Washington State Department of Transportation (WSDOT) Peer Review Report

August 2014

TMIP

Better Methods. Better Outcomes.

U.S. Department of Transportation
Federal Highway Administration

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TMIP

Better Methods. Better Outcomes.

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List of Acronyms

ADOT	Arizona Department of Transportation
AZTDM	Arizona Travel Demand Model
BMC	Baltimore Metropolitan Council
Caltrans	California Department of Transportation
CARB	California Air Resources Board
CEC	California Energy Council
CGE	Computable General Equilibrium
DTA	Dynamic Traffic Assignment
FAF3	Freight Analysis Framework 3
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GHG	Greenhouse Gas
GSP	Gross State Product
HHTS	Household Travel Survey
LCP	Least Cost Plan
LRT	Light Rail Transit
MAFC	Mid-America Freight Coalition
MAG	Maricopa Association of Governments
MDSHA	Maryland State Highway Administration
MOVES	Motor Vehicle Emissions Simulator
MPO	Metropolitan Planning Organization
MSTM	Maryland Statewide Travel Model
NHTS	National Household Travel Survey
ODOT	Oregon Department of Transportation
PECAS	Production, Exchange and Consumption Allocation System
QFRM	Quick Response Freight Manual
QRS II	Quick Response System II
RTPO	Regional Transportation Planning Organization
SCAG	Southern California Association of Governments
SCTG	Standard Classification of Transported Goods
SHRP	Strategic Highway Research Program
STEAM	Surface Transportation Efficiency Analysis Model
TDM	Travel Demand Management
TSM	Transportation Systems Management
UPO	Urban Planning Office
UPWP	Unified Planning Work Program
UWM	University of Wisconsin Milwaukee
VIUS	Vehicle Inventory and Use Study
VMT	Vehicle Miles Traveled
WSDOT	Washington State Department of Transportation

1.0 Executive Summary

The Washington State Department of Transportation (WSDOT) peer review was supported by the Travel Model Improvement Program (TMIP) sponsored by the Federal Highway Administration (FHWA). The objective of the WSDOT peer review was to seek background information and recommendations on how WSDOT should approach developing a statewide Washington travel demand forecast model. The information sought by WSDOT included:

- The purposes to which statewide travel models have been or could be applied;
- Key challenges in developing and applying statewide models;
- Resources required to develop a statewide model;
- Strategies for model development work planning;
- How economic data is used in the travel model or could be produced by components of the overall model framework.

The peer review panel was convened on July 1, 2014, at which seven expert panelists convened along with an amalgamation of WSDOT, both state and federal transportation representatives, and agency stakeholders. The peer review panel members included: Alan Horowitz, of the University of Wisconsin-Milwaukee, Keith Killough of the Arizona Department of Transportation, Becky Knudson of the Oregon Department of Transportation, Doug MacIvor of the California Department of Transportation; Subrat Mahapatra of the Maryland State Highway Administration, Ken Cervenka of the Federal Transit Administration, and Vidya Mysore of FHWA. Greg Giaimo of the Ohio Department of Transportation also provided commentary in written format.

At the beginning of the Peer Review session, each panelist provided a brief ten-minute presentation of their statewide or large-scale modeling experience at the request of WSDOT. The purpose of these presentations was to inform WSDOT of the state of the practice in statewide modeling, including information on data, model structure, and model applications, as well as the identification of the challenges to anticipate in large-scale model development.

WSDOT explicitly identified the following potential applications for a Washington statewide travel demand model:

- Statewide long range multi-modal planning
- Transportation investment scenarios evaluation
- VMT, greenhouse gas, and air quality analyses
- Economic impact analyses
- Coordinate and provide travel demand forecasting across regional boundaries
- Provide travel demand forecasting for regions without a model
- Transportation and land use interaction analyses

Throughout the remainder of the one-day session, panelists provided responses to a list of questions crafted by WSDOT to further gather information on model development and possible applications. In the response to these questions and through additional discussion, the expert panelists provided an array of suggestions and recommendations for WSDOT to consider as they move forward with the development of their statewide model.

The panelists agreed that the first step WSDOT should take in the model development process is the creation of a list of statewide needs from the model and to prioritize this list based on which needs are immediate versus those that can be incorporated further down the line.

Secondly, the panelists recommended that WSDOT identify a specific budget, schedule, and staff for the model development effort. The panelists recommended that WSDOT carefully consider schedule length and management's expectations when developing the budget. Panelists also underscored the importance of coordination with Metropolitan Planning Organizations (MPOs) in the model development process, as maintaining communication with regional agencies will be critical in this process.

One panelist recommended an initial model development timeline from 12 to 18 months, including staff time. The panelists collectively identified $1 million as a good starting figure for a more planning-level model that meets substantive validation requirements. It was also noted that this $1 million estimate did not include data acquisition and also that an additional $1 million would be needed for the incorporation of a full truck component.

The panelists suggested that WSDOT conduct a complete data inventory to identify all available data for application in the model and then to cross reference the available data to the identified analysis needs. After reviewing what data is available in relation to potential modeling needs, WSDOT can scope model development in phases relating to existing data and secondary data.

The panelists agreed that properly phasing the model development process would be imperative to building a successful and logical statewide model, and WSDOT should focus on the basic components of the model first. Panelists emphasized that simplicity is key in large-scale models, as is maintaining realistic expectations and managing uncertainty when developing a new model. Panelists stressed the importance of testing the model's sensitivity, particularly for extreme scenarios, in the model development process to assess how and which critical assumptions drive forecast results. The following bullets summarize the panelist recommendations for various statewide model components.

- Model Structure: When WSDOT questioned whether it would be logical to work with a state with a good statewide model from which they could borrow the structure and adjust the inputs to reflect the state of Washington, it was noted that Maryland attempted to borrow a mode choice structure from another model and it did not produce a successful outcome. The borrowed model approach has limitations.
- Coordination with MPO Modeling: The panelists highlighted the importance of maintaining consistent demographic and employment data inputs with those used in MPO and regional models. The panelists also suggested that transit representation within urban areas be sketchy to avoid duplication of effort with MPO models.
- Cross-state and Border Modeling Issues: The panel recommended that WSDOT address all 48 states, Canada, and Mexico in the statewide model. It was recommended that WSDOT consider examining international externals due to its coastal location. The panel also noted that a "halo" of out-of-state zones can be used for the passenger component of long distance travel.
- Economic Modeling: The panelists suggested the use of REMI, TREDIS, SHRP2 C11 tools, or similar existing tools until WSDOT's CGE model is operational.
- Air Quality Modeling: The panel recommended that the State leave this responsibility for MPOs to avoid duplication of effort.
- Land Use Modeling: The panelists recognized that land use modeling is challenging on the statewide level. It was suggested that population and employment cooperative forecasts be considered particularly as multiregional efforts that utilize data available at the regional level.

- Time-of-Day Modeling: The panelists suggested that time-of-day modeling may be further down the line in model development phasing and may require extensive data at the household level. It was noted that DTA could be another option to achieve time-of-day forecasts, but the process is computationally intensive.
- Data: Many existing data from national sources and the data collected by other states and MPOs within the state can be used to develop the initial version of the statewide model. For highway side data, panelists recommended that WSDOT review all existing counts, for example the HPMS source counts, Automatic Traffic Recorders (ATRs), spot counts, and project counts, and prepare the budget to clean count data. Panelists suggested looking at existing HHTSs and possibly high speed rail studies for long distance behavioral information and recommended review of passive data sources, like AirSage, transit card, Bluetooth, and other data sources for potential applicability.

Moving forward with the information and recommendation accrued at the peer review, WSDOT will identify and prioritize their agency needs for the statewide model to create a model development plan that collaborates with MPOs, regional transportation planning organizations, state force, consultants, and academic professionals.

2.0 Introduction

2.1 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 sessions and supporting technical documentation provided by the Washington State Department of Transportation (WSDOT) and the peer review panelists.

2.2 Acknowledgements

The FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review to inform the prospective development of a Washington-state travel demand forecast model (WTDFM) and for sharing their valuable experience.

The peer review panel members were:

- Alan Horowitz, University of Wisconsin-Milwaukee (UWM);
- Keith Killough, Arizona Department of Transportation (ADOT);
- Becky Knudson, Oregon Department of Transportation (ODOT);
- Doug MacIvor, California Department of Transportation (Caltrans);
- Subrat Mahapatra, Maryland State Highway Administration (MDSHA);
- Ken Cervenka, Federal Transit Administration (FTA); and
- Vidya Mysore, Federal Highway Administration (FHWA).

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

2.3 Peer Review Purpose

The peer review was supported by the Travel Model Improvement Program (TMIP) sponsored by FHWA. Model peer reviews can serve multiple purposes, including identification of model deficiencies, recommendations for model enhancements, guidance on model applications, and model development recommendations. 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-supported peer review provides a forum for this knowledge exchange.

The objective of the WSDOT TMIP peer review was to seek background information and recommendations on how WSDOT should approach developing a state-wide Washington travel demand forecast model. WSDOT does not have a statewide model at this time. WSDOT supplied a list of questions to the panelists which are detailed later in this document, but in broad terms the information sought included:

- The purposes to which statewide travel models have been or could be applied;
- Key challenges in developing and applying statewide models;
- Resources required to develop a statewide model;
- Strategies for model development work planning;

- How economic data is used in the travel model or could be produced by components of the overall model framework (the question of economic data and potential economic forecasts is listed here because it was a key differentiator between the example statewide models presented by the panelists and constitutes an important model architecture question).

The peer review panel spent one day—July 1, 2014—presenting background on panelists' statewide model experiences and responding to specific questions from WSDOT. A general audience of representatives from stakeholder agencies across the state was also invited; the audience had the opportunity to ask questions and offer comments. This report documents the results of the peer review discussions and the resultant panel recommendations.

2.4 Report Organization

This report is organized into the following sections:

- *Executive Summary* – a succinct overview of the panel's discussion and recommendations.
- *Background* –an overview of the state of Washington, WSDOT, and WSDOT's broad goals for developing a statewide model.
- *Example Models* – summaries of the state or large-scale models developed or used by the panelists, with relevant background on the states or regions treated.
- *Peer Review Discussion* – panel discussion structured around the questions posed by WSDOT.
- *Peer Review Panel Recommendations* – the panel's recommendations to WSDOT.

In addition, the report includes three Appendices:

- *Appendix A* – list of peer review participants
- *Appendix B* – peer review meeting agenda
- *Appendix C* – biographies for each of the peer review panel members

This report structure resembles the peer review agenda (see Appendix B) but some regrouping of material was done for clarity. As is typical in peer reviews, audience questions and panel responses lead the panel discussion in many directions so this written representation of that discussion arranges material by topic, not necessarily in the order in which the points were made in the course of the review session.

3.0 Background

3.1 Washington State

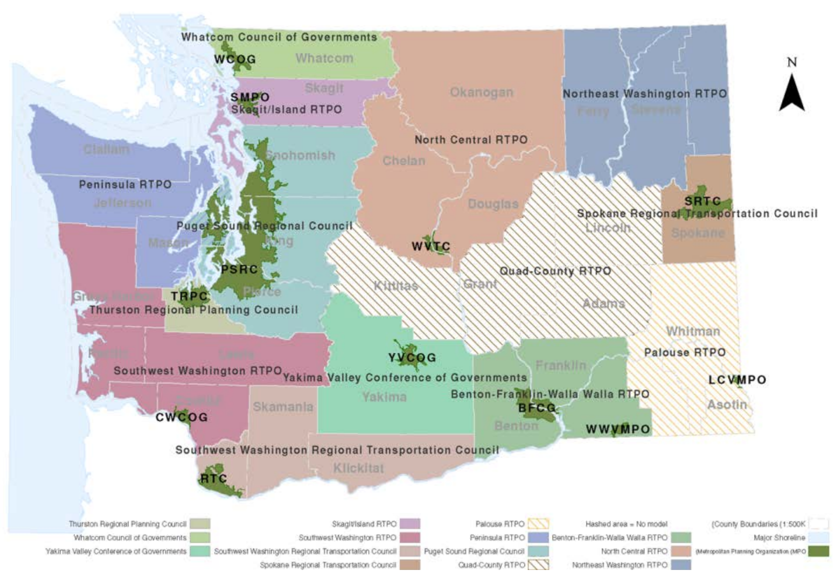
As of the 2010 Census, Washington had a total population of 6,724,540 in approximately 2,620,076 households, providing an average household size of 2.51 for the state. The Bureau of Labor Statistics reports statewide employment at 3,160,000 at the time of the Census.

Washington state's economic output and employment is centered in five major industries: manufacturing (28% of total state economy), wholesale (11% of total statewide economy), construction (5% of total state economy), agriculture (2% of total state economy), and transportation (2% of total state economy). Some of the major industry subsectors include: aerospace manufacturing, fuel refinement, agriculture (apples, milk, wheat, and potatoes), and forestry.[1] Figure 1 provides a map of the planning regions within Washington State.

The Washington Growth Management Act (GMA) (Chapter 36.70A RCW) enacted in 1990, requires that Regional Transportation Planning Organizations (RTPOs) with responsibilities similar to those of Metropolitan Planning Organizations (MPOs) in the federal planning process and allocation of funding, are responsible for growth management related tasks with regard to comprehensive planning, capital investment, and protection of natural lands.

Additionally, the Least Cost Planning (LCP) requirement was enacted in Washington's Regional Transportation Plan legislation (RCW 47.80.030). This law states that, "each regional transportation planning organization shall develop in cooperation with the department of transportation, providers of public transportation and high capacity transportation, ports, and local governments within the region, adopt, and periodically update a regional transportation plan that is based on a least cost planning methodology that identifies the most cost-effective facilities, services, and programs."[2]

Figure 1: Map of Washington Planning Regions



[1] WSDOT. Washington State Freight Mobility Plan. 2014. Available at: http://www.wsdot.wa.gov/NR/rdonlyres/FD4FC83A-098F-4E0D-A570-0727D8B26888/0/WashingtonStateFreightMobilityPlanPublicComment6102014.pdf

[2] Washington State Legislature: RCW 47.80.030 Regional transportation plan — Contents, review, use. Available at: http://apps.leg.wa.gov/rcw/default.aspx?cite=47.80.030

3.2 Washington State Department of Transportation (WSDOT)

WSDOT is charged with constructing, maintaining, and operating the highway, ferry, and other transportation systems throughout the state. WSDOT partners with local agencies to service local roads, rail, airports, and other transportation alternatives. The following bullets summarize the breadth of WSDOT's responsibilities:

- Nearly 20,000 state highway lane-miles;
- more than 3,600 bridge structures, including the four longest floating bridges in the United States;
- 47 safety rest areas;
- 23 ferry vessels active in the largest vehicle-ferry system in the United States and third largest in the world;
- 20 ferry terminals;
- 23 million ferry passengers annually;
- $16.3 billion capital improvement program; and
- More than 6,800 full-time employees.[3]

Washington State has a very diverse array of transportation modes and infrastructure. There are seventeen state-managed airports as illustrated in Figure 2. These airports are not only critical to passenger transportation, but also in the movement of critical goods and resources.

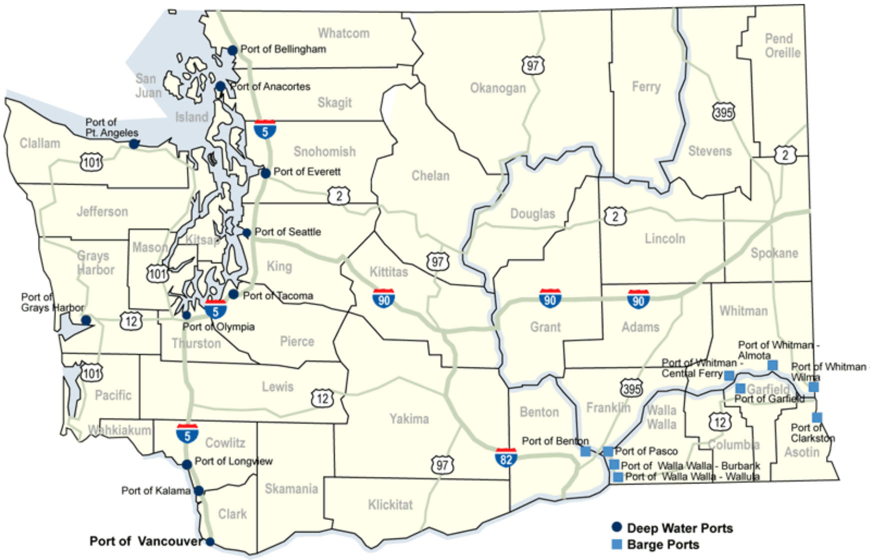
Figure 2: Washington State-Managed Airports[4]

In addition to these valuable air outlets for passenger and commodity transport, Washington state is also home to 11 deep water ports and nine large barge ports. These ports are mapped in Figure 3.

[3] http://www.wsdot.wa.gov/about/

[4] http://www.wsdot.wa.gov/aviation/Airports/

Figure 3: Washington State Ports[5]



Washington State is home to 25 transit systems and the WSDOT Intercity Bus Program, which are integral components of the transportation system. These transit service providers are specified by name and location in the list below.[6]

- Ben Franklin Transit: Benton City, Kennewick, Pasco, Prosser, Richland, West Richland
- Clallam Transit System: Clallam County
- Community Transit: Snohomish County
- C-TRAN: Vancouver, WA
- Everett Transit: City of Everett
- Grant Transit Authority: Grant County
- Grays Harbor Transit: Grays Harbor
- Intercity Transit: Lacey, Olympia, Tumwater
- Island Transit: Whidbey and Camano islands
- Jefferson Transit: Jefferson County
- King County Metro: Seattle/King County
- Kitsap Transit: Bremerton and Kitsap County
- Link Transit: Wenatchee, Chelan County, Douglas County
- Mason Transportation Authority: Mason County
- Pacific Transit: Raymond, Pacific County
- Pierce Transit: Tacoma, Pierce County
- Pullman Transit: Pullman
- River Cities Transit: Kelso and Longview
- Skagit Transit: Skagit County
- Sound Transit:Central Puget Sound Regional Transit Authority

[5] http://www.wsdot.wa.gov/Freight/MarinePortsMap.htm

[6] http://www.wsdot.wa.gov/Transit/TransitSystems.htm

- Spokane Transit: City of Spokane and surrounding communities
- Tri-Met: Vancouver, Portland
- Twin Transit: Centralia, Chehalis
- Valley Transit: Walla Walla
- Whatcom Transportation Authority: Bellingham
- Yakima Transit: Yakima
- WSDOT's Travel Washington Intercity Bus Program:
    - Grape Line: Walla Walla, Touchet, Pasco
    - Dungeness Line: Port Angeles, Edmonds, Seattle
    - Apple Line: Ellensburg, Wenatchee, Omak
    - Gold Line: Kettle Falls, Colville, Chewelah, Deer Park, Spokane

WSDOT's Rail Division manages the Amtrak Cascades intercity passenger rail service, which runs along the Pacific Northwest Rail Corridor. The 467-mile corridor is one of 11 federally-designated rail corridors in the country. In addition, WSDOT currently supports the Cascades High-Speed Rail Program, which is comprised on several projects to enhance existing services between Seattle and Portland.[7]

WSDOT's six policy goals include: safety, preservation, mobility, environment, stewardship, and economic vitality. The DOT collaborates with regional agencies, local jurisdictions, and private contractors to support these goals by organizing and executing projects, as well as managing and allocating resources.

3.1 Broad WSDOT Goals for a Prospective State Model

Washington's Governor, Mr. Jay Inslee, issued an executive order on April 29, 2014, outlining the importance of a statewide model given key policy challenges facing the state. The peer review documented in this report is one of the early steps WSDOT staff members have taken in response to the governor's initiative. The peer review session began with the introductions by Stacy Trussler of the WSDOT Urban Planning Office (UPO) and welcome remarks and policy context by Washington State Secretary of Transportation, Ms. Lynn Peterson. Mr. Shuming Yan, deputy director of the WSDOT UPO presented concept-level purposes to which WSDOT would likely put a statewide model and background information of the State. This section of the report summarizes the WSDOT conceptual thinking about such uses.

WSDOT faces large-scale policy challenges similar to those faced by Departments of Transportation and other transportation agencies across the US. It is concerned with climate change mitigation and adaptation, rapidly-growing goods movement needs, large forecasted growth in both population and the state economy, and an increasingly-constrained funding environment that makes investment scenario evaluation analysis an even more important exercise than in the past. In addition, Washington faces some unique aspects of transportation and land use planning not common among its peer states: the fact that the state has an explicit Growth Management law with attendant regulations and the legal requirement that transportation planning within the state be conducted consistently with LCP principles.

Finally, the Secretary remarked several emerging challenges for transport modeling of which the panelists and WSDOT staff should be aware. The Secretary observed that recent research has illustrated that the market for travel is more nuanced than many state-of-the-practice modeling

[7] http://www.wsdot.wa.gov/rail/

and supporting data-gathering techniques realize. Ms. Peterson cited examples such as the numerous different motivations for commercial vehicle travel within and outside of cities and the emerging awareness of the way traveler gender - among other individual traveler characteristics - differentiates travel behavior.

Ultimately, for the purposes of the panel discussion WSDOT explicitly identified these likely applications for a Washington statewide model:

- Statewide long range multi-modal planning
- Transportation investment scenarios evaluation
- VMT, greenhouse gas, and air quality analyses
- Economic impact analyses
- Coordinate and provide travel demand forecasting across regional boundaries
- Provide travel demand forecasting for regions without a model
- Transportation and land use interaction analyses

3.2 MPO Modeling Examples in Washington State

After the WSDOT introductory remarks about the state, the agency, and conceptual goals for a statewide model, modeling staff from the three largest MPOs in Washington provided brief overviews of their regions and their regional travel demand forecast models. Since the topic of how a state model would best interact with regional models is of key interest to WSDOT, the MPO model overviews are summarized in Table 1. The question of how state models can and should interact with regional models is addressed later in the “Panel Discussion Details” and “Panel Recommendations” sections.

Table 1: WA Regional Model Characteristics

Model Characteristic	PSRC Model	SRTC Model	SW WS RTC
Geography	4 Counties (King, Kitsap, Pierce, Snohomish)	1 County (Spokane)	4 Counties (Clark, WA; Multnomah, OR; Washington, OR; Clackamas, OR)
Population (2010)	3,700,000	479,000	2,200,000
Employment (2010)	1,900,000	210,000	923,000
Model Type/ Functionality	Travel Demand • Trip-based • Activity-based Land Use Air Quality Benefit/Cost	Trip-Based • 4-step Air Quality	Trip-Based • 4-step
Software	INRO/EMME	PTV VISUM	EMME
Traffic Analysis Zones	Internal = 3700 External = 50 Park and Rides = 250	Internal = 519 External = 34 Park and Rides = 12	Internal • WA = 665 • OR = 327 External = 13 (Total = 1007)
Networks	Highway and Transit 2010, 2020, 2040 Programmed/ Un-programmed	2010 Base 2020 Interim 2030 Interim 2040 No-build 2040 Build	Not Available
Time Periods	AM Peak = 6AM – 9AM Midday = 9AM – 3PM PM Peak = 3PM – 6PM Evening = 6PM – 10PM Night = 10PM – 6AM	AM Peak = 7AM – 8AM AM = 6AM – 9AM PM Peak = 5PM – 6PM Midday = 9AM – 3PM PM = 3PM – 6PM Night = 6PM – 6AM	Multi-Class Highway Assignments: • AM/PM 1-Hour • 1-Hour Midday Transit Assignments: • PM Peak 1-Hour • Peak All-Day • Off-Peak All-Day
Modes	Auto: • 11 Classes/ Modes Transit: • Walk-Access • Drive-Access Non-Motorized: • Walk • Bike	Auto: • Drive Alone • Shared Ride Transit: • Walk-Access • Drive-Access Walk/Bike Truck	Drive Alone Drive-with-Passenger Passenger Bus Light Rail Transit (LRT) Bus-LRT Bike & Walk
Trip Purposes	Home-Based (HB) Work • 4 Income Classes HB College HB School (K-12) HB Shop HB Other Non-Home Based (NHB) Work NHB Other	HB Work HB Retail HB School HB Other HB College NHB Commercial	Not Available

4.0 Example State and Large-Scale Models

4.1 Introduction

At the beginning of the Peer Review session, each panelist provided a brief ten-minute presentation of their statewide or large-scale modeling experience at the request of WSDOT. The presentations provided a diverse array of modeling areas, ranging in size from California to Maryland. This section will provide more detail regarding application capabilities and general characteristics of the models presented. Below is a list of these models and their respective agencies.

- Arizona Statewide Travel Demand Model (AZTDM)
- California Statewide Travel Demand Model (CSTDM)
- Maryland Statewide Travel Model (MSTM)
- Oregon Statewide Integrated Model (SWIM)
- RADIUS and Mid-America Freight Coalition (MAFC) Freight Model

4.2 Main Applications of the Example Models

ADOT developed the AZTDM to evaluate the "what if" of current and future scenarios to assist stakeholders in addressing mobility, accessibility, and economic development needs. The model has been used in corridor studies, including the Arizona Passenger Rail Corridor Study (Phoenix to Tucson), the I-11 and Intermountain West Corridor Study, the North-South Freeway and Revenue Analysis, and Arizona's Key Commerce Corridors Study. The model has also been applied in various design concept studies, planning-to-programming project prioritization, forecasts of state highway system volumes, and regional transportation plan development from agencies such as the Central Yavapai Metropolitan Planning Organization, Central Arizona Governments, and three new MPOs (Sun Corridor, Lake Havasu City, and Sierra Vista).

The California Statewide Travel Demand Model is used for long range planning, air quality analysis, and freight movement analysis. One of the primary drivers of the air quality modeling capabilities was the California Energy Commission's (CEC) desire for future fuel projections and fleet projections.

The Oregon Statewide Integrated Model is used to: analyze transportation, land use and the economy in a dynamic, integrated manner. It is used to inform policy and funding decisions and identify potential unintended consequences of changes in infrastructure, services, or regional characteristics. Specific model applications include: the Willamette Valley Forum (2001), evaluating Eastern Oregon Freeway Alternatives (2001), ODOT Economic and Bridge Options Report (2003), Oregon Transportation Plan Analysis (2006), Oregon Freight Plan Analysis (2010), and Economic Impact Analysis Related to a Major Seismic Event (2013).

The RADIUS Model and Mid-America Freight Coalition (MAFC) Freight Model are multi-state models based on the Quick Response System 2 (QRS 2) platform. The former cover two regionally significant corridors that cross state lines: the I-39 corridor from South Beloit, Illinois, to Madison, Wisconsin, and the I-94 corridor from Northern Illinois to Madison, Wisconsin. RADIUS is used for short-term estimation of freeway work zone traffic volumes considering the possibility of diversion using Dynamic Traffic Assignment (DTA). The MAFC model is intended for shipment-level analysis for establishments in the greater Midwest. The Mid-America Freight Coalition (MAFC) Freight Model is a multi-state model that estimates truck movements across the Midwest.

Maryland's key drivers for the development of their statewide model were development of the Statewide Plan and the Smart Green & Growing Initiative. Development of the Statewide Plan requires use of the model for identification of regionally-significant corridors, which involves estimation of passenger travel, rural region travel, and freight travel metrics. The statewide model is used for other long-range planning and investment studies, corridor studies, scenario planning and freight analysis. The MSTM is also being used for the quantitative assessment of adaptation needs, extreme weather scenarios (emergency planning), travel demand management strategies, and reliability analysis.

WSDOT expressed additional interest in how each statewide model was applied to prioritize projects across different modes. Mr. Killough responded that the AZTDM is designed to forecast intercity rail, but the model is not used to compare transit versus highway studies. Mr. Mahapatra stated that the MSTM can conduct system-level studies of corridors that extend beyond MPO boundaries, as it was designed in this manner to model AMTRAK rail, intercity bus services, MARC commuter rail, and commuter bus services.

4.3 Overview of Example Models

Each model was designed with the above-described applications in mind. This section provides additional detail regarding the development processes and general characteristics of the models presented at the Peer Review. Figure 4 presents a map to geographically represent the models that were discussed by WSDOT staff and the expert panel.

Figure 4: Map of Example Models

4.3.1 Arizona Statewide Travel Demand Model (AZTDM)

Arizona's AZTDM is entering into its fourth generation. The first generation of the statewide model was developed in 2009. This version was a three-step model with a coarse highway network and 1,098 TAZs. The model utilized imported trip generation rates and Quick Response Freight Manual (QFRM) Truck Trip Generation. The second generation of the AZTDM was developed in 2011. This version of the model was enhanced to include 6,090 TAZs and a detailed highway network. The model applied National Household Travel Survey (NHTS)-based trip generation rates and trip distribution. A freight model based on Freight Analysis Framework 3 (FAF3) data, a long-distance trip model, and an improved highway assignment process were each incorporated into the second generation of the AZTDM.

The third and current generation of the AZTDM applies a four-step model, including a transit network and assignment. The model includes person mode choice, a TRANSEARCH-based truck freight model, economic impact analysis, and focused regional models for small MPOs. The fourth generation of the AZTDM is in development stages. This model will include NHTS Add-On information, a population geo-synthesis model, an activity-based travel demand model, a dynamic traffic assignment model, and an integrated land use-transportation model.

Mr. Killough noted that the challenges experienced in the Arizona statewide model development effort included computing environments, funding sources, securing appropriate staff, and assembling data, which included NHTS Add-On Samples only for the two largest MPOs, the limited long-distance travel data, and improved traffic count data. It was also noted that purchased freight data may present issues during model validation.

4.3.2 California Statewide Travel Demand Model

The California Statewide Travel Model is a tour and commodity-based model that includes 5,450 TAZs and 103 freight model zones. Caltrans conducted a $12 million household travel survey (HHTS) that prompted 48,000 returns. A GPS add-on was used for quality assessment to this survey effort. Additionally, $80,000 was allocated for open source population synthesis development. MPOs are able to use different population synthesis products with the model. Since Caltrans data do not now include truck classification counts, the department is investigating development of a loop detector add-on that will allow traffic counters to sense vehicle type and produce classification counts. Caltrans is also commissioning a future California version of the Vehicle Inventory and Use Study (VIUS), which has been discontinued by US Census Bureau. Caltrans noted that their main model development challenges resided in data acquisition and development.

WSDOT asked whether the California Statewide Travel Demand Model includes ferry movements. Caltrans responded that the model does not include ferries, although they are considered as part of the abstract transit treatment.

4.3.3 Maryland Statewide Transportation Model (MSTM)

The MSTM is a multi-layer travel demand model that operates at national, statewide, and regional levels to forecast and analyze key measures of transportation system performance. The model was developed to assess travel demand in non-MPO regions; conduct regional what-if scenarios due to land use, network changes based on new projects and facilities, and policy changes both in and around Maryland; intercity transit (commuter rail, intercity bus); assist MPO modeling efforts with “external” inputs; and provide a tool that connects all the available MPO models. Performance measures estimated by the model include the following:

- Vehicle Miles Traveled,
- Vehicle Hours Travel and Delay,
- Persons Hour Travel and Delay,
- Congested Lane Miles,
- Accessibility (auto and transit),
- Connectivity (auto and transit),
- Internal vs. External Trips, and
- Economic Indicators.

MD SHA plans to include dynamic traffic assignment features to model over-saturated conditions, reliability metrics and economic indicators in future model updates.

When developing the MSTM, MD SHA experienced challenges obtaining data from the rural regions and bordering state counties through travel (person and freight), as well as maintaining consistency in data and network assumptions throughout the modeled area. Maryland found that keeping the business case for statewide model development process focused and complimentary and institutionalizing the program for decision-making and staff support also presented challenges to the modeling staff. As Maryland's state-level transportation questions become much more focused on operations, accessibility, reliability, economy, and quality of life, MD SHA had to create a model to meet these demand and sustain its applicability for the planning applications amidst the shifting political environment.

4.3.4 Oregon Statewide Integrated Model

Oregon's model development effort has been ongoing since 1994. Development of the model has been a multi-agency effort led by the Oregon Modeling Steering Committee and implemented through the Oregon Modeling Improvement Program. The Program follows a five-step approach:

1. Resource Acquisition – funding, quality staff, good equipment;
2. Outreach – Oregon Modeling Steering Committee, Peer Review panels, Oregon Modeling User Group;
3. Development – Jointly Estimated Model in R (MPOs), Oregon Small Urban Model framework, Statewide Integrated Model, GreenSTEP, activity-based model;
4. Implementation – developed standards and best practices; and
5. Data Integration – recent household survey, freight data, INRIX, AirSage, Bluetooth.

Getting the statewide model into application as soon as possible was necessary for a successful and effective program. Challenges were not only technical, there were also challenges integrating use of the model into the long range planning process. It was important to demonstrate the value of the analytical tool to the state and local planners. Oregon also noted that it was difficult to locate specific data and expensive to collect the data that the agency did not already obtain. ODOT approached model development from a long term programmatic view, relying on expertise from an international peer panel from model design to model development. Both contributions from internal staff, consultants and the peer panel were required to pool together the resources and knowledge necessary for successful model development and application.

4.3.5 RADIUS and Mid-America Freight Coalition (MAFC) Freight Model

The RADIUS and MAFC Freight Model operates using a Quick Response System II (QRS II) and General Network Editor platform. These are two separate models. The RADIUS covers about ½ the population of Wisconsin in both urban and rural areas. The model applies user equilibrium assignment but includes a choice step to split trips between freeway and possible alternative routes. In this choice step, some drivers never divert, some drives always divert, and some drivers choose whether or not to divert, but there is a bias to the original route. The majority of the model parameters were derived from studies of work zones in Portage, Tomah, and Milwaukee.

The following steps outline the RADIUS development process:

1. Extracted a traffic network from NAVTEQ, keeping just major collectors, arterials and freeway. Performed checks and fixes.
2. Identified all stopped controlled and signalized intersections.
3. Input the correct geometry and timing for these intersections.
    - Three types of signals:
        - Fixed-time
        - Actuated
        - Adaptive
4. Selected time periods for analysis:
    - Weekday AM
    - Weekday (M-R) PM
    - Friday PM
    - Sunday PM
5. Ran the model statically (MPO style) to obtain a seed OD table and directional split information for roads without directional counts.
6. Obtained counts for all roads that have them: TRADAS, VSPOC, ATRs
    - By hour and by time period
    - Split bidirectional counts
    - Some counts trusted more than others.
7. Estimated four dynamic OD (origin-destination) tables.
    - Using whole-table least squares, weighted
    - Each table contains 6 hours of data

The MAFC Freight Model is a microscopic truck demand estimator and assignment model that covers 10 Midwest states. Recent and planned updates to the model include an upgrade from a descriptive model to a planning model and an increase in the number of commodities from five to 27 specific commodities specified by Standard Classification of Transported Goods (SCTG) three-digit codes. The upgrade will also incorporate a multinomial logit tour-choice model, randomized, fixed-shares of empties, randomized commodity "enhancers" to scale up the results to match all trucks, and assignment sensitivity to time, distance, tolls, and hours of service rules, including rest periods.

4.4 Development Costs of Example Models

Recognizing that each agency is unique in the resources and costs associated with the model development process, the panelists offered sketch estimates of the expenses associated with their statewide or large-scale model's development.

4.5 Lessons Learned in Developing and Applying Example Models

During the peer review, the panelists and audience members described many lessons they learned in the course of developing models for other states or for similar geographic scales. These observations can be thought of as strategic issues WSDOT (and others) should be aware of in the course of defining a scope for statewide model development. This section of the report summarizes the lessons learned pertinent to planning for, implementing, and sustaining statewide models or models of similar scale regardless of when the pertinent discussion occurred during the peer review session. The final section of this report uses these lessons plus the detailed discussion documented in the following section as the basis for explicit recommendations to WSDOT on how it should proceed with developing a Washington statewide model.

The panel was in general agreement about the following lessons:

- States have found statewide models to be valuable. A 2006 survey of state DOTs indicated that those with models found them to be worth the investment. Maryland and California agree that their models are useful for transportation decision-making. Oregon in particular has found its model to be invaluable in supporting major investment studies: model results comparing ways to prioritize bridge preservation/replacement investments were instrumental in supporting a successful referendum on bonding the required funds.
- Statewide models can be sensitive to pricing and tolling strategies but not at the level of detail found in regional models.
- Statewide models are generally insensitive to non-pricing Transportation Demand Management (TDM) strategies due to their more aggregate design. States such as Maryland and California typically treat policy and programmatic TDM in separate post-model analysis. Oregon relies on metropolitan models for TDM analysis.
- All models are designed for different purposes. It is very important to align the use of a model within the analytical boundaries inherent in the design. One model cannot answer all questions, so describing the strengths and weaknesses of modeling tools is key to avoiding the appearance of “dueling models

WSDOT questioned if any of the agencies experienced conflicts with MPO model forecasts. Maryland has not yet experienced any conflicts with MPO forecasts as a result of the model’s focus on an aggregated zone structure, careful calibration of the state model, and avoidance of producing air quality estimates or directly comparable forecasts. Arizona explicitly avoids producing competing forecasts and calibrates total VMT and RMS within MPO portions of state model. A panelist suggested that MPOs should include work items in their Unified Planning Work Programs (UPWPs) to coordinate their modeling efforts with those of the statewide model.

5.0 Panel Discussion Details

5.1 WSDOT Questions

The panel discussion was structured by a list of questions WSDOT developed in advance of the review session. Those questions are listed below for easy reference and then appear as headings in the following section as a means of organizing the panel discussion.

- What types of policy analyses can a statewide model perform? Can the analyses be done with other tools?
- What decision process to go through and what tradeoffs should be considered in designing a statewide model?
- How should a statewide model interact with MPO models?
- How to account for economic impacts? What steps should be taken to plan and design the model outputs to inform economic analyses?
- How to account for fuel use, emissions and land use?
- How to account for time of day travel?
- How to treat different modes?
- Specific to truck trips, how to incorporate the routing decisions made by trucking companies in the model?
- What data sources did you use to develop your model? How often do you update the model, including survey data?
- For model development, did you use consultants or in-house model developers?
- What challenges did you overcome in developing your models? If you had a chance to start over again, what would you do differently?

5.2 Panel Responses to WSDOT Questions

The following section provides a summary of the responses that panelists provided to the WSDOT questions, as well as other questions and elements that were incorporated into the peer review discussion.

5.2.1 What types of policy analyses can a statewide model perform? Can the analyses be done with other tools?

Dr. Horowitz remarked that a NCHRP Statewide model survey-based report[8] he authored in 2006 indicates that states use their models for a spectrum of analysis applications. That survey found that 32 states had their own models at that time--with additions since then states with models now number about 40. The state models range from modest ones used for long-range planning and facility planning to sophisticated ones, like the Oregon Statewide Model, which is used for a wider variety of applications.

Maryland's model has been used to support the development of the statewide transportation plan, to study regionally or inter-regionally significant corridors, and to study rural region travel.

[8] Alan J. Horowitz, "Statewide Travel Forecasting Models", National Cooperative Highway Research Program Synthesis #358, 2006.

It produces both passenger and freight travel metrics to support such studies. Maryland has conducted extensive scenario planning analysis to understand the outcomes across various performance metrics. It has also been used recently to study extreme weather scenarios for emergency planning purposes, for example a key roadway put out of service by a storm, to conduct Transportation System Management and reliability analyses, and to support the state's Smart Green & Growing Initiative through climate change adaptation studies.

Arizona uses its model to support the state "Planning to Programming" initiative, a planning process that assesses different possible future investment focus areas in a structured fashion. It is contemplating how to use its model to study means of increasing roadway reliability, especially for freight and goods movement, and is examining recent Strategic Highway Research Plan 2 (SHRP2) reports on reliability techniques that can be used in models.[9]

Oregon's model has been used for a variety of studies. Of particular note was an application testing different staging schedules for dealing with the state's backlog of bridge preservation and replacement needs. The findings indicated that given the distribution of economic activity in the state, the traditional engineering approach for prioritizing the repair of high-volume bridges, was less effective in minimizing negative economic impacts than a strategic repair approach. The model helped Oregon DOT staff devise a staging plan that was later successfully funded by bonds approved in a statewide referendum.

An audience member raised the question of how statewide models do or can handle tourist travel. Mr. Killough responded that the Arizona model's long-distance personal travel component includes tourist destinations such as national parks as special attractions. Mr. MacIvor remarked that estimating tourist travel explicitly is not currently in the California Statewide Model since it is a low priority for the state, which at present has chosen to concentrate on ensuring that its model is useful for examining and comparing future large-scale investment scenarios.

Regarding the question of off-model analysis, Arizona uses the REMI TranSight tool for evaluating the economic effects of changes to the transportation system as reflected in its statewide travel model.

Ms. Knudson recommended that WSDOT prioritize their analysis questions but avoid creating features that constrain future analysis options, for example: hard-coding operating costs. Mr. Killough seconded the importance of prioritizing analysis questions in the development of the model.

Mr. MacIvor noted that budget and agency resources, such as staff and training, will dictate much of the model's development path. He noted that identifying a specific software platform that works for the state modeling team and will be sustainable is critical, but to recognize that models are not the only analysis tool out there and it will be helpful to investigate other options, as well.

Mr. MacIvor also remarked that WSDOT examine easily available data, which may suggest development directions for the state. After identifying the easily available data, it will be helpful

[9] SHRP2 Solutions Modeling Reliability Fact Sheet. Available at: http://shrp2.transportation.org/documents/capacity/SHRP2_C04-C05_Improved_Models_for_Ops_Strategies_Factsheet.pdf

National Academy of Sciences. SHRP 2 Report S2-C04-RW-1: Improving Our Understanding of How Highway Congestion and Pricing Affect Travel Demand. 2013. Available at: http://www.trb.org/Main/Blurbs/168141.aspx

National Academy of Sciences. SHRP 2 Capacity Project C05: Understanding the Contributions of Operations, Technology and Design to Meeting Highway Capacity Needs. 2012. Available at: http://www.trb.org/Main/Blurbs/166939.aspx for WSDOT to generate a data development plan that highlights what data that WSDOT should purchase to fill the holes in the available data.

WSDOT questioned which other methods the panelists would suggest for addressing uncertainty associated with forecasting. Mr. Killough responded that forecast staff needs to be aware of the context in which forecasts are made to judge the validity of upstream forecasts, for example: economic growth and population evolution. Mr. MacIvor offered that sensitivity analysis can be conducted to assess how key inputs and assumptions drive the forecasts results. WSDOT could push the tests to extremes, well beyond politically-acceptable ranges, for the purpose of understanding implications.

5.2.2 What decision process to go through and what tradeoffs should be considered in designing a statewide model?

California started by assessing available budget and existing data, which included a complete data inventory as the second step in its model development process. Both Maryland and Oregon created lists of analysis needs and available data and cross-referenced them to suggest both directions for early model development and data 'holes' that further model development work planning would need to address. Dr. Horowitz recommended building on these ideas by scoping a phase 1 model that can use secondary (existing) data followed by a phase 2 that includes primary data collection in its work plan. Ms. Knudson of Oregon recommended proceeding with model development even if all data is not available, because the model evolution can then scope the data products that need to be developed.

5.2.3 How should a statewide model interact with MPO models?

Mr. Mahapatra responded that cooperation is valuable, for example much of Maryland's statewide data is taken from the MPOs. The statewide and MPO models are seen as complementary in that while state objectives may focus more on network implications, MPO models look other areas like land use and air quality. Long-distance and visitor travel are not at top of the MPO priority list, but these issues could be significant priorities for the state. Mr. Mahapatra suggested that WSDOT communicate the responsibilities for each model, both state and regional, clearly.

Dr. Horowitz noted that a 2006 survey of statewide models indicated that MPOs prefer that statewide models provide external station volumes. However, in Wisconsin, the Milwaukee area is covered by just a few zones due to institutional issues. Therefore, it is critical that WSDOT establish cooperation efforts early in the model development process and recognize that it is not a problem if results differ.

Ms. Knudson remarked that MPOs were partners with ODOT from the beginning of the statewide model's development. The MPOs wanted various types of information from the statewide model, including external station volumes and economic activity estimates that reached beyond scope of their models. The State of Oregon produces official statewide revenue and population forecasts that MPOs and state agencies must use for analysis. Scenario analysis is used to represent ranges of potential futures, such as optimistic and pessimistic versions that produced variations on the revenue and population estimates. These all can be common inputs to both MPO and state models.

Mr. Killough stated that Arizona's MPOs utilize external volumes, but otherwise the MPO models provide more data for the statewide model than interacting with the statewide model directly. Arizona carefully avoids "competing forecasts."

Mr. MacIvor noted that regional transportation planning guidelines were adopted in California two years ago in response to Senate Bill 375. The statewide model is the prime estimator of emissions for MPO models external-to-external trips. Also, internal-to-external trip length is difficult for MPO models, so there is impetus to use the statewide model for more air quality work. This is a work in progress at Caltrans.

Mr. Cervenka questioned if panelists had validated the statewide model 'externals' volumes to counts. Arizona validated the AZTDM at screenlines outside the MPOs. Caltrans plans to validate counts at the externals. Oregon does externals classification counts, as does Maryland. Maryland also noted that they may also use license plate checking for external-to-external trips.

5.2.4 How to account for economic impacts? What steps should be taken to plan and design the model outputs to inform economic analyses?

The SWIM2 model represents the behavior of the land use, economy and transport system in the State of Oregon using a set of connected modules that cover different components of the full system. There are eight modules:

- **ED** – The Economics and Demographics module determines modelwide production activity levels, employment and imports/exports.
- **SPG** – The Synthetic Population Generator module samples household and person demographic attributes (SPG1) and assigns a household to an alpha zone (SPG2).
- **ALD** – The Aggregate Land Development module allocates modelwide land development decisions among study area a-zones considering floorspace prices and vacancy rates.
- **PI** – The Production allocations and Interactions module determines commodity (goods, services, floorspace, labor) quantity & price in all exchange zones to clear markets, including the location of business and households by beta zone.
- **PT** – The Person Travel module generates activity-based person trips for each study area person in the synthetic population, during a typical weekday.
- **CT** – The Commercial Transport module generates mode split for goods movement flows and generates truck trips, combining shipments and possible transshipment locations, for a typical weekday.
- **ET** – The External Transport module generates truck trips from input O-D trip matrices representing import, export (within 75 miles) and through movements based on PI and external station growth rates.
- **TS** – The Transport Supply module assigns vehicle, truck and transit trips (separately) to paths on the congested transport network for a 24-hour period, generating time and distance skims for AM and off-peak periods.

Reporting often relates the differences in state employment and production for alternative policy analysis scenarios. Information is reported by industry sectors, geographic regions and commodity flows.

Dr. Horowitz noted that Oregon's SWIM internalization of the economic forecasting is rare among state models and may be beyond what WSDOT wants to attempt in the first phase of Washington model development. He noted, though, that the Montana statewide model incorporates a simpler economic component in the form of HEAT (a TREDIS forerunner) that seems to work well and might be a more feasible early step for model development.

Maryland takes statewide economic forecasts produced by the University of Maryland as inputs for its land use allocation model component which in turn produces county-level population and employment control totals for the statewide travel model. At this time the economic and land use allocation processes do not take feedback from the travel model. Maryland has also applied the Surface Transportation Efficiency Analysis Model (STEAM) benefit-cost tool to its statewide model outputs for some studies.

Arizona now uses the REMI TranSight tool to estimate economic impacts of scenarios run through the statewide travel model. The Arizona TranSight implementation takes as inputs travel impedance skims and estimates effects on employment, gross state product (GSP), and the relative competitiveness of Arizona to adjacent states. REMI customized Arizona's TranSight to include a household sub model to forecast changes in household characteristics such as income and size. Mechanisms exist to feed the TranSight outputs back to the statewide travel model but Arizona does not generally do so. Mr. Killough remarked that techniques described in the SHRP CO3 and CO11 research could be used in lieu of REMI or TREDIS, and noted that Arizona aspires to fully integrated economic, land use, and transport modeling like that of Oregon.

California estimates economic impacts in a manner similar to that of Arizona since the former's state model does not now do economic forecasting internally. California statewide estimates of transport system investment economic impacts takes inputs from the MPO economic forecasts, runs the state travel model, and feeds state travel model outputs to state economists on staff who run an implementation of the TREDIS tool.

Ms. Barb Ivanov (WSDOT Director of Freight Planning) remarked that Washington has tested a prototype statewide computable general equilibrium (CGE) economic model and found that it is usefully sensitive. Until the new CGE model is fully operational Washington can use an existing REMI model suite to assess economic development strategies.

5.2.5 How to account for fuel use, emissions and land use?

California's statewide model outputs vehicles by speed bin in EMFAC-ready format. Greenhouse gas (GHG) estimation is handled by separate post-model calculation.

In the AZTDM, fuel is a consumption factor. Air quality estimation is conducted through the application of the Motor Vehicle Emission Simulator (MOVES), while land use utilizes population forecasts from the Arizona state demographer. There is no formal requirement for employment forecasts, but the AZTDM uses the ADOT Risk Analysis Process, a Delphi process that includes a consortium of key developers, MPOs and academics.

In the Oregon statewide model, fuel is an input defined through vehicle operating costs. SWIM is not designed to report criteria emissions or GHG.

The MSTM does not do criteria emissions, but uses MOVES for GHG calculation. Land use inputs are a 'cooperative forecast,' developed through the analysis of possible effects of transport scenarios on the population and employment. The state has also experimented with sensitivity testing on fuel price changes.

WSDOT staff noted that Washington State imposed a law on GHG reduction in 1990, implying that GHG estimates will be a critical output of the statewide model. Mr. MacIvor responded that the VMT-GHG relationship is not linear, and furthermore GHG reductions are not coupled one-to-one with VMT reductions. Mr. MacIvor suggested application of the Vision tool to assess GHG scenarios, which uses travel model results as an input.

Mr. Mahapatra noted that Maryland expects large population and employment growth in the future; so the focus is on reducing VMT per capita by applying smart growth strategies. It was also noted that California has evaluated the issue of truck trips generated by denser growth and the effect that this has on already-crowded arterials.

When the panelists were asked if they had conducted lifecycle analysis on GHG, Mr. MacIvor responded that the CEC does look at lifecycle issues.

Mr. Cervenka asked if California was developing a state PECAS model. Mr. MacIvor responded that California's PECAS model incorporation is in stasis. Mr. Killough noted that Arizona is currently assessing expansion of the Maricopa Association of Governments (MAG) Sun Corridor MegaRegion AZ-SMART model to create statewide land use forecasts.

5.2.6 How to account for time-of-day travel?

In the California statewide model, time-of-day is estimated by a separate sub model, which segments demand into five time periods. Arizona uses the diurnal distribution of travel by purpose derived from the 2009 NHTS Add-On Samples collected for the Maricopa Association of Governments and the Pima Association of Governments. The Oregon statewide model currently reports daily patterns, but it is designed to produce four time periods that may be utilized as better data becomes available. Maryland responded that they apply 2002 NHTS data, which precludes highly-detailed time-of-day models, and therefore the model does not have enough information to conduct this type of analysis.

Dr. Horowitz remarked that DTA can be a good method of accounting for time-of-day travel, but it is computationally intensive. One-hour slices would be adequate for statewide model. Dr. Horowitz noted that the MAFC Freight Model estimates departure time as part of shipment synthesis. Maryland is currently looking at half hour DTA time slices. This involves a 16-hour run time, but the process is not yet converging.

It was noted that the advantage of using a destination choice model versus gravity model is that destination choice models have more explanatory variables but these variables do not complicate the process. The gravity model is a special case of destination choice.

5.2.7 How to treat different modes?

In an effort to allocate enough time for high priority topics, mode specifications were not discussed in isolation.

5.2.8 Specific to truck trips, how to incorporate the routing decisions made by trucking companies in the model?

WSDOT defines "routing" as individual truck movements based on truck load. For example, routing would be determined by identifying whether a vehicle is following a fixed pattern or going to different locations every day and whether it is carrying full loads, part loads, or traveling empty. WSDOT clarified that they wanted to know how the panelists modeled trucks in general and how they were able to model route choice. WSDOT noted that truck route choice is important for incorporation in the statewide model because different truck trip types will react differently to toll deployments.

California's statewide model divides truck trips by long distance and short distance. Caltrans borrowed the Calgary structure and data, but they are currently funding their own survey. The California Air Resources Board (CARB) surveyed all trucks coming out of the Port of Los Angeles and the Port of Long Beach. When new data is available, Caltrans plans to examine truck-only strategies using DTA or microsimulation to assess effective capacity gains.

The AZTDM includes long distance truck data, which was first based on FAF data but is now Transearch-based. For commercial non-freight movement, ADOT borrowed MAG's short-haul model but removed the short-haul freight component.

Oregon's SWIM has a tour-based truck model, which starts with estimating economic activity and goods flows and then converts the good flows to trucks and assigns trips using a traveling-salesman algorithm. The SWIM model uses FAF and Oregon Commodity Survey data.

Ms. Knudson noted reasonable confidence in Oregon's economic estimates and, thus, in the accuracy of truck forecasts at certain, broader geographic levels. Caltrans developed a commodity flow model, which also functions reasonably well at a larger, broader scale.

The MSTM borrows a trip-based freight model from the Baltimore Metropolitan Council (BMC) that is validated to counts. MD SHA recently hosted a peer review of the MSTM that recommended a logistics-based approach rather than trip-based approach but noted that the former logistics-based approach continues to rest on a variety of assumptions. MD SHA experienced success in reviewing data to identify commodities that tend to use only one or a limited set of modes, which renders modeling commodity flows easier.

Dr. Horowitz recommended that WSDOT handle only long-distance movements that have reasonable data as the amount and quality of truck movement data available is limited.

Mr. Mysore commented that Florida built a supply chain method based on long-haul characteristics in a seven-step process. The process begins with "freight land use," which supports the estimation of goods moving to the freight land uses. Mr. Mysore suggested that WSDOT focus on long-distance freight trucks in a method similar to Florida. Florida worked with IMS/Global Insight to customize Transearch data by adding 'intelligence' to the data so that Florida could recalibrate the model, which was originally built based on FAF data.

WSDOT questioned capabilities of the long-haul model given the majority of congestion problems are located in the urban areas rather than trunk route segments. Mr. Mysore noted that proper integration of the MPO and state models, for example the state model loads long-haul flows into the MPO externals, will yield an urban tour-based model that handles both long-haul distribution and short-haul (freight and non-freight) estimation. Florida mined the ATRI GPS data to produce an origin-destination table for statewide model calibration.

The panelists warned that ATRI GPS data may include inaccurate origin-destination information and the samples may not be entirely representative; therefore, WSDOT should be very careful if applying this data. The panel also advised that WSDOT plan to spend money developing their understanding of the freight system and its behaviors, recognizing that freight route estimation is still within a "discovery" phase in this field.

5.2.9 What data sources did you use to develop your model? How often do you update the model, including survey data?

Mr. MacIvor stated that lack of data is always a concern for model development. He suggested looking at what are the five most important questions the state has to answer, and then figure out what tool to use to answer these questions. Mr. MacIvor also noted that California has a two-year update cycle. They will be releasing the RFP for a California version of the VIUS in January 2015. Mr. Killough responded that Arizona releases model updates annually. Table 2 summarizes the responses from each of the panelists regarding model data sources.

Table 2: Model Data Sources

Category► Data▼	AZTDM	California SWM	MSTM	Oregon SWM	RADIUS/MAFC Freight Model
Demographic	State Demographer (population forecasts)	Census (PUMS, CTPP) Re-run pop synthesis using recent data	LEHD (employment)	Official state forecast from DAS OEA ES202 (employment)	No response
Travel	2009 NHTS (short-distance passenger travel) 2002 NHTS (long-distance passenger travel) CTPP (ACS journey-to-work) BTS (border-crossing data)	CA Travel Survey (long-distance passenger) Considering NHTS Add-on (long distance)	NHTS 2002 (long distance passenger) ACS (journey-to-work) Will use NHTS in 2015 (rural regions) 2007 HHTS from Baltimore/ Washington	HHTS, NHTS, ACS/CTPP,	No response
Highway/ Transit Networks	Engineering shapefiles GTFS ("abstracted transit") Counts	Network updates from MPOs	INRIX (speed)	Moving to GTFS network (not yet considered future networks)	Radius used network and speeds from NAVTEQ (saved development time) Counts
Land Use	None	No response	Cooperative Land Use Forecast	Real Estate Model Outputs in Portland County (zoning) City/MPO Parcel Data	No response

Category▶ Data▼	AZTDM	California SWM	MSTM	Oregon SWM	RADIUS/MAFC Freight Model
Freight	FAF and Transearch	Want to establish truck classification count program	FAF (freight) FHWA data (truck counts/ speeds)	FAF, Oregon Commodity Flow Surveys	MAFC used Dun and Bradstreet

WSDOT asked the panelists what investments their agency made for primary data development for or in cooperation with their MPOs. California's "CA VIUS" effort will coordinate with MPOs, and they also have a prospective truck count program. Arizona uses continuous count locations. The number of count locations has been expanded from 80 to 180 over last five years. The state of Maryland maintains road network centerline data and statewide traffic counts. They are examining a routable centerline network for the entire state and have an Open Data Hub initiative that is now underway at the state level.

Prof. Cynthia Chen of University of Washington observed that HHTSs are increasingly under-representative of the population, even when designed to be representative. Prof. Chen also noted that HHTSs are often costly, question-heavy, and untimely with regard to policy analysis, as the data is often outdated by time of use. Prof. Chen suggested that WSDOT consider a rolling survey approach, like the ACS, as this method enables more customized add-ons. Prof. Chen also suggested a modular instrument design that differentiates between core and optional questions to standardize and minimize questions.

It was also noted that WSDOT should be aware that both a full and random sample are not necessary to estimate all the models in a typical ABM. Household location choice may provide better estimates on a different sample than a typical HHTS. It was suggested that WSDOT assess passively collected data, such as AirSage, transit card, and Bluetooth information, while noting that this type of data is variable-sparse, noisy, and still relatively unknown.

5.2.10 For model development, did you use consultants or in-house model developers?

One panelist noted that private-sector or university-based consultants bring both strengths and weaknesses for model development efforts. Academic consultants provide helpful creativity and insight but also present risks to the project schedule. Post-doctoral and student staff may move on despite the project timeframe, which can result in quality issues as the appropriate 'project memory' is no longer there. On the positive side, consultants can be helpful in their ability to honestly critique model inputs and functionality, and private-sector consultants can cost-effectively deliver a great deal of work on schedule when properly scoped and directed.

The panelists added that it can be useful to have consultants execute a preliminary needs assessment and model planning exercise, the product of which is a model development work plan. California spent about $150,000 in total for such an effort that included outreach to senior agency management, an existing data inventory, model development planning, and data development planning. Oregon funded a similar effort to launch development of its model, as it does for all its planning efforts, and noted that the work plan product can be structured in a prioritized fashion so that as funding becomes available the highest-priority tasks within the budget form the de facto project scope. Ms. Knudson also remarked that $150,000 for such an effort would "do a good job." Maryland commissioned a smaller-scale model planning exercise for less than $50,000 and found it to be useful. While Arizona DOT did not commission a model planning effort, Mr. Killough did so while at the Southern California Association of Governments (SCAG) for the sum of $75,000 for planning a land use model component and the same amount to plan for an activity-based model component.

5.2.11 What challenges did you overcome in developing your models? (Modified by the facilitator during the review to be: If you had a chance to start over again, what would you do differently?)

Maryland began development of the MSTM with coordination with the MPOs, similar to the one being held by WSDOT. MD SHA established a structured cooperation process up front. Mr. Mahapatra suggested that WSDOT address foundation data, for example a routable network, early in the model development process. Mr. Mahapatra also suggested that WSDOT assess multi-resolution possibilities early on in the model development process. Mr. Mahapatra warned that "statistics are no substitute for judgment" (quoting Henry Clay), implying that WSDOT should carefully assess all input and output for reasonability. It was also suggested that WSDOT involve their intended end-user group with hands-on involvement opportunities in the early stages of model development.

Dr. Horowitz responded that the major challenges experienced in the development of both the RADIUS & MAFC Freight Models were the need for more time, more budget, and a bigger computer.

Ms. Knudson recommended that WSDOT start simple with their model development process and proceed incrementally, avoiding the "black box." Ms. Knudson stressed WSDOT should figure out how to communicate results of the model and establish buy-in from local and state planners with understandable results as soon as they are able, as well as manage end-user expectations of the modelling analysis. Lastly, Ms. Knudson recommended that WSDOT treat consultants and in-house staff members as one team.

Mr. Killough seconded comments from the preceding three panelists, particularly consultant-staff integration and encouraging coordination amongst all parties involved in the model development process.

Mr. MacIvor reiterated the importance of managing expectations, especially among management. He noted that formal training on the model may be helpful in this sense. Mr. MacIvor also suggested that WSDOT consider having an external review to simplify some model components. Additional recommendations included establishing a solid state storage for speed and cost, to quality check all data prior to utilizing it for the model, and to simplify the model in the initial stages with the knowledge that WSDOT can add additional functionality to the model once it has the basics done right. Mr. MacIvor advised that WSDOT understand when they are reaching the point of diminishing returns on investment with regard to data and to ensure that they communicate the model's availability and capabilities clearly to all potential users.

Mr. Cervenka identified the following goals for WSDOT to incorporate into their model development: taking on only what they could handle, think simple and smart, produce useful results early, for example accessibility analysis or congestion analysis, and to be honest with management regarding uncertainties in the forecasts.

6.0 Panel Recommendations

6.1 Organization of Recommendations

To summarize the panel's comments in the form of recommendations for WSDOT's statewide model development process, this section will discuss the following topics for consideration:

- Model Development Cost
- Model Development Process Recommendations;
- Model Structure and Features Recommendations;
- Data Development Recommendations; and
- Next Steps.

6.2 Model Development Cost

The panel was given several funding scenarios including $500,000, $1 million, $2 million, $3 million, and $5 million or more, for developing a statewide model. The panelist identified $1 million as a good starting figure for a planning-level model to meet various policy and investment scenario analysis needs while also meeting substantive validation requirements. With this budget the model could include: a solid highway component and a transit network focusing on high capacity, intercity passenger travel. It was also noted that this $1 million estimate did not include data acquisition and also that $1 million be added to for the incorporation of a full truck component.

6.3 Model Development Process Recommendations

The panelists agreed that the first step in the model development process is creation of a list of statewide analytical needs and prioritization of this list based on which needs are immediate versus those that can be incorporated further down the line. Secondly, the panelists recommended that WSDOT identify a specific budget, schedule, and staff for the model development effort.

Oregon noted currently one FTE is dedicated to statewide model development and application. Ms. Knudson noted that this level of staff support is insufficient; indicating that staff budgeting might need to be higher than WSDOT currently anticipates.

Once budget, schedule, and staff have been clearly identified by WSDOT, the panelists suggested that WSDOT conduct a complete data inventory to identify all available data for application in the model and then to cross reference the available data to the identified analysis needs. After reviewing what data is available in relation to potential modeling needs, WSDOT can scope model development in phases relating to existing data and secondary data.

One panelist recommended that the initial phase of the model only take into account existing data sources, and then a second phase of the model incorporate secondary data. Another panelist suggested that WSDOT proceed with the initial model development without all of the necessary data but scope the data projects needed into the process.

The panelists agreed that properly phasing the model development process would be imperative to building a successful and logical statewide model. WSDOT should focus on the basic components of the model first, and then incrementally approach model advancements based on statewide priorities. It was noted that the state model should focus on creating a routable highway network that can assess 'high-level,' larger-scale movements, including intercity traffic. Hiring a consultant to execute a preliminary needs assessment and model planning exercise was also suggested.

The panelists also reiterated the importance that WSDOT identifies the following aspects of the model at the beginning of the model development process keeping the budget, schedule, and resources close in mind: software platform, resolution, and user expectations. Panelists agreed that managing expectations from statewide and regional planners will be critical to ensuring usable model results for all stakeholders.

Panelists also emphasized the importance of coordination with MPOs in the model development process. MPOs often rely on statewide models for external trip information. Additionally, MPO and statewide models often collaborate on land use and economic data projections. Maintaining communication with regional agencies will be critical in this process.

Finally, panelists noted the importance of recognizing the return on investment in model processes. Prior to incorporating more modules or functions to their model, the agency should first consider what they will get from these model modifications and if these adjustments are worth their cost. It was noted that simplicity is key in large-scale models, as is maintaining reasonable expectations and understanding the aspect of uncertainty in all forecasts.

6.4 Model Structure and Features Recommendations

The panelists recommend that model structure and features directly reflect the needs of the state in relation to available data and resources of the agency. Therefore, the panel emphasized the importance of the development of a routable highway network. Once this network is in place, WSDOT can expand their model scope. The following bullets describe the specific modeling recommendations:

- Model Structure: When WSDOT questioned whether it would be logical to work with a state with a good statewide model from which they could borrow the structure and adjust the inputs to reflect the state of Washington, it was noted that Maryland attempted to borrow a mode choice structure from another model and it did not produce a successful outcome. The borrowed model approach has limitations.
- Coordination with MPO Modeling: The panelists highlighted the importance of maintaining consistent demographic and employment data inputs with those used in MPO and regional models. The panelists also suggested that transit representation within urban areas be sketchy to avoid duplication of effort with MPO models.
- Cross-state and Border Modeling Issues: The panel recommended that WSDOT address all 48 states, Canada, and Mexico in the statewide model. It was recommended that WSDOT consider examining international externals due to its coastal location. The panel also noted that a “halo” of out-of-state zones can be used for the passenger component of long distance travel.
- Economic Modeling: The panelists suggested the use of REMI, TREDIS, SHRP2 C11 tools, or similar existing tools until WSDOT’s CGE model is operational.
- Air Quality Modeling: The panel recommended that the State leave this responsibility for MPOs to avoid duplication of effort.
- Land Use Modeling: The panelists recognized that land use modeling is challenging on the statewide level. It was suggested that population and employment cooperative forecasts be considered particularly as multiregional efforts that utilize data available at the regional level.

- Time-of-Day Modeling: The panelists suggested that time-of-day modeling may be further down the line in model development phasing and may require extensive data at the household level. It was noted that DTA could be another option to achieve time-of-day forecasts, but the process is computationally intensive.

Panelists stressed the importance of testing the model's sensitivity, particularly for extreme scenarios, in the development process to assess how critical assumptions drive forecast results.

6.5 Data Development Recommendations

Many existing data from national sources and the data collected by other states and MPOs within the state can be used to develop the initial version of the WSDOT statewide model. As identified in Section 6.2, the panelists recommended that WSDOT conduct an all-inclusive data assessment to determine what data is readily available to WSDOT, and from there the agency can identify any data gaps for potential further investment.

For highway side data, panelists recommended that WSDOT review all existing counts, for example the HPMS source counts, Automatic Traffic Recorders (ATRs), spot counts, and project counts, and prepare the budget to clean count data.

Mr. Cervenka of the Federal Transit Administration (FTA) recommended the use of the FHWA HERE data, a purchased national data set of roadway travel speeds based on probe vehicles,[10] for problem identification analysis, accessibility analysis, and model calibration/validation. Mr. Mahapatra suggested that WSDOT investigate the potential use of commercial data products such as the origin-destination tables available from cell phone providers.

Panelists suggested that long distance behavioral data would pose a challenge both in data and in trip distribution, but to look at existing HHTSs and possibly high speed rail studies for more information. If WSDOT would like to implement a HHTS, it was suggested that a rolling approach to conducting a HHTS may be appropriate for WSDOT, given this type of survey would allow WSDOT to create customized add-ons and prioritize the questionnaire. A household location choice survey was also recognized as a possibility for WSDOT application. It was determined that the initial statewide model can be developed without conducting surveys, but local surveys could be conducted later in the model development process.

Panelists identified passive data sources, like AirSage, transit card, Bluetooth, and other data sources for review for applicability. These sources may often be noisy and difficult to tell a story with, but they may provide useful data outlets once reviewed.

6.6 Next Steps

WSDOT should next identify and prioritize their agency needs related to statewide policy analysis. WSDOT should also identify a target budget, schedule, and resources for the statewide model, with a separate resource list for data. Using this information, WSDOT can develop the model in phases accordingly. A small, upfront consultant contract to design a blueprint for statewide model has proven successful for various states and was recommended as a possibility for WSDOT.

Sustained executive management support will be critical to the statewide model's success. Staff should be honest with management about what can be accomplished with a statewide model. MPO and regional transportation organizations should be involved throughout the entire model

[10] See http://ops.fhwa.dot.gov/freight/freight_analysis/perform_meas/

development process, as should state forces, consultants and universities and research institutions, as appropriate. State force needs to be involved every step of the way to ensure clear understanding of the model construct for ongoing model applications and continuous model improvements.

Appendix A 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.

A.1 Peer Review Panel Members

Panel Member	Affiliation
Alan Horowitz	University of Wisconsin-Milwaukee (UWM)
Becky Knudson	Oregon Department of Transportation (ODOT)
Doug MacIvor	California Department of Transportation (Caltrans)
Keith Killough	Arizona Department of Transportation (ADOT)
Subrat Mahapatra	Maryland State Highway Administration (MD-SHA)
Ken Cervenka	Federal Transit Administration (FTA)
Vidya Mysore	Federal Highway Administration (FHWA)

A.2 Local Agency and Partner Agency Staff

Name	Affiliation
Lynn Peterson	Washington State Department of Transportation
Amy Scarton	Washington State Department of Transportation
Stacy Trussler	Washington State Department of Transportation
Shuming Yan	Washington State Department of Transportation
Natarajan "Jana" Janarthanan	Washington State Department of Transportation
Chris Johnson	Puget Sound Regional Council
Ryan Steward	Spokane RTC
Shinwon Kim	Vancouver RTC

A.3 TMIP Peer Review Support Staff

Name	Affiliation
Jeff Frkonja	RSG

Appendix B Peer Review Panel Meeting Agenda

This section contains the agenda of the peer review.

July 1, 2014

8:30 am - 8:35 am	Welcome and Introduction (Amy Scarton)
8:35 am - 8:45 am	Opening Remarks (Lynn Peterson)
8:45 am - 9:00 am	Overview of Modeling in Washington State and Major MPOs • WA Transportation factsheet (Shuming Yan) • Modeling overview at three major MPOs Puget Sound Regional Council (Billy Charlton) Spokane RTC (Ryan Steward) Vancouver RTC (Shinwon Kim)
9:00 am - 9:45 am	Panel Presentations (Panel Members)
9:45 am - 2:45 pm	Facilitated Panel Discussion (All)
2:45 pm - 3:00 pm	Break
3:00 pm – 4:50 pm	Focused Panel Discussion and Recommendation (Panel Members)
4:50 pm - 5:00 pm	Closing Remarks (Amy Scarton)
5:00 pm	Adjourn

Appendix C Peer Review Panel Biographies

C.1 Alan Horowitz, University of Wisconsin-Milwaukee

Alan J. Horowitz is a transportation engineer and an urban planner. His research spans the areas of travel forecasting and traffic impacts. Since coming to the UWM in January 1979, Professor Horowitz has been continuing his research into values of travel time, and conducting new research about urban trip tours, land-use impact assessment, single-route ridership forecasting, trip assignment, subarea focusing, ride quality of highways, intermodal passenger transfer facilities, transportation benefits, freight planning, applications of GIS to transportation networks, hazardous materials routing, intelligent transportation systems, and travel forecasting. Dr. Horowitz is the author of the Quick Response System II travel forecasting software platform.

C.2 Keith Killough, Arizona Department of Transportation

Keith Killough, a native of Detroit, Michigan, is an Urban Planning graduate of the Massachusetts Institute of Technology and holds certification from the American Institute of Certified Planners. Mr. Killough is a member of several Transportation Research Board committees including the second Strategic Highway Research Program's Technical Coordinating Committee on Capacity, the Intercity Passenger Travel Policy Study Committee, and various standing and research committees. He has been the transit industry representative to the Federal Highway Administration's Travel Model Improvement Program that provided oversight to the Los Alamos National Laboratory's TRANSIMS model development project. Mr. Killough has held positions with public agencies in Boston, Detroit, Los Angeles, and Phoenix; and with consulting firms in Washington, D.C. and Los Angeles. Mr. Killough has been Deputy Executive Officer for Countywide Planning with the Los Angeles County Metropolitan Transportation Authority, where he was instrumental in the planning and implementation of the Metro Red Line Subway and the Metro Rapid Bus projects; and Technical Services Director for the Southern California Association of Governments. He is currently Director for Transportation Systems Analysis in the Multimodal Planning Division of the Arizona Department of Transportation where he is responsible for statewide traffic monitoring, travel demand modeling, geographic information systems, and air quality planning.

C.3 Becky Knudson, Oregon Department of Transportation

Becky Knudson is a senior transportation economist for the Oregon Department of Transportation. Her responsibilities range 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, and facilitates the Oregon Modeling Steering Committee and is the program manager for the Transportation Land Use Modeling Improvement Project which conducts work on the Oregon Statewide Integrated Model (SWIM). Her primary technical duties involve analysis using the Oregon Statewide Integrated Model (SWIM). Most recent studies using the Oregon SWIM include:

"Economic Impact Analysis related to a Major Seismic Event for the Cascadia Subduction Zone" 2013, which was presented at the 2014 TRB annual meeting. http://www.oregon.gov/ODOT/TD/TP/docs/Statewide/TRB_Paper_14_3017_revised.pdf

"Oregon State Highway Performance Data and Metrics Related to Freight" 2013 http://www.oregon.gov/ODOT/TD/TP/docs/Reports/FreightCorridorMetrics_RC_3.13.13.pdf

"Oregon Freight Plan Modeling Analysis" 2010
http://www.oregon.gov/ODOT/TD/TP/docs/ofp/ofpmodelingmemo.pdf

Becky was the project manager of the statewide Oregon Household Activity/Travel Survey 2009-2011, which collected data to be used for statewide and urban model development activity. She has a Master's degree in Economics from Oregon State University and has been with ODOT for 17 years.

C.4 Doug MacIvor, California Department of Transportation

Currently chief of Macro, Meso, Micro Freight Modeling and Data, Doug MacIvor has 34 years year of experience working at Caltrans. Mr. MacIvor has 29 years of long range planning studies, traffic and travel studies, and capital outlay support. He is a member of the TRB Freight Data Committee, and has participated in five NCFRP Panels regarding freight movement issues. Mr. MacIvor is presently in charge of the California Statewide travel demand model, California Statewide Freight Forecasting Model (commodity based), and multiple data projects that relate to these models. He is also currently leading a three-agency effort involving Caltrans, the California Energy Commission, and the Air Resources Board to develop a California Based VIUS.

C.5 Subrat Mahapatra, Maryland State Highway Administration

Mr. Subrat Mahapatra is a Transportation Engineering Manager in the Office of Planning and Preliminary Engineering at the Maryland State Highway Administration. He is the project manager for the Maryland Statewide Transportation Model program. He provides analytical and program support for various travel modeling and traffic analysis initiatives at his agency and the Maryland Department of Transportation. Mr. Mahapatra leads several mobility and reliability performance measurement efforts at SHA including the Maryland State Highway Mobility Report and Reliability Roadmap. He also oversees the SHRP2 Capacity and Reliability Products Implementation at the agency. He works closely with the MPOs, other federal and state agencies, local governments and the university research community to develop analytical engines to support coordinated transportation programs and solutions for performance based planning and data driven decision-making. He serves on multiple NCHRP and SHRP2 research panels at the TRB. He has a Master's degree in Civil Engineering from the University of Maryland at College Park and has over 12 years of professional work experience.

C.6 Ken Cervenka, Federal Transit Administration

Mr. Ken Cervenka is a Community Planner at the FTA. Ken Cervenka has worked at the FTA since 2007. His mayor responsibilities include technical assistance to MPOs, transit providers, and other agencies interested in preparing transit rider "on-board" surveys and transit ridership forecasts. For forecasts submitted by project sponsors in support of New Starts and Small Starts projects, his responsibilities include a formal assessment of the plausibility of those forecasts for use in FTA's project evaluation process. Prior to joining FTA, Ken worked as the travel forecasting manager at the North Central Texas Council of Governments, the MPO for the Dallas-Fort Worth area.

C.7 Vidya Mysore, Federal Highway Administration

Mr. Vidya Mysore is a Freight Analysis and Modeling Specialist for the FHWA. Mr. Mysore has over 25 years of experience in travel modeling and joined FHWA in 2013. Mr. Mysore has experience in freight transportation modeling and planning, operations, engineering, economics, and land use, trade, and transportation logistics to create fact-based, forward-looking Freight

Technical Solutions at all levels of government. He is nationally recognized as a modeling, freight forecasting, and analytical expert. Mr. Mysore has a strong understanding of federal, state, and local level policy procedures and works with transportation professionals to build strong Freight Planning, Management and Operations programs. Mr. Mysore is currently a panel member for NCFRP Project-44, Factors Influencing Freight Modal Shift, and an advisory board member for the Tier 1 University Transportation Center at the Georgia Institute of Technology. Mr. Mysore is also leading SHRP2 C20 (Freight Data and Model Innovation) Implementation Plan support and guiding the development of FAF 4.0 and beyond.

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