

# AN INTRODUCTION TO THE TPB TRAVEL DEMAND FORECASTING MODEL

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# Overview

- Geography: COG, TPB, Travel model
- Uses of the TPB travel demand model
- Development & maintenance of the TPB model
- Model structure
- Data for estimation & calibration
- Model inputs (Land use & transp. networks)
- Demographic models & trip generation
- Future directions

I made a similar presentation to the subcommittee on 3/11/14.

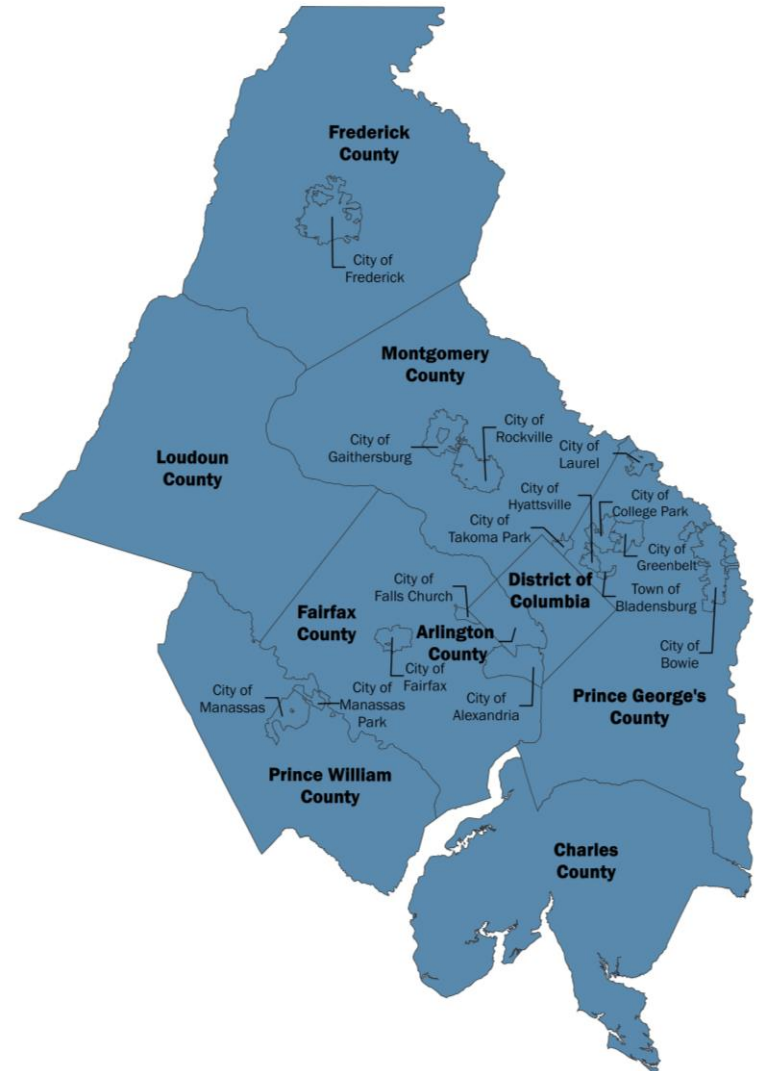


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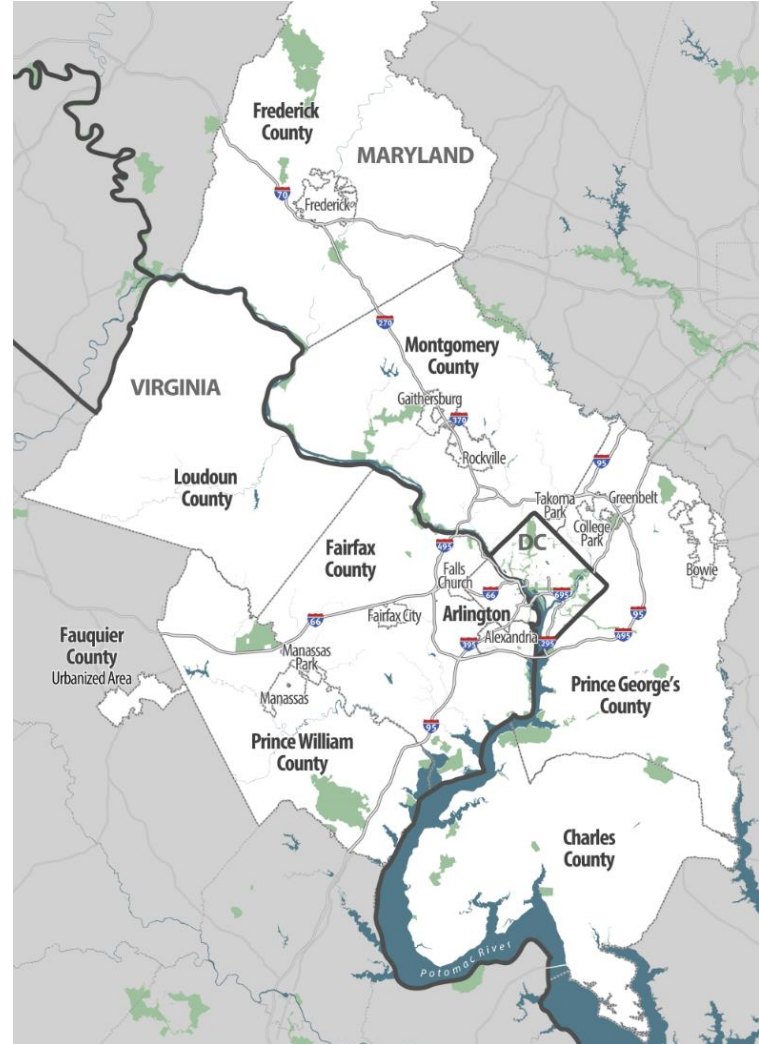
# About COG

- Metropolitan Washington Council of Governments (COG) is an independent, nonprofit association
- Brings area leaders together to address major regional issues in the District of Columbia, suburban Maryland and Northern Virginia
- Membership is comprised of 300 elected officials from 24 local governments, the Maryland and Virginia state legislatures, and U.S. Congress



# About TPB

- National Capital Region Transportation Planning Board (TPB) is 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 in order for federal-aid transportation funds to flow to metropolitan Washington



# Area covered by the TPB travel model

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

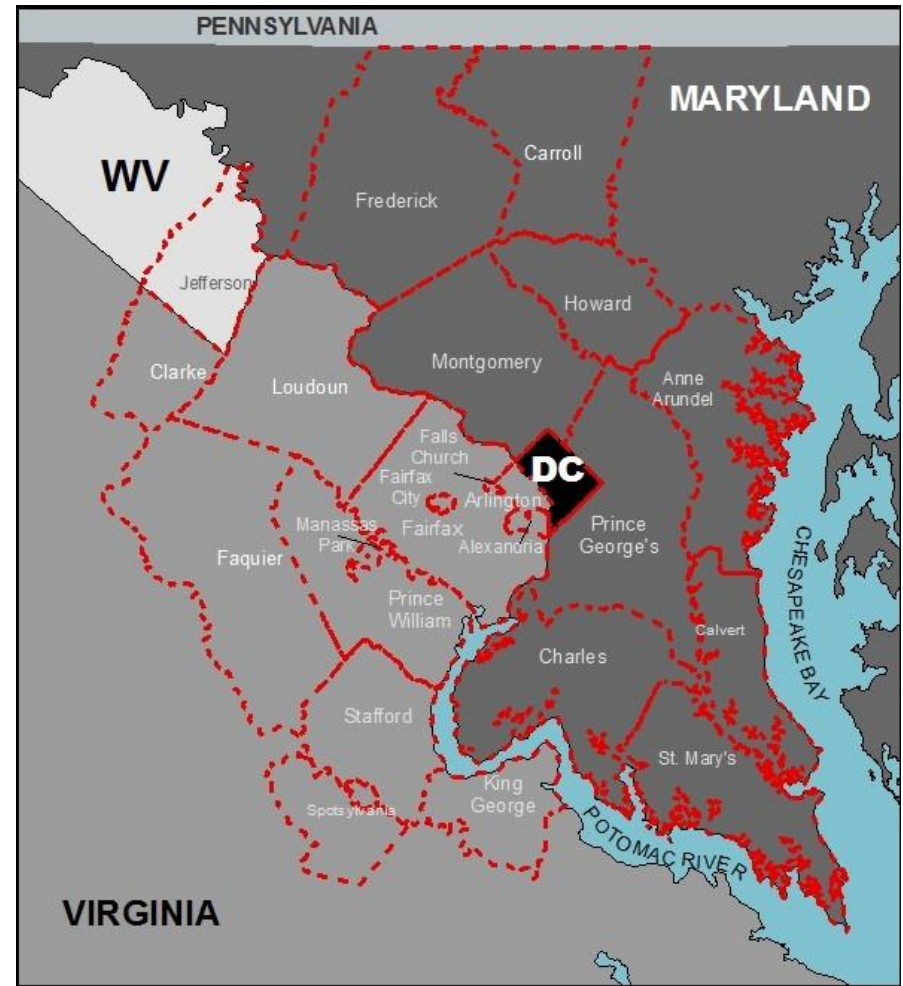


Image credit: Jessica Mirr



# Uses of the TPB travel demand model

- Updating and assessing the adequacy of the regional long-range transportation plan (LRTP), a 25+ year plan
- Air quality conformity determinations of the LRTP & TIP
- Project planning studies
- Special regional studies

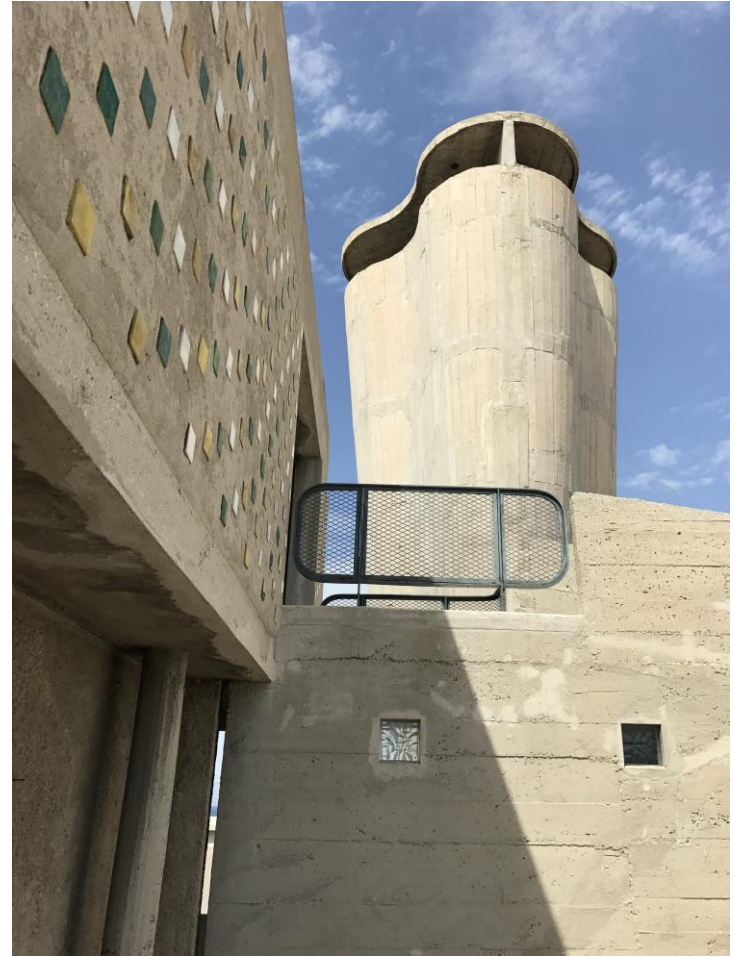


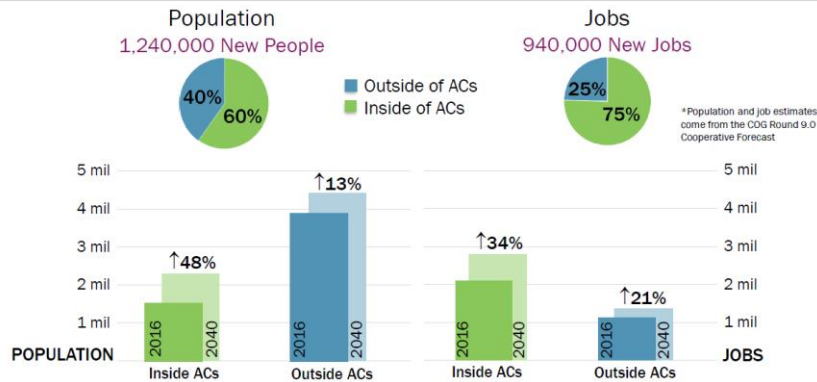
Image credit: Mark Moran



# Activity centers

- Continue to make use of the regional activity centers
- Example: Evaluation of the performance of the LRTP

## Most population and job growth in Activity Centers



- The majority of new jobs and population are forecast to be in Regional Activity Centers.
- The population is forecast to increase at a faster rate inside Activity Centers (48%) compared to the overall rate of growth (23%) over the next 25 years.

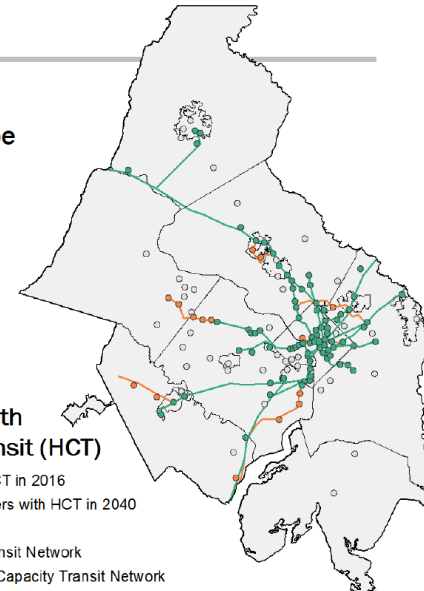
## More Activity Centers connected to high-capacity transit

In 2040, 15 new Activity Centers will be connected to high-capacity transit

2016: 82 Activity Centers (59%)  
2040: 97 Activity Centers (69%)

### Activity Centers with High Capacity Transit (HCT)

- Activity Centers with HCT in 2016
- Additional Activity Centers with HCT in 2040
- All Other Activity Centers
- 2016 High Capacity Transit Network
- 2040 Additions to High Capacity Transit Network



Slides 20, 24 of Swanson, John. "Performance Analysis of the Draft 2016 CLRP Amendment." presented at the October 19, 2016 meeting of the National Capital Region Transportation Planning Board, held at the Metropolitan Washington Council of Governments, October 19, 2016.

# Development & maintenance of the TPB model (1)

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- COG/TPB staff develops and maintains, with consultant assistance, a series of regional travel demand models
- These regional models are developed under the guidance of the Travel Forecasting Subcommittee (TFS), a subcommittee of TPB's Technical Committee
- At any given time, COG/TPB staff typically maintains at least two regional travel demand models
  - An adopted, production-use model
  - One or more developmental models, which may eventually become a production-use model
- The production-use model is the one that is used planning studies conducted by COG/TPB and is made available to outside parties for their use





# Development & maintenance of the TPB model (2)

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- Current production-use model
  - TPB Travel Demand Forecasting Model (TDFM), Generation 2, Version 2.3.70
  - Became the production-use model on 10/18/17 when TPB adopted two resolutions
    - R3-2018: Resolution finding that the Off-Cycle Amendment to the 2016 CLRP conforms with the requirements of the Clean Air Act Amendments of 1990
    - R4-2018: Resolution approving the Off-Cycle Amendment to the 2016 CLRP



# Development & maintenance of the TPB model (3)

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- Current production-use model: TDFM Gen. 2, Version 2.3 family of models
  - Calibrated to year-2007 conditions in 2012
    - Calibration Report for the TPB Travel Forecasting Model, Version 2.3, on the 3,722-Zone Area System. January 20, 2012.
  - Validated to year-2010 conditions in 2013
    - Milone, Ronald. “2010 Validation of the Version 2.3 Travel Demand Model.” Memorandum, June 30, 2013.
  - Travel model user’s guide is developed for each version of the model, e.g.
    - User’s Guide for the COG/TPB Travel Demand Forecasting Model, Version 2.3.70: Volumes 1 and 2. November 28, 2017.

All documentation is on the web: <https://www.mwcog.org/transportation/data-and-tools/modeling/model-documentation/>



# Development & maintenance of the TPB model (4)

- Developmental models
  - TPB TDFM Gen. 2, Ver. 2.3.75 & 76 (trip-based; upcoming AQC)
  - TPB TDFM Gen. 2, Ver. 2.5 (trip-based)
  - TPB TDFM Gen. 3/NextGen (trip-, tour-, activity-based, hybrid?)
  - TPB TDFM Gen. 4 (trip-, tour-, activity-based, hybrid?)



Image credit: Mark Moran



# Structure of an aggregate, trip-based travel demand model

- Aggregate, trip-based model, a.k.a. four-step model
- 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

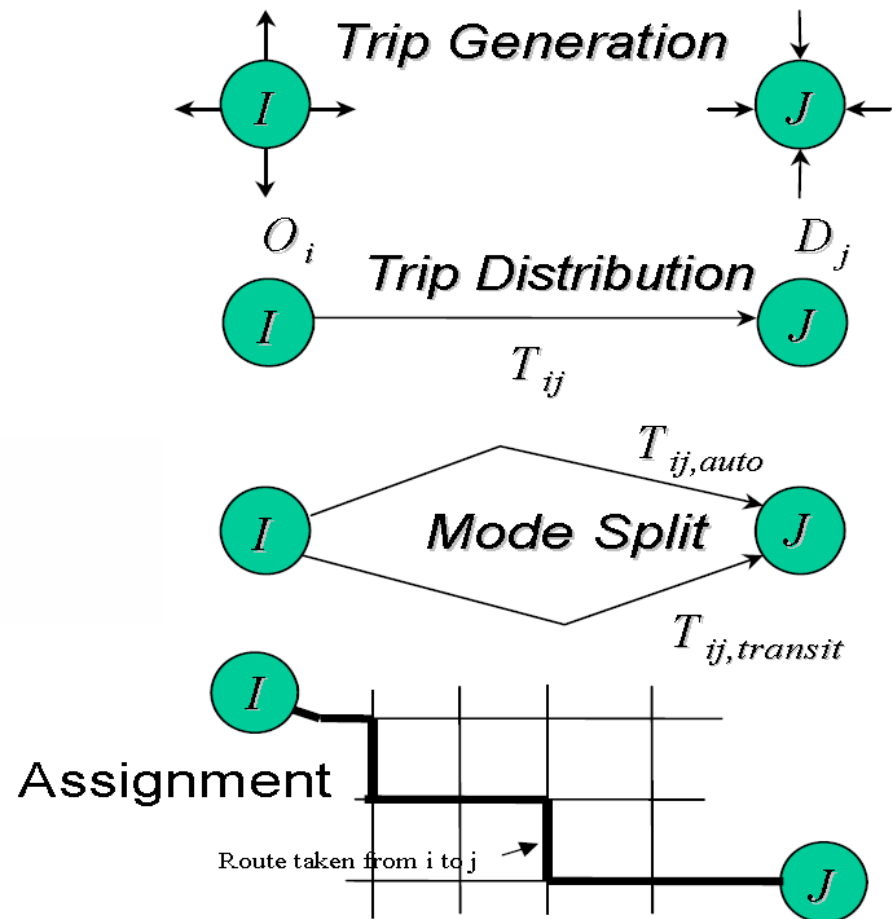
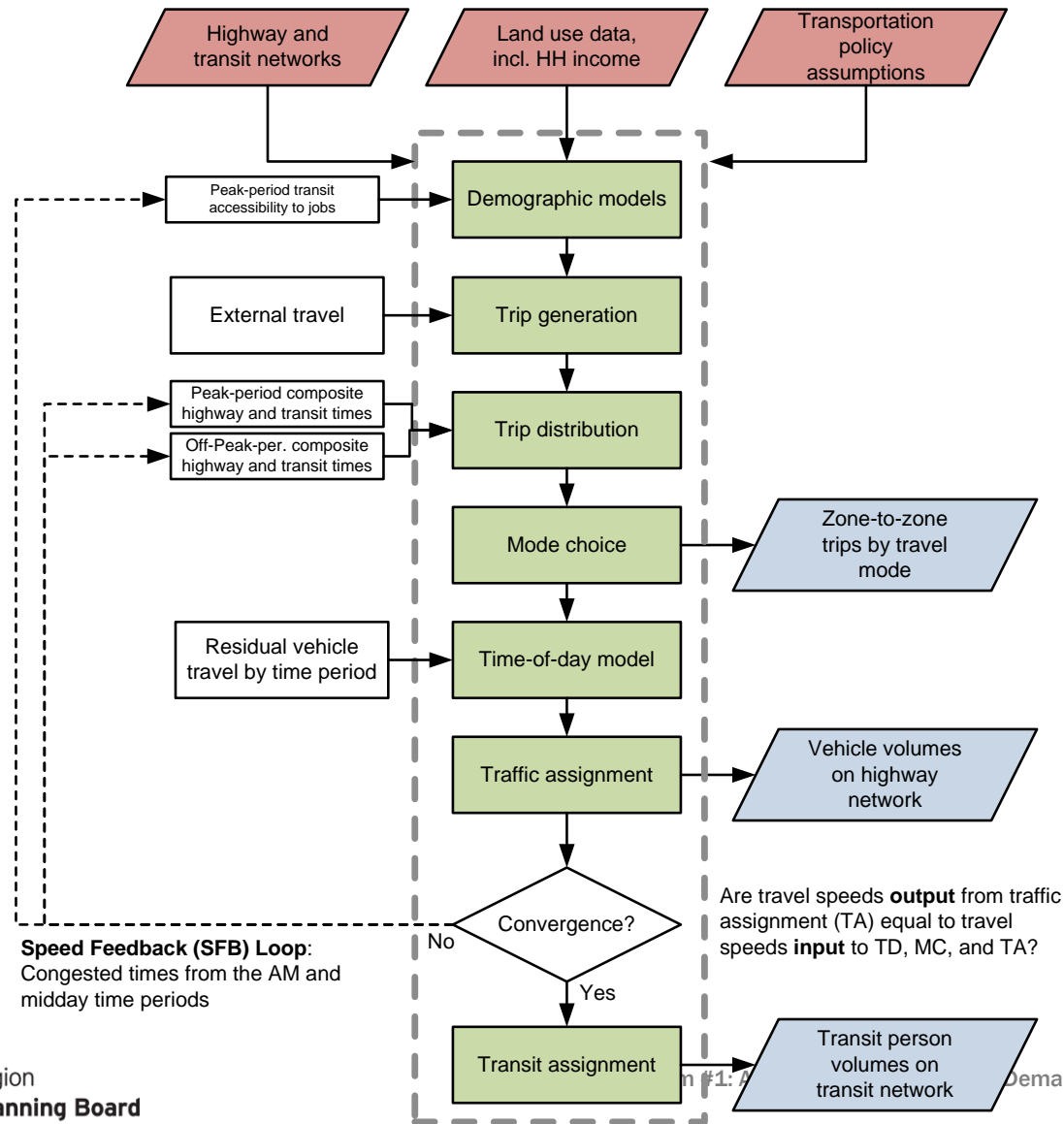


Image credit: Meyer, Michael D., and Eric J. Miller. Urban Transportation Planning: A Decision-Oriented Approach. McGraw-Hill Higher Education, 2001. p. 272.

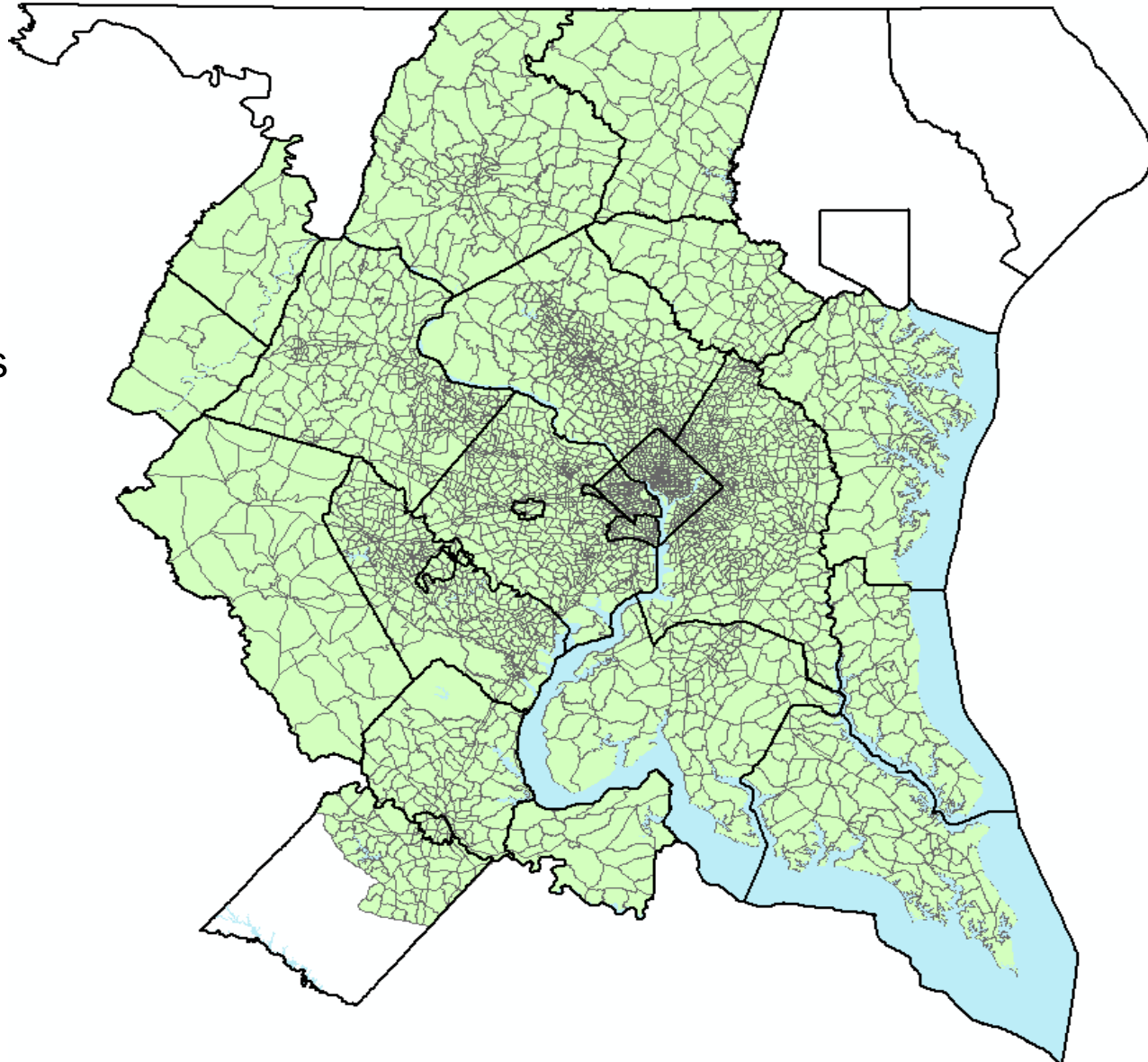


# TPB Travel Demand Forecasting Model



# 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)



# Primary data sets for estimation & calibration

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- 2007/2008 COG/TPB Household Travel Survey
- 2000 CTPP and 2007 American Communities Survey (ACS)
- Mode choice
  - 2008 Metrorail Passenger Survey
  - 2008 Regional Bus Survey
  - 2007-2008 On-Board Survey of Maryland Transit Administration (MTA) Riders, which includes MARC commuter rail service
  - 2005 Virginia Railway Express (VRE) Passenger Survey
- Truck and commercial vehicles: 2005 commercial vehicle survey (COG/TPB)



# Model inputs: Land use forecasts

- Households
- Household population
- Group quarters population
- Total population
- Total employment (ORIO)
  - Office employment
  - Retail employment
  - Industrial employment
  - Other employment
- Uses of land use data
  - Calculating area type
  - Demographic models
  - Trip generation

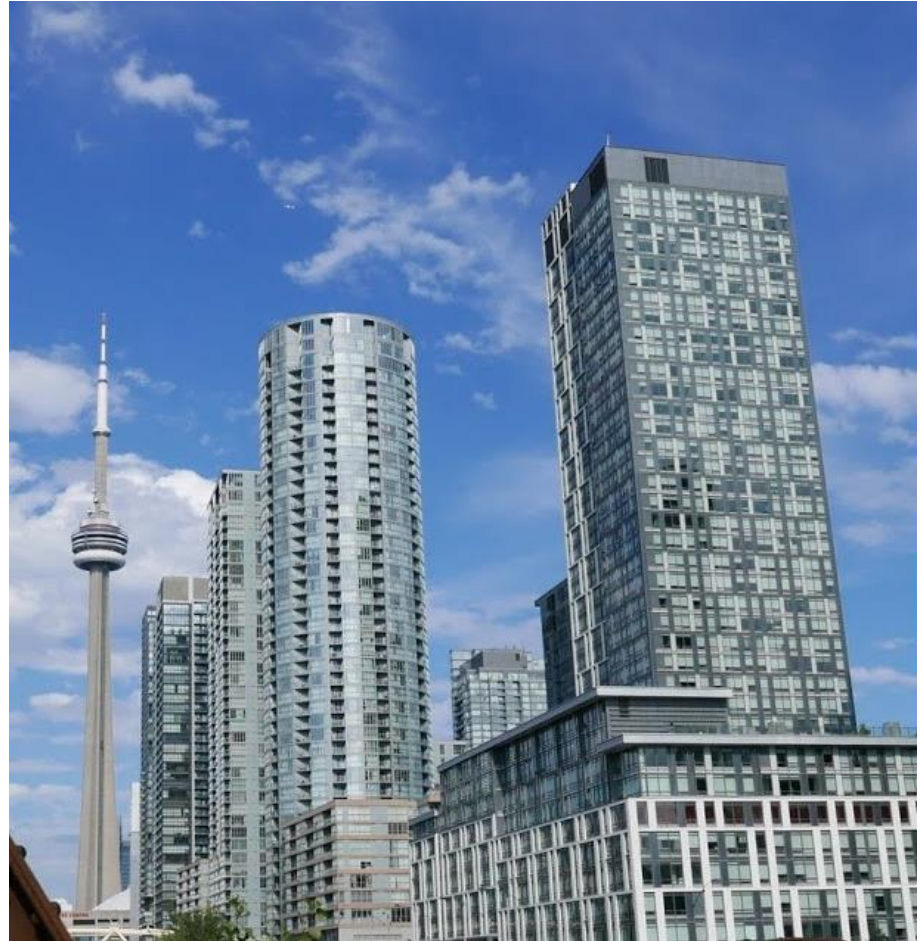


Image credit: Mark Moran





# Model inputs: Land use forecasts

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- Zone-level land activity forecasts are developed by COG's Cooperative Forecasting Program, via its Cooperative Forecasting and Data Subcommittee
- COG does not use a formal land use model
  - In the early 1970s, COG tried using a land use model (EMPIRIC), but staff was not satisfied with its performance, and abandoned its use.
- Instead, like many MPOs, COG uses a process, often known as a “modified Delphi process,” which involves reconciling top-down and bottom-up land activity forecasts



# CTPP-based employment adjustment (1)

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- Before the zone-level land activity data can be used as an input to the travel model, it must undergo an adjustment process, known as the CTPP-based employment adjustment
- This ensures that a consistent employment definition is used by all counties and jurisdictions in the modeled area
- Rationale: Different jurisdictions in the modeled area use different definitions of employment. For example,
  - Baltimore region jurisdictions develop their base-year employment estimates using data from Bureau of Economic Analysis (BEA).
  - By contrast, Washington region jurisdictions develop their base-year employment estimates using data from the Quarterly Census of Employment and Wages (QCEW) collected by the Bureau of Labor Statistics (BLS).

See, for example

- Griffiths, Robert E. Memorandum to TPB Technical Committee. "Travel Model Employment Data Adjustment Factors." May 7, 2004.
- ———. Memorandum to Ronald Milone. "Travel Model Employment Data Adjustment Factors for Round 7.0." August 10, 2005



# CTPP-based employment adjustment (2)

- Current adjustment factors:

Jurisdiction	CTPP-Based Adjustment Factor
District of Columbia	1.00
Montgomery Co., Md.	1.00
Prince George's Co., Md.	1.00
Arlington Co., Va.	1.00
City of Alexandria, Va.	1.00
Fairfax Co., Va.	1.00
Loudoun Co., Va.	1.00
Prince William Co., Va.	1.00
Frederick Co., Md.	1.00
Howard Co., Md.	0.88
Anne Arundel Co., Md.	0.94
Charles Co., Md.	1.00
Carroll Co., Md.	0.93
Calvert Co., Md.	1.00
St. Mary's Co., Md.	0.94
King George Co., Va.	1.00
City of Fredericksburg, Va.	1.00
Stafford Co., Va.	1.00
Spotsylvania Co., Va.	1.00
Fauquier Co., Va.	1.22
Clarke Co., Va.	1.34
Jefferson Co., WV.	1.25



# Model inputs: Transportation networks

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- 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



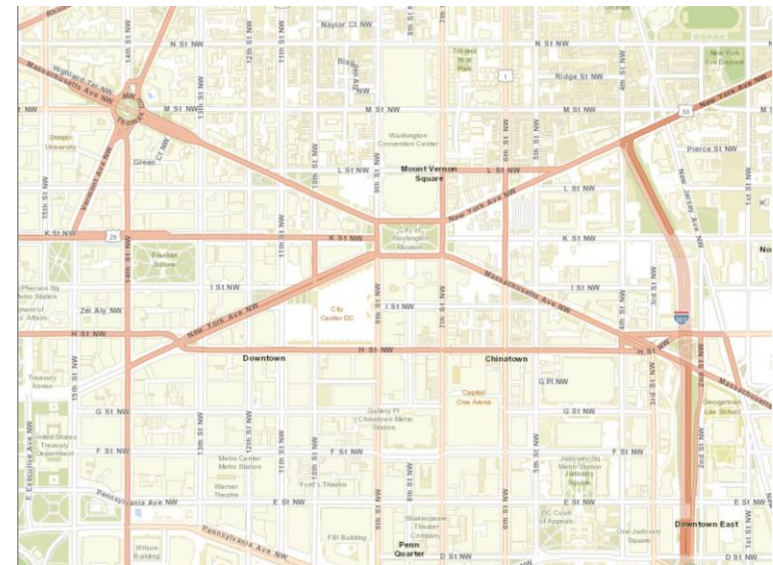
# Highway Network

- 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)

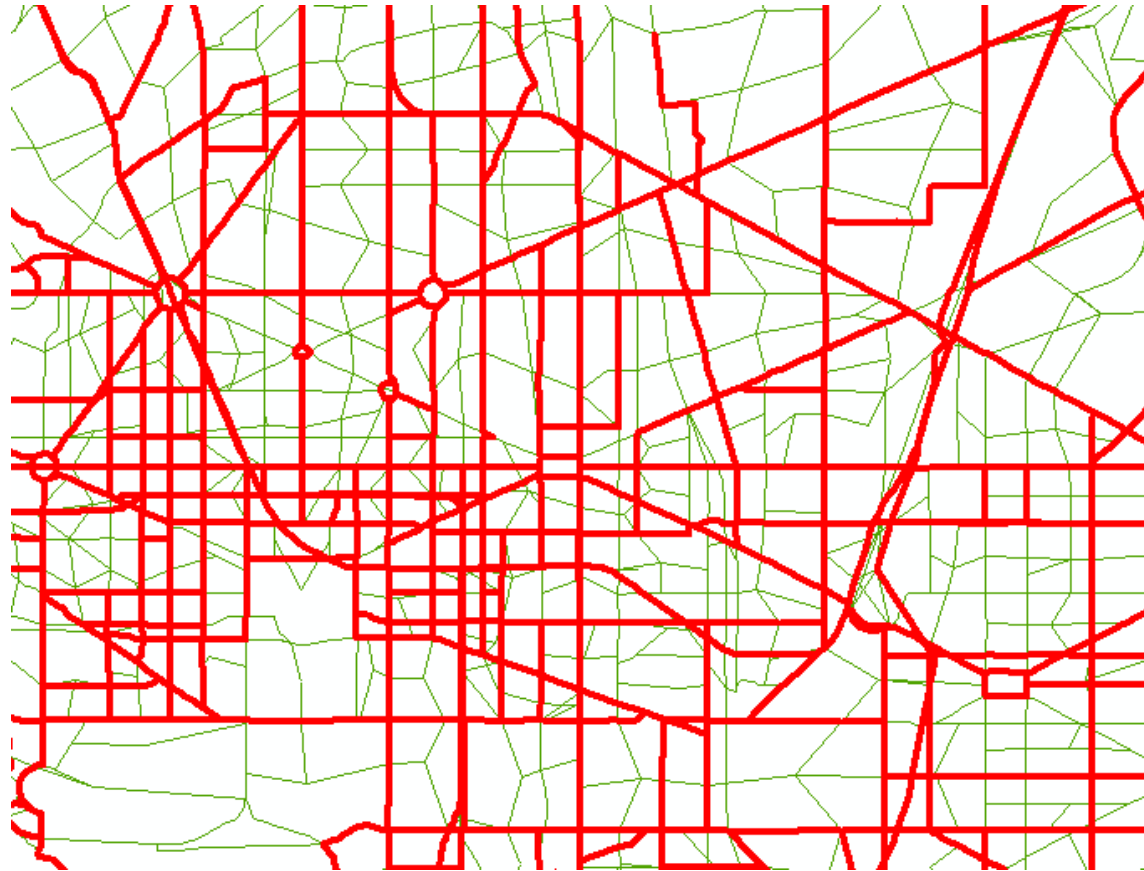


All-streets network



# Transit Network

- Transit network is built on top of COG's highway network
- Two time periods
  - Peak (AM peak, 7:00 - 7:59 AM)
  - Off Peak (midday, 10:00 AM - 2:59 PM)
- We calculate
  - Avg. headway
  - Avg. run time



# Area type

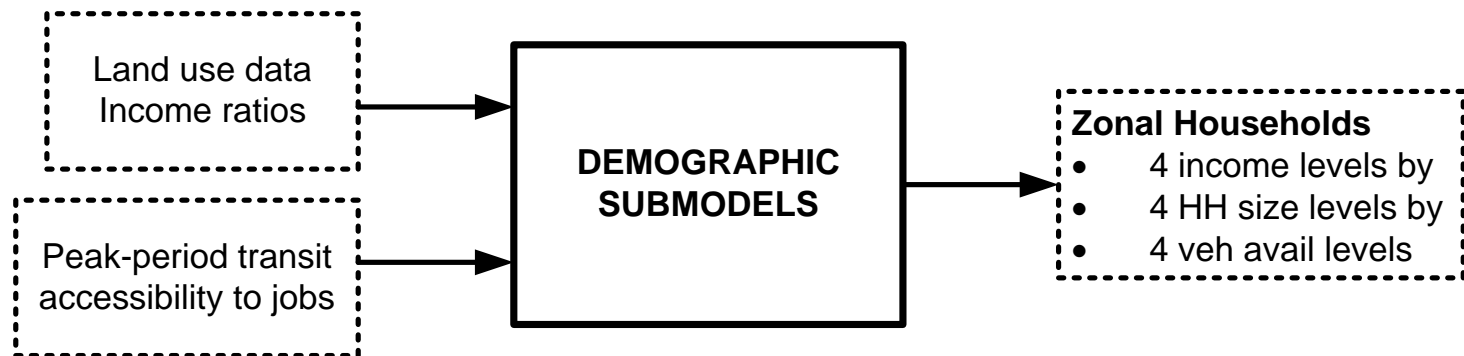
- A measure of the land use density and mixing
- A function of zonal population density and zonal employment density
  - 1 = Urban; 6 = Exurban
- Both link capacity and free-flow link speeds = f (area type, facility type)

One-Mile "Floating" Population Density (Pop/Sq mi)	One- mile "Floating" Employment Density (Emp/Sq mi)						
	0-100	101-350	351-1,500	1,501-3,550	3,551- 13,750	13,751- 15,000	15,001+
0-750	6	6	5	3	3	3	2
751-1,500	6	5	5	3	3	3	2
1,501-3,500	6	5	5	3	3	2	2
3,501-6,000	6	4	4	3	2	2	1
6,001-10,000	4	4	4	2	2	2	1
10,001-15,000	4	4	4	2	2	2	1
15,001+	2	2	2	2	2	1	1



# Demographic models (1)

- HH size model (1, 2, 3, 4+)
- HH income model (1st quarter, 2nd, 3rd, 4th)
- HH vehicle availability model (0, 1, 2, 3+)
- Thus, we apportion zonal households into 64 subclasses





# Demographic models (2)

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- HH size and HH income models are “aggregate share” models calibrated from 2000 CTPP
  - HH income model was adjusted with 2007 ACS
- HH vehicle availability model is a discrete choice model estimated using the COG 2007/2008 Household Travel Survey
  - Vehicle availability = function of
    - HH size
    - HH income
    - Transit accessibility to jobs
    - Area type
    - DC indicator variable

Source: Martchouk, M. (2010, September 17). *Ver. 2.3 travel model, demographic sub-models: Household size, household income, and vehicle availability*. Presented at the September 17, 2010 meeting of the Travel Forecasting Subcommittee.



# Trip generation

- Compute the number of daily person trips and daily truck/commercial vehicle trips produced by and attracted to each TAZ\*
- Total person trips (motorized & non-motorized)
- Trip ends
  - Production: Home end of a HB trip or the origin of a NHB trip
  - Attraction: Non-home end of a HB trip or the destination of a NHB trip

\* Daily means average weekday



Image credit: Mark Moran



# Trip generation: Trip purposes

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- Person travel
  - Home-Based Work (HBW)
  - Home-Based Shop (HBS)
  - Home-Based Other (HBO)
  - Non-Home-Based Work (NHW)
  - Non-Home-Based Other (NHO)
- Commercial travel
  - Medium truck (single unit, two axles, 6 or more tires)
  - Heavy truck (all combination vehicles)
  - Commercial vehicles (autos and light duty trucks used to transport commercial goods and services)



# Trip generation: Productions

- Trip production model
- Cross-classification model
- Estimated using the 2007/2008 Household Travel Survey
- Example: HBW

Income Level	HH Size	Vehicles				Subtotal
		0	1	2	3+	
00k - 50k	1-PSN	0.41	0.65	0.54	0.66	0.58
	2-PSN	0.67	0.86	1.27	1.34	1.05
	3-PSN	0.91	1.34	1.89	1.92	1.55
	4+PSN	1.34	1.34	1.70	2.50	1.69
	Subtotal	0.55	0.80	1.35	1.75	0.94
50k-100k	1-PSN	1.00	1.06	1.04	1.04	1.05
	2-PSN	1.20	1.29	1.41	1.51	1.39
	3-PSN	1.25	1.70	1.95	2.05	1.93
	4+PSN	1.34	1.82	1.99	2.69	2.24
	Subtotal	1.06	1.20	1.63	2.14	1.55
100k-150k	1-PSN	1.08	0.99	1.09	1.29	1.03
	2-PSN	1.72	1.78	1.78	1.87	1.79
	3-PSN	1.72	1.82	2.05	2.51	2.23
	4+PSN	1.75	1.97	1.98	2.71	2.26
	Subtotal	1.33	1.36	1.86	2.42	1.92
> 150k	1-PSN	1.16	1.04	1.20	0.87	1.07
	2-PSN	1.72	1.82	1.87	1.90	1.88
	3-PSN	1.72	2.16	2.28	2.93	2.62
	4+PSN	1.75	2.24	2.60	2.97	2.75
	Subtotal	1.33	1.57	2.15	2.58	2.25
TOTAL		0.72	1.10	1.78	2.33	1.63



# Trip generation: Attractions

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- Linear regression equations that use land use data, including employment and population, to predict the number of attractions in a TAZ
- Developed using district-level data from the 2007/2008 Household Travel Survey
- Estimated by trip purpose and two area type groupings (area types 1-2 and area types 3+)
- Examples
  - $HBW\_Attr_{1-2} = 1.118 * TOTEMP$
  - $HBW\_Attr_{3+} = 0.8546 * TOTEMP$
  - $HBS\_Attr_{1-2} = 1.995 * RETEMP + 0.301 * TOTPOP$
  - $HBS\_Attr_{3+} = 3.102 * RETEMP + 0.221 * TOTPOP$



# Other modeling steps

- Trip distribution
- Mode Choice
- Trip assignment
- (Not covered in this presentation)

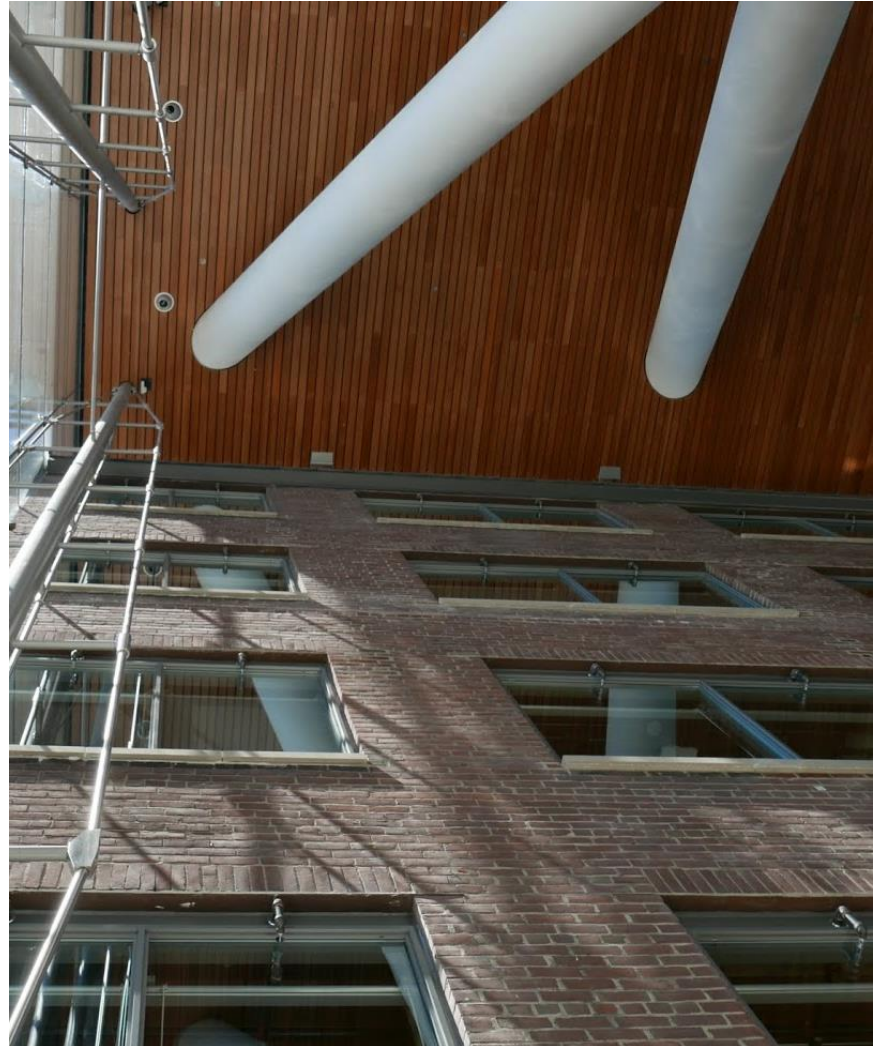


Image credit: Mark Moran

# Future directions: Developmental models



Image credit: Mark Moran



# Possible future directions in modeling

		Travel Supply and Trip Assignment	
		Aggregate (e.g., TAZ-level, macroscopic traffic assignment)	Disaggregate (e.g., TAZ, MAZ, or parcel-level; DTA/mesoscopic/microscopic assignment)
Travel Demand	Aggregate (e.g., zone-level, trip-based, 4-step model)	Quadrant 1 (current TPB travel model)	Quadrant 2
	Disaggregate (e.g., person and household level, activity-based model)	Quadrant 3	Quadrant 4 (long-term goal)

- Three possible paths between current model and long-term goal





# Strategic plan for improving the TPB travel model

- Strategic plan, as amended in 2018: 3 phases over 8 years

Phase	Description	Duration (Years)	Fiscal Years
1	Updates to the existing four-step model (Gen. 2, Ver. 2.3 & 2.5)	3	2016-2018
2	Development of a Gen. 3 (NextGen) model with existing data	3	2019-2021
3	Development of a Gen. 4 model with new data*	2	2022-2023

\* New household travel survey currently underway; To be ready for use in FY 2020.



# Comparison of modeling approaches

Trip-Based Model (current TPB model)	Activity-Based Model (ABM)
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

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

- Gen. 3/NextGen model: Model type not yet decided (trip-based, tour-based, ABM, hybrid?)
- No matter what model form is chosen, it is not expected that there would be changes in regional metrics (e.g., VMT, mode choice).
- Advantage of ABM: More detailed information about travelers
- Disadvantage of ABM: More complicated model and longer model run times



# Conclusions

- Your zone-level land activity forecasts are a vital input to the regional travel model – Thank you!
- We must apply an adjustment to employment data before it can be used by the model
- Our three demographic models are used to make forecasts that we do not currently get from the land use planners (HHs by HH size, HH income, and vehicle availability)
- Starting our 3-year process to develop the Gen. 3/NextGen TPB travel demand forecasting model



Image credit: Mark Moran



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