is that we will be able to begin the implementation of the peer-review recommendations in the next 3-4 months.

Appendix F Slides from Peer Review Sessions #1, #2, & #4

Session #1

The following slides were presented in Session #1 in June 5, 2013:

History of the Model

- Before 2003
  - SAS Model Manager 2000 platform
  - TRANPLAN Network
- 2003 – 2007
  - Updated to base-year 2000 (forecast-year 2020)
  - Transition to CUBE Voyager platform
  - New roadway links added
  - Minor adjustments to trip-generation coefficients and centroid connectors
- After 2007
  - Update to base-year 2009 – 2010
  - Update to forecast-year of 2035
  - Other changes and improvements

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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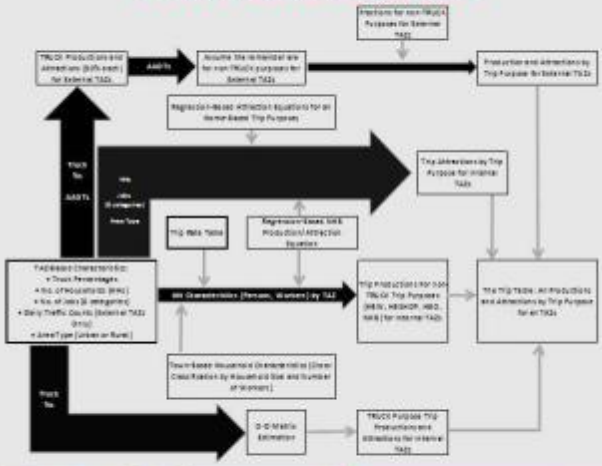
Estimating Trip Productions and Attractions



History of the Model
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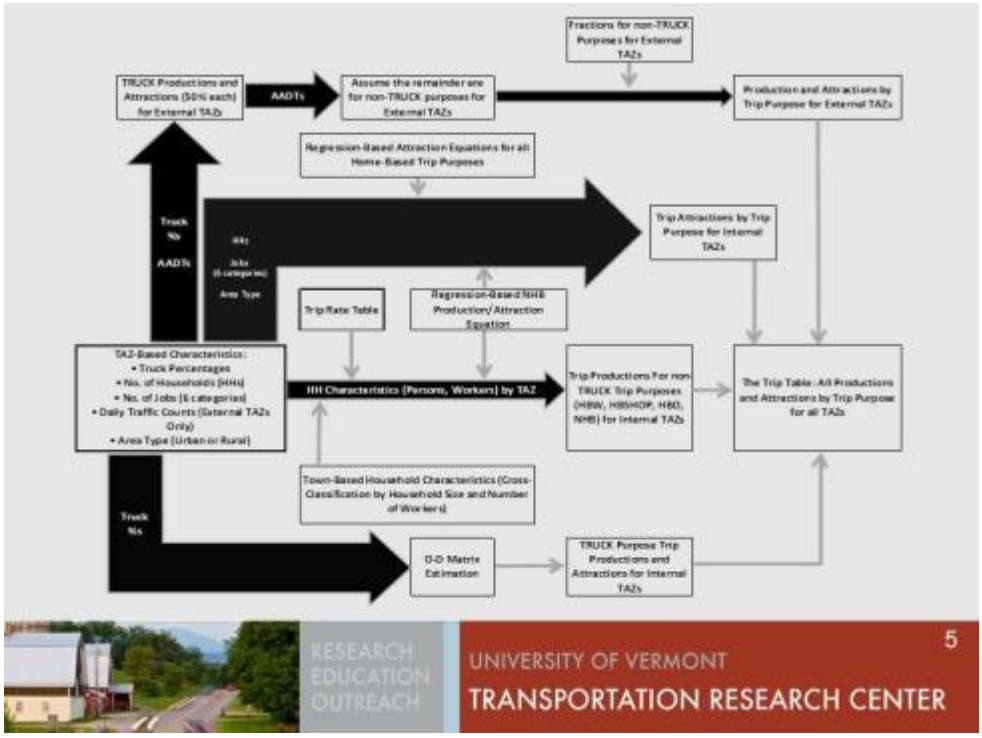
Fractions for non-TRUCK Purposes for External TAZs
TRUCK Productions and Attractions (50% each) for External TAZs
AADTs
Assume the remainder are for non-TRUCK purposes for External TAZs
Production and Attractions by Trip Purpose for External TAZs
Regression-Based Attraction Equations for all Home-Based Trip Purposes
Truck %s
AADTs
Trip Attractions by Trip Purpose for Internal TAZs
Trip Rate Table
Regression-Based NHB Production/Attraction Equation
TAZ-Based Characteristics:
• Truck Percentages
• No. of Households (HHs)
• No. of Jobs (6 categories)
• Daily Traffic Counts (External TAZs Only)
• Area Type (Urban or Rural)
HH Characteristics (Persons, Workers) by TAZ
Trip Productions for non-TRUCK Trip Purposes (HBW, HBSHOP, HBO, NHB) for Internal TAZs
The Trip Table: All Productions and Attractions by Trip Purpose for all TAZs
Town-Based Household Characteristics (Cross-Classification by Household Size and Number of Workers)
Truck %s
O-D Matrix Estimation
TRUCK Purpose Trip Productions and Attractions for Internal TAZs
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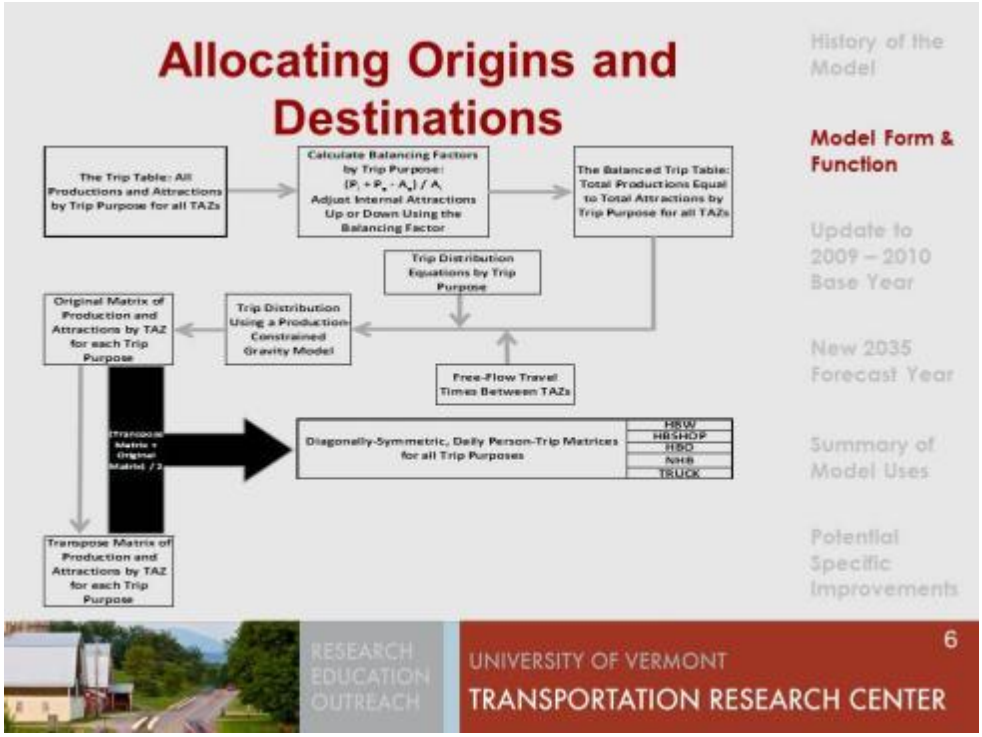
Allocating Origins and Destinations
History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements
The Trip Table: All Productions and Attractions by Trip Purpose for all TAZs
Calculate Balancing Factors by Trip Purpose: (P1 + P2 - A1) / A1 Adjust Internal Attractions Up or Down Using the Balancing Factor
The Balanced Trip Table: Total Productions Equal to Total Attractions by Trip Purpose for all TAZs
Trip Distribution Equations by Trip Purpose
Original Matrix of Production and Attractions by TAZ for each Trip Purpose
Trip Distribution Using a Production Constrained Gravity Model
Free-Flow Travel Times Between TAZs
Transpose Matrix + Original Matrix / 2
Diagonally-Symmetric, Daily Person-Trip Matrices for all Trip Purposes
HBW
HBSHOP
HBO
NHB
TRUCK
Transpose Matrix of Production and Attractions by TAZ for each Trip Purpose
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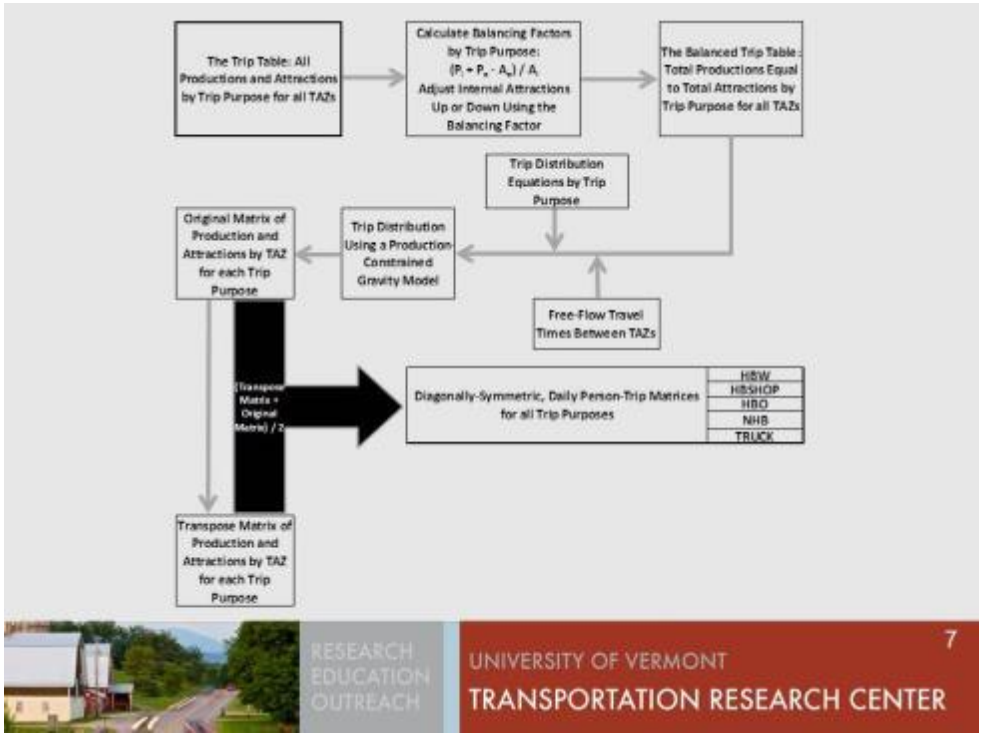
The Trip Table: All Productions and Attractions by Trip Purpose for all TAZs
Calculate Balancing Factors by Trip Purpose: (P_i + P_e - A_e) / A_i Adjust Internal Attractions Up or Down Using the Balancing Factor
The Balanced Trip Table: Total Productions Equal to Total Attractions by Trip Purpose for all TAZs
Trip Distribution Equations by Trip Purpose
Original Matrix of Production and Attractions by TAZ for each Trip Purpose
Trip Distribution Using a Production-Constrained Gravity Model
Free-Flow Travel Times Between TAZs
(Transpose Matrix + Original Matrix) / 2
Diagonally-Symmetric, Daily Person-Trip Matrices for all Trip Purposes
HBW
HBSHOP
HBO
NHB
TRUCK
Transpose Matrix of Production and Attractions by TAZ for each Trip Purpose
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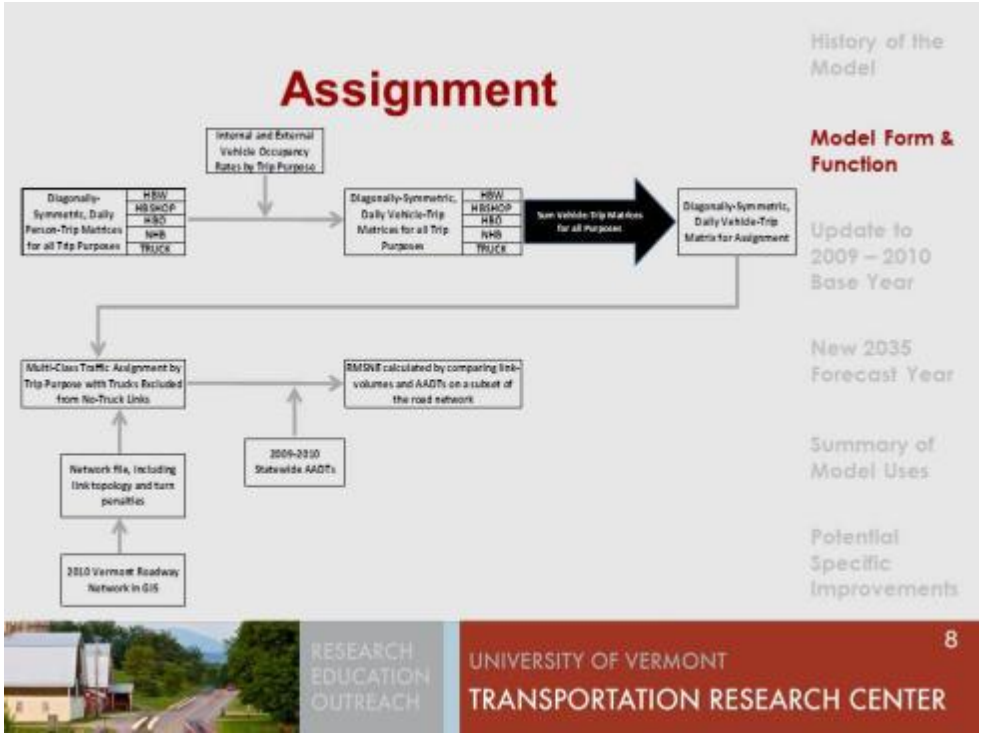
Assignment
History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements
Internal and External Vehicle Occupancy Rates by Trip Purpose
Diagonally-Symmetric, Daily Person-Trip Matrices for all Trip Purposes
HBW
HBSHOP
HBO
NHB
TRUCK
Diagonally-Symmetric, Daily Vehicle-Trip Matrices for all Trip Purposes
Sum Vehicle-Trip Matrices for all Purposes
Diagonally-Symmetric, Daily Vehicle-Trip Matrix for Assignment
Multi-Class Traffic Assignment by Trip Purpose with Trucks Excluded from No-Truck Links
RMSNE calculated by comparing link-volumes and AADTs on a subset of the road network
2009-2010 Statewide AADTs
Network file, including link topology and turn penalties
2010 Vermont Roadway Network in GIS
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Update to 2009-2010 Base Year

- Updates to Input Data
  - Households by TAZ: 2010 U.S. Census
  - HH Size / No. of Workers Cross-Class by Town: 2005 – 2009 American Community Survey
  - Employment: 2009 Employment Data from the Vermont Department of Labor and the Bureau of Economic Analysis
- Updates to Input Parameters
  - 2009 National Household Travel Survey

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Input Parameters Updated

- Regression Factors for Trip Rate Table
- Home-Based Trip Rates for Trip Rate Table
- Regression Equations for Trip Attraction and Non-Home-Based Trip Production
- Vehicle Occupancies by Purpose
- Trip Distribution Equations by Purpose for Trip Distribution

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Summary of Changes to Input Parameters

History of the Model

Model Form & Function

Update to 2009 – 2010 Base Year

New 2035 Forecast Year

Summary of Model Uses

Potential Specific Improvements

Purpose	Vehicle Occupancy Rates				I↔E Distributions		Home-Based Trip Rates	Internal Trip Distributions			
	Existing		New					Avg. Trip Length (min.)		% of Trips	
	I-I	I↔E	I-I	I↔E	Existing	New		Existing	New	Existing	New
HBO	1.56	1.74	1.75	1.85	38%	21%	↔	18.6	20.5	34%	35%
HBSHOP	1.37	1.74	1.48	1.93	17%	15%	↑	20.8	17.4	14%	21%
HBW	1.15	1.74	1.13	1.05	30%	9%	↓	21.8	20.9	25%	13%
NHB	1.39	1.74	1.51	1.78	13%	55%		14.5	19.1	21%	31%

Variable	Existing βs					New βs				
	NHB	HBW	HBSHOP (Urban)	HBSHOP (Rural)	HBO	NHB	HBW	HBSHOP (Urban)	HBSHOP (Rural)	HBO
No. of HHs	0.297				1.143	0.89				0.67
Retail Jobs	1.143		4.115	6.660		2.56		4.74	5.06	
Manufacturing	0.668									
Non-Manuf.	1.722	1.450			1.179	0.41	0.59			0.96
Government	2.450					0.86				
Primary School	1.485									
University	1.485									

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Summary of Changes to Input Parameters

History of the Model

Model Form & Function

Update to 2009 – 2010 Base Year

New 2035 Forecast Year

Summary of Model Uses

Potential Specific Improvements

Purpose	Vehicle Occupancy Rates				I↔E Distributions		Home-Based Trip Rates	Internal Trip Distributions			
	Existing		New					Avg. Trip Length (min.)		% of Trips	
	I-I	I↔E	I-I	I↔E	Existing	New		Existing	New	Existing	New
HBO	1.56	1.74	1.75	1.85	38%	21%	↔	18.6	20.5	34%	35%
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Variable	Existing βs					New βs				
	NHB	HBW	HBSHOP (Urban)	HBSHOP (Rural)	HBO	NHB	HBW	HBSHOP (Urban)	HBSHOP (Rural)	HBO
No. of HHs	0.297				1.143	0.89				0.67
Retail Jobs	1.143		4.115	6.660		2.56		4.74	5.06	
Manufacturing	0.668									
Non-Manuf.	1.722	1.450			1.179	0.41	0.59			0.96
Government	2.450					0.86				
Primary School	1.485									
University	1.485									

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Road Network Improvements

- Identified new links since 2000 and omitted links and added these to the road network
- Aligned TAZs with the CCMPO regional travel model
- Modify the model road network with modified roadways since 2000
- Updated turn penalties and corrected network connectivity errors
- Updated and corrected all roadway capacities

History of the Model
Model Form & Function
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Summary of Model Uses
Potential Specific Improvements

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Data for Employment Growth Rates

- From economy.com with calculation by EDR Group for the Vermont Freight Plan:
  - County-level growth rates
  - By employment sector
  - 2009 – 2039
- From the Vermont Department of Labor's long-term occupational projections program:
  - Statewide growth rates
  - By employment sector
  - 2010 – 2020
- Neither is totally consistent with the sectors used in the Model

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Employment Growth Rates

- Used an average to estimate growth rates by the employment sectors in the Model
- Conducted an iterative optimization to allocate new growth rates by sector and County:
  - Used the average statewide growth rates by sector and the total County-level growth rates as control
  - Calculated initial County-level growth rates by sector as a weighted average based on 2009 employment
  - Adjusted the County-level growth rates by sector until they yielded weighted-average totals for 2035 that satisfied both the control totals

History of the Model
Model Form & Function
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New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Forecast employment growth rates, 2010 – 2035

County	Retail	Manufacturing	Non-Manufacturing	Government	Education	Sector-Wide
Addison	0.9%	-1.1%	0.8%	0.2%	0.3%	0.6%
Bennington	0.7%	-1.2%	0.6%	0.0%	0.3%	0.3%
Caledonia	0.9%	-0.7%	0.8%	0.2%	0.3%	0.6%
Chittenden	0.9%	0.0%	0.9%	0.2%	0.4%	0.7%
Essex	0.7%	-1.2%	0.4%	0.0%	0.3%	0.3%
Franklin	0.9%	0.0%	0.8%	0.2%	0.3%	0.6%
Grand Isle	1.0%	0.0%	1.2%	0.2%	0.3%	1.0%
Lamoille	1.1%	0.0%	1.4%	0.2%	0.3%	1.1%
Orange	0.9%	-0.6%	0.8%	0.2%	0.3%	0.6%
Orleans	0.9%	0.0%	0.9%	0.2%	0.3%	0.7%
Rutland	0.7%	-1.2%	0.6%	0.2%	0.3%	0.4%
Washington	0.7%	-0.6%	0.7%	0.2%	0.3%	0.5%
Windham	0.6%	-1.2%	0.5%	-0.3%	0.3%	0.3%
Windsor	0.7%	-1.2%	0.5%	-0.2%	0.3%	0.3%
Statewide	0.8%	-0.6%	0.8%	0.1%	0.3%	0.6%

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Data for Population Growth Rates

- From economy.com, calculation by EDR Group for the Vermont Freight Plan:
  - County-level growth rates
  - By population, not housing
  - 2009 – 2039
- Household growth estimates were sparse and inconsistent, so households were assumed to grow in equal proportion to population

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Forecast household growth rates, 2010 – 2035

County	Growth Rate
Addison	0.3%
Bennington	-0.1%
Caledonia	0.3%
Chittenden	0.6%
Essex	0.1%
Franklin	0.6%
Grand Isle	1.0%
Lamoille	0.8%
Orange	0.3%
Orleans	0.4%
Rutland	0.0%
Washington	0.2%
Windham	-0.1%
Windsor	0.0%
Statewide	0.3%

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2035 Forecast-Year Outputs

- Used growth rates to update TAZ-based characteristics
- Left parameters, rates, coefficients and roadway geometries unchanged
- Ran the Model through the assignment step to get 2035 trip table, a 2035 vehicle-trips matrix, and 2035 traffic volumes on links

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Summary of Model Uses

Year 1	• Southeast Vermont bridge closure investigation • Burlington area emissions analysis of 5+-axle trucks
Year 2	• Burlington-Middlebury corridor analysis for proposed I-89 Exit 12B • Route 22A corridor analysis to support Stantec
Year 3	• Morristown By-Pass Travel Demand Project, repeating an analysis conducted in 2002 • Support to VHB on the VTrans VT-NY Intercity Passenger Rail Study • Support to ICF International on the VTrans Greenhouse Gas Modeling Project • Quebec Highway A-35 Extension Assessment Project • Town of Cabot pass-through traffic flow analysis
Year 4	• Support to KFH Group on an examination of intercity bus travel by Vermonters • Analysis of the Travel Behavior of Younger Vermonters to follow-up on the national study published by USPIRG
Year 5 (ongoing)	• Agency Funding Gap Study – analysis of bridge funding shortfalls

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Potential Specific Improvements

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Potential Specific Improvements

- Agency-wide strategic planning challenges:
  - Aging and damaged infrastructure
  - Changing demographics and economy
  - Land use
  - Stagnant and declining transportation fund revenues
  - Energy goals
  - Climate change, extreme weather events and associated impacts to infrastructure
  - Freight movement and trade globalization
  - Security needs and issues
  - Resiliency to a changing world

History of the Model
Model Form & Function
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Summary of Model Uses
Potential Specific Improvements

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Questions for the Peer Review Panel

1. FHWA identified issues in the current model, particularly as it relates to the use of different modeling platforms. How should these issues be addressed to ensure VTrans has a credible and effective model?
2. Resiliency planning has become a major focus at VTrans. Hurricane Irene caused significant damage to the state's transportation infrastructure. A major focus of our planning efforts in this area will be infrastructure design that can withstand such storms. How can VTrans use the model for resiliency planning?
3. Vermont has set ambitious objectives towards the goal of reducing energy use and emissions. These included, for example:
   a. Keep VMT annual growth rate to 1.5% (half of the national average) or less for that portion controlled by the state.
   b. Increase public transit ridership by 110%, to 8.7 million annual trips by 2030.
   c. Quadruple passenger rail trips, to 400,000 Vermont-based trips by 2030.
   d. Reduce share of SOV commute trips by 20% by 2030.
   e. Double bicycle and pedestrian share of commute trips, to 15.6%, by 2030.
   f. Double ride share commute trips, to 21.4% of all commute trips, by 2030.

   How can we use the model to monitor and evaluate progress towards goals/targets?
4. While there will continue to be a need to evaluate an occasional highway capacity project, system preservation will dominate the work of VTrans. What role, if any, could a travel demand model have in system preservation, and possibly disinvestment?
5. Performance-based planning and programming are a core component of MAP-21 requirements. How can the model assist us in developing and monitoring performance measures moving forward? Can the model play a role in an asset management system?
6. VTrans is in the process of developing a fair-share methodology, with the aim of ensuring developers pay for the proportional impact triggered by development. How can we use the model to contribute to the fair-share methodology?
7. Bicycling, walking, transit, and rail are important components of the Vermont's transportation system. Some of these modes, particularly bicycling and walking, are primarily local in scope. Is the State's travel demand model the appropriate scale to prioritize corridors for improvements (i.e. where to widen lanes for bicycle use)?

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Potential Specific Improvements

- Seasonal component - average winter day, average summer day, and annual average day
- Tourist-travel (multi-day) component
- Freight module consisting of commodity flows between Counties and across the state boundary
- Feedback between traffic assignment and trip distribution steps
- Multi-modal travel - passenger rail, bus, and air
- Roadway grade and pavement condition for road-network links for speed and emissions estimation
- Square-footage basis for trip-generation
- Calibrating of traffic assignment sub-module with empirical speed/density data
- Improving the road-network level of detail to get more refined estimates of travel speeds, vehicle-miles of travel, and emissions
- Peak-hour travel estimates, along with the current daily travel estimates
- Developing and tracking parking supply for modeling NHB travel and ridesharing
- Breakdown of NHB trips into "NHB-Business" and "NHB-Personal"

History of the Model
Model Form & Function
Update to 2009 – 2010 Base Year
New 2035 Forecast Year
Summary of Model Uses
Potential Specific Improvements

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Peer Review Schedule

Session #2
Date: Wednesday June 19
Time: 2:00 - 4:30 PM EST
Agenda: Discussion of key issues and questions, areas for improvement
Participants: All peer review attendees

Session #3
Date: Wednesday July 10
Time: 2:00 - 4:00 PM EST
Agenda: Independent panel meeting convened to assemble comments and feedback
Participants: Expert panel members, TMIP staff

Session #4
Date: Wednesday July 31
Time: 2:00 - 4:00 PM EST
Agenda: Comments and feedback presented by peer review panel to broader group
Participants: All peer review attendees

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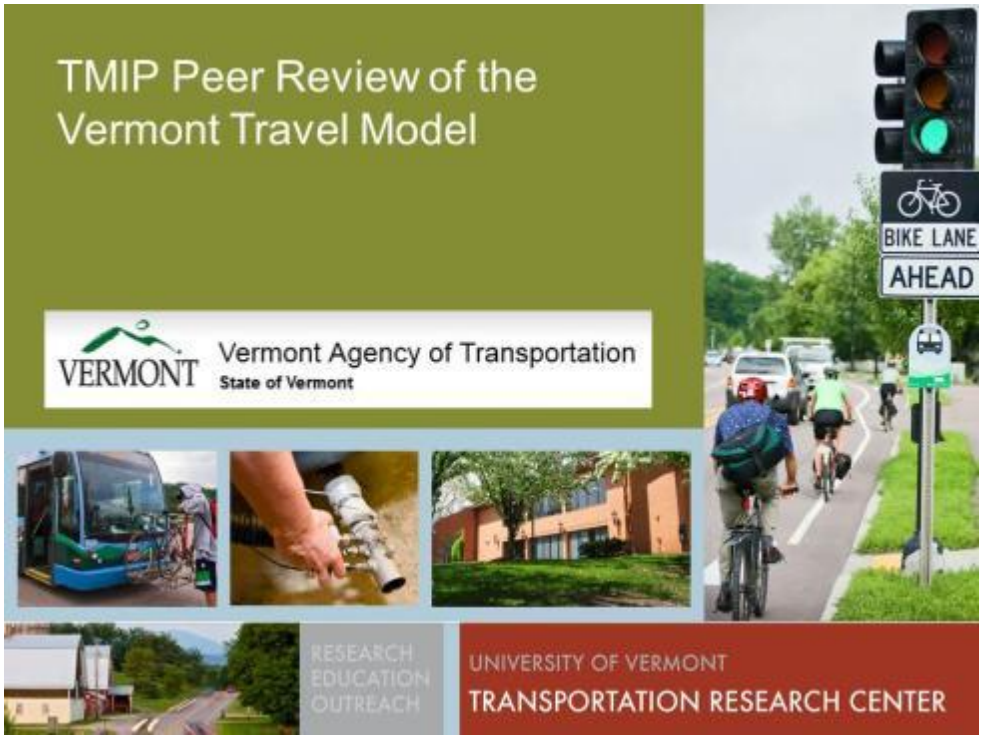
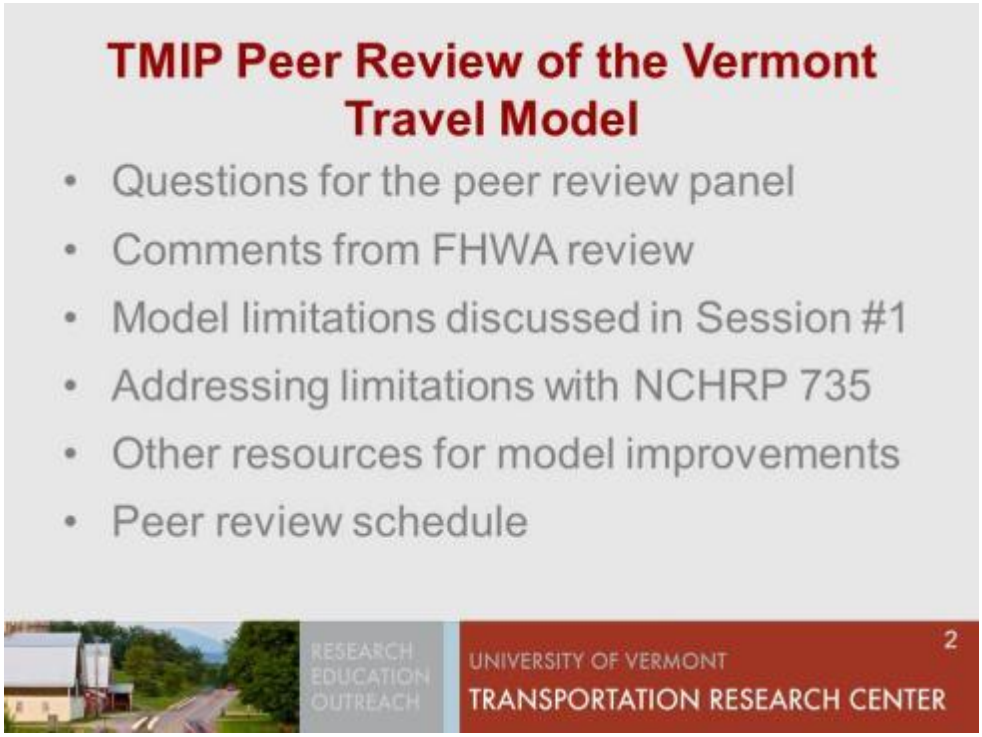
Session #2

The following slides were presented in Session #2 on June 18, 2013:





Questions for the Peer Review Panel

1. FHWA identified issues in the current model, particularly as it relates to the use of different modeling platforms. How should these issues be addressed to ensure VTrans has a credible and effective model?
2. Resiliency planning has become a major focus at VTrans. Hurricane Irene caused significant damage to the state's transportation infrastructure. A major focus of our planning efforts in this area will be infrastructure design that can withstand such storms. How can VTrans use the model for resiliency planning?
3. Vermont has set ambitious objectives towards the goal of reducing energy use and emissions. These included, for example:
   a. Keep VMT annual growth rate to 1.5% (half of the national average) or less for that portion controlled by the state.
   b. Increase public transit ridership by 110%, to 8.7 million annual trips by 2030.
   c. Quadruple passenger rail trips, to 400,000 Vermont-based trips by 2030.
   d. Reduce share of SOV commute trips by 20% by 2030.
   e. Double bicycle and pedestrian share of commute trips, to 15.6%, by 2030.
   f. Double ride share commute trips, to 21.4% of all commute trips, by 2030.

   How can we use the model to monitor and evaluate progress towards goals/targets?

Questions for the Peer Review Panel

4. While there will continue to be a need to evaluate an occasional highway capacity project, system preservation will dominate the work of VTrans. What role, if any, could a travel demand model have in system preservation, and possibly disinvestment?
5. Performance-based planning and programming are a core component of MAP-21 requirements. How can the model assist us in developing and monitoring performance measures moving forward? Can the model play a role in an asset management system?
6. VTrans is in the process of developing a fair-share methodology; with the aim of ensuring developers pay for the proportional impact triggered by development. How can we use the model to contribute to the fair-share methodology?
7. Bicycling, walking, transit, and rail are important components of the Vermont's transportation system. Some of these modes, particularly bicycling and walking, are primarily local in scope. Is the State's travel demand model the appropriate scale to prioritize corridors for improvements (i.e. where to widen lanes for bicycle use)?

Comments from FHWA review

- Differences between the official Model platform and those used by consultants or regions
  - Complete model runs with forecast
  - Extraction of data from the Model
- Review or *validation* of highway network
- Reduced average trip impedances from zone refinement
- Short- and long-distance travel aggregation
- Potential discrepancy between the default speed / capacity tables and the future year assignments
- Value of flow adjustments for model fit
- Value of a comprehensive user's manual

Questions for the peer review panel

Comments from FHWA review

Model limitations discussed in Session #1

Addressing limitations with NCHRP 735

Other resources for model improvements

Peer Review Schedule

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Model Limitations Discussed in Session #1

- Assumptions regarding NHB travel
- Growth forecasting
- Feasibility of including transit
- Long- and short-distance travel
- Vehicle-ownership model
- Economic modeling

Questions for the peer review panel

Comments from FHWA review

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Assumptions regarding NHB travel

- No longer includes commercial truck travel
- Updated trip-generation regression-equation coefficients:
  - Households - 0.89
  - Retail Jobs - 2.56
  - Manufacturing Jobs - *removed*
  - Non-Manufacturing Jobs - 0.41
  - Government Jobs - 0.86
  - Primary School Jobs - *removed*
  - University Jobs - *removed*
- Regression-equation r-squared - 0.64
- 29% of all person-trips per day – 611,586
- Trip distribution (gamma) coefficients: a: 87,565; b: 1.338; c: 0.098
- Diagonal symmetry

Questions for the peer review panel

Comments from FHWA review

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Model Limitations Discussed in Session #1

- Growth forecasting
  - Standard source?
  - Capping minimum household growth rate at 0.0%,
  - Sources of information for population growth vs. household growth
- The feasibility of including transit fully in a Model with only a daily temporal resolution: does it make sense to include only certain types of regional transit, or none at all? Can the hourly variations in transit use be reflected in a daily model?
- Long-distance and short-distance travel: which trip purposes and modes are critical in the separation of distance categories?

Questions for the peer review panel

Comments from FHWA review

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Model Limitations Discussed in Session #1

- Vehicle-ownership model
  - For effective VMT estimation
  - For effective household-level forecasting
- Economic modeling
  - For effective assessments of economic impact
  - For effective economic forecasts

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Addressing limitations with NCHRP 735

- Long-distance and rural trip generation:
  - Urban/rural distinction: Is this suggesting that urban/rural be treated separately for all trip purposes in the trip generation module? Or just for NHB?
  - What is the difference between a trip-based model with "stops" for long-distance trips, and a tour-based model?
  - With only passenger-car and commercial truck travel in the model, would trip-distances over 300 miles be required?
  - "Rural" trip-making is still greatest on weekdays, but "long-distance" trips are more focused around the weekend-days.
  - New set of purposes: business, pleasure, and personal-business?

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Addressing limitations with NCHRP 735

- Long-distance and rural trip generation (cont.):
  - TAZ characteristics for generation of rural and long-distance trips:
    - Population density
    - Road density
    - Land-use mixture
    - Variation in population density
  - Use these characteristics instead of households and job categories as regression-equation factors?
  - Exact locations of the most popular tourist destinations to do a "distance-to-tourist-area" factor to support long-distance trip rates?
  - Transferability of parameters
    - Find similar states?
    - Handle it regionally? Locally?

Questions for the peer review panel
Comments from FHWA review
Model limitations discussed in Session #1
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Other resources for model improvements

- Vehicle-ownership models and their effect on VMT estimation and household-level travel forecasting
  - **Travel Model Validation and Reasonableness Checking Manual** provides guidelines for using vehicle ownership/availability as a validation process:
    - *The best state of the practice for socioeconomic models is the use of a discrete choice formulation usually a multinomial or ordered response logit model, to simulate the "choice" of the number of vehicles (or workers, children, etc.). This type of model can be readily estimated using data from a household activity/travel survey.*
  - Good place to start?
  - Do we need good household-level income data?

Questions for the peer review panel
Comments from FHWA review
Model limitations discussed in Session #1
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Other resources for model improvements

- Economic modeling
  - Economic model with a travel component or travel model with an economic component?
  - From NCHRP 735: *Small samples and demographic or economic models do not provide the statistical strength to make judgments about capital investment priorities or to understand travelers' decisions based on various price points.*

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Peer Review Schedule

Session #3
Date: Wednesday July 10
Time: 2:00 - 4:00 PM EST
Agenda: Independent panel meeting convened to assemble comments and feedback
Participants: Expert panel members, TMIP staff

Session #4
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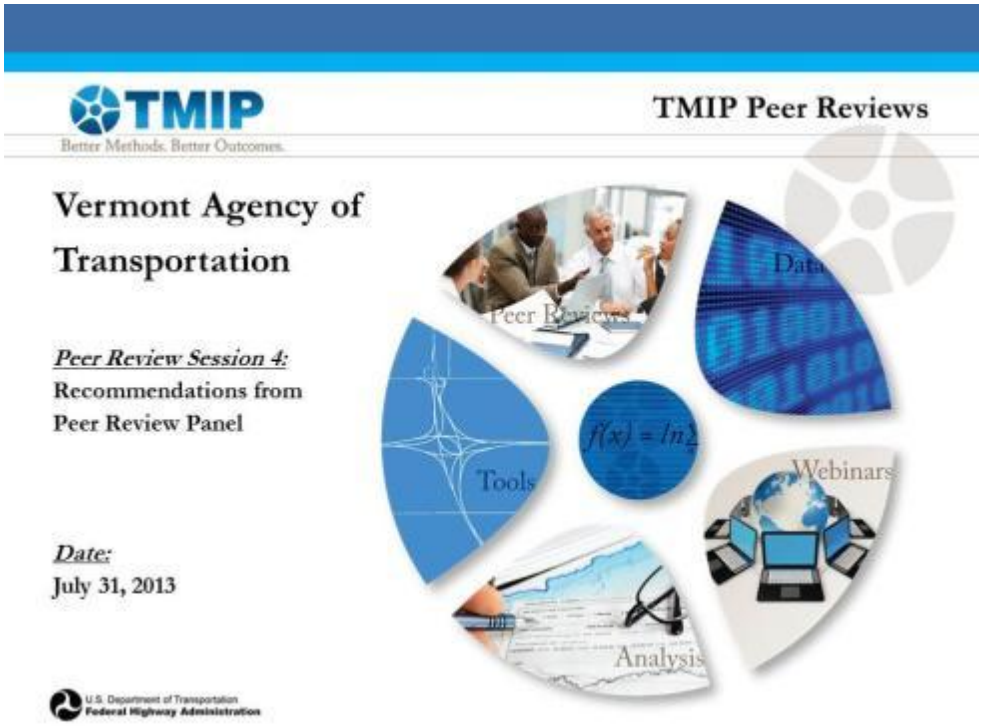
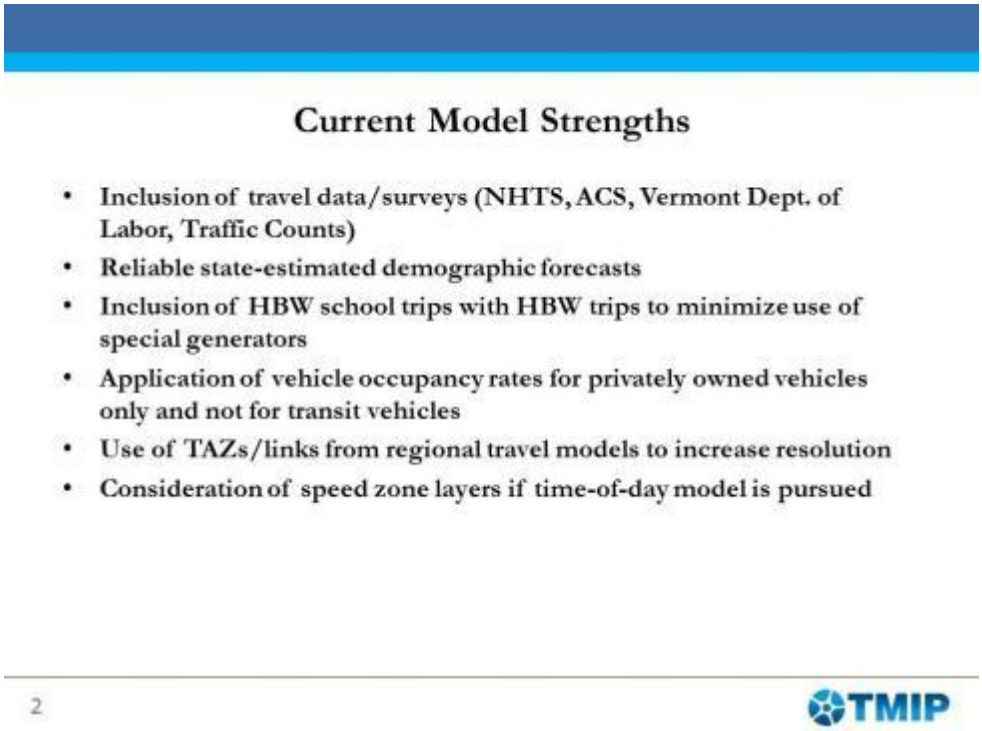
Session #4

The following slides were presented at Session #4 held on July 31, 2013:





General Recommendations

- Expand the external model area by including a halo over the state line
- Expand roadway network to include interstates, major arterials, and collectors with accurate speeds, lengths, and classifications
- Reassess centroid connectors
- Consider seasonal trip tables
- Consider future year beyond 2030
- Establish one freight model component based on either commodity flows or truck/rail vehicles
- Develop in-house expertise in application of the model

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Consistent Themes in Response to Seven Questions

- Focus on a single model platform
- Strengthen agency understanding of model sensitivity and appropriate uses for statewide model application
- Minimize dependence on the one statewide model by developing consistent/compatible tools to meet agency needs
- Identify project types and metrics desired for project prioritization before redesign of model features

4 TMIP

(1) Response to FHWA Identified Issues

- Address fundamental model development considerations from FHWA
- Develop Users' Guide and Technical Reference
- Define short/medium/long term priorities based on current model -
  For example:
  - Short-Term: Create one comprehensive statewide model package, Check consistency between sub models, Assess appropriateness of model to meet agency needs
  - Mid-Term: Identify second phase of model enhancement (to occur while the current model is in use) based on agency priorities
  - Long-Term: Develop "wish list" of features that are lacking from the Short- and Mid-Term enhancements

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(2) Resiliency Planning

- Consider dynamic traffic assignment to assess traffic patterns in emergency response
- Identify metrics for alternatives comparison to guide model development
- Develop at-risk location inventory in network via link attributes
- Automate the incorporation of at-risk location data into the network
- Recognize that emergency contingency planning is associated with links damaged by an emergency event not general facility design

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(3) Evaluation of Energy/Emission Goals

- Include a mode choice model component
- Identify sensitivities in energy/emission performance measures
- Recognize difficulty in addressing performance measures given scale/ resolution of statewide model – more appropriate for regional model
- Consider a separate aggregate model to apply data from the statewide model and the MPO model to evaluate energy/emissions information
- Consider scenario testing in the long-term

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(4) System Preservation and Disinvestment

- Identify performance measures desired for project prioritization before adjusting model
- Review Oregon's HERS-ST (applies statewide model growth rates to evaluate needs/options) for transportation investment optimization
- Consider evaluating volumes and road wear for project prioritization
- Coordinate with pavement program staff to determine need for this type of effort

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(5) Performance Measurement & Asset Management

- Identify/prioritize model design features for each performance metric desired based on agency needs
- Develop post processing methodology to determine economic impact/GDP value of individual links
- Apply additional economic assessment software (STEAM, T-PICS, TREDIS, REMI, Transight) to model output
- Consider use of a separate project-specific benefit/cost model

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(6) Fair-Share Methodology

- Develop VMT estimates for new development by land use type and trip purpose to determine change over time/assess impact fees
- Recognize that statewide model resolution is not adequate for the post processing methodology to determine long-range growth rates for background traffic
- Consider micro-simulation model which applies future volumes/growth rates from the regional model
- Look into off-model techniques for development impact assessments (ITE Trip Generation Manual) for use as a separate/compatible tool

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(7) Corridor Prioritization: Transit, Biking, & Waking

- Recognize that statewide model may not be appropriate resolution for evaluating non-motorized transportation improvements
- Develop separate/compatible tool for non-motorized transportation
- Consider micro-simulation models for local area analysis
- Consider survey efforts to understand current travel by mode
- Consider tiered approach to activity-based model development for non-motorized travel as a long-term priority

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Suggested Reading Materials

- Special Report 288 "Metropolitan Travel Forecasting"
- TCRP Report 95
- NCHRP Synthesis 406 "Advanced Practices in Travel Forecasting"
- A Transportation Modeling Primer, Edward A. Beimborn Center for Urban Transportation Studies University of Wisconsin-Milwaukee, May 1995, updated June 2006

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Other Suggestions/Questions/Comments

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