TPB TRAVEL DEMAND FORECASTING MODEL

Program Update

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TPB Regional Public Transportation Subcommittee
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National Capital Region
Transportation Planning Board

Agenda Item #3

Overview

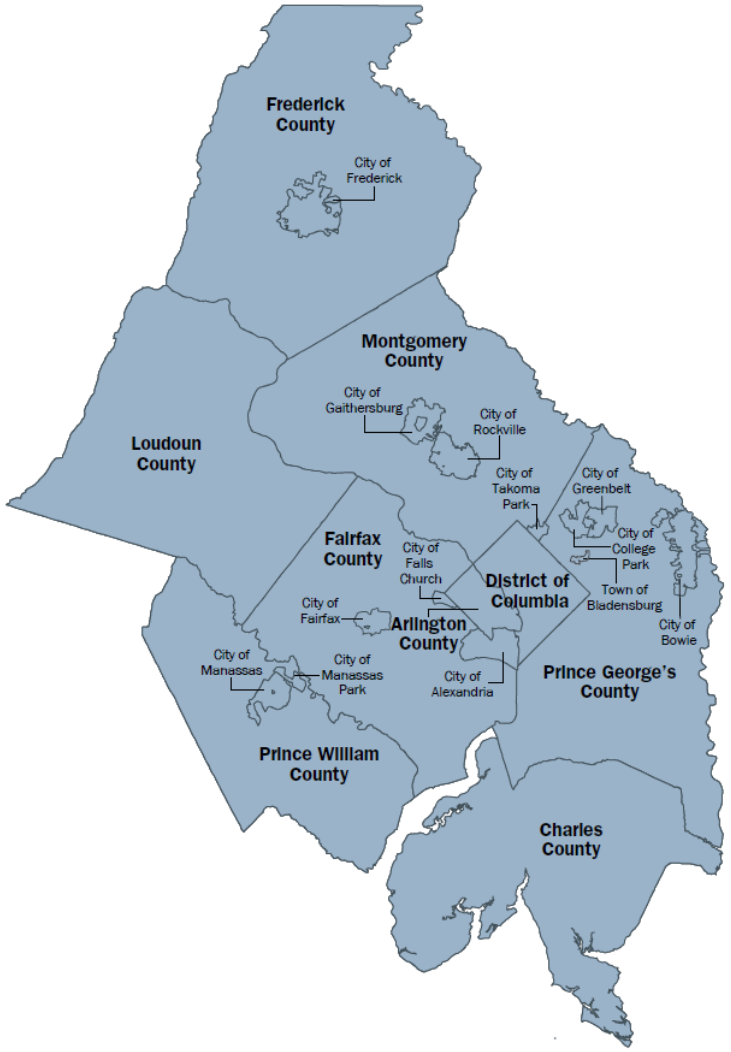
- Geography: Planning area vs. modeled area
- Introduction to regional travel demand forecasting models (TDFMs)
- Comparison of model types, including pros & cons of four-step models (FSMs) vs. activity-based modesl (ABMs)
- Motivation for developing an ABM
- TDFMs developed by COG/TPB staff, with consultant assistance
- Model inputs
  - Land use forecasts
  - Transportation networks
- Next steps & conclusions

Last presented to you on this topic in 2018:

Moran, “How TPB Staff Develops Transit Networks Used by the Regional Travel Model.” February 27, 2018

Both COG & TPB have same planning area

- 5M people, 3M jobs, 17M trips per day
- COG
  - Founded in 1957. Independent, nonprofit association
  - Membership: 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress
- TPB
  - The federally designated Metropolitan Planning Organization (MPO) for the region.
  - Plays an important role as the regional forum for transportation planning.
  - Prepares plans and programs that the federal government must approve for federal-aid transportation funds to flow to metropolitan Washington.
  - Founded in 1965. Associated with COG in 1966.



TPB Modeled area

- Modeled area is larger than COG member area, TPB planning area, or MSA
- Size of modeled area influenced by air quality conformity requirements
- 7M people; 4M jobs; 20M trips per day
- 6,800 square miles
- 22 jurisdictions, including DC, suburban Maryland, Northern Va., and one county in W. Va.

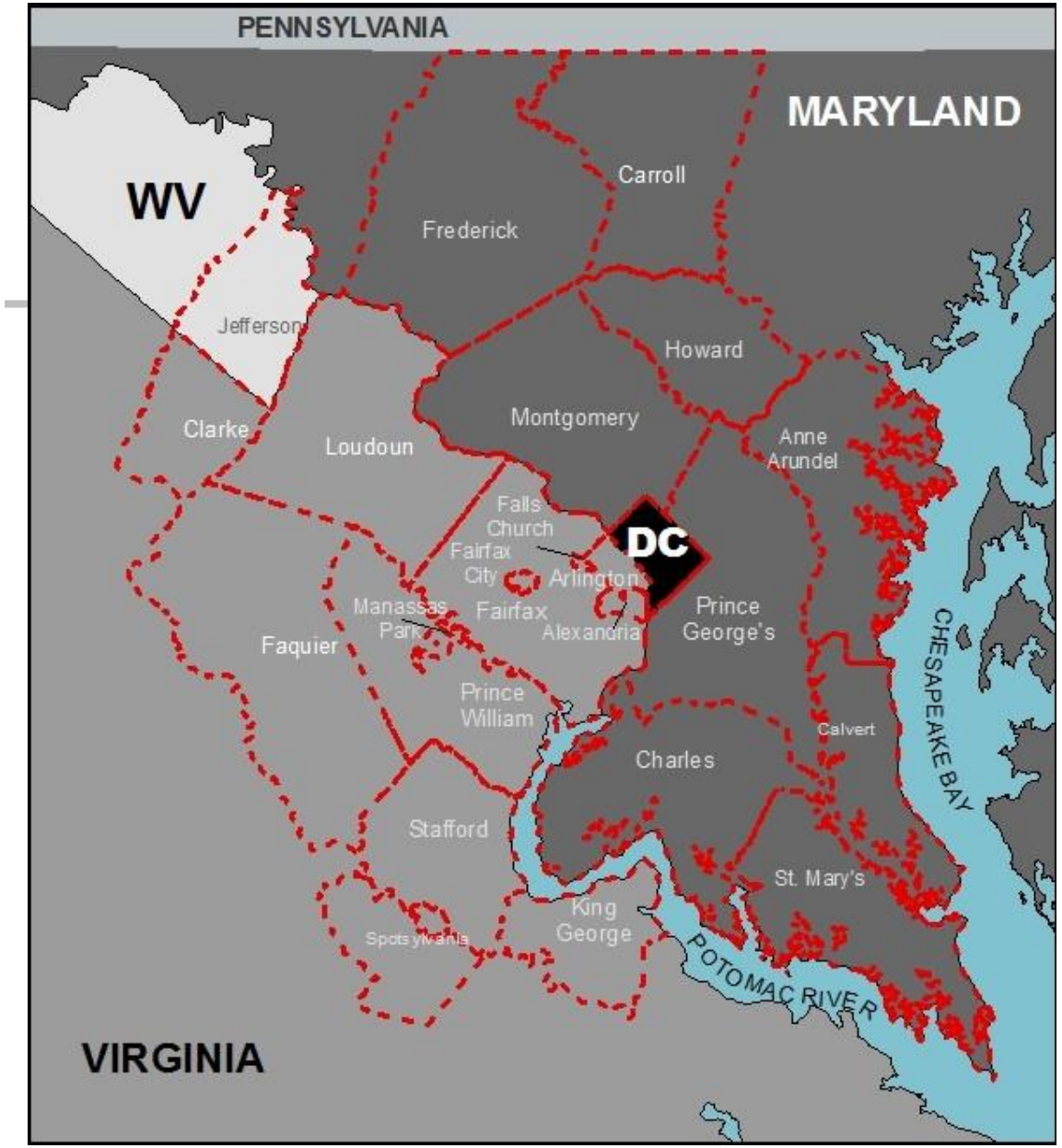


Image credit: Jessica Mirr

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/person level)
- Supply-side model can be aggregate (e.g., static traffic assignment) or disaggregate (e.g., dynamic traffic assignment)
- Primary inputs: 1) Land activity forecasts by TAZ; 2) Transportation networks (highway and transit); 3) Transportation policy assumptions.
- Example outputs: 1) Trips by travel mode; 2) Vehicle volumes on highway network; 3) Person volumes on transit network.
- Equilibration between demand-side and supply side models (typically via a speed-feedback loop)

Image credit: Mark Moran

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 to represent 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).

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)
- Scenario studies and special regional studies, e.g., CLRP Aspirations Scenario (2013), Long-Range Plan Task Force (LRPTF) Study (2017)
- Project planning studies by implementing agencies (TPB takes a supporting role)
- Provides a foundation for stakeholder model development efforts, e.g., 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 models

- 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.e., 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

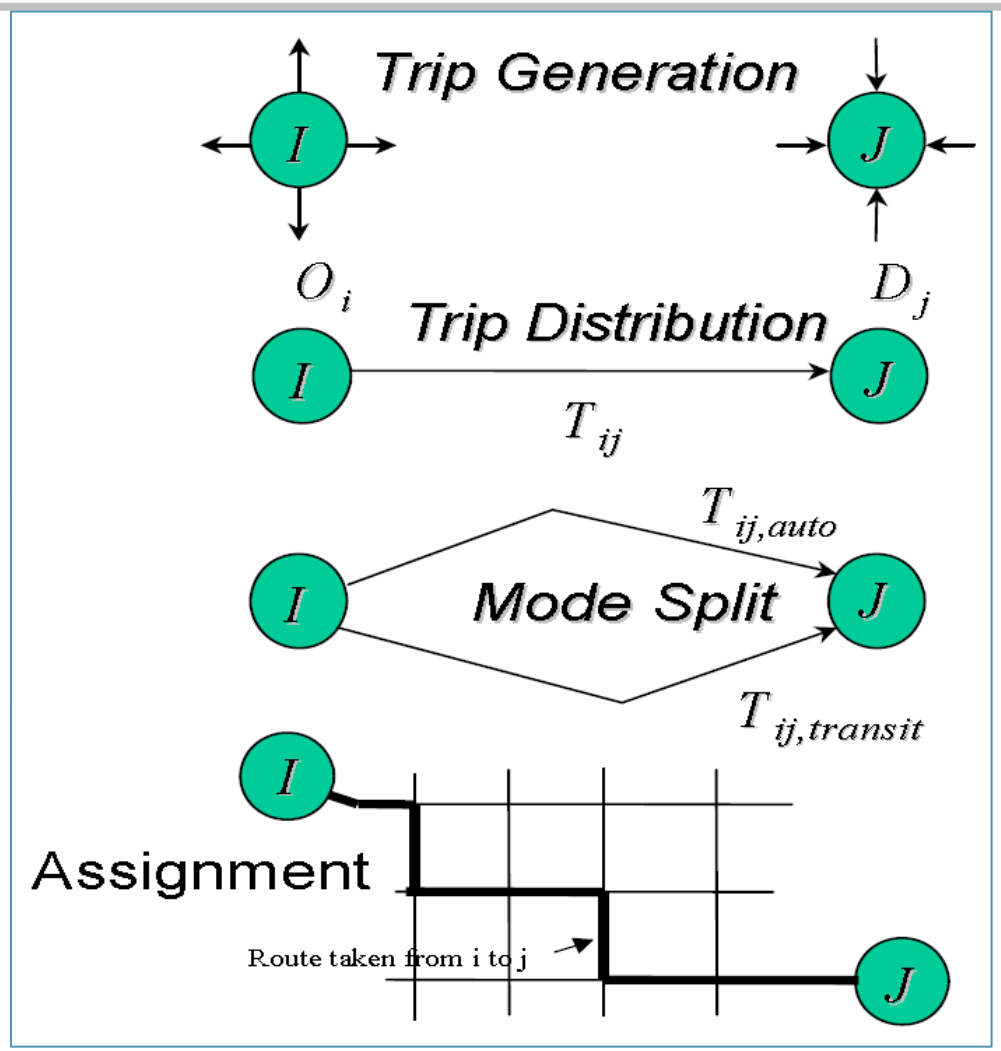


Image credit: Meyer, Michael D., and Eric J. Miller. Urban Transportation Planning: A Decision-Oriented Approach. McGraw-Hill Higher Education, 2001. p. 272.

Types of TDFMs: Disaggregate, activity-based models

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

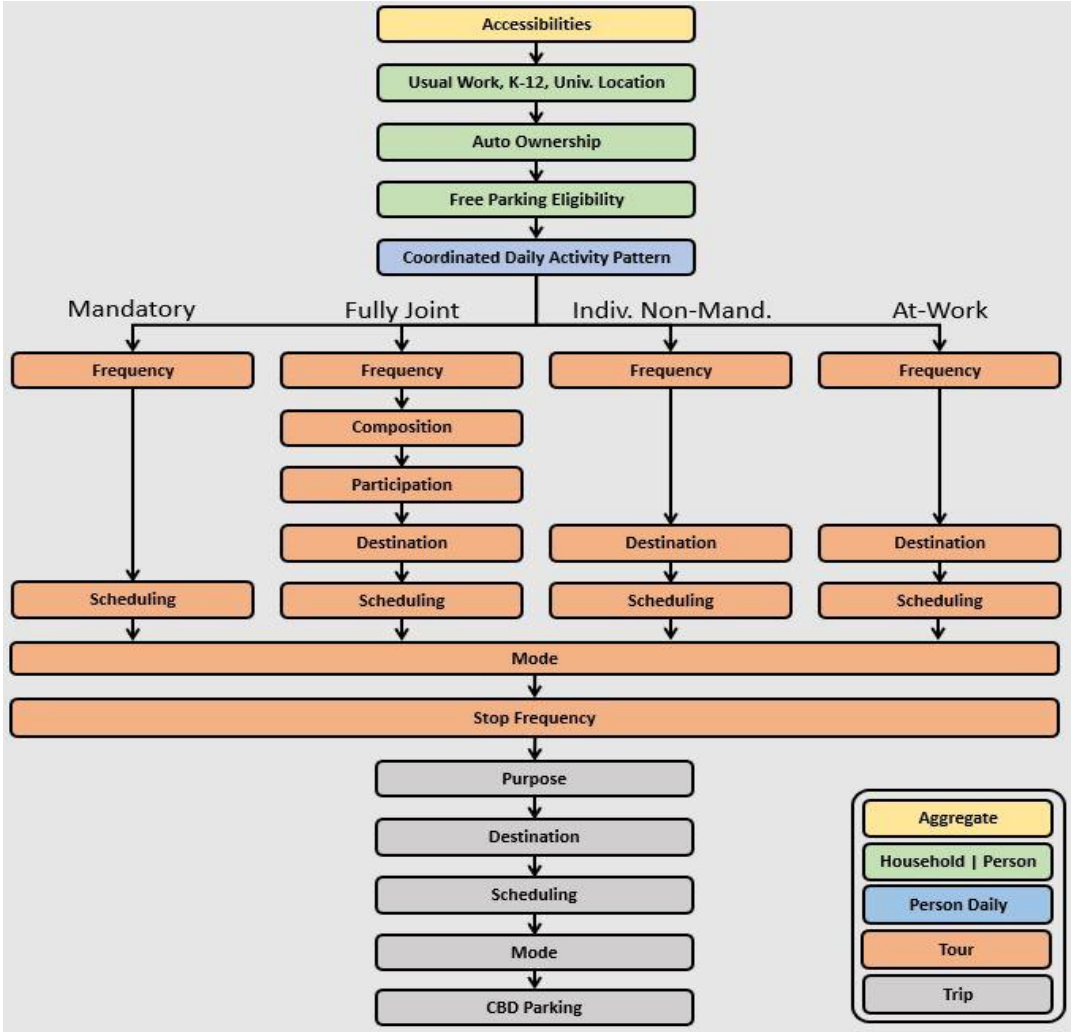


Image credit: ActivitySim

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 ABMs 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
    - facilitate their use with disaggregate supply models, such as DTA.
  - ABMs explicitly model certain aspects of travel demand, such as telecommuting, transit subsidy, and vehicle type choices.
- 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

- COG/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.
- TDFMs are developed under the guidance of the Travel Forecasting Subcommittee (TFS), which reports to the TPB Technical Committee
- At any given time, the COG/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 COG/TPB and made available to outside parties for free.
  - Developmental models: Under development by COG/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 **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 COG/TPB Household Travel Survey and various transit on-board surveys 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

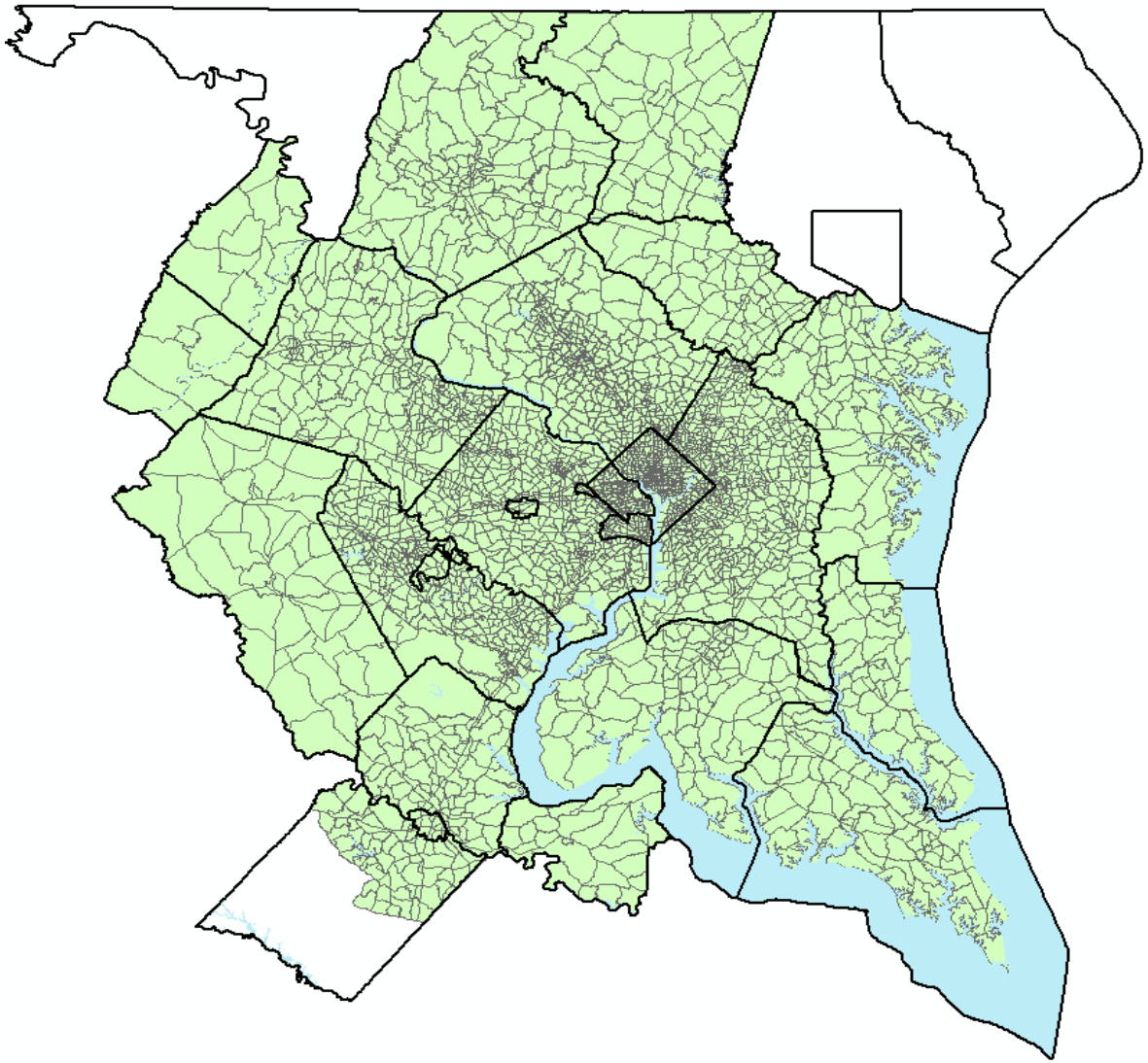
- TPB **Gen3 Travel Model** is the TPB's primary developmental TDFM. It is being developed jointly by COG/TPB staff and a consultant team (RSG & BMG)
- Demand model: Disaggregate, tour-based/activity-based model (ABM). Time scale: Average weekday divided into 30-minute increments.
- Supply model: Aggregate 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 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 COG/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).
  - Beta release was 11/7/25
  - Contract ended 12/31/25

Zone system: Transportation Analysis Zones (TAZs)

- TAZs
  - 3,675 internal zones
  - 47 external stations
  - 3,722 total TAZs
- 6,800 sq. mi.
- 22 jurisdictions
- DC & three states (MD, VA, WVA)



Model inputs: Land use forecasts

- Households & Household population
- Group quarters population & Total population
- Total employment
  - Office employment
  - Retail employment
  - Industrial employment
  - Other employment
- Uses of Cooperative Forecast land use data
  - Calculating area type (Gen2 & Gen3)
  - Gen2
    - Aggregate demographic models
    - Aggregate trip generation
  - Gen3
    - Generates synthetic population data using zonal population data from the Cooperative Forecasts (and other data) as controls
    - Uses zonal employment data from the Cooperative Forecasts as size terms in the workplace location choice model

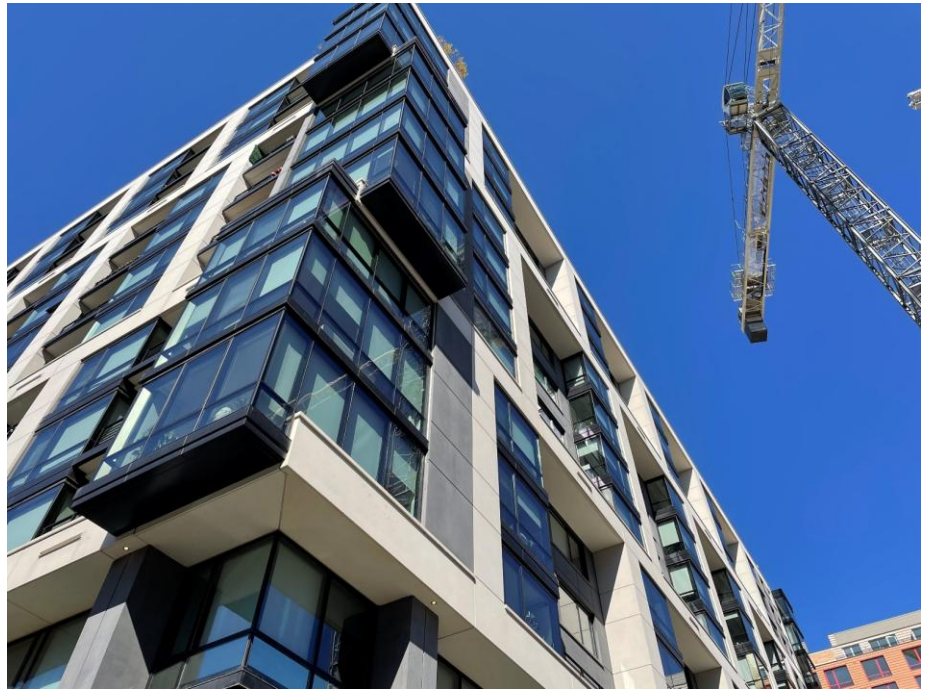


Image credit: Mark Moran

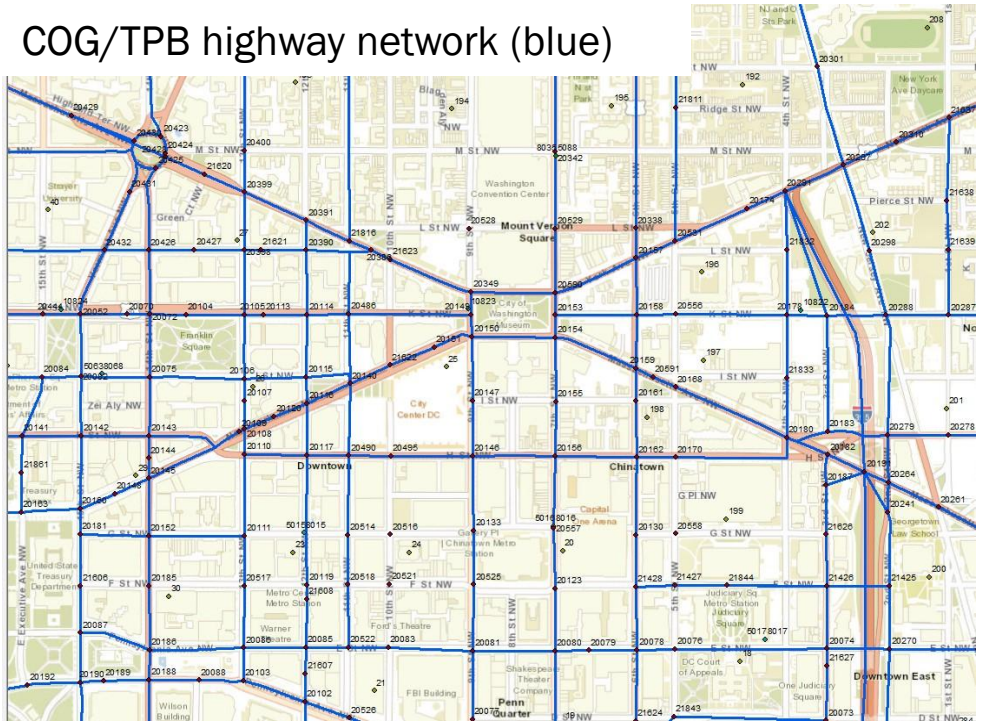
Model inputs: Transportation networks

- Highway network
  - Aggregate-level (not all streets)
  - Coverage: Freeways (all), Arterials (all), Collectors (some), Local (few)
- Transit network
  - Built on top of the highway network, plus additional features:
  - Transit-only infrastructure (stations, rail links, PNR lots, access links)
  - Transit service: Two times of day: Peak period & off-peak period

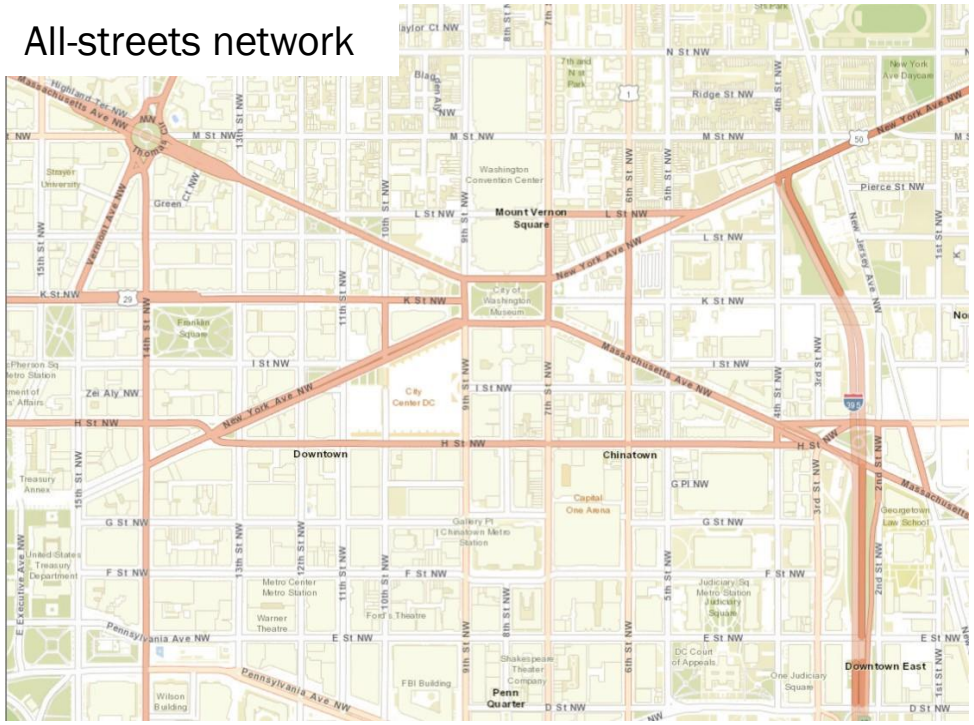
Highway network

- Links represent road segments
- Nodes represent intersections, merge/diverge points, & zone centroids
- Simplistic depiction of roadway connectivity and capacity
- Used to model vehicle flows between (but not within) TAZs

COG/TPB highway network (blue)

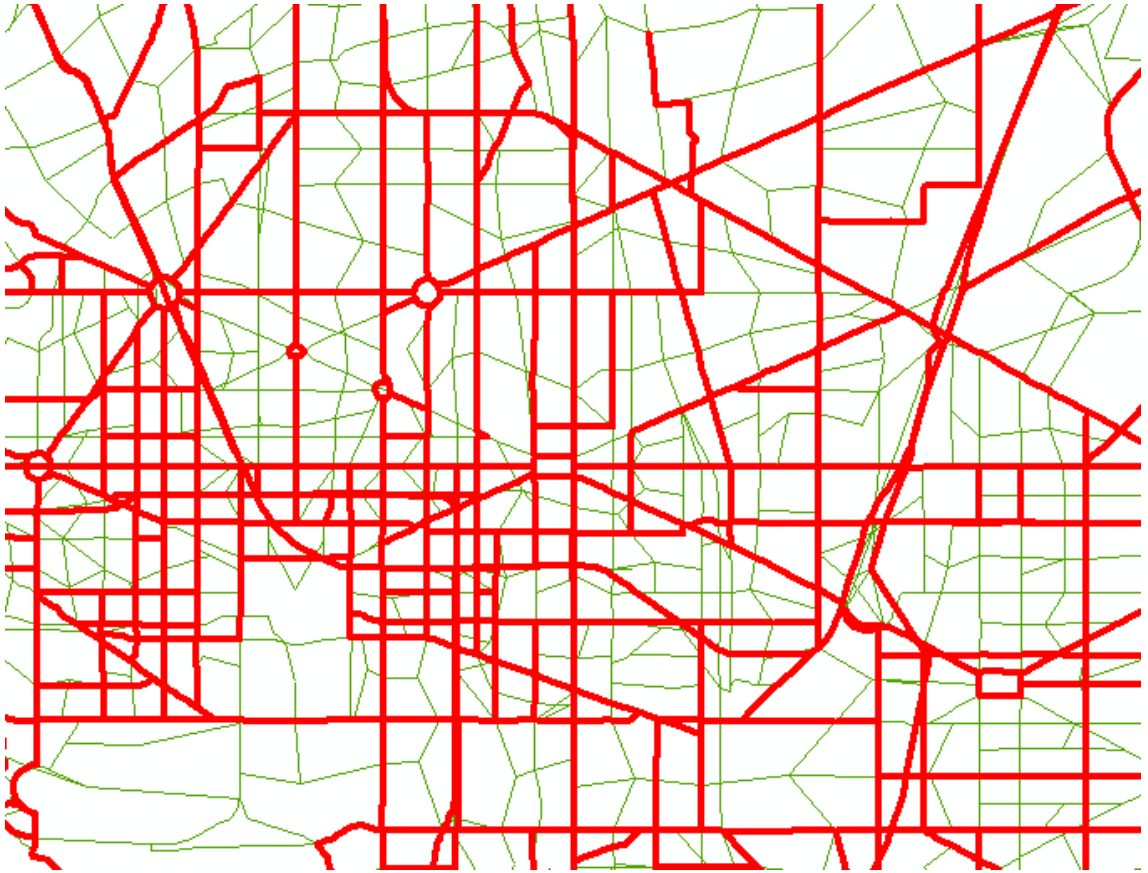


All-streets network



Transit network: Built on top of highway network

- Gen2: Two time periods
  - Peak (AM peak, 7:00 - 7:59 AM)
  - Off Peak (midday, 10:00 AM – 2:59 PM)
- Gen3: Four time periods.
  - AM peak (6:00 AM - 8:59 AM)
  - Midday (9:00 AM – 2:59 PM)
  - PM peak (3:00 PM – 6:59 PM)
  - Nighttime (7:00 PM – 5:59 AM)
- We calculate
  - Avg. headway
  - Avg. run time



Transit networks

- Transit schedule data
  - Machine-readable format: GTFS
  - Paper schedules, PDF files, websites
- 85% of our transit schedule data is in GTFS format (goal: 100%)
- Transit agencies providing GTFS data (on the right):

WMATA - Metrobus/rail
Arlington County – ART Bus
City of Alexandria – DASH Bus
DC Circulator
Fairfax City – CUE Bus
Fairfax County – Fairfax Connector
Falls Church
Frederick County - TransIT
Howard County – Howard Transit
City of Laurel - Connect-a-Ride
Lee Coaches Commuter Bus
MARC Train
Maryland MTA
Montgomery County – Ride-On Bus
Prince George's County – The Bus
Prince William County - OMNI Link/Ride

Use of GTFS to code transit networks

- GTFS data has greatly increased the efficiency of our annual network updates and minimizes errors.
- GTFS helps ensure the travel model is informed by the very latest information.
- Because GTFS is both machine processible and uses a standard format, one can process it using computer programs, which reduces manual processing and staff time.
- However, there are still some issues regarding the regional GTFS data (e.g., format can vary across agencies).
- Greater consistency across transit providers would facilitate regional use.

Goal: Standardization of GTFS across region

- Encourage all transit agencies to publish schedule data in GTFS format
  - Google provides free software for agencies to publish schedule in GTFS format
- Encourage all transit agencies in the region to agree on one standard format
- Specify data type (e.g., numeric, character) and domain for each attribute of the GTFS files

Next Steps

- Staff will continue to distribute the beta version of the Gen3 Model per request.
- Staff will complete post-beta model updates, conduct additional sensitivity tests to confirm reasonableness of model response, and incorporate these updates into a new model version.
- New contract for consultant on-call modeling support to begin in Jan./Feb.
- Staff plan to continue to support both the trip-based (Gen2) and activity-based (Gen3) models for an indefinite period.
- Depending on the success of the beta release, staff hope to be able to declare the Gen3 Model to be production ready by spring 2026.

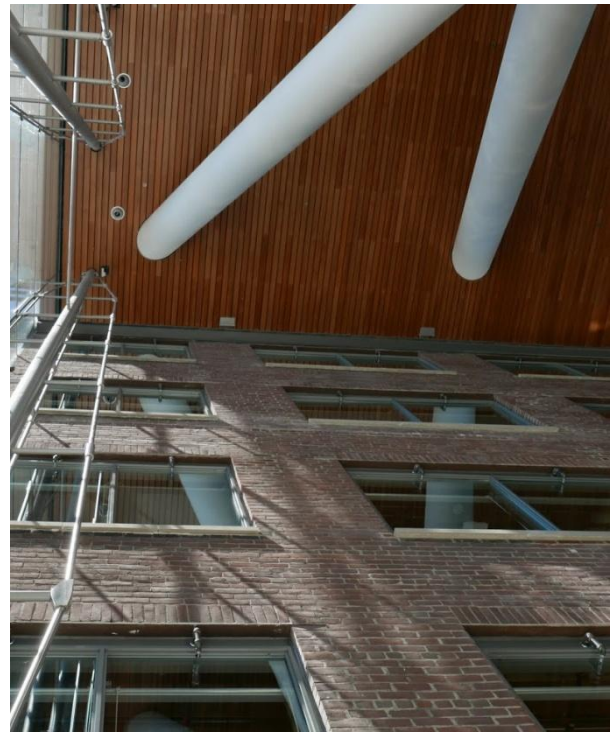


Image credit: Mark Moran

Conclusion

- Your transit route information is a vital input to the regional travel model -- Thank you!
- Transit assignment
  - Gen2 uses two time-of-day periods
  - Gen3 uses four time-of-day periods
  - But, for both models, we need the same type of data from you.
- Gen3 Travel Model improvements
  - Better transit assignments
  - Better at pricing and equity studies
  - Possible future enhancement: Congested transit assignment.

Image credit: Mark Moran

Acknowledgements

- Feng Xie, Program Manager, Model Development Group, Travel Forecasting and Emissions Analysis Team
- COG/TPB Travel Forecasting and Emissions Analysis Team who have worked on Gen3 Model or its associated networks, including Ray Ngo, Meseret Seifu, Bahar Shahverdi, Glenn Lang, Dusan Vuksan, Nazneen Ferdous, Jane Posey (retired), Wanda Owens, and Jian (Jim) Yin
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- Baseline Mobility Group, especially Mushtaqur Rahman

Image credit: Mark Moran

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