Baltimore Metropolitan Council (BMC)

Activity-Based Travel Model Peer Review Report

Report Date: April 2014

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U.S. Department of Transportation
Federal Highway Administration

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1.0 Introduction

1.1 Disclaimer

The views expressed in this document do not represent the opinions of 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 Baltimore Metropolitan Council (BMC). The BMC provides technical assistance and staff support to Baltimore Regional Transportation Board (BRTB), the federally designated Metropolitan Planning Organization (MPO) for the Baltimore region.

1.2 Acknowledgements

The FHWA wishes to acknowledge and thank the peer review panel members for volunteering their time to participate in the peer review of the BMC travel demand forecast model (TDFM) and for sharing their valuable experience.

The peer review panel members were:

- Ken Cervenka - Federal Transit Administration (FTA),
- Brian Gardner - Federal Highway Administration (FHWA),
- Ram Pendyala - Arizona State University,
- Erik Sabina - Colorado DOT (CDOT),
- Peter Vovsha - Parsons Brinckerhoff Consult (PB Consult),
- Kermit Wies - Chicago Metropolitan Agency for Planning (CMAP), and
- Lei Zhang - University of Maryland, College Park.

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

1.3 Report Purpose

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

The objective of the current TMIP peer review was to seek guidance and recommendations on the following features of the BMC's activity-based travel demand model, which is currently under development:

- The sufficiency of the model framework, structure, and methodology to address identified regional policies of interest, and
- The model validation criteria, targets, and sensitivity testing.

The peer review panel spent one day (12/06/2013) responding to specific questions from BMC and its planning partners. The results of those discussions and recommendations from the panel are presented in this report.

1.4 Report Organization

This report is organized into the following sections:

- *Overview of BRTB* – this section gives an introduction to the demographics, land use and transportation characteristics of the region, and *BRTB*'s planning responsibilities.
- *Development of the Baltimore Region Transportation Model* – this section provides a historical context of travel modeling at BMC, the agency's current model improvement program, and their goals for the peer review.
- *Regional Transporation Model Improvement Plan* – this section covers an assessment of BMC's model enhancement needs, analytical needs for an ABM model, and data collection plan.
- *BMC's activity-based model structure* – this section covers an overview of the proposed ABM model structure.
- *Peer review panel recommendations* – this section provides the peer review panel's recommendations to BMC.

In addition, the report includes four 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
- *Appendix D* – panel's presentation on findings and recommendations

2.0 Baltimore Regional Transportation Board Overview

2.1 BRTB Responsibilities

The Baltimore Regional Transportation Board (BRTB) is the federally designated Metropolitan Planning Organization (MPO) for the cities of Annapolis and Baltimore, and the counties of Anne Arundel, Baltimore, Carroll, Harford, and Howard (see Figure 2-1). The agency is responsible for transportation planning and policy in the region. Specifically, the agency provides policy direction and oversight in the development of a federally mandated Long Range Transportation Plan (Plan It 2035, a copy of the Plan is available here: http://www.baltometro.org/plans/final-plan-it-2035-2), Short Range Plan (2014-2017 STIP/TIP, a draft list of the projects by jurisdiction is available here: http://www.baltometro.org/plans/transportation-improvement-program-2014-2017), and the transportation component of the State Air Quality Implementation Plan. In addition, BRTB manages the Unified Planning Work Program (UPWP), which provides a list of transportation-related tasks and studies to be undertaken in the region over a period of one year. The Baltimore Metropolitan Council (BMC) provides technical assistance and staff support to the MPO policy board. For instance, BMC is responsible for maintaining the transportation model for the Baltimore planning region.

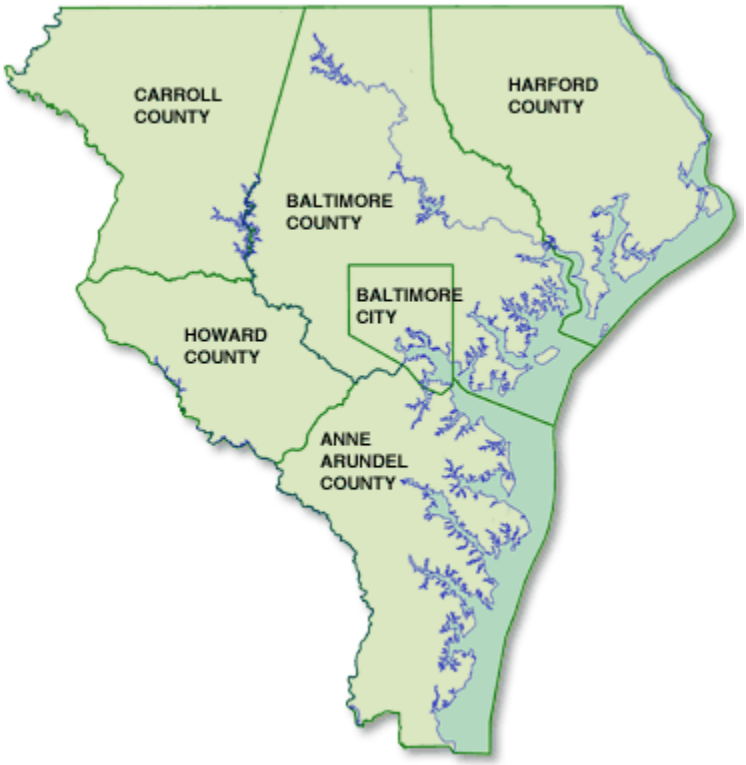

Figure 2-1: Baltimore Regional Transportation Board (BRTB) MPO Area (source: Baltimore Metropolitan Council website, available at: http://www.baltometro.org/about-the-region/map)

2.2 Regional Characteristics

The current (2010) population, number of households, and employment in the Baltimore region are over 2.6 million, 1 million, and 1.5 million, respectively (source: BMC's presentation to the peer review panel). In the next 30 years, these numbers are expected to rise by 14%, 17%, and 26%, respectively (see Figure 2-2). In addition, historic data shows a positive growth in the 65+ population age group (see Table 2-1). Further, average household size in the region has decreased, and 1- and 2-person households have increased over the years.[1]

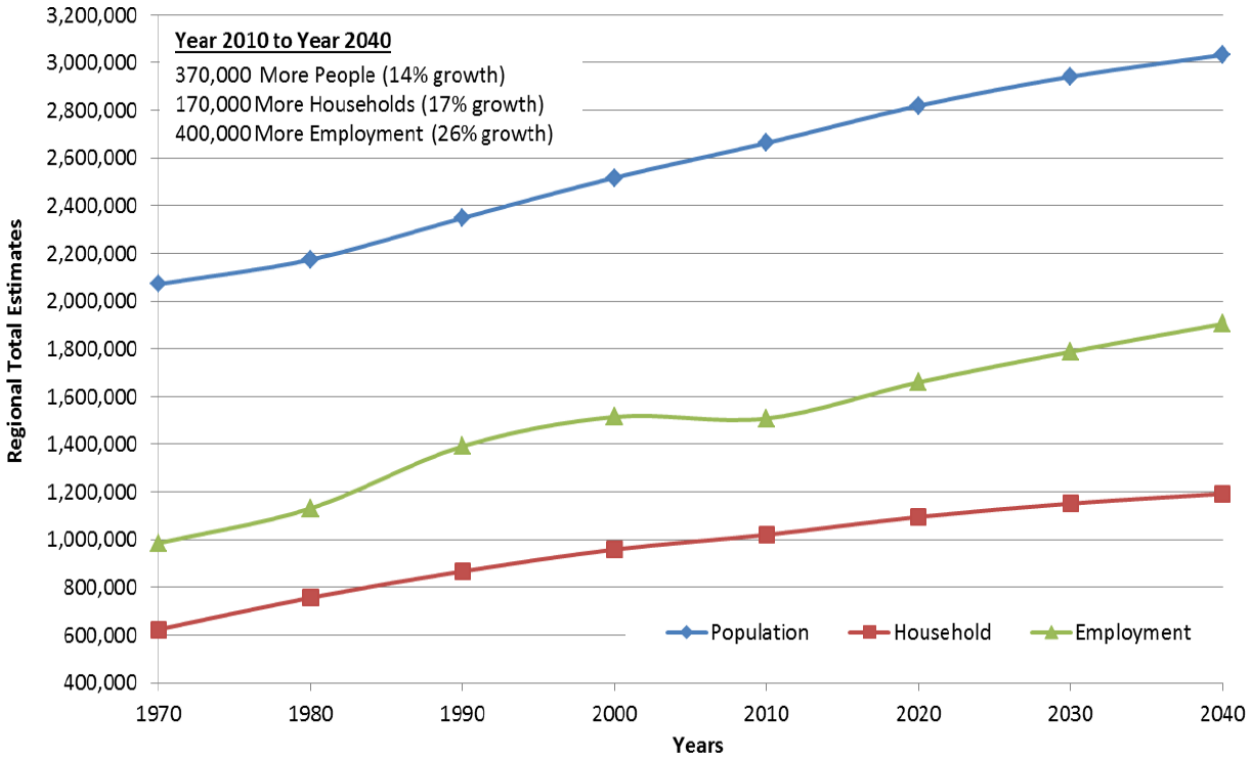

Figure 2-2: Historical Growth and Projection in Households, Population, and Employment (reproduced from BMC's peer review panel presentation)

Table 2-1: Population Age Distribution in Baltimore MPO Area (source: 1980, 1990, and 2000 Census and 2009 American Community Survey)

Age	1980	1990	2000	2009
0-4	6.3%	7.6%	6.5%	6.5%
5-19	24.5%	19.4%	21.4%	19.6%
20-44	38.4%	42.2%	37.0%	34.4%
45-64	20.7%	19.1%	23.0%	27.1%
65+	10.1%	11.6%	12.0%	12.4%

[1] Source: Critical Issues and Challenges in the 21st Century. The report is published by the BMC and is available at: http://www.baltometro.org/PlanIt2035/planit2035ch2pt1.pdf.

There are also substantial inter-regional interactions in terms of where people live and work (see Figure 2-3). For example, the number of workers who live in the City of Baltimore but work in Washington D.C. has risen from about 115,000 to 130,000 workers between 2000 and 2010. Over the same period, the reverse flow of workers (i.e., workers who live in Washington D.C. but work in Baltimore) has increased from about 45,000 to 60,000 (source: BMC's presentation to the peer review panel).

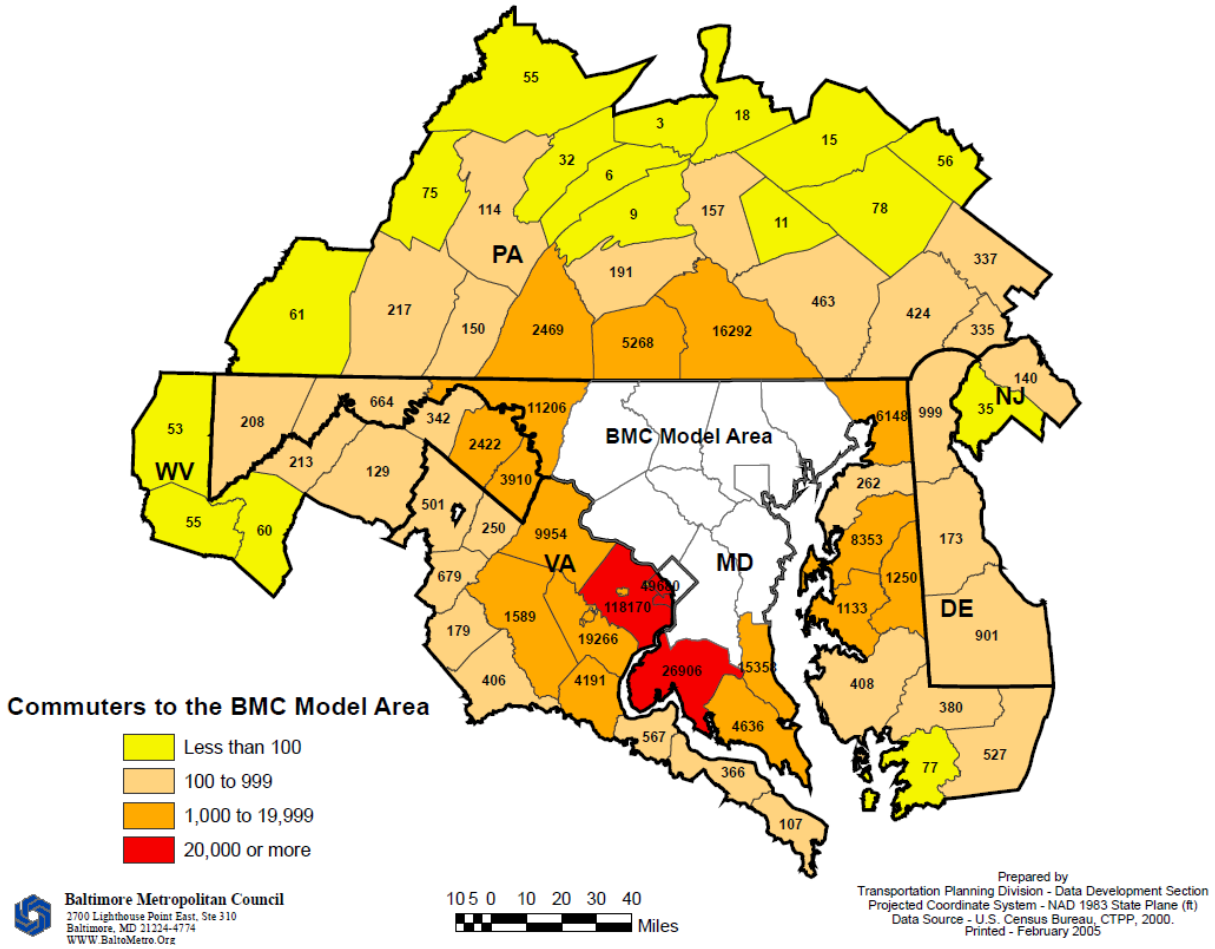

Figure 2-3: Commuters to Baltimore Model Area (data source: U.S. Census Bureau, CTPP 2000. The figure is available at: http://www.baltometro.org/images/stories/BMC_CommuteShed.pdf)

In addition, the region faces a number of environmental challenges such as established statewide goals for greenhouse gas reduction and protection of the Chesapeake Bay Critical Area. A portion of the Chesapeake Bay falls within the jurisdiction of Baltimore City, Anne Arundel County, Baltimore County, and Harford County. Thus, any land use and transportation planning in these jurisdictions must protect the quality of the Bay. When considering freight, the region is expecting significant changes in cargo movements at the Port of Baltimore and in freight movements across the study area due to the Panama Canal Expansion Project, which is

expected to double the capacity of the Canal by 2015[2]. The Port of Baltimore is one of the two ports on the East Coast that are ready to efficiently handle super-sized ships that are expected to use the Canal once the project is complete.

In 2013, the state of Maryland raised the motor fuel tax by 3.5 cents. Maryland fuel tax will be adjusted annually to reflect the Consumer Price Index in the future. The action addresses the depletion of the State's Transportation Trust Fund. The increase in the trust fund will allow Maryland Departpemnt of Transportaion (MDOT) to implement needed transportation projects.

It is clear from the above discussion that the Baltimore region is currently facing a number of challenges that can be adequately addressed only by advanced modeling tools. In the next two chapters, existing travel demand model for the region, its limitations, and the agency's plan to improve available modeling tools are discussed.

[2] Source: "Panama Canal Expansion Study" Phase I Report: Development in Trade and National and Global Economies, November 2013. The report is available here: http://www.marad.dot.gov/documents/Panama_Canal_Phase_I_Report_-_20Nov2013.pdf

3.0 Development of the Baltimore Region Transportation Model

3.1 Introduction

This section of the report provides an overview of the existing BMC transportation model, including a brief description of the current version of the model, the latest enhancements made to the model, and limitations of the model. Previous peer reviews and BMC's goals for the current peer review are also discussed here.

3.2 Existing Transportaion Model

The current Baltimore Region Travel Demand Model is a four-step trip-based model that runs on the CUBE Voyager software platform. In addition to the MPO areas (i.e., Baltimore City, Annapolis City, Anne Arundel County, Baltimore County, Carroll County, Harford County, and Howard County), the model includes Montgomery County, Prince George's County, Frederick County, and Washington D.C (see Figure 3-1). The model has 1,809 transportation analysis zones (TAZs): 1,387 in the Baltimore region, 380 in the Washington region, and 42 are external zones. The model considers seven trip purposes as follows:

- Home-based work,
- Home-based school,
- Home-based shop,
- Home-based other,
- Non-home-based (NHB) journey to/from work,
- Non-home-based journey at work, and
- Non-home-based other.

The time periods that are modeled include:

- AM peak (6:30 – 9:30),
- Midday (9:30 – 3:30),
- PM peak (3:30 – 6:30), and
- Night (6:30 pm – 6:30 am).

The model system underwent a major overhaul in 2006 with enhancement to the mode choice model (nested mode choice model) and inclusion of a toll choice model. The model was validated against observed data for the year 2000 (the report is available here: http://www.baltometro.org/reports/ValidationV3point3.pdf), and again more recently against 2008 data.

Despite all these enhancements and updates, the existing trip-based model for Baltimore has been deemed inadequate to fully address the agency's current and future transportation needs. Some of the limitations of the trip-based model are highlighted below:

- Modeling inter-regional interaction between Baltimore and Washington D.C., York County, and Pennsylvania. Related issues include:
    - Balancing urban area trip purpose productions and attractions.

  - Effect of difference in Cooperative Forecasting[3] methodology/assumptions between metropolitan regions. For example, inter-regional labor force movement.
  - Representing transit in Washington D.C.
- Modeling congestion pricing. Related issues include:
  - Distribution of value-of-time (VOT).
  - Direct comparison of toll alternatives and transit.
  - Tunnel/bridge toll choice – regular fare/commuter discount.
  - Income and value of time differences between Baltimore and Washington region.

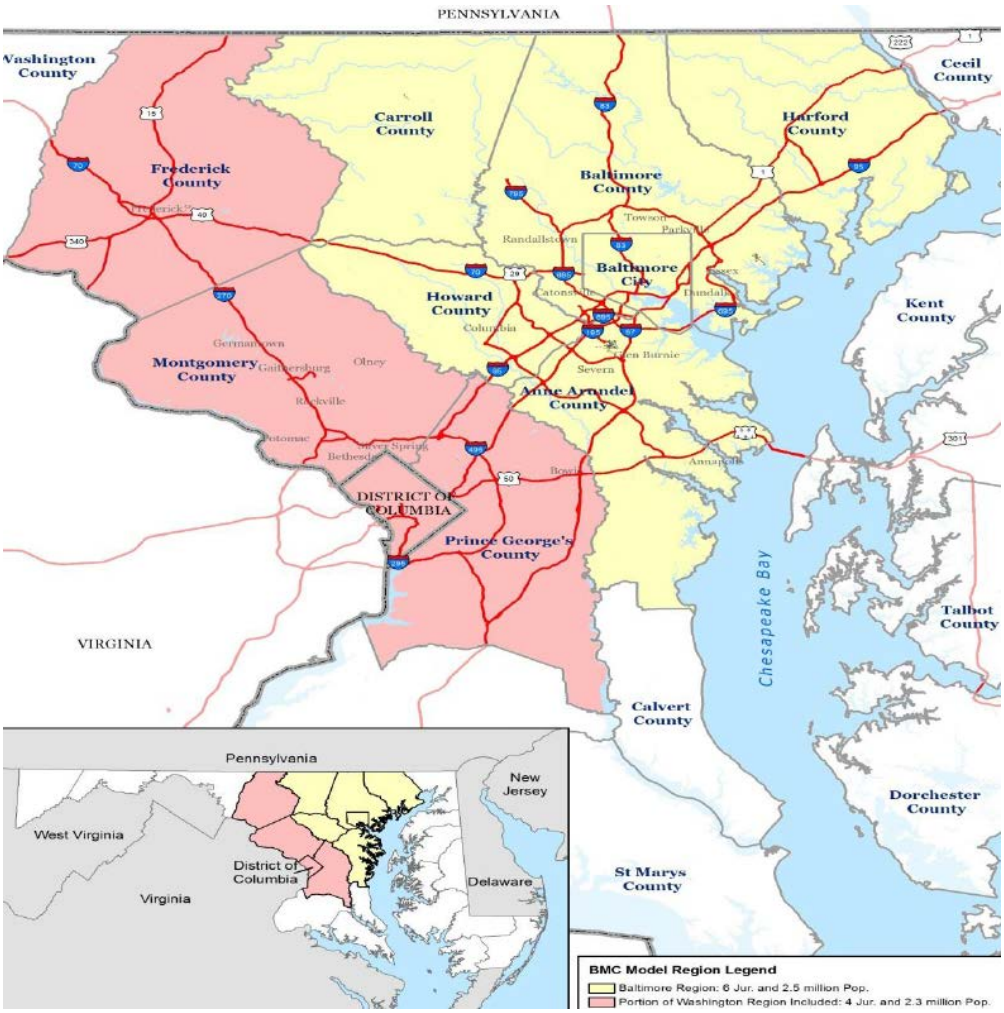

Figure 3-1: BMC's Trip-Based Transportation Modeling Area

- Modeling transit oriented development. Related issues include:
  - TAZ structure.

[3] The Cooperative Forecastings are made by a subcommittee of the BRTB called the Cooperative Forecasting Group. The Group is responsible for developing population, households, employment, and labor force projections for the MPO region in conjunction with Metropolitan Washington Council of Governments (MWCOG).

  - Estimation of non-motorized trips.
  - Land use effects on travel choices and travel choices effects on land use.
- Modeling mode choice. Related issues include:
  - Representing central business district (CBD) with a dummy variable.
  - Modeling commuter rail and local/fixed rail service.
  - Modeling walk access/egress time.
- Network assignment. Related issues include:
  - Fixed number of iterations for network convergence and feedback.
  - Four Time Periods: AM peak, PM peak, mid-day, and overnight.
  - Modeling delay and peak spreading.
  - Summarizing outputs.
- Other issues include:
  - Generating light and heavy truck and commercial vehicle based on Quick Response Freight Manual (QRFM).
  - Limited information on special generators (regional shopping malls, universities, intermodal transfer facilities), external travel, and visitors.
  - Modeling air passengers.
  - Segmentation of base and future year income class.
  - Connecting the MOVES emission model with the travel demand model.

In addition to a passenger travel demand model, the agency also has a trip-based truck model.

3.3 Previous Peer Reviews

In the last decade, the agency hosted two previous peer reviews: one in September 2004, and another one in February 2005. A brief overview of these previous peer reviews is provided below.

- First Peer Review: This was a two-day review held in September 2004. The key focus of the review was to evaluate the status of the BMC travel model improvement process and to provide guidance on near-term and long-term model development issues. The Panel provided recommendations on a number of subjects/issues including population and employment forecast, mode choice validation, external and port-related truck survey, treatment of trips to the airport, and time-of-day/feedback related issues.[4]

- Second Peer Review: This was a one-day Peer Review that took place in February 2005. In this review, the agency asked the panel to evaluate their existing travel demand forecast model, make recommendations for model enhancements, and review their model improvement process. The panel's recommendations included advice on traffic analysis

[4] The report on the first peer review is available at:
http://www.fhwa.dot.gov/planning/tmip/resources/peer_review_program/bmc/report1/index.cfm

zone, employment and population data, demographic factors to be considered to improve the explanatory power of the model, and run time/speed of the model.[5]

3.4 BMC's Goals for the Current Peer Review

BMC's activity-based travel demand model is currently at an early stage of development. The agency applied for and organized the peer review to seek guidance and advice from an independent panel of experts on the following specific subjects and issues:

1) How travel response to toll/pricing should be represented and modeled? Mode choice and route choice, or route choice only?
2) What spatial resolution should be used for discrete choice models? Parcel, micro-zone, or traffic analysis zone?
3) At what spatial resolution for overlapping areas covered in the BMC model but part of Metropolitan Washington Council of Governments (MWCOG) juridsctions be modeled, given that there are inconsistencies between BRTB and MWCOG data?
4) How the transit modes should be defined?

[5] The report on the second peer review is available at: http://www.fhwa.dot.gov/planning/tmip/resources/peer_review_program/bmc/report2/index.cfm

4.0 Regional Transportation Model Improvement Plan

To overcome the limitations of the existing trip-based model and to support the agency's Long-Range Transportation goals and objectives, the Model Development Working Group, which is comprised of technical staff from the state, regional, and local agencies, prepared a 10-year model development and enhancement plan, commonly referred to by the agency as the "model development blueprint." The Working Group was responsible for prioritizing regional policies of interest and identifying corresponding travel demand model(s). The Working Group's findings are summarized in Table 4-1. As can be observed from the table, an activity-based travel demand model will be able to accommodate most of the policies that are of high priority to the agency. Thus, the Group ranked the development of an activity-based model for the Baltimore region as a high priority. The Group also identified several other models, such as a dynamic highway traffic flow model, external models, and a vehicle evolution model, as high priority models as well (see

Table 4-2 for BMC's model development priority list).

Table 4-1: Summary of BMC's Model Enhancement Need and Existing Tool Capacity

Model Category	Priority Ranking		
	High	***Medium***	***Low***
Personal Travel Model	Reduce SOV	Stretching Demand	Telecommute
	Promote Public Transit	VMT Fee/Fuel Tax	Add Lanes
	Roadway Pricing	Demographic Scenarios[2]	Livability Concept[1,2]
	Location Choice[1]	Evolution of Population[2]	
	Effect of Land Development[1]	Equity Concerns	
Commercial Vehicle and Truck Model	Commercial and Freight Activity		
Highway Traffic Flow Model	Regional Traffic Operation Plan		
Vehicle/Air Quality Model	Vehicle Emission and Usage	Vehicle Emission	Tracking Emission
Special Generator/Events Models		Air Passenger	
		GQ and Military	
		Capture Special Market Demand	

Additional Model Land use Planning Category: 1 Process/Model
2 Demographic Model

Existing Tool:
Limited Capacity
Acceptable Capacity
Very Limited
No Capacity

Table 4-2: BMC's Model Development Priority

High Priority Group	Medium Priority Group	Low Priority Group
Activity-Based Personal Regional Travel Model [i]	Commercial Vehicle and Truck Model [ii]	Dynamic Transit Assignment [i]
Dynamic Highway Traffic Flow Model [iii]	Multi Modal Freight Model [ii]	Air Passenger Model [i]
Activity Model and DTA Integration [iv]	Military Base Model [i]	Multi Modal Visitor Model [i]
External Models [i]	College University Model [i]	Bike Network Model [iii]
Synthetic Population – Additional Control SubModel [i]	Older Resident Model [i]	Pedestrian Network Model [iii]
Vehicle Evolution Model [i]	Population Evolution Model [i]	Special Generator/Events Models [i]
Air Quality Model (MOVES) – ABM Integration [iv]	PECAS-ABM Integration [iv]	

i: Model to capture personal travel demand
ii: Models to capture travel demand for movement of goods and services
iii: Models to capture flow of traffic on transportation network
iv: Models to capture interactions between all components of travel system

4.1 Analytical Needs for ABM Model

In August 2013, soon after the initiation of the ABM development process, the agency organized a model design workshop for the state and local agency planning partners. The workshop helped the stakeholders and consultants identify and understand unique socio-economic and transportation attributes that are specific to the Baltimore region and must be considered in the eventual model design. In particular, the workshop identified a number of emerging trends and scenarios and corresponding policies and strategies, summarized in Table 4-3, that should be considered in the design and specification of the activity-based model currently under development.

Table 4-3: Desired Technical Capability of the Proposed ABM Model System

Emerging Trends/Scenarios	Policies and Strategies
Aging population	*Travel demand management* • Congestion pricing/managed lanes • Reduce SOV/auto traffic • Parking restriction/pricing • Reduce travel demand
Childless/multigenerational house	
Traffic congestion	
Peak spreading	
Fuel prices	
Land use/economic activities and transportation system interaction	*Land use* • Transit oriented development • Livability concept
Air quality and GHG	
Equity concerns	

Emerging Trends/Scenarios	Policies and Strategies
	• Mix development
VMT tax	*Transit network improvements/conditions*
Telecommuting	*Roadway network improvements/condition*
Information communication technology	

4.2 Data Collection Plan

The base year for the proposed activity-based model is 2012. The agency undertook a household travel survey in 2007-2008 that will be used for model estimation and validation. The datasets listed in Table 4-4 will be used for additional model calibration, validation, and back-casting exercises. The agency is currently not engaged in any data collection effort, though updating transit information with data from a more recent transit on-board survey is under consideration.

Table 4-4: List of Observed Data and Usage Plan for the Development of Activity-Based Model

Data	Year		Utilization			Remark/current status
			Estimation	Validation	Backcast	
Activity-Based Household Survey	2007/2008		2007/2008	2007/2008		
Trip Based On-board Transit Survey	2007/2008			2007/2008		
Highway Network	Yearly 2007 and onwards		2010	2012	2005	
Transit Network	Yearly 2007 and onwards		2010	2012	2005	
Land Use/Socio-Economic Data (Estimated)	Yearly 2007 and onwards		2010	2012	2005	TAZ structure changed from 2008 to 2010
Hourly Direction Traffic Counts	Yearly 2007 and onwards			2012	2005	
HPMS VMT	Yearly 2007 and onwards			2012	2005	
Transit Boardings	Yearly 2007 and onwards			2012	2005	
INRIX	Yearly 2007 and onwards			2012		
Other Speed Data	Yearly 2007 and onwards			2012	2005	
Observed Work Flow (Census/CTPP)	2000	2010		2010		
Observed Work Flow (ACS 5 year)	2009 and onwards			Latest		
LEHD (Work Place data)	Yearly 2007 and onwards			Latest		
School Enrollment by Grade		2012	2010	2012	2005	
College Enrollment		2012	2010	2012	2005	
Master Establish File Data (jobs)	2005	2010	2010			
Parcel Data (Property View)	Yearly 2007 and onwards		2011	2011	2005	
Parking Data						Need to expand existing data to cover rest of Baltimore, Annapolis, and Towson
FAF (Freight Data)	2007	2011				Need to view the data for potential use
ATRI (Trucking Data)						Need to view the data for potential use
Stated Preference Survey	1999					Need to view the data for potential use
Video License Plate Survey, Road Side Survey	2008					Need to review usability, contact MWCOG
Airport Passenger Survey	2007, 2009	2011				TPB (proposal)
AirSage (OD Data)						Need to view the data for potential use
Before After VOT Survey of ICC by UoMD		2011				Need to view the data for potential use
2009 NHTS Data						Proposal
ATRI Data						Proposal
TPB Commercial Vehicle Survey	2005					Proposal
I-95 Corridor Coalition Data						Will check on this
MTA Automatic Passenger Counts Data						Need to review usability

5.0 Proposed Regional Activity-Based Model Structure

The work on BMC's activity-based model began in June 2013 with a completion date scheduled for June 2016. The model includes three mandatory activities (work, school, and university) and five non-mandatory activities (meal, shop, personal business, social/recreation, and non-school escorting). It is intended that, where possible, parcel-level spatial resolution will be used for the land use data. For scheduling activities, a 30-minute temporal resolution will be adopted. The components of the proposed model structure are discussed next.

5.1 BMC's Activity-Based Model Components

Figure 5-1 shows the overall model structure and model components proposed for the Baltimore region. A brief description of each model component is provided below.

- **Auto Ownership**: This is a household-level model that predicts the number of autos owned by a household.
- **Regular Workplace Location**: This is a person-level model that will be applied to each employed individual to predict workplace location zone.
- **Regular School Location**: This is a person-level model that will be applied to each student to predict school location zone.
- **E-ZPass Ownership**: This binary choice model is to be used to predict whether or not a household owns an E-ZPass transponder.
- **Transit Pass Ownership**: This binary choice model will be used to predict whether or not a household owns a transit pass.
- **Daily Activity Pattern**: For each individual, this model predicts the number of tours (0, 1, or 2+) and the number of stops (0, 1, or 2+) for each activity purpose, including travel to work and school.
- **School Escorting**: This model will be applied at half-tour level (i.e., home to school and school to home). The model will be used to predict on which half-tours a student is escorted to/from school, which household member escorts the student, and whether escorting is done on a work tour.
- **Fully Joint Travel**: This model will be applied at household-level to predict the number of fully joint tours with two or more household members and which household members participate in each joint tour.
- **Work-Based Sub-Tour Generation**: This model predicts the number and purpose of any sub-tours made during a work tour.
- **Work Mode Choice**: This model predicts the main mode for work tour.
- **School Mode and Time-of-Day Choice**: This model will be used to predict the main tour mode, (in 30 minute intervals) the time period for arriving at school and the time period for leaving school.
- **Work Time-of-Day Choice**: This model predicts (in 30 minute intervals) the time period arriving at work, and the time period leaving work.

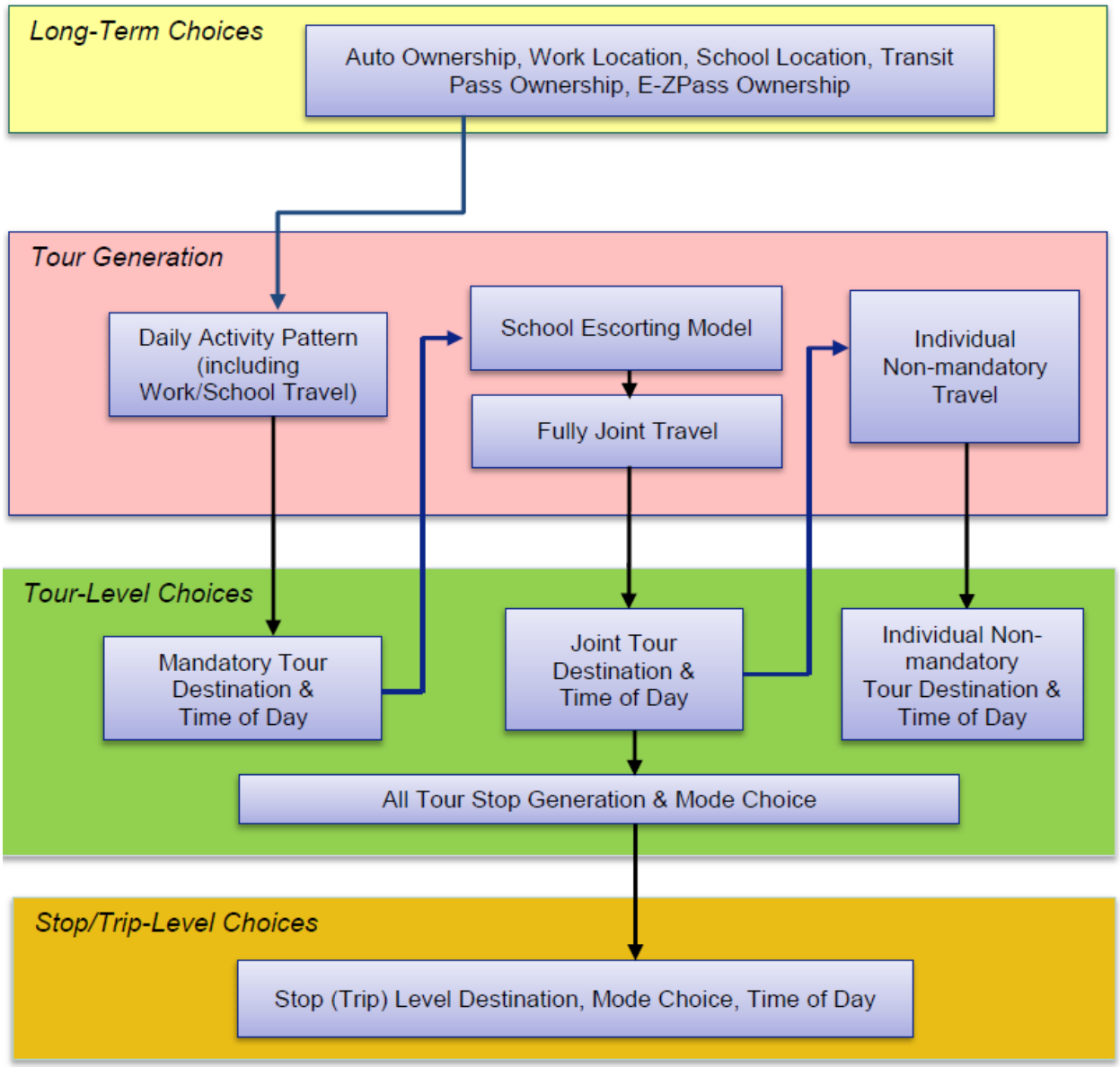

Figure 5-1: BMC's Activity-Based Model Component
(Reproduced from "Model Design Plan for BMC Activity-Based Model", Draft Report, September 2013)

- **Other Tour Time-of-Day Choice**: This model predicts in 30 minute intervals the time period arriving at the primary destination and the time period leaving the primary destination for non-mandatory tours.
- **Other Tour Mode and Destination Choice**: This model predicts the primary destination zone and main tour mode for non-mandatory tours.
- **Intermediate Stop Generation**: This model predicts the number and activity purpose of any intermediate stops made on the half-tour. The model prediction is conditional on day pattern.
- **Intermediate Stop Location**: This model predicts the destination zone of each intermediate stop (conditional on tour origin and destination) and location of any previous stops.
- **Trip Mode Choice**: This model predicts trip mode conditional on tour mode.

- **Trip Departure Time**: This model predicts trip departure time, conditional on available time windows.

5.2 Modeling Road Pricing

BMC's goals for the peer review were discussed in section 3.4. One of the key issues presented in detail was how to model road pricing. Specifically, how to improve the treatment of road pricing in the mode choice model. The current proposal to model road pricing includes the following enhancements:

1. Simulate value-of-time for each individual, possibly by tour purposes. For this, a truncated log-normal distribution may be used.

2. Segmentation of trip tables used in aggregate highway assignment by value-of-time level (This technique is currently being implemented in the Houston H-GAC activity-based model).

The main difference between the proposed approach and more traditional segmented mode choice models where the auto mode is divided into "toll" and "free" alternatives are:

1. In the proposed approach, mode choice is applied separately for the travelers in each segment rather than using segmentation to create separate mode alternatives.

2. Use of multiple segments of value-of-time instead of usual toll/non-toll segments.

3. Though there is no guarantee that a "free" path will be used in the development of travel time skims, the proposed approach is likely to increase the probability of a free path being chosen for the lowest value-of-time segments.

6.0 Panel Response to Topics of Interest and Recommendations

This chapter summarizes the panel's discussion on the topics of interest to BMC and the other meeting participants. Specifically, Section 6.1 includes responses to the questions the BMC posed to the panel at the outset of the meeting, and Section 6.2 addresses other meeting participant concerns and questions. For a list of all meeting participants, please see Appendix A.2

6.1 Recommendations Corresponding to Specific Issues

Question #1: How travel response to toll/pricing should be represented and modeled? Mode choice and route choice, or route choice only?

Panel's Recommendation: Mode choice components should be tied to high-level behavioral preferences (value-of-time (VOT) segmentation) and network components should be based on performance. Segmentation by value-of-time is a good idea. It is reasonable to do logit route-type choice, or alternately binary choice, within each segment. If the number of VOT segments mimics a continuous distribution, then binary choice will not be needed; if less, then still test binary choice.

Question #2: What spatial resolution should be used for discrete choice models? Parcel, micro-zone, or traffic analysis zone?

Panel's Recommendation: Use a consistent geographic micro-zone scale (e.g. parcels) across the entire BMC modeling region. Use empirical data to the extent possible and use disaggregation algorithms when not.

Question #3: At what spatial resolution should the Metropolitan Washington Council of Governments (MWCOG) juridsctions that are part of the BMC model area be modeled, given that there are inconsistencies between BRTB and MWCOG data?

Panel's Recommendation: See panel's recommendation for question two. Also, one of the audience members indicated that land use data for the MWCOG region is available at the parcel level.

Question #4: How should the transit modes be defined in the model?

Panel's Recommendation: Emphasize unique service variables in network coding (e.g. station type), elaborate path building choice logic, and keep the mode choice model shallow. Binary, or Conventional vs. Premium, distinguish between walk, P&R and K&R access/egress. Allow multi-class transit assignment by user class (income group and age).

6.2 Recommendations Corresponding to Audience Concerns

In addition to providing recommendations to specific agency expressed issues, the panel also addressed the following audience concerns and questions since the discussion was open:

Question #1: Is 2007 household travel survey data too old to estimate the model?

Panel's Recommendation: No, year 2007 data is not too old. However, newer data will be useful for validating model sensitivity to background influences. Consider establishing a continuous survey program.

Question #2: What level of accuracy may be expected from the network assignment results?

Panel's Recommendation: ABM does not, by itself alone, guarantee better assignment results due to inherent limitations of static assignment and network accuracy. Effects of this project on goals of climate change will be limited to travel choice and constraints. The addition of more assignment time periods will assist in troubleshooting and re-calibrating network assignments. Many more solutions to assignment precision are available in dynamic traffic assignment (DTA).

Question #3: What are the dimensions along which the model should be validated?

Panel's Recommendation: Need to obtain diurnal traffic counts. There are many more dimensions for validation in ABM. Some can be internally validated against the survey. Consider validation of transit results per FTA guidance (e.g. district to district linked flows). It may not be possible to undertake certain types of disaggregate validation due to constraints of data availability (e.g. time-of-day, speed data).

Question #4: How is the effect of land use being incorporated in the model?

Panel's Recommendation: The current model structure seems to include land use effect only in the mode choice model. The entire model sequence should adequately reflect the interest in understanding the causal relationships between built environment, accessibility, and travel choice (i.e. beyond mode choice).

Finally, the panel made the following additional suggestions/observations that may provide useful guidance during the model development process:

- Planned 2014 transit ridership survey: Make sure it has relevant questions for ABM validation (e.g. retrieve tour details). Documentation from the recent ridership survey in Cleveland and Columbus, Ohio areas may be useful.
- Geographic disaggregation: Consider using smaller zones, point-based activities, micro-analysis zones for better modeling of transit access/egress.
- Activity-based model structure and specification: The proposed model structure is consistent with the state of the practice.
- Temporal disaggregation: Is 30 minutes too coarse? How about 15 minutes? How about a continuous time model? This will help pave the way for eventual DTA.
- Peak spreading: Consider including explicit flexibility of work schedules as a person attribute to permit policy analysis.

6.3 Next Steps

In June 2013, BMC started the process of developing an activity-based model (ABM) for the Baltimore region with a goal to have a fully functional model by June 2016. In December 2013, the agency organized the current peer review to seek guidance and recommendations on a number of key issues that may enhance the model development process, including design framework, methodology to address policies of interest, model validation, and sensitivity testing. Next, the agency and the consultant will review the panel's recommendations and identify the most effective ways to incorporate the findings as they continue with the ABM model development effort. Once substantial progess has been made, but prior to model implementation phase, the agency intends to seek guidance from the panel again on issues such as model structure, estimated parameters, elasticity, and performance.

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
Ken Cervenka	Federal Transit Administration (FTA)
Brian Gardner	Federal Highway Administration (FHWA)
Ram Pendyala	Arizona State University
Erik Sabina	Colorado DOT (CDOT)
Peter Vovsha	Parsons Brinckerhoff Consult (PB Consult)
Kermit Wies	Chicago Metropolitan Agency for Planning (CMAP)
Lei Zhang	University of Maryland, College Park

A.2 Local Agency and Partner Agency Staff

Name	Affiliation
Charles Baber	Baltimore Metropolitan Council (BMC)
Birat Pandey	Baltimore Metropolitan Council (BMC)
Matt de Rouville	Baltimore Metropolitan Council (BMC)
Hejun Kang	Baltimore Metropolitan Council (BMC)
Brian Ryder	Baltimore Metropolitan Council (BMC)
Todd Lang	Baltimore Metropolitan Council (BMC)
Emry Hines	Baltimore County
Subrat Mahapatra	MDOT, State Highway Adminstration
Derek Gunn	MDOT, State Highway Adminstration (SHA)
Dennis Simpson	Maryland Transportation Authority (MdTA)
Tyson Byrne	Maryland Department of Transportation
George Cardwell	Anne Arundel County
Ben Pickar	Howard County
Charles Grant	Maryland Transit Administration (MTA)

A.3 Consultant Staff

Name	Affiliation
Thomas Rossi	Cambridge Systematics, Inc.
Feng Lie	Cambridge Systematics, Inc.

A.4 TMIP Peer Review Support Staff

Name	Affiliation
Nazneen Ferdous	RSG

Appendix B Peer Review Panel Meeting Agenda

This section contains the agenda of the peer review.

B.1 BMC Model Peer Review

December 6, 2013

8:30 - 9:00 a.m.	I. Welcome and introductions (BMC) • Context for the meeting, existing tool and challenges • ABM project overview and long term model development plan
9:00 - 11:30 a.m.	II. ABM project details (BMC/CS) • Analytical Requirements and Data • Details of Model Design Framework • Model Validation Process • Other Topics (requested by panel in advance)
11:30 - 12:00 p.m.	III. Lunch break
12:00 - 1:30 p.m.	IV. Questions and answers/discussion
1:30 - 3:30 p.m.	V. Panel work session (panelists only)
3:00 - 3:45 p.m.	VI. Finding and recommendation (panelists)
3:45 - 4:15 p.m.	VII. Recap/discussion of panel recommendation
4:15 - 4:30 p.m.	VIII. Next steps/closing

Appendix C Peer Review Panel Biographies

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

C.1 Ken Cervenka (Federal Transit Administration (FTA))

Ken Cervenka has worked at the Federal Transit Administration (FTA) since 2007. His major 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.2 Brian Gardner (Federal Highway Administration (FHWA))

Brian Gardner is a team leader at the Federal Highway Administration. He has managed a variety of modeling research efforts and planning studies. Brian's specialties include project management, program management, open source communities, transport simulation, and travel demand forecasting.

C.3 Ram Pendyala (Arizona State University)

Ram M. Pendyala is a Professor of Transportation Systems in the School of Sustainable Engineering and the Built Environment at Arizona State University. His expertise lies in the study of human activity-travel behavior, transport demand forecasting, sustainable mobility strategies, public transportation systems, and the land use, travel, energy, and air quality impacts of a wide range of transportation policies and technologies. Ram has conducted sponsored research for a number of federal, state, and local agencies, and has extensively published peer-reviewed journal articles and book chapters in the field of transportation modeling. Prior to joining Arizona State University in 2006, he served on the faculty at the University of South Florida in Tampa for 12 years. He serves or has served on the editorial boards of a number of journals including *Accident Analysis and Prevention*, *Transportation*, *Transport Reviews*, *Journal of Choice Modeling*, and *Transportation Letters*. He is the chair of the Travel Analysis Methods Section of the Transportation Research Board and the immediate past chair of its Committee on Traveler Behavior and Values. He is also a past chair of the International Association for Travel Behaviour Research (IATBR). Ram has his PhD and Master's degrees from the University of California at Davis.

C.4 Erik Sabina (Colorado Department Of Transportation (CDOT))

Erik Sabina is the Information Management Branch Manager at Colorado Department of Transportation. Before CDOT, Erik was the Regional Modeling Manager at the Denver Regional Council of Governments, where he led several leading-edge modeling projects, including the development of an activity-based travel model for the DRCOG region; the first regional travel survey to cover the entire Colorado Front Range area; and the on-going effort to develop an implementation of UrbanSim for the Denver region. Erik has published numerous papers on activity-based model development and related topics, and has frequently served as an invited speaker and panelist throughout the US, most recently serving as co-chair of the TRB 2012 Innovations in Travel Modeling conference, held in Tampa, FL in May, 2012. Erik holds a BS

degree in Aerospace Engineering from the University of Colorado, and a MS in Transportation from the Massachusetts Institute of Technology.

C.5 Peter Vovsha (Parsons Brinckerhoff Consult (PB Consult))

Peter Vovsha has 28 years of experience in the development and application of transportation models. He has developed numerous models and computerized procedures for advanced discrete-choice models of travel behavior and integrated multi-modal network simulations. As a principal modeler, he has developed transport models for several large-scale regional model development projects in major cities such as Moscow, Tel-Aviv, Jerusalem, New York, Columbus, Montreal, and Ottawa. Peter is one of the leading experts in the development and application of the advanced tour-based and activity-based model systems in practice. He is pioneering in design of the new generation of advanced activity-based models that has been widely adopted in U.S. and worldwide (eight out of twelve activity-based models developed or being developed in practice in the U.S. were designed by Peter).

C.6 Kermit Wies (Chicago Metropolitan Agency for Planning (CMAP))

Kermit Wies is with the Chicago Metropolitan Agency for Planning (CMAP) where he serves as Deputy Executive Director for Research and Analysis. Kermit has over 28 years' experience in urban systems modeling and planning and is the principal author of the 2030 Regional Transportation Plan for the Chicago metro area. Over the past several years, Kermit has been overseeing CMAP's development and implementation of new modeling techniques including an agent-based economic application for freight. Kermit has overall responsibility for CMAP's analysis and evaluation work program in support of implementing Chicago's GO TO 2040 comprehensive regional plan.

C.7 Lei Zhang (University of Maryland, College Park)

Dr. Lei Zhang is an Associate Professor in the Department of Civil and Environmental Engineering at the University of Maryland, College Park. His research focuses include transportation systems analysis, transportation and land use planning, transportation economics and policy, agent-based modeling, and integration of transportation operations and planning.

Appendix D Panel's Presentation on Findings and Recommendations

BMC Modeling Peer Review Panel Meeting

12/6/2013

Panel topics of interest

Survey currency

Planned 2014 ridership survey. Make sure it has relevant questions for ABM validation. E.g. retrieve tour details. Documentation from Cleveland and Columbus. FTA Luvs It.

Geographic disaggregation

Smaller zones, point-based activities, micro-analysis zones for better modeling of transit access/egress.

Temporal disaggregation

Is 30 minutes too coarse? How about 15 minutes? How about a continuous time model? This will help pave the way for a DTA.

Validation

Constraints of data availability on disaggregate validation. E.g. time-of-day. Speed data.

Peak spreading

Suggest including explicit flexibility of work schedules as a person attribute to permit policy analysis.

Audience concerns

Adequacy of survey data

2007 is not too old. Newer data will be useful for validating model sensitivity to background influences. Consider establishing a continuous survey program.

Precision of assignment results

ABM does not, by itself, guarantee better assignment results due to inherent limitations of static assignment and network accuracy. Effects of this project on goals of climate change will be limited to travel choice and constraints. Addition of assignment time periods will assist in troubleshooting and re-calibrating network assignments. Many more solutions to assignment precision are available in DTA.

Validation topics

Need to obtain diurnal traffic counts. There are many more dimensions for validation in ABM. Some can be internally validated against the survey. Validation on transit per FTA guidance (e.g. district to district linked flows).

Land use effects

Does the entire model sequence adequately reflect the interest in understanding the causal relationships between built environment, accessibility and travel choice. (i.e. beyond mode choice).

Specific requests

Tolling and managed lanes

Mode choice components should be tied to high-level behavioral preferences (value-of-time segmentation) and network components should be based on performance. Segmentation by value of time is a good idea. It is o.k. to do logit route-type choice, or alternately binary choice, within each segment. If the number of VOT segments mimics a continuous distribution, then binary choice will not be needed; if less, then still test binary choice.

Zone density in MWCOG

Use a consistent geographic micro-zone scale (e.g. parcels) across the entire BMC modeling region. Use empirical data to the extent possible and use disaggregation algorithms when not.

Definition of modes in mode choice

Emphasize unique service variables in network coding (e.g. station type), elaborate path building choice logic, and keep the mode choice model shallow. Binary, or Conventional vs. Premium, distinguish between walk, P&R and K&R access/egress. Multi-class transit assignment by user class (income group and age).

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