Arlington County Travel Model Update

November 17th, 2023

Travel Model Updates:

- Updated Highway and Transit Coding
- Updated Area Type Model
- Recalibration/Revalidation of Model
  - Simplified Tour Sub-models
    - New Time Of Day Modeling Process
  - Highway Assignment
  - Transit Assignment
- Public Transport Crowding
- New Air Passenger Model
- New Intermediate Year Modeling

- Data Sources:
  - 2019 Air Passenger Survey
  - 2020 US Census
    - (2014-2018 ACS/PUMS)
  - 2017/2018 Regional Travel Survey (MWCOG)
  - Regional Transit On-Board Survey
  - Arlington Count Data

Bentley

Input Data: Highway Network

- Mostly same network as MWCOG
- Different in the County
  - More detail (425 zones)
  - True shape network
  - Stop signs/signals, turn lanes
  - Includes bike trails
  - Uses Facility Limitation (coded by period)

Facility Types
Freeway
Expressway
Major Arterial
Minor Arterial
Collector
Local
Ramps

Facility Limitations
No restriction
Only HOV2+ allowed
Only HOV3+ allowed
No heavy trucks allowed
Only Dulles Airport traffic allowed
No through trucks
No traffic allowed at all

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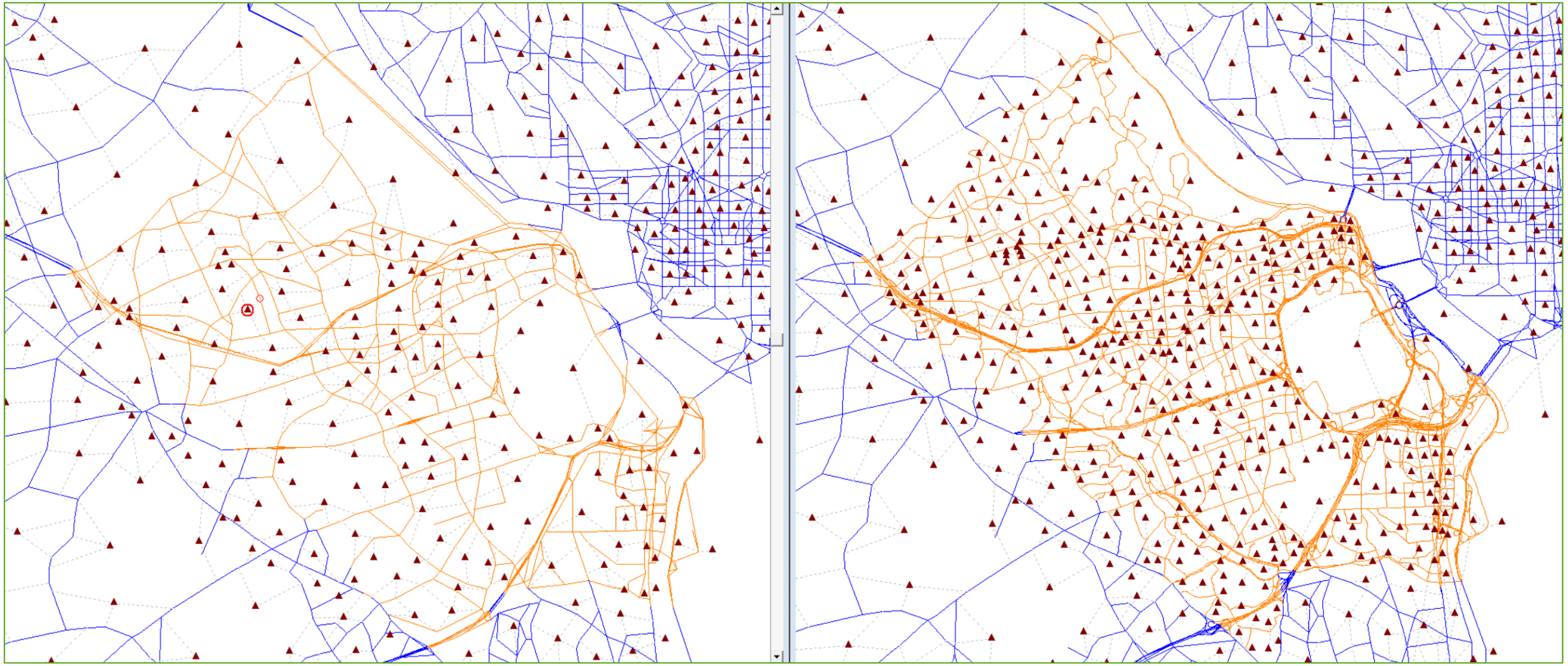
Network Detail

MWCOG

Arlington County Travel Model



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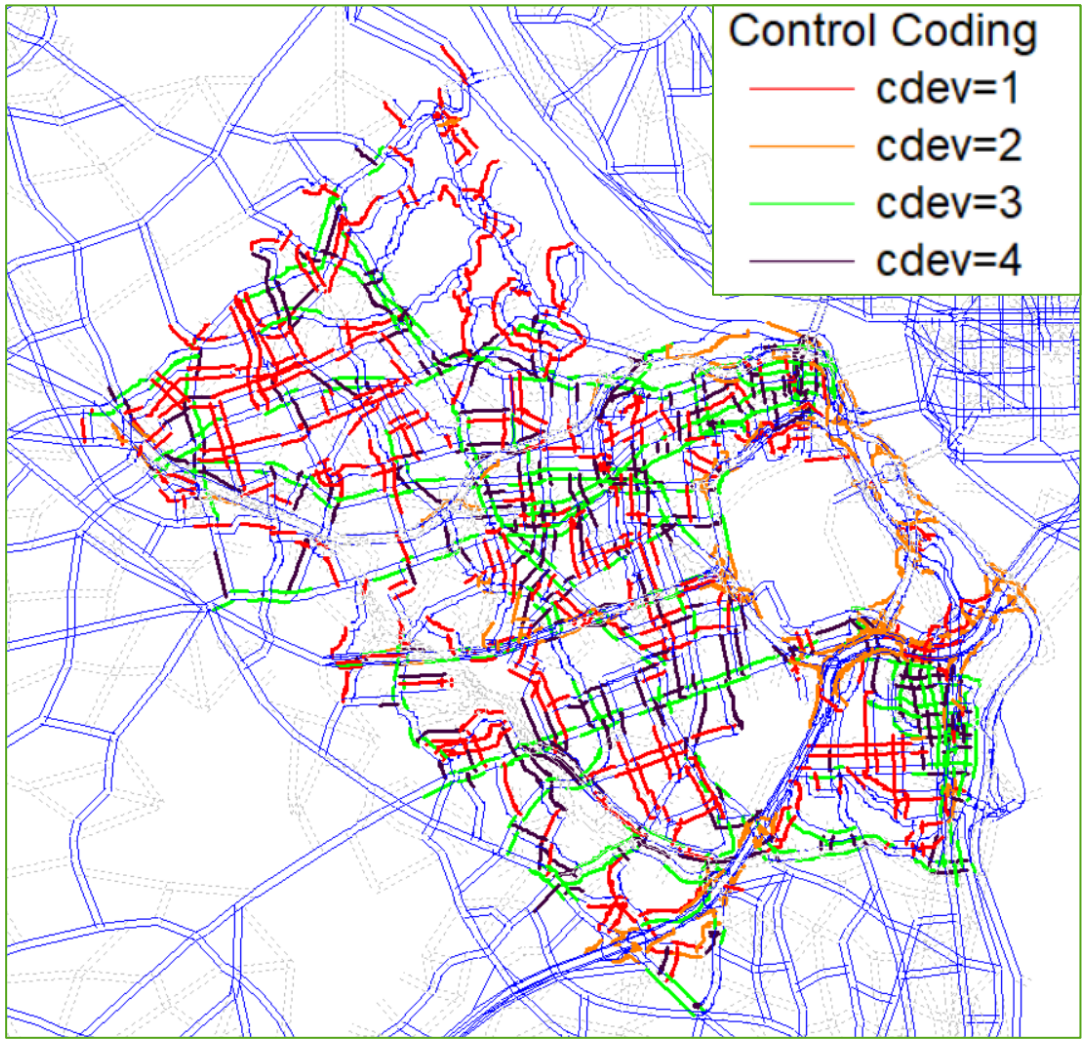
Control Device Coding / Modeling

- Coding only applies to approach links in Arlington County
- Four control types
  - Stop Sign (cdev = 1)
  - Yield Sign (cdev = 2)
  - Signal, Major Approach (cdev = 3)
  - Signal, Minor Approach (cdev = 4)
- “addln” code to model turn lanes
- Applied during network prep
  - Formulation based on HCM equations
  - Applies at link level (speed/capacity)



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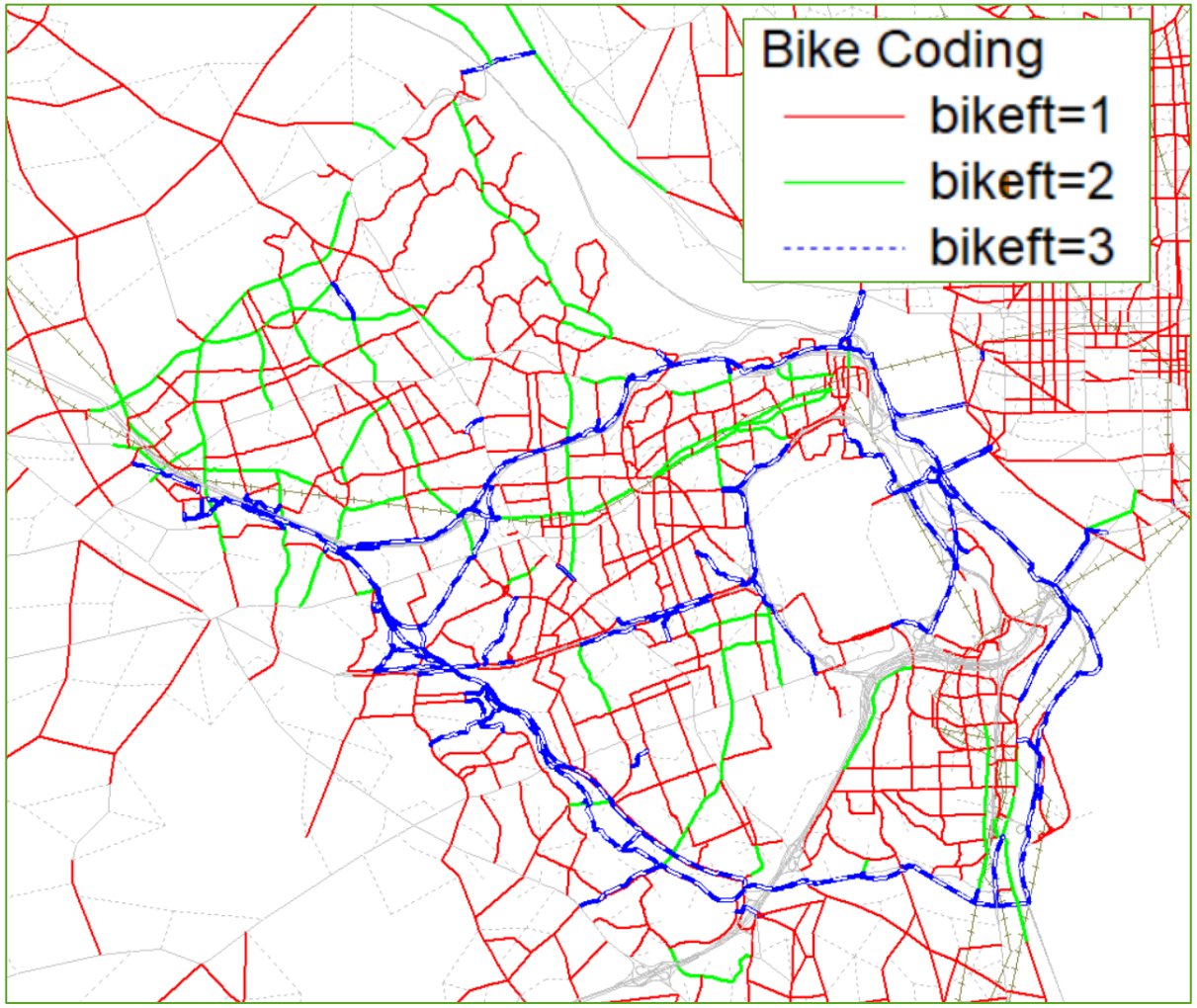
Input Data: Bicycle Network

- Bike network is integrated with highway network
- Bike facility types:
  - No special bike treatment (bikeft = 1)
    - Exclude freeway, expressway, major arterial
  - Marked bike path (bikeft = 2)
  - Off-street bike trail (bikeft = 3)
- Trails coded only in Arlington County
- Different “effective speed” by facility type
- Assign bike trips to network by period



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Input Data: Transit Network

- Mostly same line coding as MWCOG
  - Most lines include some branches
- Easier to use
  - Coding of drive-access links unnecessary
  - No “percent walk” calculation
    - Modeled in CUBE PT
  - Consolidation to a single file

MWCOG

```
;* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
LINE NAME="WMU05O",
LONGNAME="WMATA;MINNESOTA AVE STA & BUS BAY C;FITCH PL NE & 51ST ST NE;2018;0",
ONEWAY= Y,MODE= 01,HEADWAY[1]= 30,RUNTIME= 35,
         N=  21203 -21671  21202 -21201 -21182  20662  20692 -21702  21305,
            -21306 -21694 -21695 -21691 -21700 -21307 -21696 -21184  21199,
            -21184 -21677 -21185 -21186 -21681 -21682 -21965  21680
;* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
LINE NAME="WMU05O",
LONGNAME="WMATA;MINNESOTA AVE STA & BUS BAY C;FITCH PL NE & 51ST ST NE;2018;0",
ONEWAY= Y,MODE= 01,HEADWAY[1]= 33,RUNTIME= 34,
         N=  21203 -21671  21202 -21201 -21182  20662  20692 -21702  21305,
            -21306 -21694 -21695 -21691 -21700 -21307 -21696 -21184  21199,
            -21184 -21677 -21185 -21186 -21681 -21682 -21965  21680
```

Arlington County Travel Model

```
LINE  NAME=WMU05O,
      LONGNAME="WMATA MINNESOTA AVE STA TO FITCH PL AND 51ST ST NE",
      MODE=1, OPERATOR=1,
      HEADWAY[1]=30, HEADWAY[2]=33, HEADWAY[3]=30, HEADWAY[4]=33,
      N=21203,
       -21671  21202 -21201 -21182  20662  20692 -21702  21305 -21306,
       -21694 -21695 -21691 -21700 -21307 -21696 -21184  21199,
       -21184 -21677 -21185 -21186 -21681 -21682 -21965  21680
```


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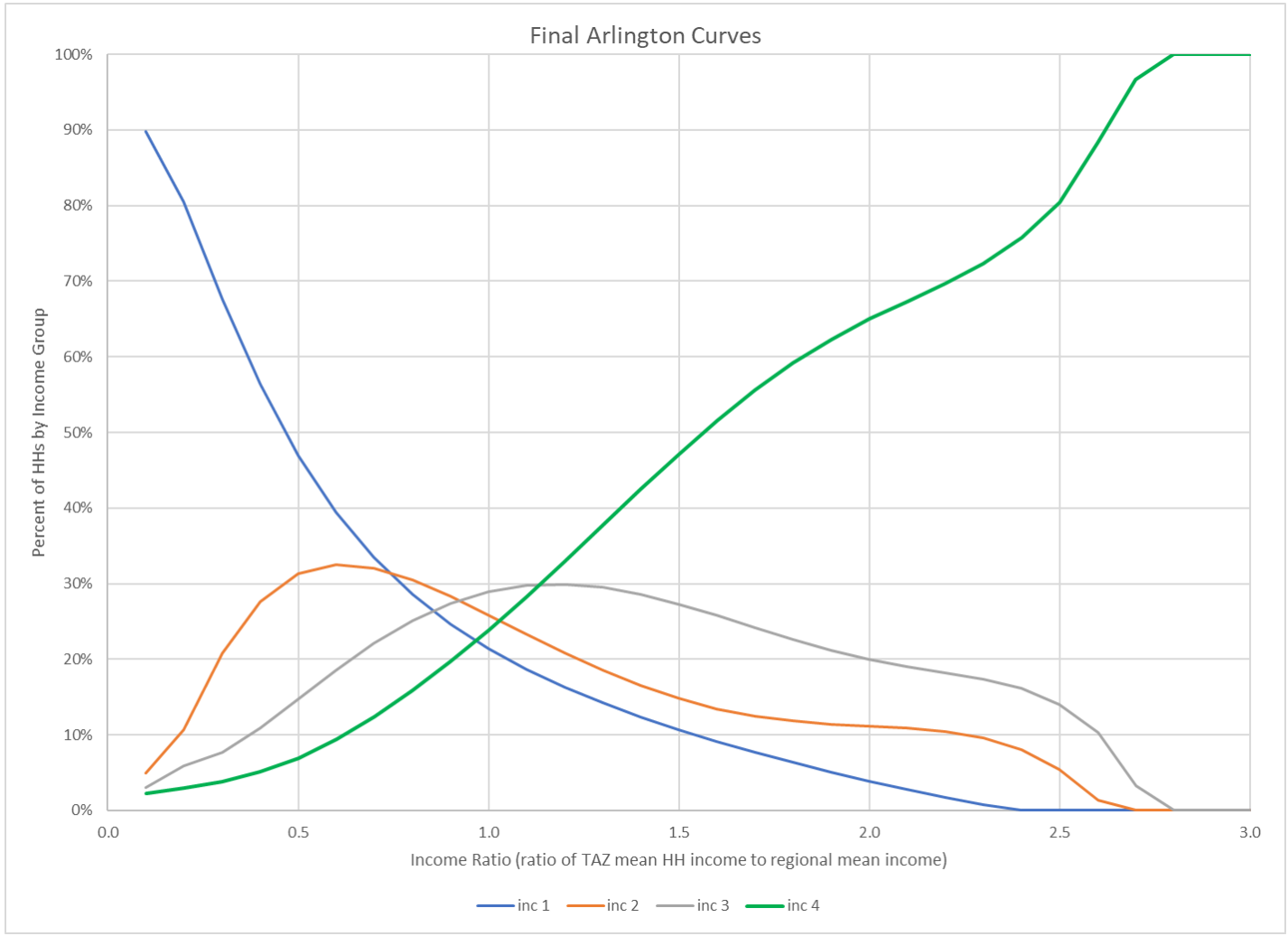
Arlington County Model Approach: Simplified Tour Model (STM)

1. HH synthesis
2. Tour frequency
3. Tour destination choice
4. Mode Choice
5. Intermediate stops
   - Number of stops
   - Stop location
6. Time period
7. Trip accumulation / Assignment

Household Synthesis Submodel

- Generates Household Database
  - Characteristics Modeled:
    - Size (1-5+)
    - Income Group (1-4)
    - Workers (0-3+)
    - Vehicles Available (0-3+)
    - Autonomous Vehicles Available (0-3+)
    - Life Cycle (1-3)
  - Key inputs: Land Use, Income, Accessibility
  - Operation: Calibrated Lookups from Census and LOGIT estimation



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Tour Frequency

- Probability of HH making 0, 1, 2, … round-trip tours by purpose
- Key Inputs: HH attributes, accessibility, area type
- Operation: LOGIT estimation

MWCOG 2007-08 Survey

Regional Number of Tours

	0	1	2	3	4	5	6	7	8	9	10
HBW	32.8%	43.7%	20.2%	2.70%	0.39%	0.12%					
SCH	79.9%	10.1%	7.3%	2.04%	0.53%	0.15%	0.04%				
HBU	96.6%	3.1%	0.26%	0.02%							
HBS	70.1%	17.1%	7.6%	3.1%	1.3%	0.5%	0.11%	0.11%	0.08%	0.03%	0.01%
HBO	47.5%	23.0%	13.0%	6.7%	4.4%	1.94%	1.45%	0.80%	0.45%	0.25%	0.45%

MWCOG 2018 Survey

Regional Number of Tours

	0	1	2	3	4	5	6	7	8	9	10
HBW	36.1%	40.1%	19.9%	3.05%	0.61%	0.17%	0.02%	0.00%	0.02%		
SCH	79.1%	10.3%	6.8%	2.72%	0.80%	0.18%	0.06%	0.01%			
HBU	94.9%	4.3%	0.70%	0.05%	0.03%						
HBS	69.9%	18.7%	7.7%	2.1%	1.2%	0.3%	0.12%	0.06%	0.02%	0.00%	0.03%
HBO	54.7%	21.6%	12.0%	5.6%	2.7%	1.50%	0.79%	0.43%	0.33%	0.15%	0.30%

Model 2019 Estimate

Regional Number of Tours

	0	1	2	3	4	5	6	7	8	9	10
HBW	35.67%	40.03%	19.24%	3.98%	0.80%	0.23%	0.03%	0.01%	0.02%		
SCH	79.18%	11.26%	6.89%	1.92%	0.58%	0.13%	0.05%	0.00%	0.01%		
HBU	95.22%	4.06%	0.65%	0.04%	0.03%						
HBS	70.58%	18.82%	7.53%	1.75%	0.93%	0.21%	0.10%	0.05%	0.01%	0.01%	0.02%
HBO	55.57%	22.83%	11.07%	4.73%	2.53%	1.40%	0.73%	0.41%	0.30%	0.14%	0.28%

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Tour Destination Choice

- Main destination zone of tour
  - School, university, work, or other place of longest stay
- Key variables: travel time, area type, city centre flag, accessibility, etc..
- Operation: LOGIT estimation
- Calibrated with 2018 Travel Survey

Purpose	Average Tour O/D Direct Hwy Time 2007 Survey	2018 Survey	2019 Model Estimate
HBW	29.88	36.64	36.01
SCH	12.18	7.42	7.41
HBU	21.27	13.54	13.62
HBS	13.74	9.51	9.51
HBO	14.98	11.37	11.37
ATW	13.13	5.31	4.83

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Intermediate Stop Model

- Models Secondary Purposes within Tour chain
  - Mostly shop, personal business
  - More stops if high income, kids, long tour, dense origin or destination
- Key variables: travel time, area type, city centre flag, accessibility, etc..
- Operation: LOGIT estimation
- Calibrated with 2018 Travel Survey

First half-tour Calibration

Survey						
# Stops	hbw	sch	hbu	hbs	hbo	atw
0	76.6%	91.2%	71.9%	70.6%	84.7%	95.7%
1	16.4%	6.7%	16.4%	20.7%	10.8%	3.6%
2	4.9%	1.5%	7.1%	6.2%	2.8%	0.6%
3	1.5%	0.4%	2.6%	1.4%	1.0%	0.0%
4	0.4%	0.1%	1.2%	0.6%	0.3%	0.0%
5	0.2%	0.1%	0.3%	0.3%	0.1%	0.0%
6	0.0%	0.0%	0.3%	0.2%	0.1%	0.0%
7	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%
avg	0.34	0.12	0.48	0.42	0.23	0.05

Model						
# Stops	hbw	sch	hbu	hbs	hbo	atw
0	76.4%	91.2%	72.0%	70.6%	84.8%	95.8%
1	16.3%	6.7%	16.4%	20.7%	10.7%	3.6%
2	5.0%	1.5%	7.0%	6.2%	2.9%	0.6%
3	1.5%	0.4%	2.6%	1.4%	1.0%	0.0%
4	0.4%	0.1%	1.2%	0.6%	0.4%	0.0%
5	0.2%	0.1%	0.3%	0.3%	0.1%	0.0%
6	0.0%	0.0%	0.3%	0.1%	0.1%	0.0%
7	0.1%	0.0%	0.2%	0.0%	0.0%	0.0%
avg	0.34	0.12	0.47	0.42	0.23	0.05

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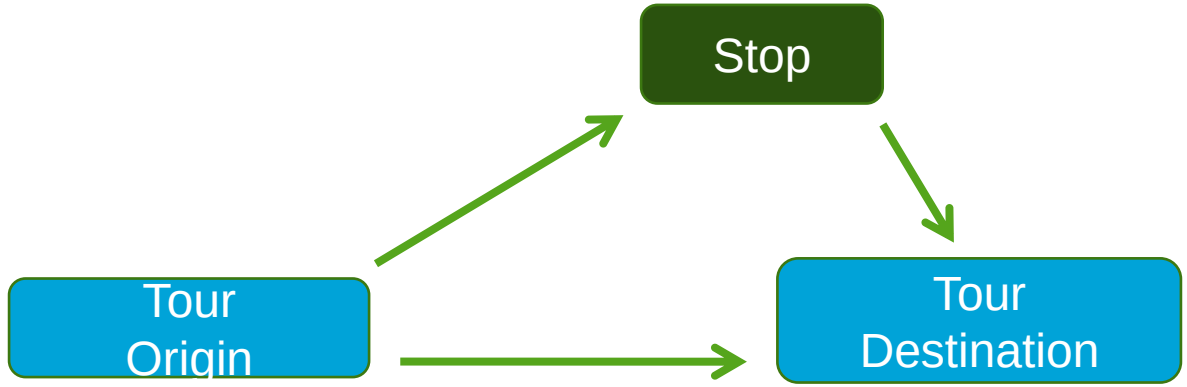
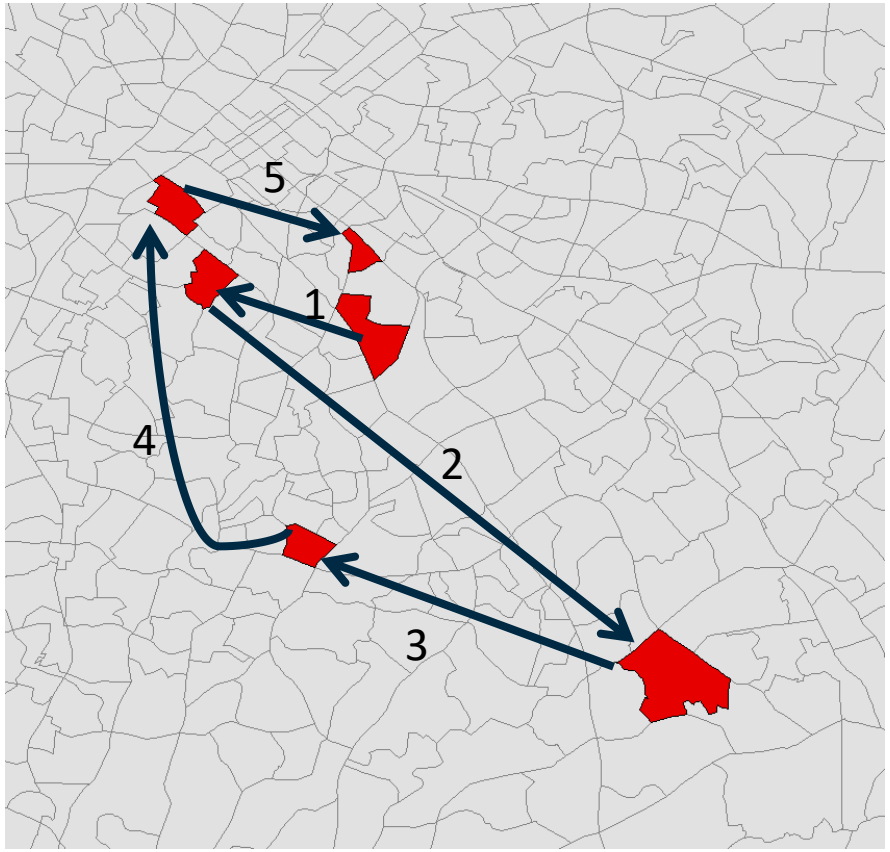
Stop Location Model

- Models Stop Destination in Tour's Trip Chain (operates similar to destination choice)
- Limit the search to save run time
  - Max search distance
  - Max detour time
  - Avoid zones that are clearly bad options
- Considers a few hundred zones for each tour
- Operation: LOGIT estimation
- Calibrated with 2018 Travel Survey





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Mode Choice

- Similar to four-step logit model
- Instead of aggregate zone-zone shares, estimate a mode for each tour (Assumes one mode per tour)

2018 SURVEY

MODE	hbw		sch		hbu		hbs		hbo		atw	
drive alone	60.4%	76.8%	4.0%	51.8%	46.1%	78.8%	61.0%	89.2%	52.9%	87.0%	42.2%	51.8%
shared ride	16.4%		47.7%		32.7%		28.2%		34.1%		9.6%	
walk-transit	10.3%	15.9%	1.8%	2.0%	8.6%	9.5%	2.0%	2.0%	1.7%	2.3%	1.8%	1.8%
pnr-transit	4.5%		0.0%		0.3%		0.0%		0.3%		0.0%	
knr/tnc-transit	1.0%		0.1%		0.5%		0.0%		0.3%		0.0%	
walk	4.1%	6.0%	7.1%	8.6%	7.4%	10.8%	7.9%	8.4%	9.2%	10.1%	45.3%	45.8%
cycle	1.9%		1.5%		3.4%		0.5%		0.9%		0.5%	
taxi	1.3%		0.0%		1.0%		0.5%		0.7%		0.6%	
school bus			37.6%									

MODEL

MODE	hbw		sch		hbu		hbs		hbo		atw	
drive alone	60.4%	76.4%	4.1%	51.6%	46.2%	78.7%	60.9%	89.2%	53.0%	86.8%	42.5%	51.8%
shared ride	16.0%		47.5%		32.5%		28.3%		33.8%		9.3%	
walk-transit	10.1%	16.2%	2.0%	2.2%	8.6%	9.4%	1.9%	2.0%	1.9%	2.5%	1.8%	1.8%
pnr-transit	5.2%		0.0%		0.4%		0.0%		0.3%		0.0%	
knr/tnc-transit	0.9%		0.2%		0.4%		0.1%		0.3%		0.0%	
walk	4.1%	6.0%	6.8%	8.5%	7.5%	10.8%	7.8%	8.3%	9.4%	10.1%	44.7%	45.7%
cycle	1.9%		1.7%		3.3%		0.5%		0.7%		1.0%	
taxi	1.3%		0.1%		1.0%		0.5%		0.7%		0.6%	
school bus	0.0%		37.7%		0.0%		0.0%		0.0%		0.0%	

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How can we simulate **Crowding** in our system?

Transit vehicle capacity limits can impact the simulation

Inside the PT algorithm: Perceived Link Travel Time Adjustment → On-board travelling experience affected!

Inside the PT algorithm: Wait Time Adjustment → Time waiting for the service affected!

In Arlington Model → **external crowding mechanism → affecting demand modelling level (skimming → mode choice)**

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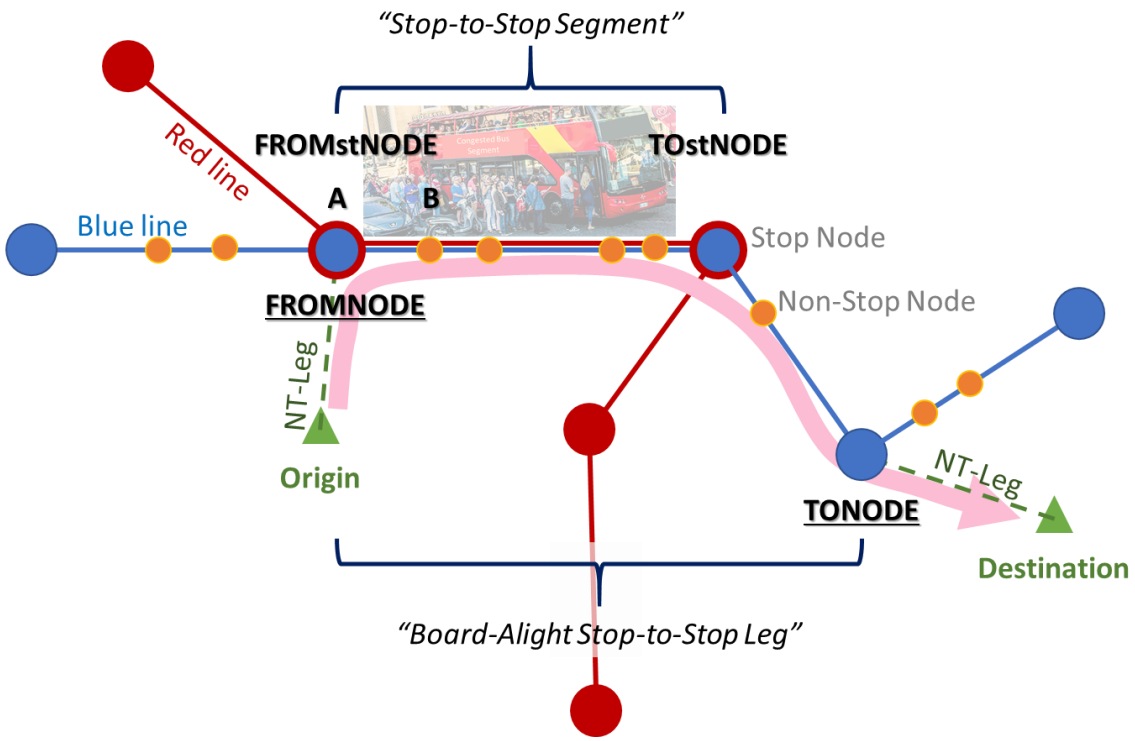
PT Crowding process in Arlington Model



***Assumption**: crowding affecting demand/mode-choice more than route-choice*

Methodology (within feedback-loop):

- "Uncrowded" PT assignment with standard route-evaluation and passenger's loading (no capacity constraint)
- Post-processing of "uncrowded" PT assignment ➔ average crowding level between OD pairs
- Apply OD crowding measures at demand (e.g., **Mode Choice**) level

Advantages:

- Avoid complexity/runtime of iterative PT crowding assignment
- Overcoming needs for more detailed PT crowding data
- Still able to evaluate effects of the system capacity within the overall model

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PT Crowding in Arlington: **UTILIZATION**

$$U = \mathbf{100} * \frac{Vol - (LDF \cdot SeatCap)}{CrushCap - (LDF \cdot SeatCap)} = \mathbf{100} * \frac{"Standing" \ Passengers}{Max \ "Standing" \ Passengers}$$

If ("Standing" Passengers > Max "Standing" Passengers) → U > 100

LDF Load Distribution Factor [0%-100%], representing the percentage of occupied seats when crowding ("standing") starts to occur, defined by the modeler as a characteristic of the vehicle.

$SeatCap$ Seating Capacity per period, i.e., maximum number of seating passengers the vehicle can accommodate in the simulation period [passengers/period]. The modeler specifies the vehicle Seating Capacity the program multiplies times the service frequency to calculate the capacity for the simulation period.

$CrushCap$ Crush Capacity per period, i.e., maximum seating plus maximum standing capacity of the vehicle in the simulation period [passengers/period]. The modeler specifies the vehicle Crush Capacity the program multiplies times the service frequency to calculate the capacity for the simulation period.

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PT Crowding in Arlington Model: Capacities

MODE	NAME	SeatCap	CrushCap	LDF
1	BUS	42	60	100
2	XBUS	42	60	100
3	METRO	480	960	100
4	RAIL	1040	1040	100
5	LRT	430	430	100
6	BUS1	42	60	100
7	XBUS1	42	60	100
8	BUS2	42	60	100
9	XBUS2	42	60	100
10	BRT	42	60	100

	Vehicle capacities		
Mode	SeatCap	CrushCap	Notes
Bus	42	60	average for all bus systems
Metrorail	480	960	average per train; crush = 120 persons/car * 8 cars/train
Commuter Rail (VRE, MARC, Amtrak)	1040	1040	average per train; standees not allowed
LRT	430	430	no data for the LRT mode. The major future LRT line is the Purple Line. It uses a fixed 5-car train with a total capacity of 430

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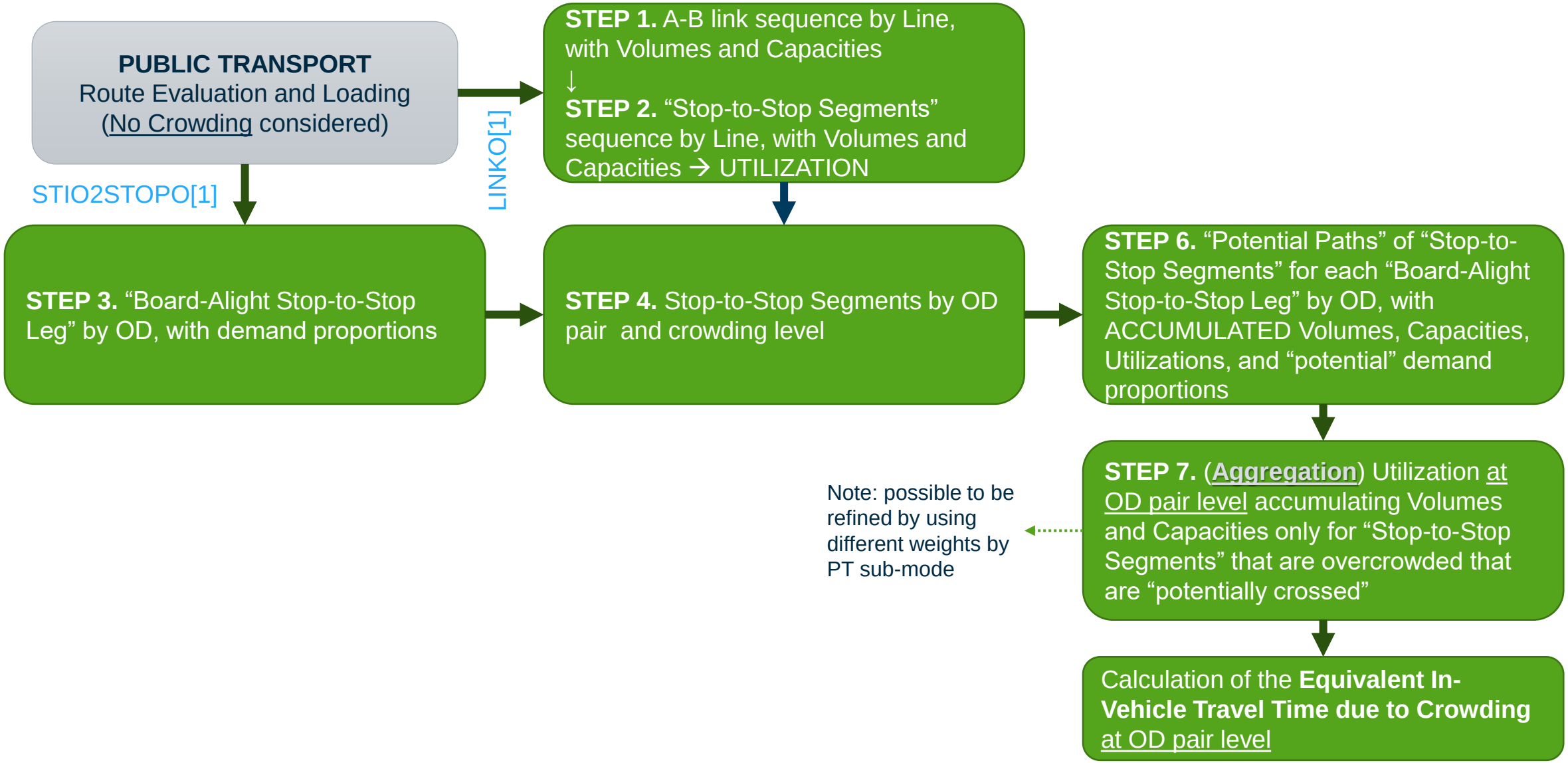
PT Crowding external process in Arlington Model



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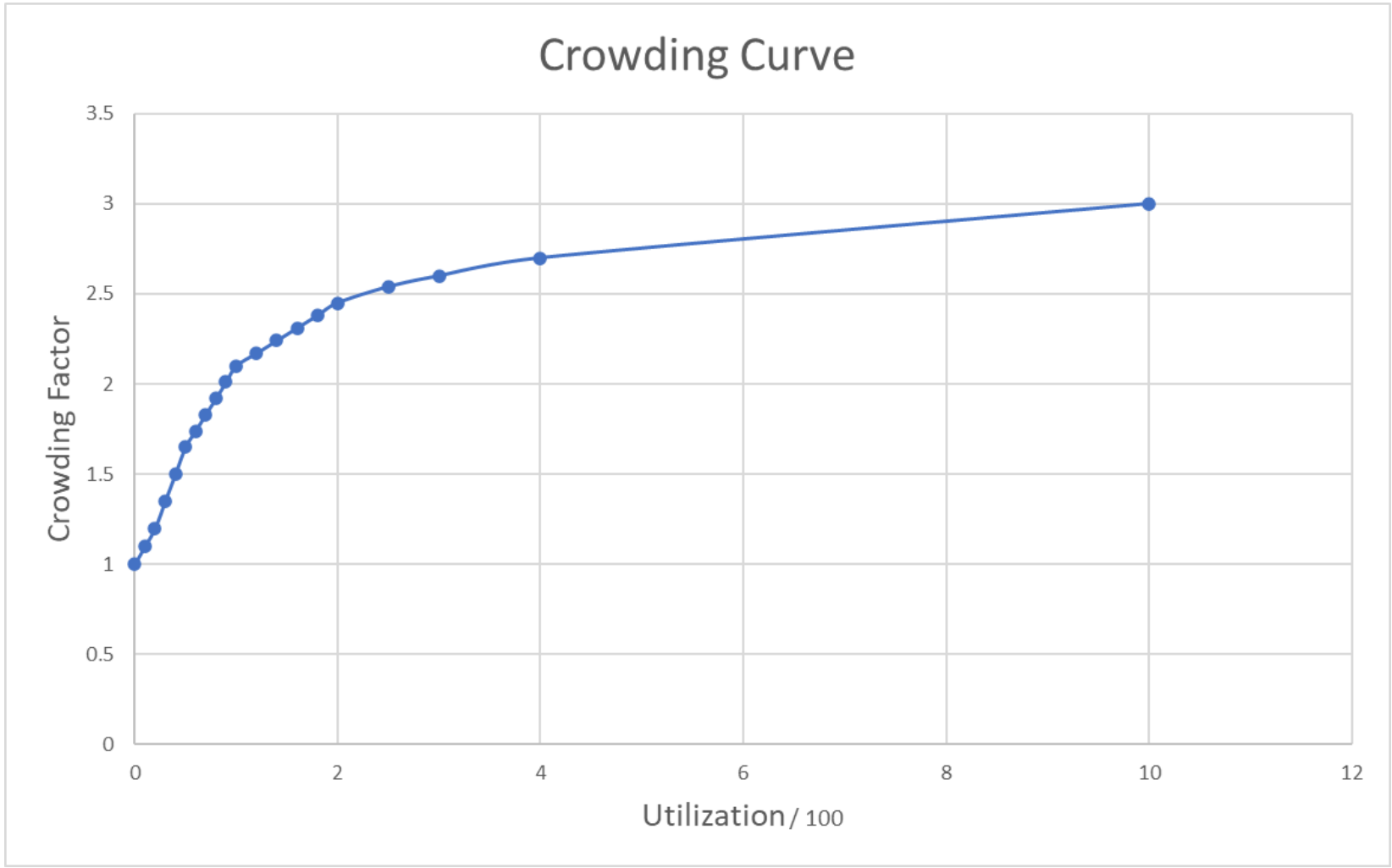
PT Crowding in Arlington: **Crowding Curve**

Utilization/100	Crowd Factor
0	1
0.1	1.1
0.2	1.2
0.3	1.35
0.4	1.5
0.5	1.65
0.6	1.74
0.7	1.83
0.8	1.92
0.9	2.01
1	2.1
1.2	2.17
1.4	2.24
1.6	2.31
1.8	2.38
2	2.45
2.5	2.54
3	2.6
4	2.7
10	3



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Time of Day Model

- Follows Mode choice and estimated time period for first-half and second half of tour
  - Four periods (AM, MD, PM, NT)
- Operation: LOGIT estimation
- Key variables: Time, Number of Stops, Income, areatype, lifecycle
  - Because it considers time, it can consider peak spreadingCalibrated with 2018 Travel Survey

SCH

Survey		A-P			
		AM	MD	PM	NT
P-A	AM	0.3%	62.6%	28.3%	1.5%
	MD	0.0%	2.1%	1.2%	0.3%
	PM	0.0%	0.0%	0.4%	2.2%
	NT	0.0%	0.8%	0.1%	0.2%

Model		A-P			
		AM	MD	PM	NT
P-A	AM	0.3%	63.3%	28.1%	1.7%
	MD	0.0%	2.4%	1.1%	0.3%
	PM	0.0%	0.0%	0.2%	1.6%
	NT	0.0%	0.5%	0.2%	0.3%

HBU

Survey		A-P			
		AM	MD	PM	NT
P-A	AM	0.9%	22.2%	18.4%	6.0%
	MD	1.0%	16.1%	9.5%	6.7%
	PM	0.0%	0.0%	0.9%	11.9%
	NT	0.0%	2.7%	1.8%	2.1%

Model		A-P			
		AM	MD	PM	NT
P-A	AM	0.9%	23.9%	16.8%	5.9%
	MD	0.6%	15.8%	11.2%	5.9%
	PM	0.0%	0.0%	1.3%	11.3%
	NT	0.0%	1.8%	1.3%	3.4%

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Air Passenger Model

- Model Structure
  1. HH synthesis
  2. Tour frequency
  3. Tour destination choice
  4. Mode Choice
  5. Intermediate stops
     - Number of stops
     - Stop location
  6. Time period
  7. Trip accumulation / Assignment

SAME PROCESS AS OVERALL TOUR MODEL!

- Calibrated against 2019 Air Passenger Survey
- Only Models tours to/from:
  - Dulles
  - Reagan
  - BWI
- Some Differences:
  - Tour Purposes
  - Travel Modes

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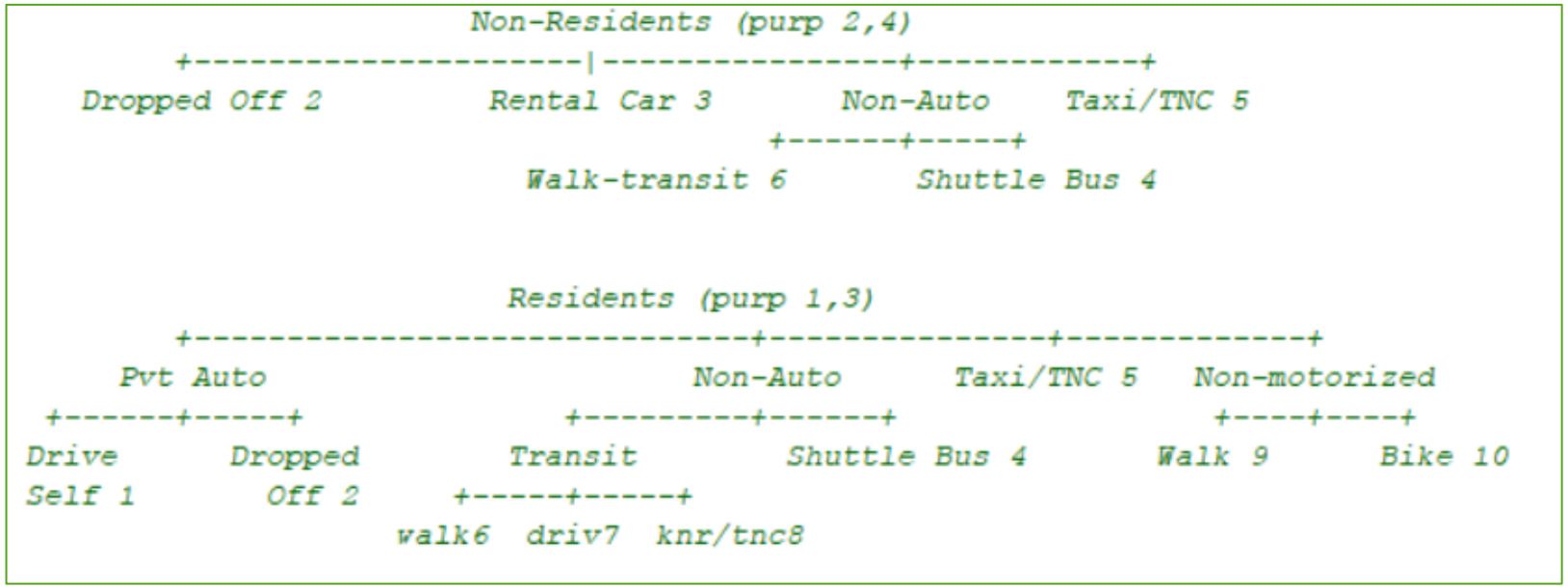
Air Passenger Differences

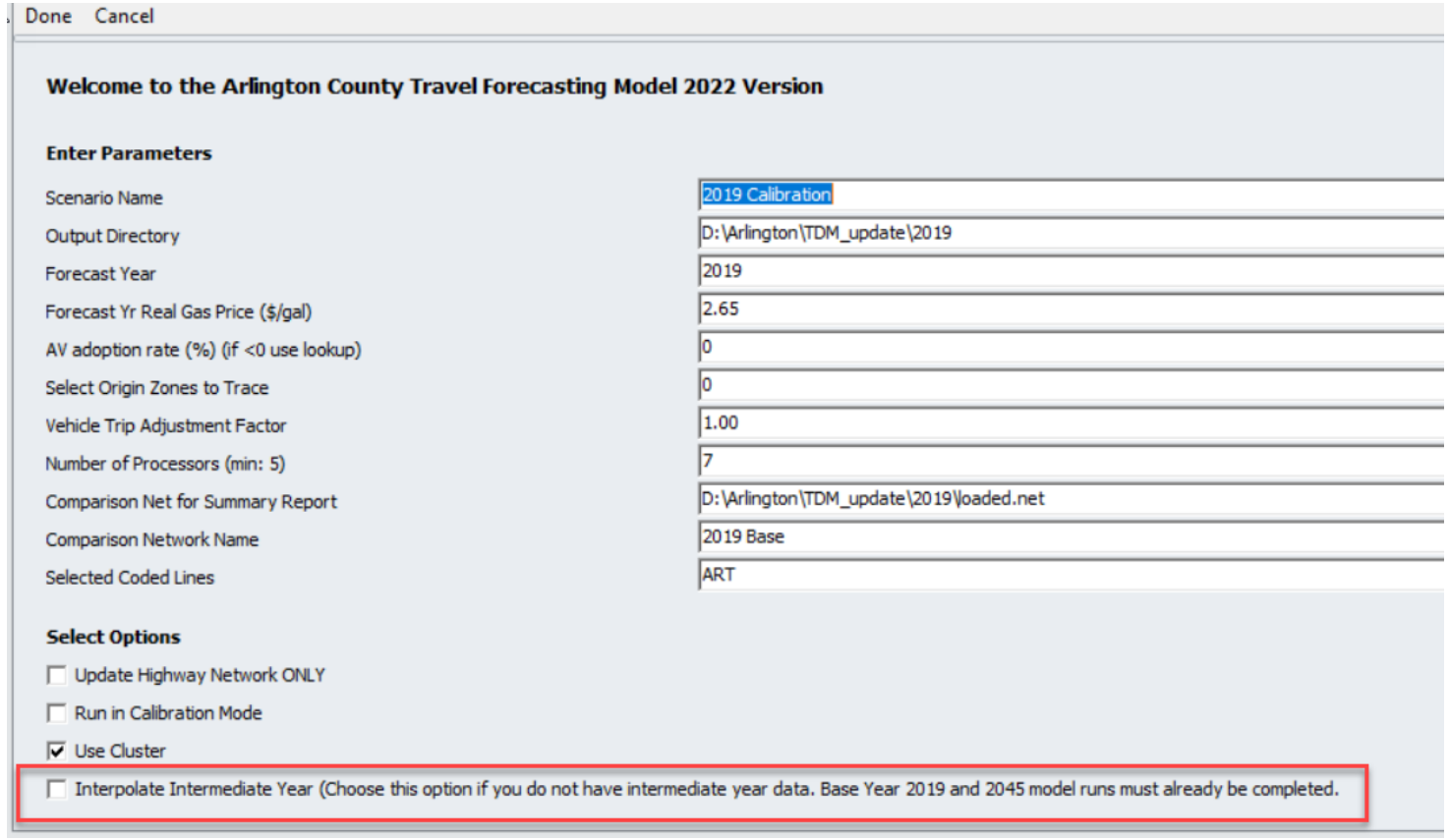
- Tour Purposes
  - Business, resident (BRS)
  - Business, non-resident (BNR)
  - Pleasure, resident (BRS)
  - Pleasure, non-resident (BNR)
- Modes
  - Drive Self
  - Drop off
  - Rental Car
  - Shuttle
  - Taxi/TNC
  - Walk-Transit
  - Drive-Transit
  - KnR-Transit
  - Walk
  - Bike

Mode Choice Structure / Nesting



Intermediate Year Modeling

- If there are no model inputs for an intermediate year, model interface has option to interpolate an intermediate forecast year
  - Have to first run through a base year 2019 and 2045 model run in full
  - Must check box in model interface
  - Interpolation is on the base year and future year trip tables, not input data



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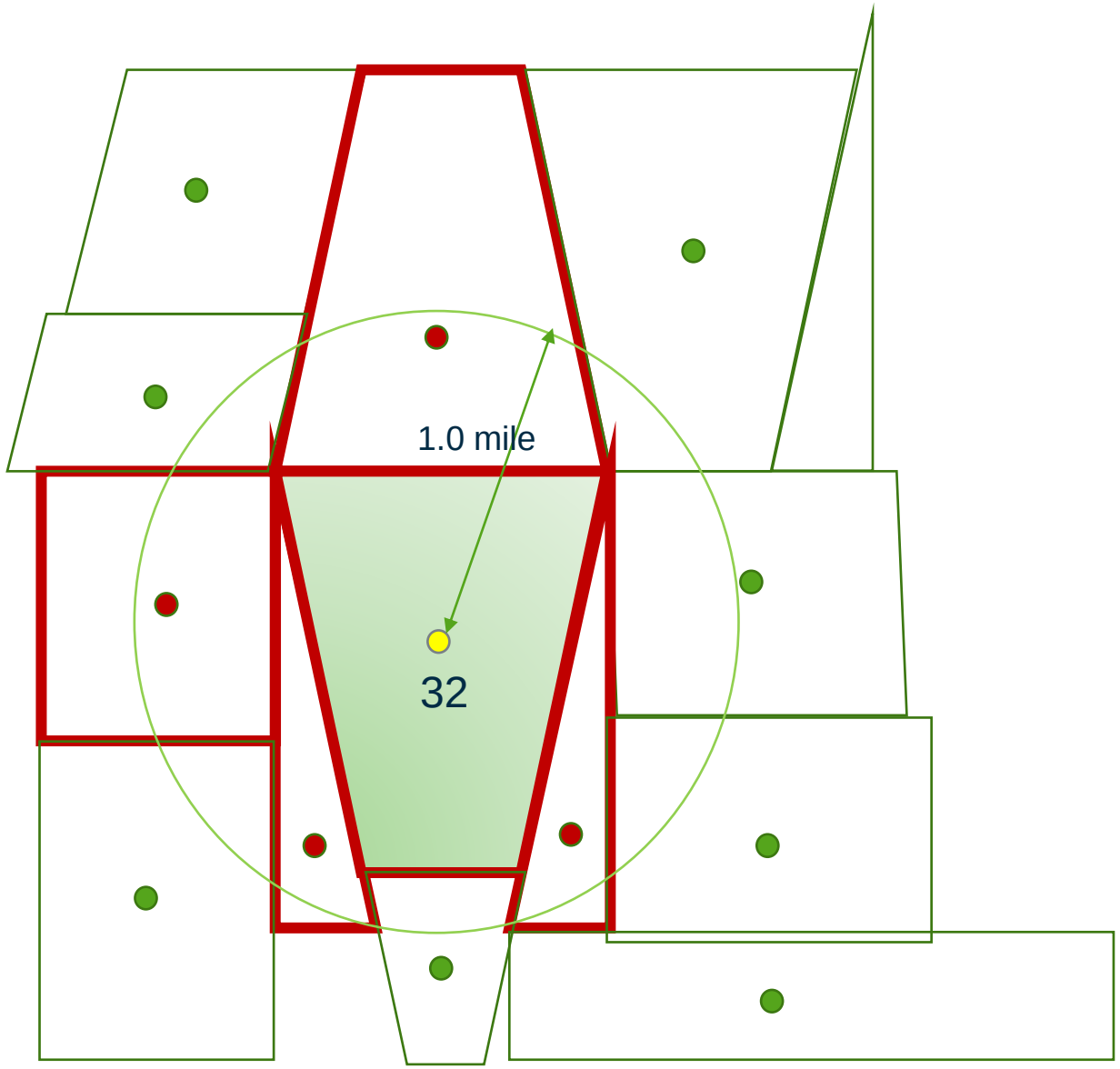
Areatype Model

1. Calculates Centroid of each zone
2. A buffer radius of 1 mile is created around the center of the zone
3. All zones centroids within this circle create a “floating zone”
4. Population and Employment density is calculated for the Floating zone
5. A lookup table is used to define the areatype



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Areatype Lookup

ATYPE CODE	Areatype
1	CBD
2	Urban High Density
3	Urban Low Density
4	Suburban High Density
5	Suburban Low Density
6	Rural

Lookup can be over-rode with the ATOveride input

Area Type Matrix		Employment Density (Employees / SQ Mile)						
		< 100	100-350	350-1500	1500-3550	3550-13750	13750-15000	>15000
Population Density (Pop / Sq Mile)	< 100	6	6	5	3	3	3	2
	100-350	6	5	5	3	3	3	2
	350-1500	6	5	5	3	3	2	2
	1500-3550	6	4	4	3	2	2	1
	3550-13750	4	4	4	2	2	2	1
	13750-15000	4	4	4	2	2	2	1
	>15000	2	2	2	2	2	1	1

Bentley