Arlington County Travel Model

MWCOG/TPB TFS

16 July 2021

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Advancing Infrastructure

Overview

❖ Recap of project status and model structure

❖ Some interesting new features

❖ Model validation

New Travel Model for Arlington County

❖ Focused model, more detail in Arlington County

❖ Simplified tour-based structure

❖ Intended uses:

  ▪ Master Transportation Planning

  ▪ Corridor & Neighborhood Studies (e.g., George Mason Drive Analysis)

  ▪ Planning for New Development (e.g., Amazon HQ2)

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Model Status

❖ Last TFS presentation: 20 Nov 2020

❖ Validation completed, forecast in progress, documentation and training by mid-September

Simplified Tour-Based Model

❖ Discrete model, uses round-trip tours

❖ Several logit models, Monte Carlo simulation

❖ Synthesizes households

❖ No time/space constraint or tour scheduling

❖ 4 time periods

❖ Runs faster than ABM, easier to understand, shorter development time

Steps
1. HH synthesis
2. Tour frequency
3. Destination choice
4. Mode choice
5. Intermediate stops & locations
6. Time of day
7. Trip accumulator
8. Highway & transit assignments
9. Speed feedback

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# Input Data

❖ Same zonal data as MWCOG, with school enrollment

- K-12
- University

❖ Same rail station/PnR lot file as MWCOG but add shadow price

- Updated parking lot capacities in VA

❖ Many fewer input files

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Highway Network

- ❖ Mostly same network as MWCOG
- ❖ Different in the County
  - ▪ More detail (425 zones)
  - ▪ True shape network
  - ▪ New "Local" road type
  - ▪ Traffic control devices, turn lanes
- ❖ Toll coding is simplified
  - ▪ Varies by segment, not by link
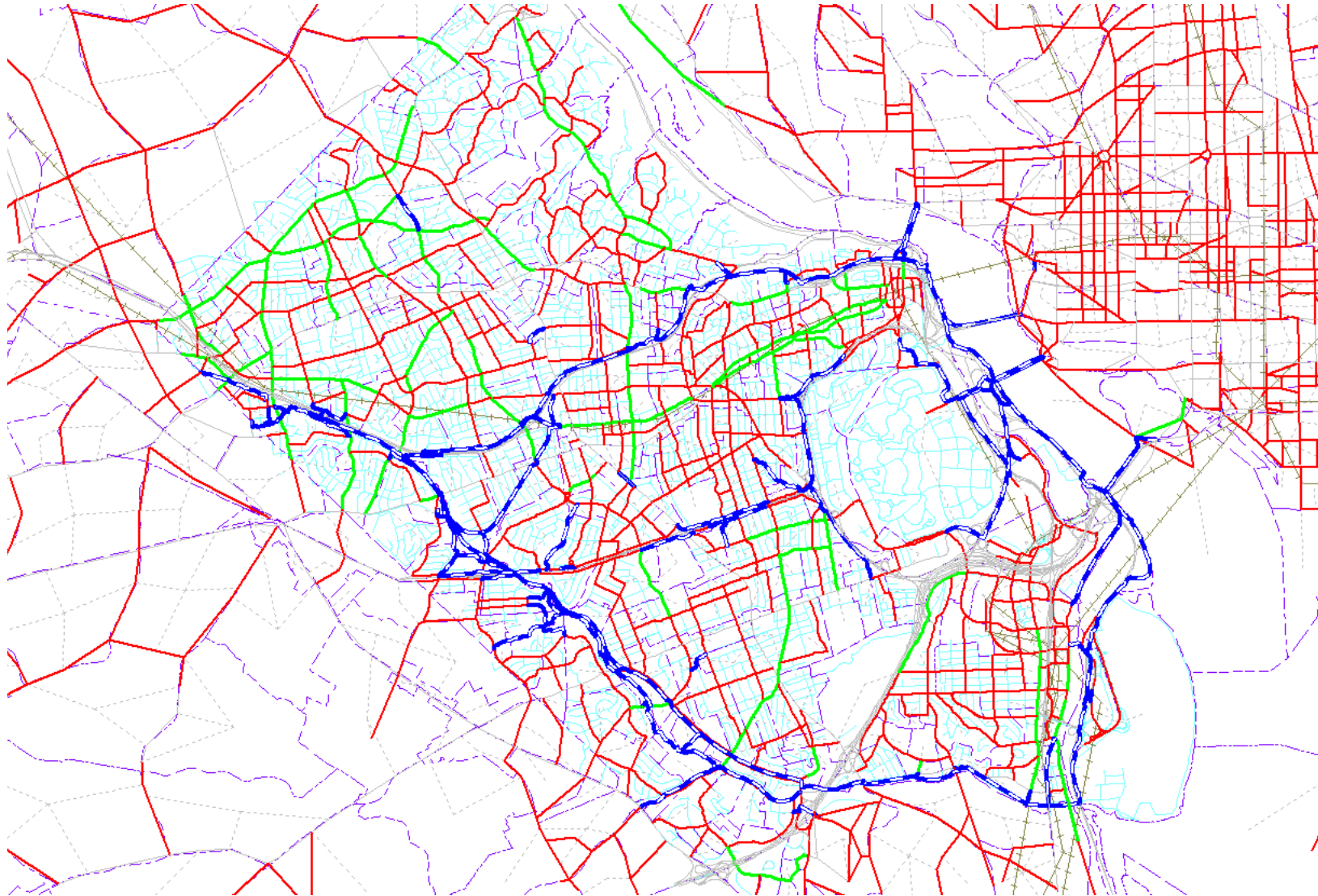- ❖ Include rail lines and bike paths

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True Shape Network

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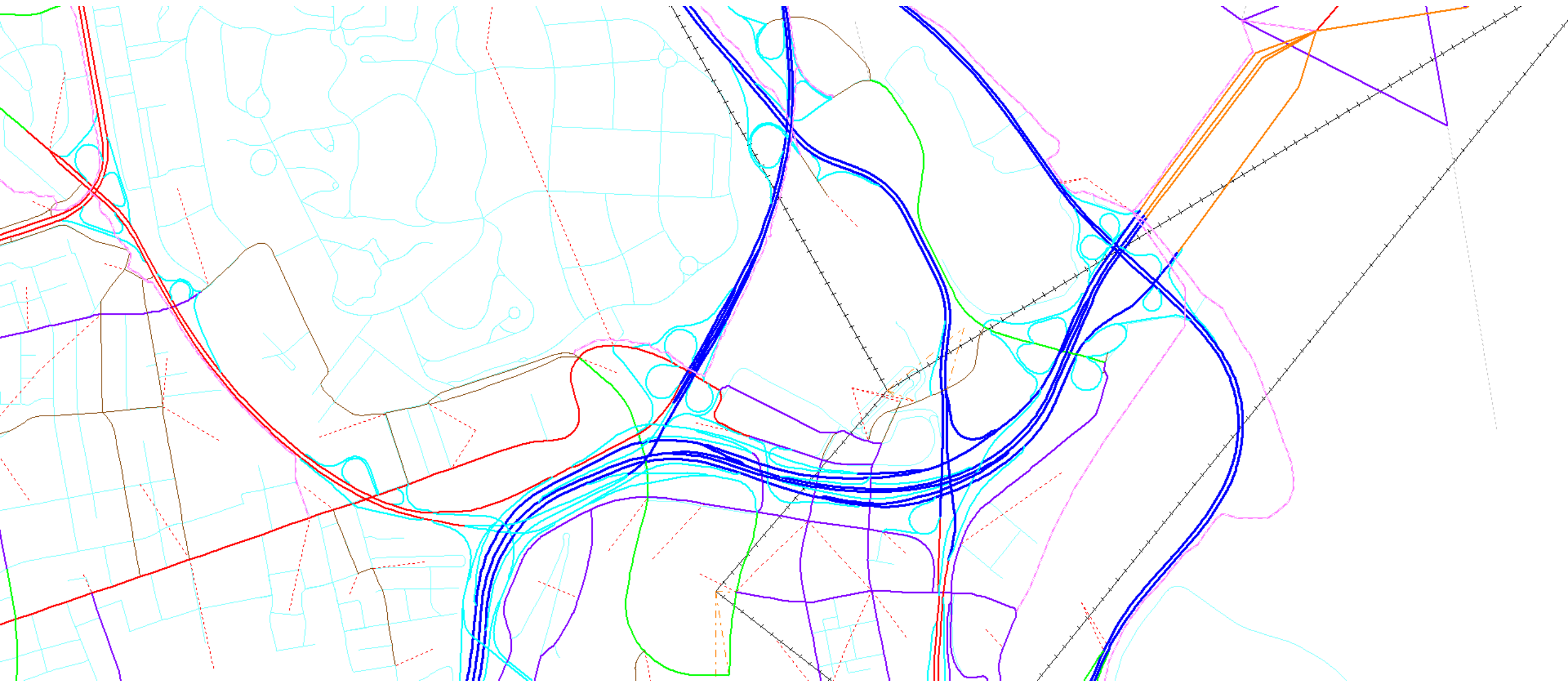
Bicycle Network

- ❖ Bike facility types:
  - ▪ On-street, no markings
    - ● No freeway, expressway, major arterial
  - ▪ On-street, bike lane
  - ▪ Off-street trail
- ❖ Trails coded only in Arlington County
- ❖ Different "effective speed" by facility type

Bike Links

Legend
Red = on-street, no markings
Green = on-street marked
Blue = off-street

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Transit Network

❖ Mostly same line coding as MWCOG

❖ No drive-access coding

  ▪ Drive access uses the highway network

❖ No "percent walk" calculation

❖ Bus fare coding is more specific, by operator

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Transit Access

- ❖ Walk, PnR, KnR/TNC
  - ▪ TNC used only for access
- ❖ PnR lot choice/constraint process
  - ▪ 3 best lots/stations for each tour
    - ● Minimize total path impedance
  - ▪ If person drives to transit, pick best available lot
    - ● If best lot full, pick 2nd, then 3rd lot
    - ● If all 3 lots full, switch to different mode
    - ● Update lot usage
  - ▪ Enforces capacity constraint
  - ▪ Avoids overestimating transit if lot fills up

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Transit Network Processing

- ❖ Use Cube's *Public Transport* module
- ❖ More sophisticated path-building
  - ▪ Include fares
  - ▪ Multiple paths
- ❖ Incorporate crowding
- ❖ Different methodology than TRNBUILD
- ❖ PT vs. TRNBUILD
  - \+ Mode-specific link times
  - \+ Flexible support link generation
  - \+ Multiple user classes
  - \- Runs slower

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Transit Multi-path Processing

❖ Probabilistic, not deterministic

- Multiple paths evaluated and averaged by O/D pair

❖ Heuristic

- Objective function is not being optimized

❖ Methodology:

- Build best path: minimize generalized cost
- Route enumeration: build other paths based on user-input rules
- Route evaluation: calculate probability of using each path

❖ Impedance values are probability-weighted averages

❖ More accurate but more complex

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HH Synthesis

❖ Attributes: size (1-5), vehicles (0-3+), workers (0-3+), income (1-4), life cycle (retired, kids, neither), AVs

❖ Synthesize 2.9 million records in 1.2 minutes

❖ Submodels based on Census data

❖ Process is similar to current MWCOG model

❖ Includes group quarters population

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HH Synthesis Validation -- Arlington

	size	income	life cycle	workers	vehicles
Observed					
0				8.4%	12.9%
1	39.0%	19.8%	16.6%	43.3%	47.4%
2	32.9%	23.2%	20.9%	40.1%	29.8%
3	12.5%	26.0%	62.5%	8.3%	9.8%
4	10.9%	31.0%			
5+	4.7%				
Model					
0				9.7%	11.9%
1	41.8%	20.3%	16.7%	42.8%	51.1%
2	31.5%	23.4%	20.5%	38.9%	28.3%
3	12.6%	26.0%	62.8%	8.5%	8.7%
4	8.9%	30.3%			
5+	5.2%				

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Tour Frequency

❖ Purposes: School, University, Work, Shop, Other, At-Work
   ▪ Sequence is important
   ▪ Lower priority purposes depend on higher priority purposes
   ▪ Special feature of a discrete model

❖ Logit model
   ▪ Based on HH variables, accessibility, area type, gasoline price

❖ Model 0 – 3 tours/HH directly; 4 – 10 tours using fixed shares

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Example: HB Shop Tour Frequency Model

❖ Key variables:
- 3+ worker dummy (+)
- Income 1 dummy (-)
- Retired HH dummy (+)
- Work tours (-)
- School/university tours (-)
- Vehicles (+)
- Composite accessibility to employment (+)

- Zonal income ratio (+)
- HH size (+)
- 5-person dummy (-)

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Tour Frequency Validation

❖ Round-trip tours per household

	Arlington Co		Regional	
	survey	model	survey	model
HBW	0.935	1.055	0.944	0.943
SCH	0.224	0.198	0.338	0.333
HBU	0.037	0.039	0.037	0.034
HBS	0.442	0.409	0.515	0.505
HBO	1.070	0.850	1.219	1.225
total	2.708	2.551	3.053	3.040

Destination Choice

- ❖ Logit model by purpose
  - ▪ Stratified by high/low income for Work, Shop, Other
- ❖ Major variables: composite time, area type, intrazonal flag, accessibility
- ❖ Double-constrained process – respects zonal attractions
- ❖ Includes step to estimate I/X tours
- ❖ Jurisdiction-Jurisdiction tour table est / obs correlation: 0.992
- ❖ No K factors or other jurisdiction-specific adjustments
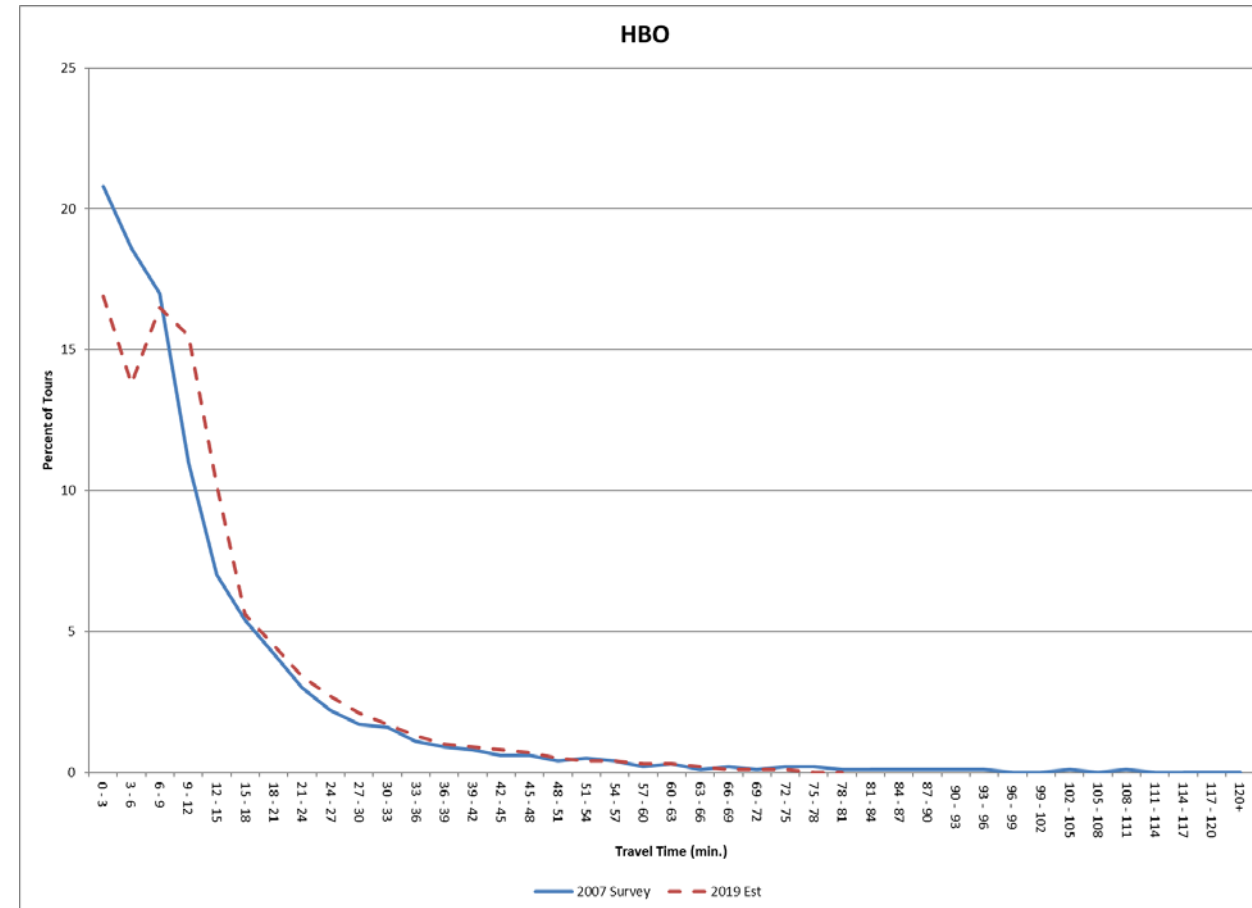 - ▪ Just the COG 11-minute bridge penalty

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Tour TLFDs

Obs average = 12.3 min
Est average = 12.7 min
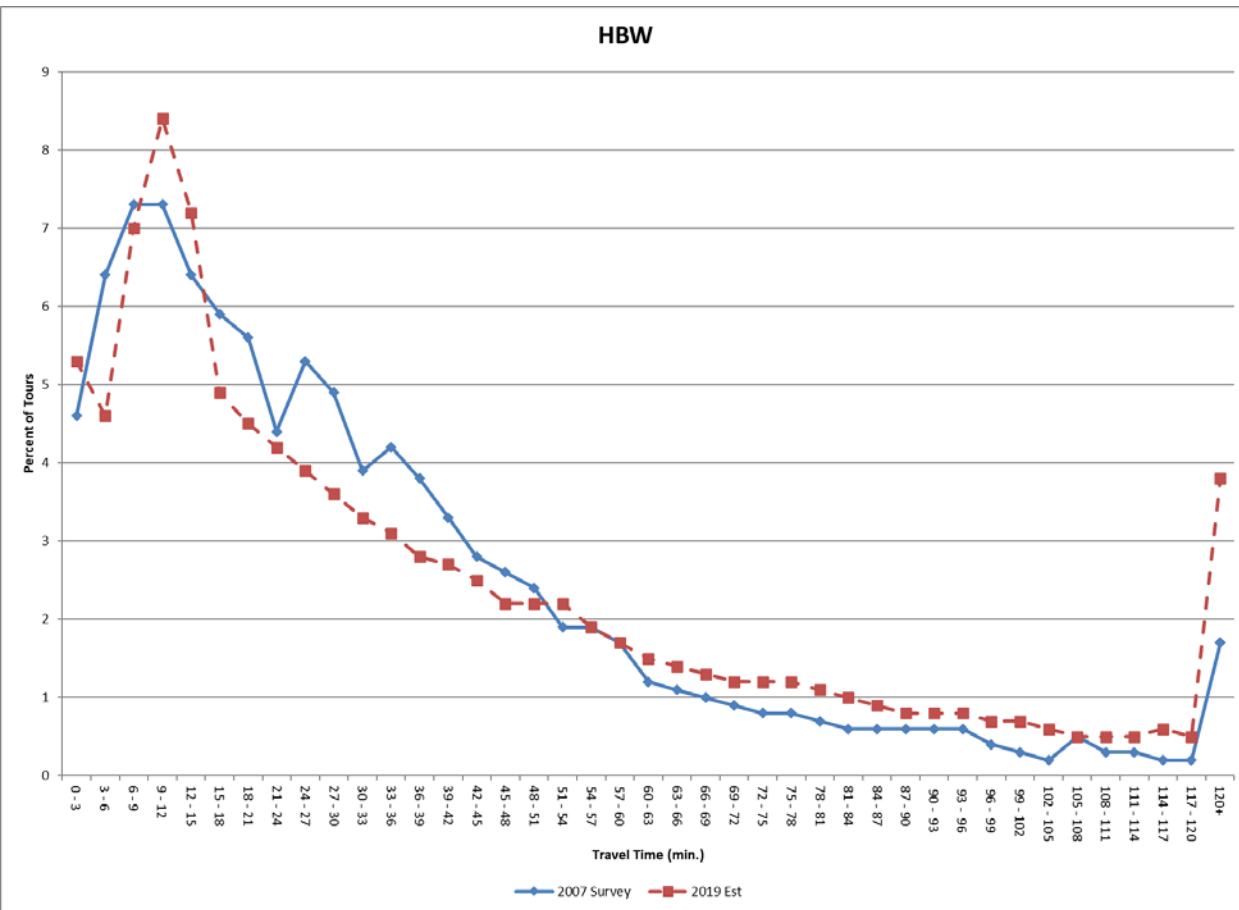
Obs average = 38.2 min
Est average = 38.3 min
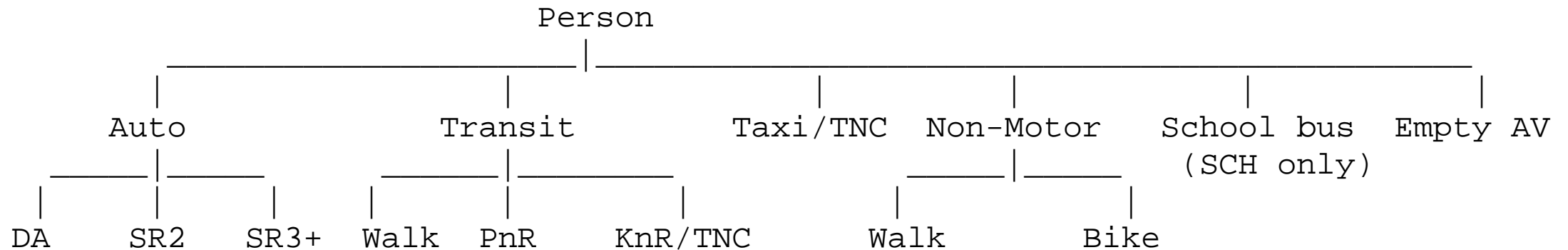
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Mode Choice

- ❖ EU / AUS approach
  - ▪ Simpler mode choice
  - ▪ Transit sub-mode / path choice handled in assignment
    - • Bus vs. Metrorail vs. commuter rail
- ❖ Use FTA coefficients
  - ▪ With some enhancements
- ❖ Explicit non-motorized mode
  - ▪ Walk and bike – estimated from survey
  - ▪ Bike assignment
- ❖ Mode options include Taxi / TNC, school bus

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MC Structure

❖ Simpler nesting structure: 2 levels

❖ Here, "Transit" is best transit (multi-path) option

❖ Drive-transit is limited by parking capacity

❖ TNC is part of KnR

```
                                     Person
          _____|_____
          |                          |                    |              |                   |        |
        Auto                      Transit            Taxi/TNC      Non-Motor          School bus   Empty AV
     _____|_____             _____|_____                 _____|_____         (SCH only)
     |      |     |            |      |         |                |            |
    DA    SR2   SR3+        Walk    PnR      KnR/TNC            Walk         Bike
```
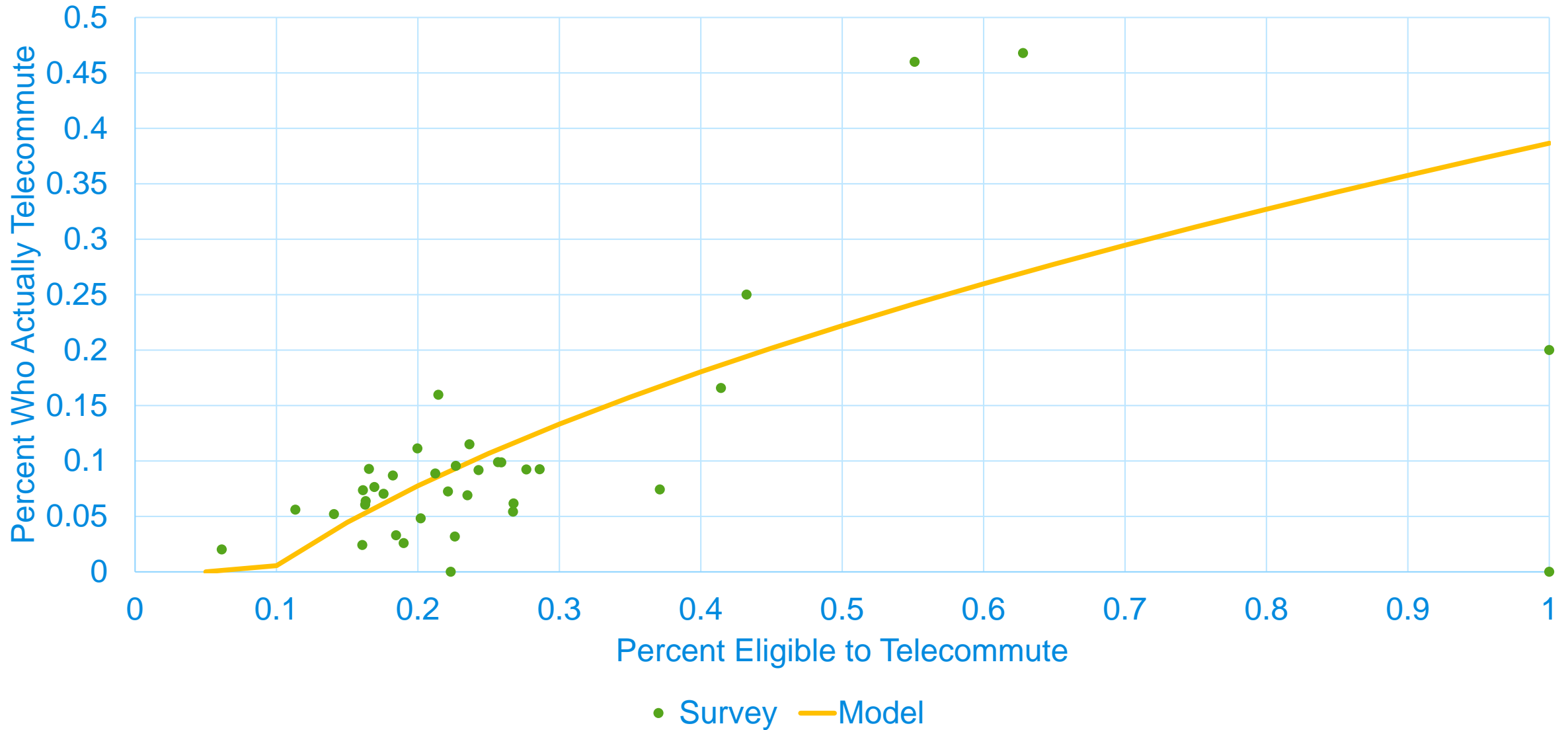
MC Validation

❖ Observed shares derived from 2008 HIS
❖ Auto by occupancy from Census ACS
❖ Transit shares modified due to recent ridership declines
❖ No observed TNC data yet

	HBW	SCH	HBU	HBS	HBO	ATW
Observed						
Auto	83.1%	45.3%	80.8%	91.1%	89.5%	61.5%
Transit	12.5%	1.8%	10.8%	1.4%	2.3%	2.6%
Taxi/TNC	0.3%	0.0%	0.0%	0.1%	0.3%	1.0%
Walk/Bike	4.1%	8.8%	8.4%	7.4%	7.9%	34.9%
Sch Bus		44.1%				
Model						
Auto	82.7%	45.9%	80.3%	91.3%	90.3%	60.2%
Transit	12.7%	1.8%	10.9%	1.7%	2.2%	3.1%
Taxi/TNC	0.3%	0.2%	0.2%	0.1%	0.3%	1.5%
Walk/Bike	4.3%	8.6%	8.6%	6.9%	7.2%	35.2%
Sch Bus		43.5%				

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Telecommuting (WFH)

- ❖ New input zonal variable: percent eligible to WFH
  - ▪ Default values by workplace jurisdiction derived from 2008 HIS
  - ▪ User-editable by workplace zone
- ❖ Apply Work Destination Choice model
- ❖ For each tour, check workplace zone
  - ▪ If no Office employment, no WFH
- ❖ Look up % eligible from input file
- ❖ Look up % who *will* WFH, based on who is eligible
- ❖ Use Monte Carlo to determine if each worker <u>will</u> WFH

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Telecommuting, MWCOG 2008 survey

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Intermediate Stop Validation

❖ Model up to 7 stops per direction

❖ Logit model by purpose and direction

❖ Key variables: mode, area type, life cycle, HH size, workers, auto time, total tours, intrazonal flag

Average Stops/Tour	1st Half-Tour		2nd Half-Tour	
	Survey	**Model**	**Survey**	**Model**
HBW	0.19	0.20	0.42	0.41
SCH	0.09	0.09	0.23	0.25
HBU	0.34	0.33	0.42	0.43
HBS	0.43	0.43	0.38	0.39
HBO	0.22	0.22	0.34	0.33
ATW	0.18	0.20	0.14	0.20
EXT	0.25	0.25	0.40	0.43

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Time of Day Validation

- ❖ Look-up table by purpose, direction, mode
  - ■ Auto, transit, non-motorized
- ❖ Percentages from survey were modified using hourly counts
- ❖ Table shows share of tours by period of 1st half-tour and period of 2nd half-tour

Survey					Model				
All Purps	AM	MD	PM	NT	All Purps	AM	MD	PM	NT
AM	0.0379	0.1466	0.1951	0.0370	AM	0.0226	0.1137	0.1457	0.0268
MD	0.0014	0.2161	0.0575	0.0246	MD	0.0017	0.2490	0.0759	0.0355
PM	0.0000	0.0020	0.0737	0.1099	PM	0.0000	0.0021	0.0748	0.1077
NT	0.0027	0.0211	0.0198	0.0545	NT	0.0040	0.0346	0.0088	0.0970

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Autonomous Vehicle Model

- ❖ Reflect influence of AVs on each travel choice
  - Privately owned passenger cars only
  - AV trucks, taxi/TNC is a future analysis
- ❖ Synthesized parameters from the literature
- ❖ Tested impacts using a sketch model; results look OK
  - Comparable to results from other modelers
- ❖ AV link volumes reported separately in assignment

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AV Ownership

❖ Default adoption rate by year, or user can enter any value

❖ Probability of AV ownership is an incremental logit model based on:

- ▪ Regional adoption rate
- ▪ Is HH low or high income?
- ▪ Does HH have multiple vehicles?

❖ HH can own 0, 1, 2, 3+ AVs

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Forecasted AV Adoption Rate
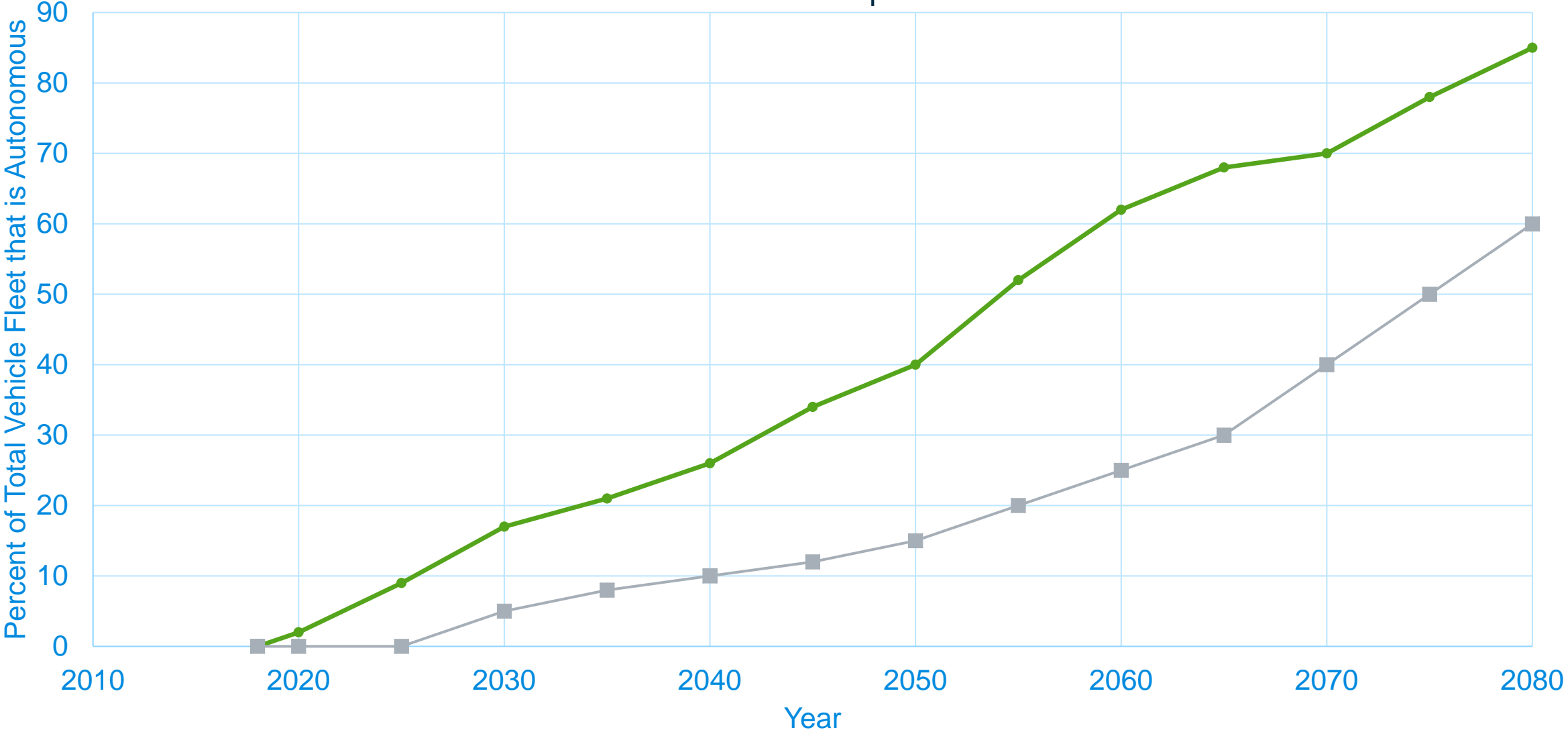
Source:
Victoria Transportation Policy Institute and
Bentley Systems

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AV Impacts

- ❖ **Slightly lower vehicle ownership**
  - ▪ AVs can be re-used, so don't need as many vehicles
- ❖ **Discretionary travel increases**
  - ▪ Kids and those with disabilities will have cars, travel is easier
- ❖ **Trip lengths increase, CBD travel increases**
  - ▪ Congestion is less bothersome, parking is easier/cheaper
- ❖ **Walk-transit decreases, drive-transit increases**
  - ▪ AVs compete with local bus but are feeders to rail and express bus
- ❖ **Slightly more peak travel**
  - ▪ It's easier
- ❖ **AVs are slower, limited impact on capacity**
  - ▪ VMT, congestion increase

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Bike Assignment

- ❖ Cycling speed varies by bike facility type
  - Reflects desirability, safety of higher types
- ❖ Capacity does matter, a little
- ❖ Cube stochastic assignment by period
  - Burrell method
    - Uniform distribution of link costs based on random perturbation
  - 5 iterations
  - Similar to our London cycling model
- ❖ Validated to count data

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Model Ease of Use

- ❖ Priority placed on ease of use

- ❖ Fewer input files needed
  - ▪ Inputs similar to MWCOG data

- ❖ Batch files not used

- ❖ One script file + 6 "subroutine" files

- ❖ Run Cube, open model script, press F9, select Work Directory, press Start

Main Interface Screen

Scenario (Work) Directory

Run Time

❖ **3 iterations of full feedback**

▪ Use peak impedance for Work, peak/free-flow average for Non-Work

❖ **Model runs on normal laptop**

▪ County machine has 5 processors

▪ Run time: 15 hours for 2019, slightly longer for 2045

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Speed Feedback

❖ Convergence criterion: number of links by speed range, between iterations

❖ Use Method of Successive Averages

❖ Balancing convergence, run time, number of processors

Speed Diff.	Number of Links by Speed Difference		
	Iter 0 v. Iter 1	Iter 1 v. Iter 2	Iter 2 v. Iter 3
0 - 1	19,534	25,611	47,021
2 - 3	3,549	24,241	5,409
4 - 5	8,744	2,587	54
6 - 7	9,212	37	1
8 - 9	8,043	10	2
10 - 11	1,335	1	
11 - 12	1,953		
14 - 15	107		
16 - 17	10		

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Validation Data

❖ Model calibrated from 2008 HIS

❖ Validated to a mixture of data

- Tours/HH, mode share, average tour length by purpose: 2008 HIS
- Traffic counts: 2019 VDOT, County counts, bridge counts
- County bicycle counts
- Transit boardings by operator: 2019-ish
- Metrorail boardings by VA station: 2019
- Cars parked at VA Metrorail and VRE stations: 2019
- Boardings by line for ART, DASH, Metrorail

Highway Validation Results

❖ Aggregate volume/count: 1.03

❖ %RMSE: 32%

❖ Link level r^2: 0.957

❖ High on VMT

❖ Truck vol/count: 1.00

❖ Truck % RMSE: 78%

Facility Type	Error	Area Type	Error
1 (frwy)	-4%	1 (CBD)	+3%
2 (maj art)	+17%	2	0
3 (min art)	+10%	3	+24%
4 (coll)	+3%	4	N/A
5 (expwy)	0	5	+16%
6 (ramp)	+6%	6 (rural)	+25%
7 (local)	+1%		

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% RMSE (non-directional)

% RMSE vs. Volume

Model vs. Count

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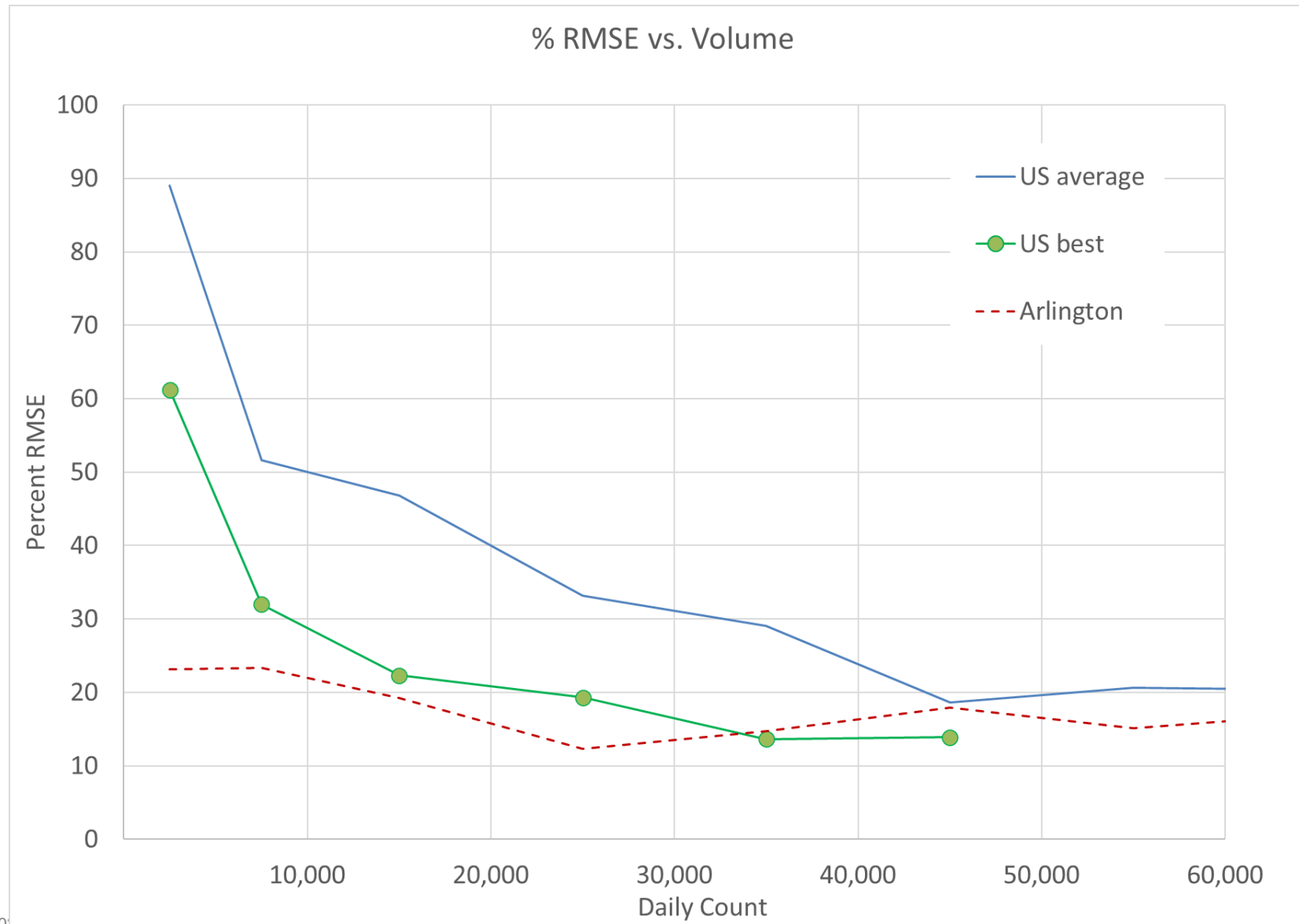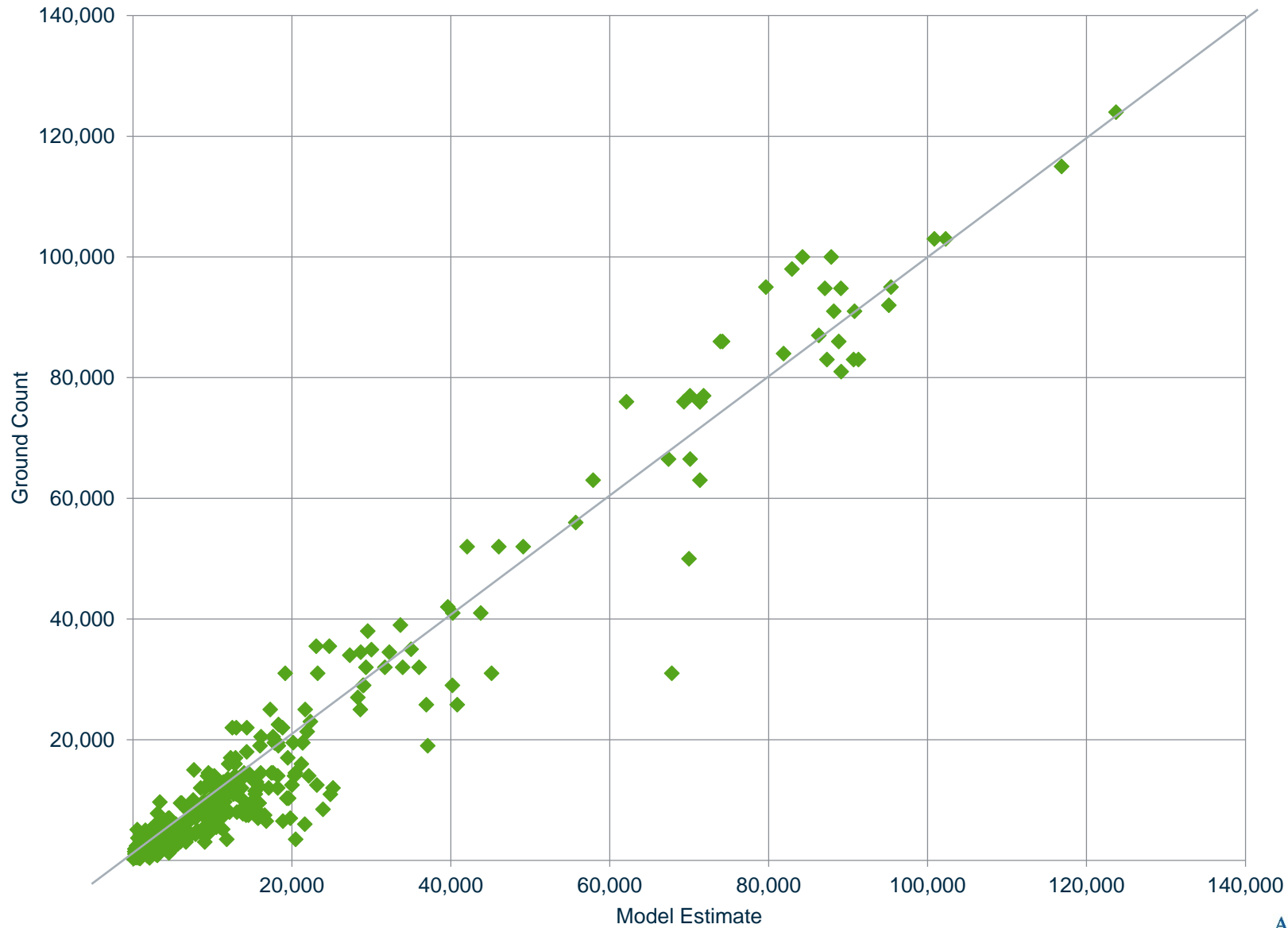
Trips Crossing the Potomac River

❖ Auto: pretty good, in total

❖ Metrorail: a bit low

Highway			
	count	model	error
American Legion Bridge	239,000	240,600	
Chain Bridge	20,600	38,900	
Key Bridge	51,600	77,700	
Roosevelt Bridge	189,600	176,200	
Arlington Mem Bridge	62,000	112,900	
14th St Bridge	202,000	219,200	
Woodrow Wilson Bridge	226,000	226,800	
Total	990,800	1,092,300	10%
Metrorail	199,337	134,180	-33%

Transit Ridership Trends

❖ Transit ridership has been declining since the 2008 survey

❖ 2018 MWCOG survey data not yet available

❖ Match 2008 transit shares → overestimate 2019 boardings, PnR

❖ Solution: adjust 2008 survey transit share targets by -15%.

Average Daily Rail Entries by Calendar Year
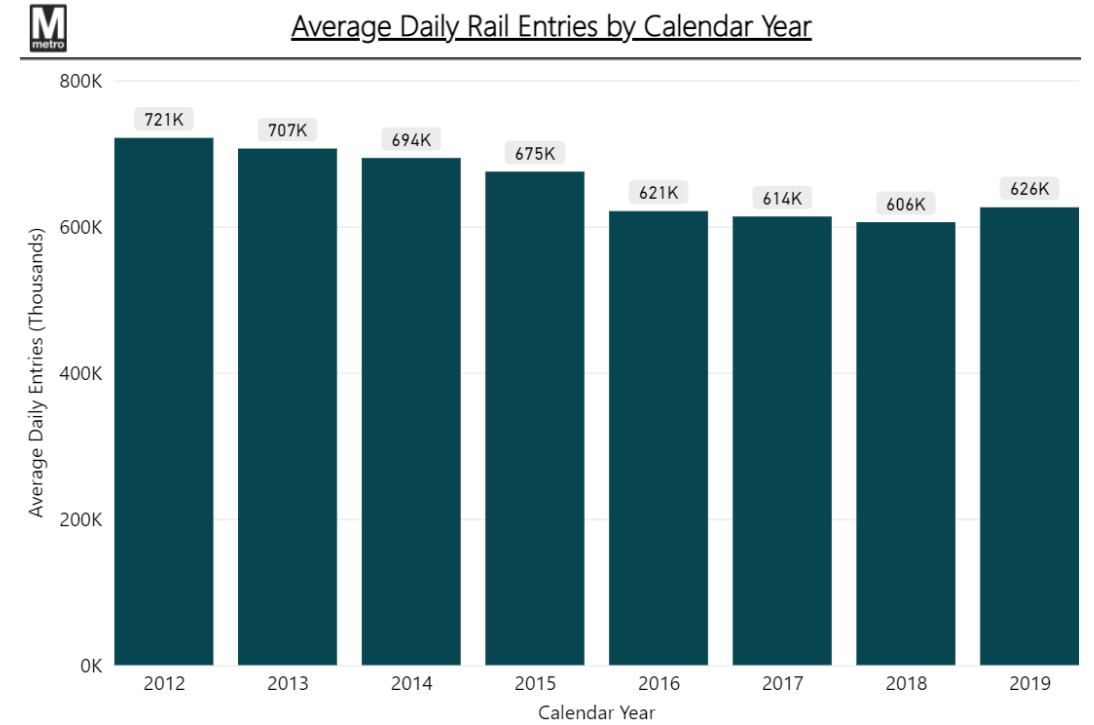
Transit Share by Area Type

❖ Model initially overestimated transit share to the CBD, underestimated it to less developed areas

❖ Solution: add transit accessibility to MC model

	Area Type of Tour Main Destination					
	1 (CBD)	2	3	4	5	6 (Rural)
Work						
Observed	41.4%	10.9%	3.4%	3.5%	0.3%	0.0%
Estimated	43.2%	11.5%	2.7%	1.4%	1.0%	1.1%
Total						
Observed	29.3%	6.3%	1.6%	1.4%	0.4%	0.4%
Estimated	23.1%	5.8%	1.7%	1.2%	0.8%	0.6%

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Transit Assignment

- ❖ Pretty good on WMATA
- ❖ Low on commuter rail
- ❖ %RMSE = 29%
- ❖ High on Fairfax Conn, low on RideOn

Est Riders by No. of Transfers

0	71.5%
1	25.2%
2	3.1%
3+	0.2%

Operator	Observed	Model	Difference	Pct Diff
WMATA bus	365,600	372,776	7,176	2%
WMATA rail	683,100	725,971	42,871	6%
MARC	40,700	22,901	-17,799	-44%
VRE	19,300	13,143	-6,157	-32%
ART	10,900	8,746	-2,154	-20%
DASH	14,300	8,157	-6,143	-43%
Fairfax City Bus	2,000	3,366	1,366	68%
Fairfax Connector	27,800	45,935	18,135	65%
Loudoun Transit	6,000	6,553	553	9%
PRTC/Omniride	8,400	11,397	2,997	36%
RideOn	71,000	49,152	-21,848	-31%
PG TheBus	10,000	7,948	-2,052	-21%
RTA Central Maryland	3,200	7,101	3,901	122%
Fredericksburg	1,000	2,385	1,385	139%
Calvert County	400	727	327	82%
Carroll County	500	687	187	37%
St Mary's STS	1,200	1,482	282	24%
MARTZ	400	175	-225	-56%
Total	1,265,800	1,288,602	22,802	2%

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ART Riders by Route

- ❖ Not too bad
- ❖ %RMSE = 59%

Route	Observed	Model	Difference	Pct Diff
41	2,233	1,175	-1,058	-47%
42	1,127	825	-302	-27%
43	750	473	-277	-37%
45	1,250	725	-525	-42%
51	317	114	-203	-64%
52	315	200	-115	-37%
53	162	416	254	157%
55	1,653	1,591	-62	-4%
61	117	52	-65	-56%
62	83	118	35	42%
72	576	1,460	884	153%
74	69	26	-43	-62%
75	602	346	-256	-43%
77	704	498	-206	-29%
84	239	142	-97	-41%
87	678	587	-91	-13%
Total	10,875	8,748	-2,127	-20%

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Virginia Metrorail Station Boardings

- ❖ Good, overall
- ❖ %RMSE = 51%
- ❖ Low at Arlington Cem, DCA
  - ▪ Need a Visitor model
- ❖ Low at Pentagon City
  - ▪ May need special generator
- ❖ High at East Falls Ch
  - ▪ ???

Station	Observed	Model	Difference	Pct Diff
Van Dorn Street	2,265	2,885	620	27%
Franconia-Springfield	5,172	8,441	3,269	63%
Huntington	5,832	5,713	-119	-2%
Eisenhower Avenue	1,585	653	-932	-59%
King Street	5,679	5,482	-197	-3%
Braddock Road	3,826	3,515	-311	-8%
National Airport	5,715	1,344	-4,371	-76%
Crystal City	10,847	7,121	-3,726	-34%
Pentagon City	12,133	3,371	-8,762	-72%
Pentagon	13,785	18,514	4,729	34%
Arlington Cemetery	1,086	14	-1,072	-99%
Vienna	8,686	8,972	286	3%
Dunn Loring	3,720	2,645	-1,075	-29%
West Falls Church	2,463	3,172	709	29%
East Falls Church	3,813	7,956	4,143	109%
Ballston	9,232	6,530	-2,702	-29%
Virginia Square	3,793	5,081	1,288	34%
Clarendon	4,478	4,832	354	8%
Courthouse	6,349	7,153	804	13%
Rosslyn	13,059	17,698	4,639	36%
McLean	2,081	3,284	1,203	58%
Tysons Corner	3,507	2,874	-633	-18%
Spring Hill	1,139	924	-215	-19%
Greensboro	1,415	1,135	-280	-20%
Wiehle Reston E	7,650	8,829	1,179	15%
Total	139,310	138,138	-1,172	-1%

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Metrorail Rider Bandwidth Plot

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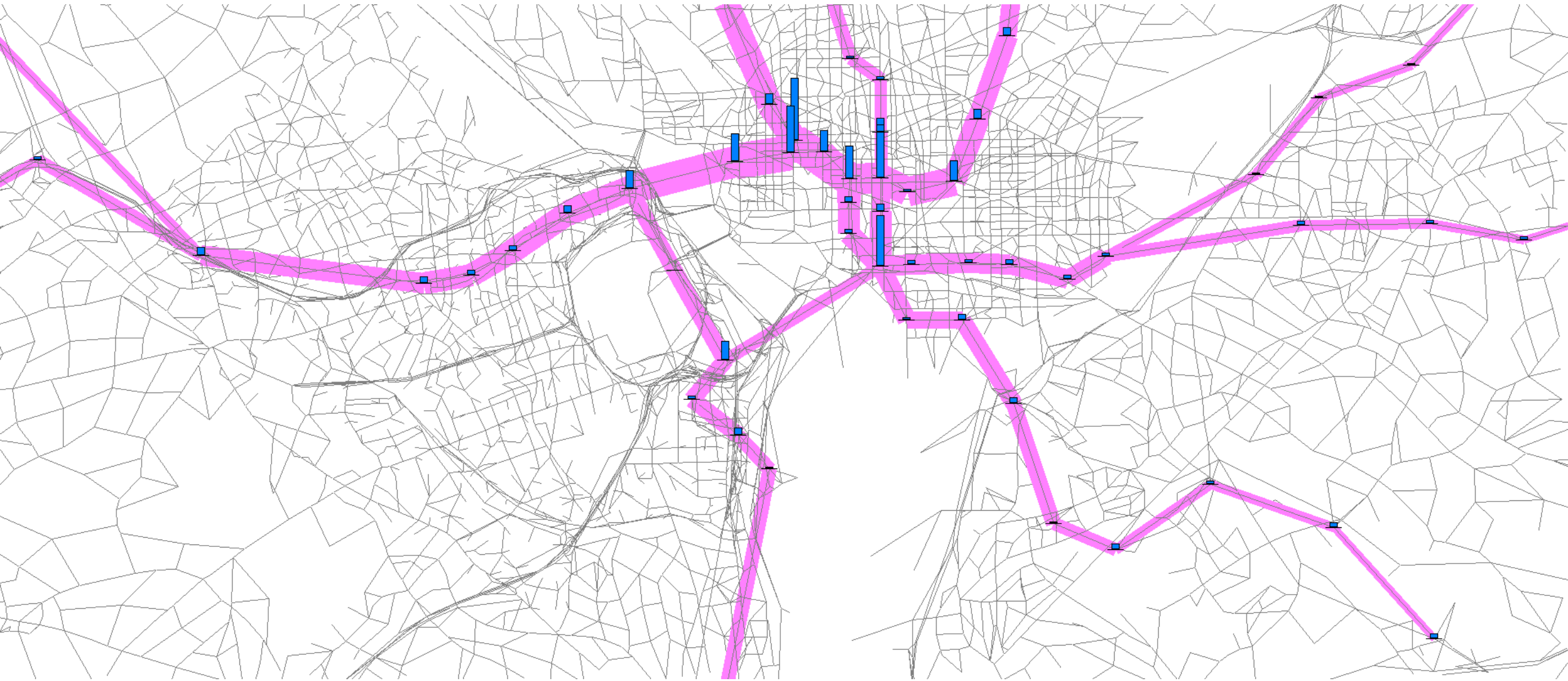
Virginia Rail Station Parking

Metrorail Station	Spaces	Count	Model	Diff	Pct Diff
Dunn Loring	1,329	953	1,329	376	39%
East Falls Church	422	486	422	-64	-13%
Franconia-Springfield	5,069	2,156	5,070	2,914	135%
Huntington	3,617	1,487	2,929	1,442	97%
Van Dorn Street	361	248	361	113	46%
Vienna	5,169	3,866	5,169	1,303	34%
West Falls Church	2,009	1,246	2,009	763	61%
Wiehle/Reston East	2,300	2,295	2,300	5	0%
Total	20,276	12,737	19,589	6,852	54%

❖ Using station "shadow pricing"

❖ Needs more work

VRE Station	Spaces	Count	Model	Diff	Pct Diff
Backlick Road	200	190	130	-60	-32%
Rolling Road	368	300	252	-48	-16%
Burke Center	1,510	550	266	-284	-52%
Manassas Park	616	300	563	263	88%
Manassas City	696	700	696	-4	-1%
Broad Run/Airport	1,081	900	525	-375	-42%
Lorton	717	225	184	-41	-18%
Woodbridge	730	490	76	-414	-84%
Rippon	656	400	27	-373	-93%
Quantico	301	200	67	-133	-67%
Brooke	727	500	386	-114	-23%
Leeland Road	1,029	760	1,029	269	35%
Fredericksburg	684	375	684	309	82%
Spotsylvania	1,500	550	238	-312	-57%
Total	10,815	6,440	5,123	-1,317	-20%

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PnR Lot Satisfaction

❖ Number of tours by PnR lot choice, by purpose

	1st Choice	2nd Choice	3rd Choice	Changed Mode
IXW	3,826	0	0	0
HBW	69,668	16,485	7,220	9,649
IXN	352	991	279	9,786
HBO	4,987	1,589	989	6,563
HBU	841	278	142	701
SCH	0	0	0	0
HBS	0	0	0	0
ATW	0	0	0	0
EXT	0	0	0	0

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Bicycle Validation

❖ Aggregate est/obs: 0.98, RMSE: 29.1%
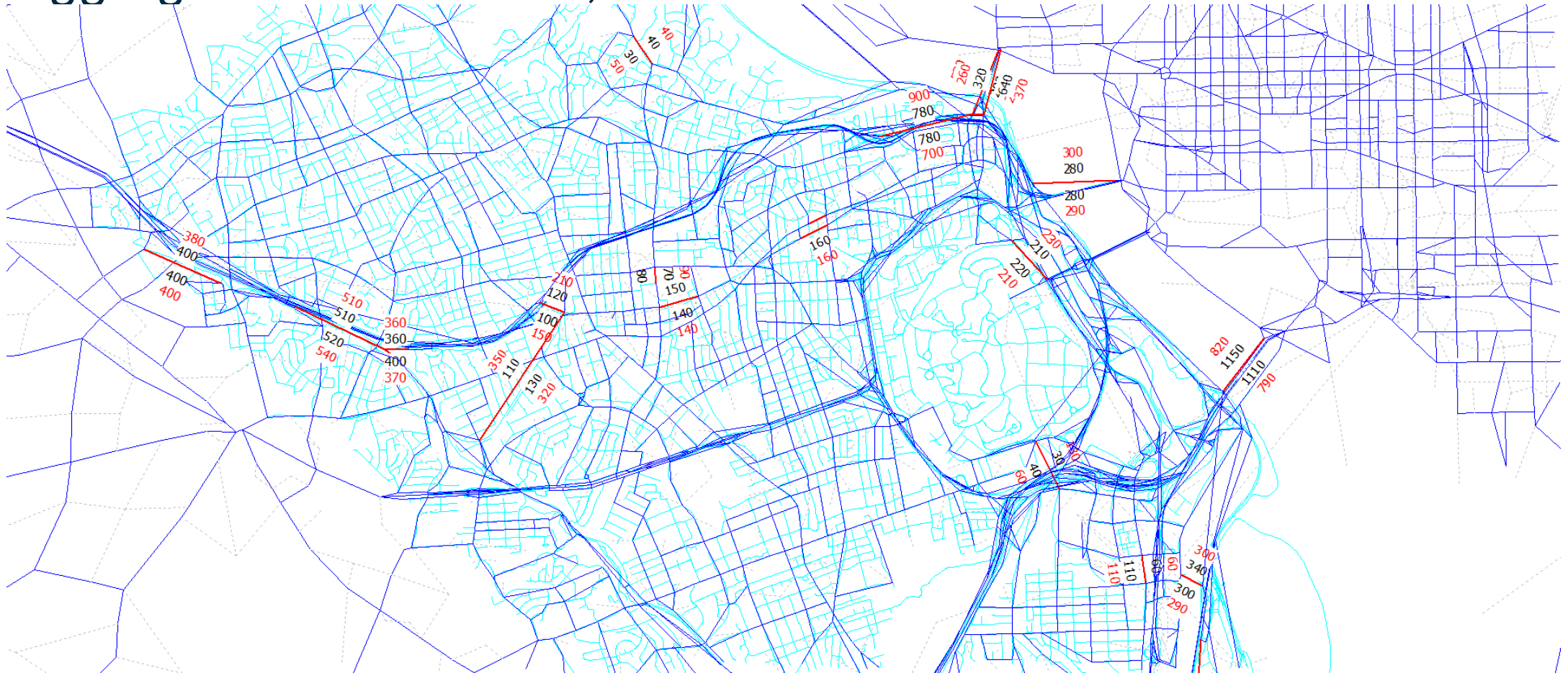
For more information…

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