TPB GEN3 TRAVEL DEMAND FORECASTING MODEL UPDATE

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Agenda Item #6

Overview

- Introduction to regional travel demand forecasting models (TDFMs)
  - Aggregate, trip-based, four-step models (TBM/FSMs)
  - Disaggregate, activity-based travel models (ABMs)
  - Pros & cons of AMBs compared to TBMs/FSMs
- Motivation for developing an activity-based travel model (ABM)
- TDFMs developed by TPB staff, with consultant assistance:
  - Gen2 (trip-based) Travel Model
  - Gen3 (activity-based) Travel Model
- Development approach for the Gen3 Model
- Implementation details: Gen2 & Gen3 models
- Next steps

What is a regional travel demand forecasting model (TDFM)?

- Mathematical/computerized representation of both the demand for and supply of transportation on the surface transportation network for a metropolitan area.
- Demand-side model: Can be aggregate (e.g., TAZ level) or disaggregate (e.g., household and/or person level)
- Supply-side model: Can be aggregate (e.g., static traffic assignment) or disaggregate (dynamic traffic assignment or microsimulation of traffic)
- Typical inputs: 1) Land activity forecasts by TAZ; 2) Transportation networks (highway and transit); 3) Transportation policy assumptions
- Typical outputs: 1) Trips by travel mode; 2) Vehicle trips/volumes on highway network; 3) Person trips/volumes on transit network
- There is generally an equilibration between demand-side and supply side models (speed feedback iterations)

Uses of a TDFM

- Forecasting where, when, and how people will travel around a region
- Estimating travel demand in the absence of observed data
- Scenario testing: alternative land uses, networks, policies
- Project planning and corridor studies
- Estimating air pollution from the on-road transportation sector (when paired with a mobile emissions model, such as the EPA's MOtor Vehicle Emission Simulator, or MOVES model).

Image credit: Mark Moran

Uses of the TPB TDFM

- Updating and assessing the adequacy of the region's LRTP/MTP
  - Performance analyses of the plan
  - Air quality conformity analyses of the LRTP and TIP, since our region has been designated a non-attainment area for the 2015 ozone National Ambient Air Quality Standards (NAAQS)
  - Studies to measure the impact of the LRTP
- Scenario studies and special regional studies, e.g., CLRP Aspirations Scenario (2013), Long-Range Plan Task Force (LRPTF) Study (2017)
- Project planning studies by TPB members (supporting role)
- Provides a foundation for stakeholder model development efforts, such as NVTA's TransAction Model, M-NCPPC's Montgomery County Travel/4 Model, and Arlington County's tour-based travel model.

Types of TDFMs

- Simplified models, e.g., trend analysis; elasticity-based models
- Strategic planning models that do not make use of a transportation network, such as VisionEval
- Complex, tactical planning models that do make use of transportation networks
  - Demand side
    - Classic aggregate, trip-based, “four-step,” travel demand forecasting model (TBM/FSM)
    - Tour-based travel demand forecasting model (TourBM). Aggregate or disaggregate.
    - Activity-based travel demand forecasting model (ABM). Typically disaggregate.
  - Supply side
    - Highway: Static traffic assignment (24-hour assignment vs. time-of-day assign); Dynamic traffic assignment (DTA); Microsimulation (last two not typically used in regional modeling)
    - Transit: Single best path vs. multi-path

Types of TDFMs: Aggregate, trip-based model

- A.k.a. four-step model (FSM)
- Trip generation: Predict the no. of trip ends generated in each zone
- Trip distribution: Predict where trips are going, i. connecting trip ends into trips
- Mode choice: Predict the share of trips made by each travel mode
- Trip assignment: Assign vehicle trips and transit person trips to relevant network

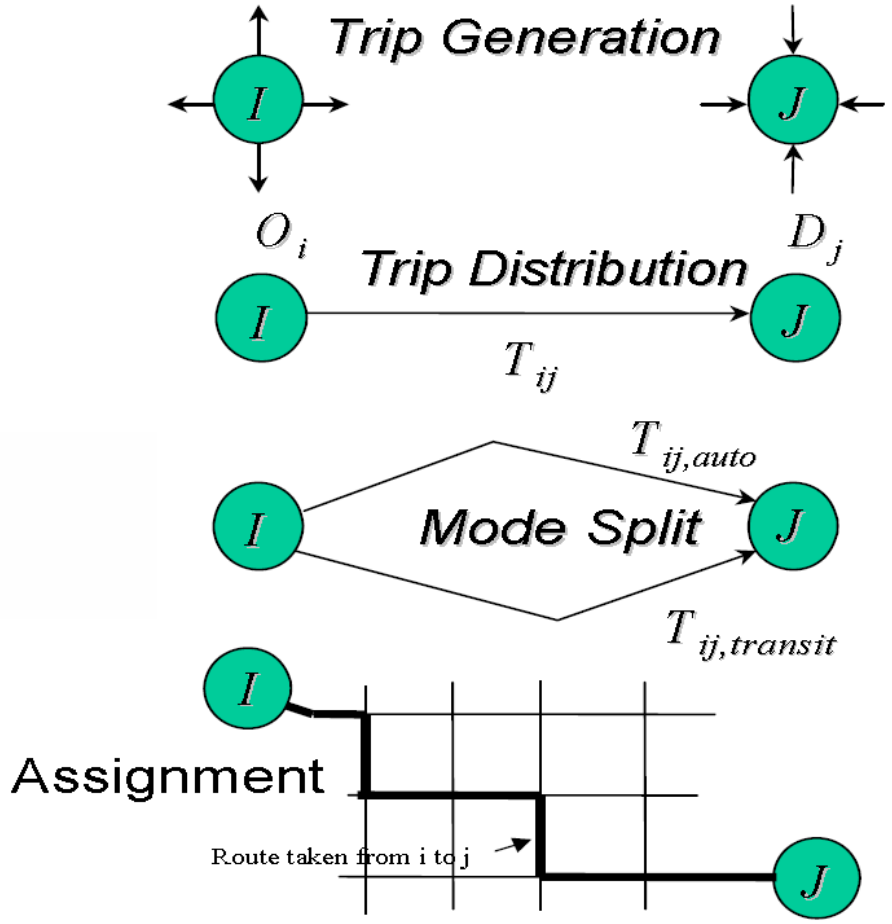

Image credit: Meyer, Michael D., and Eric J. Miller. Urban Transportation Planning: A Decision-Oriented Approach. McGraw-Hill Higher Education, 2001. p. 272.

Types of TDFMs: Disaggregate, activity-based model

- ABM closely follows an individual's decision-making process
- Long-term choices, e.g., work and school location, vehicle ownership, and transit pass/subsidy
- Daily activity patterns, e.g., mandatory activities, discretionary activities, and joint travel
- Daily tour choices, e.g., tour frequency, destination, scheduling, mode, and stop frequency
- Daily trip choices, e.g., route, time of day, mode, location, vehicle occupancy, pay/avoid toll, and parking.

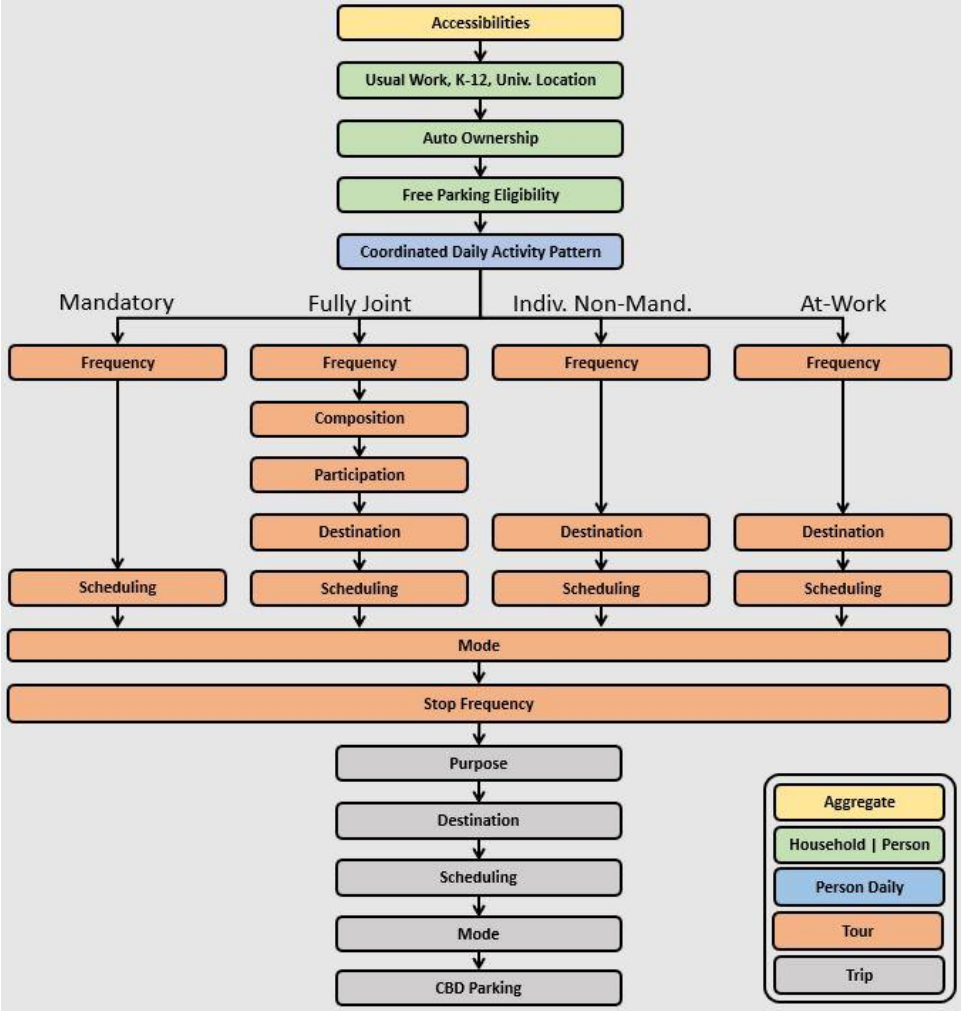

Image credit: ActivitySim

Comparison of TBM/FSMs and ABMs

Trip-Based Model (TBM/FSM)	Activity-Based Model (ABM)
Model focuses on trips	Model focuses on activities, which, in turn, lead to travel (trips)
Trips are generated from zonal aggregations of households	Trips are generated based on the simulation of individual households and persons
Each trip is independent of every other trip	Trips are chained into tours, which allows continuity of information
Timing/direction of trips is not an explicit choice (fixed factors)	Starting and ending time of activities are modeled choices
Geographic scale: TAZ	Geographic scale: Parcel, MAZ, or TAZ

Information based on Outwater, Maren, and Joel Freedman. "Activity-Based Modeling, Session 1: Executive Perspective." Travel Model Improvement Program (TMIP) Webinar Series, February 2, 2012.

Pros & cons of AMBs compared to TBMs/FSMs

- Pros
  - ABMs are tour-based models, so there is continuity of information across trip chains.
  - ABMs provide disaggregate demand, which should make them better suited than FSMs for some analyses, such as pricing & equity studies.
  - ABMs explicitly model certain aspects of travel demand, such as telecommuting, transit subsidy, and vehicle type choices.
  - ABMs provide disaggregate demand, which could, in the future, be used to feed a disaggregate supply model, such as DTA.
- Cons
  - ABMs are more complex.
    - More time to develop (estimate, calibrate, validate)
    - More difficult to debug
  - ABMs require more computing resources & generally take more time to run.
  - ABMs require staff with higher levels of modeling and analysis skills.

Motivation for developing an ABM

- In 2015, our consultant (Cambridge Systematics) developed a strategic plan for travel demand forecasting methods
- Surveyed our peer MPOs
- Findings
  - Demand-side models: 70% of our peer MPOs had developed or were developing an ABM (at the time, we had only our trip-based model).
  - Supply-side models: Many MPOs had a long-term interest in moving to DTA, but only a couple had tried DTA at the regional level.
  - Land use forecasting: No one method prevailed: Some MPOs used land-use models, some did not (COG uses a modified Delphi process, not a formal land use model).

Source: Cambridge Systematics, Inc. “Strategic Plan for Model Development, Task Order 15.2, Report 3 of 3.” Final Report. Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, October 15, 2015. https://www.mwcog.org/transportation/data-and-tools/modeling/review-of-travel-modeling-procedures/

TDFMs developed by TPB staff

- TPB staff develops and maintains, with consultant assistance, a series of regional TDFMs that are used for the regional transportation planning process in the Washington, D.C. area.
- These TDFMs are developed under the guidance of the Travel Forecasting Subcommittee (TFS).
- At any given time, the TPB staff maintains at least two regional travel demand models: A production-use model and a developmental model.
    - Production-use model: Used in planning studies conducted by TPB and made available to outside parties for free.
    - Developmental models: Under development by TPB staff and are not generally not made available to outside parties since these models are not yet considered a finished product.

TDFMs developed by TPB staff: Production-use model

- Current production-use regional TDFM for the TPB is the Generation 2/Version 2.4.6 Travel Model (**Gen2/Ver. 2.4.6 Travel Model**)
- Demand model: Aggregate, trip-based model. Time scale: Average weekday.
- Supply model: Aggregate assignment of both transit person trips (transit assignment) and private motor vehicle trips (highway assignment).
  - Transit assignment includes two time-of-day periods (peak and off-peak) represented in production-attraction (P-A) format.
  - Highway assignment includes four time-of-day periods (AM, midday, PM, and night) represented in origin-destination (O-D) format.
- Gen2 Travel Model was estimated and calibrated to year-2007/2008 conditions, using the 2007/2008 TPB Household Travel Survey and various transit on-board surveys (TOBS) conducted in 2007 and 2008. Gen2 Model has been validated to the following years: 2010, 2014, and 2018 (all pre-Covid)

TDFMs developed by TPB staff: Developmental model

- TPB **Gen3 Travel Model** is the TPB's primary developmental TDFM. It is being developed jointly by COG/TPB staff and a consultant team (RSG & BMG)
- Demand model: Disaggregate, tour-based/activity-based model (ABM). Time scale: Average weekday divided into 30-minute increments.
- Supply model: Aggregate assignment of both transit person trips (transit assignment) and private motor vehicle trips (highway assignment).
    - Transit assignment includes four time-of-day periods (AM, midday, PM, and night) represented in origin-destination (O-D) format.
    - Highway assignment includes four time-of-day periods (AM, midday, PM, and night) represented in origin-destination (O-D) format.
- Gen3 Travel Model was estimated and calibrated to year-2017/2018 conditions, using the 2017/2018 Regional Travel Survey and various transit on-board surveys (TOBS) occurring in 2017 and 2018. Gen3 Model has been validated to only year-2018 conditions (pre-Covid)

Development approach for the Gen3 Model

- **Phase 1** (FY 20–22; led by the consultant team)
  - Goal: Develop a prototype travel model that was lightly calibrated and could be used for testing by COG/TPB staff. Completed in Feb. 2022 (FY 22).
- **Phase 2** (FY 22–24; led by the consultant team)
  - Goal: Develop a travel model for production use. Completed in March 2024 (FY 24).
- **Phase 3** (FY 24–26; led by TPB staff)
  - Goal: Conduct usability testing of the Gen3 Model to ensure that the model is, in fact, ready for production use, including related programs/processes.
  - Involves running the Gen2 and Gen3 models for the same set of scenarios (e.g., air quality conformity analysis).
  - Includes conducting sensitivity tests (in addition to those conducted in the first two phases).
  - Planned beta release of model, fall 2025
  - Contract to conclude Dec. 2025 (FY 26)

Implementation details: Gen2 & Gen3 models (1)

Feature/Aspect	Gen2 Travel Model (TBM/FSM)	Gen3 Travel Model (ABM)
Sophistication & representation of travel behavior	Trip-based model: State of the practice; Used by many MPOs	Tour/activity-based model: State of the art; Used by many large MPOs
Demand model	Aggregate, trip-based	Disaggregate, tour-based/activity-based
Time step (demand model)	Average weekday, divided into 4 TOD periods	Average weekday, divided into 30-min. increments
Supply model (highway)	User equilibrium, static traffic assignment, 4 TOD periods, O-D assignment*	Same
Supply model (transit)	Single-best path (Cube TRNBUILD), 2 TOD periods, P-A assignment,	Multi-path (Cube PT), 4 TOD periods, O-D assignment
Calibration data	2007/2008 Household Travel Survey; 2007 ACS	2017/2018 Regional Travel Survey; 2018 ACS

* O-D = Origin-destination;
P-A = Production-attraction

Implementation details: Gen2 & Gen3 models (2)

Feature/Aspect	Gen2 Travel Model (TBM/FSM)	Gen3 Travel Model (ABM)
Land use inputs	Aggregate (TAZ level), COG's Cooperative Forecasts, Round 10	Disaggregate: Synthetic population generated using COG's Cooperative Forecasts, Round 10.0, Census data as controls
Software	Bentley Systems Cube (proprietary)	Bentley Systems Cube (proprietary) and ActivitySim (open source)
Hardware	Typically run on a server, either on premises or in the cloud	Same, but higher requirement on hardware specifications (processor, memory, disk space, etc.)*
Model run times	ca. 15 hours	ca. 14-15 hours
Size of model outputs	Prior to clean up: 30 GB After clean up: 10 GB	Prior to clean up: 500 GB After clean up: 200 GB

* Please refer to Page 18 of RSG, Baseline Mobility Group, and Metropolitan Washington Council of Governments. "Gen3 Model User Guide (Phase 2 of 3)." Final Report. Washington, D.C.: Metropolitan Washington Council of Governments, National Capital Region Transportation Planning Board, January 31, 2024. https://www.mwcog.org/transportation/data-and-tools/modeling/developmental-travel-model/.

Next steps

- Beta release of Gen3 Model planned for fall 2025
- Plan to provide training for interested stakeholders
- Plan to continue to support both the trip-based (Gen2) and activity-based (Gen3) models, since we know that some will want to continue to use the TBM/FSM.
- Plan to update the strategic plan for travel forecasting methods in FY 26.

Image credit: Mark Moran

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