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Gen3 Model Development Project

Travel Forecasting Subcommittee Meeting

July 17, 2020

IN PARTNERSHIP WITH

BASELINE MOBILITY

Metropolitan Washington Council of Governments

Discussion Topics

- Gen3 Design Report
  - Description (Joel Freedman)
  - COG/TPB staff perspective and review of the report (Mark Moran)
- Gen3 Phase I Model Implementation
- 2017/18 Regional Travel Survey Re-expansion

Gen3 Design Report

Gen3 Design Report

RSG
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Metropolitan Washington Council of Governments

GEN3 MODEL DESIGN PLAN

Gen3 Model Development Project | May 4, 2020

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PREPARED FOR:

METROPOLITAN WASHINGTON COUNCIL OF GOVERNMENTS

SUBMITTED BY:

RSG

With

Baseline Mobility

VERSION 1.0

FIGURE 3: EXISTING ACTIVITYSIM MODEL DESIGN

ActivitySim represent all internal travel made by residents of the MWCOG region. The decision-makers in the model system include both persons and households. These decision-makers are created (synthesized) for each simulation year and land-use scenario based on Census data and forecasted distributions of households and persons by key socio-economic categories. The decision-makers are used in the subsequent discrete-choice models in a microsimulation framework where a single alternative is selected from a list of available alternatives according to a probability distribution. The probability distribution is generated from a logit model which considers the attributes of the decision-maker and the attributes of the various alternatives. The application paradigm is referred to as Monte Carlo simulation, since a random number draw is

28

Gen3 Report Chapters

1.0	Introduction
2.0	Overview of Gen3 Product Requirements
3.0	Strengths and Weaknesses of the Current Travel Model
4.0	Introduction to ActivitySim
5.0	Model Development Plan
6.0	Current and Future Data
7.0	Traffic and Transit Assignment
9.0	Software Approach
10.0	Quality Control and Quality Assurance (QC/QA)

Assessment of Strengths and Weaknesses

Usability

How user-friendly is the model? Is it well-documented? Does it provide useful outputs?

Sensitivity

Is the model sensitive to key variables/policies/projects?

Credibility

Is the model well-calibrated and validated?

Current Travel Model (Ver. 2.3) Strengths – Usability

- Successfully applied by MWCOG staff and TPB-member agencies for key planning activities
- Well-documented
- Reasonable model runtime
- COGTools for network and scenario management
- Automated toll cost adjustment algorithm
- Automated summaries
- Beginning to use GitHub for code versioning

Current Travel Model (Ver. 2.3) Strengths – Model Sensitivities

- Considers effects of land-use on magnitude and cost of travel
- Considers key household variables – size, income, autos
  - Subset on trip distribution and mode choice
- Trip distribution sensitive to auto travel time, cost, and transit travel time (Metrorail)
- Reasonable mode choice structure, variables, and parameters
- Traffic assignment consistent with state of the practice
  - Four time periods for assignment
  - Relative gap for final assignment is 0.0001 (i.e., 10^{-4})

Current Travel Model (Ver. 2.3) Strengths –
Model Credibility

- Model has been well calibrated and validated as noted in multiple reports
  - Validated to *2007*, 2010, and 2014 conditions
- Matches VMT by state very well
  - Within 1% of each state's estimated VMT
- Overall percent root mean square error for the model is 43%
- Total transit ridership relatively close to observed, e.g., Metrorail
  - 7% underestimation in 2007 validation (p. 9-7 of 2012 calibra. rpt.)
  - 1% overestimation in 2014 validation (p. 9 of Xie, Feng. Memorandum. “Year-2014 Validation of TPB’s Version 2.3 Travel Demand Model.” March 12, 2019)

Current Travel Model (Ver. 2.3) Weaknesses – Usability

Does not consider key policies of importance to MWCOG, including:

- Transit crowding
- External transit travel
- Non-motorized modes (except for TG and access to transit)
- Employer-based transit subsidies
- Effect of travel time unreliability in travel behavior
- Telework is not explicitly modeled
- Transportation Network Companies (TNCs)
- Visitor/tourist travel (included, but data could use a refresh)
- Connected/autonomous vehicles (CAVs)
- Micro-mobility

Current Travel Model (Ver. 2.3) Weaknesses – Sensitivity

- Current model suffers from common trip-based model aggregation biases
  - Temporal
  - Spatial
  - Travel markets/demographic variables/explanatory variables
  - Treats trips as if they are independent
  - Limited opportunities for equity analysis due to above aggregation biases
- Treatment of special markets relatively simple and not current

Current Travel Model (Ver. 2.3) Weaknesses – Credibility

- Transit ridership on certain lines and modes is under-estimated (though improved with 2014 validation)
- Certain highway screenlines could be improved
- More dynamic validation would be helpful

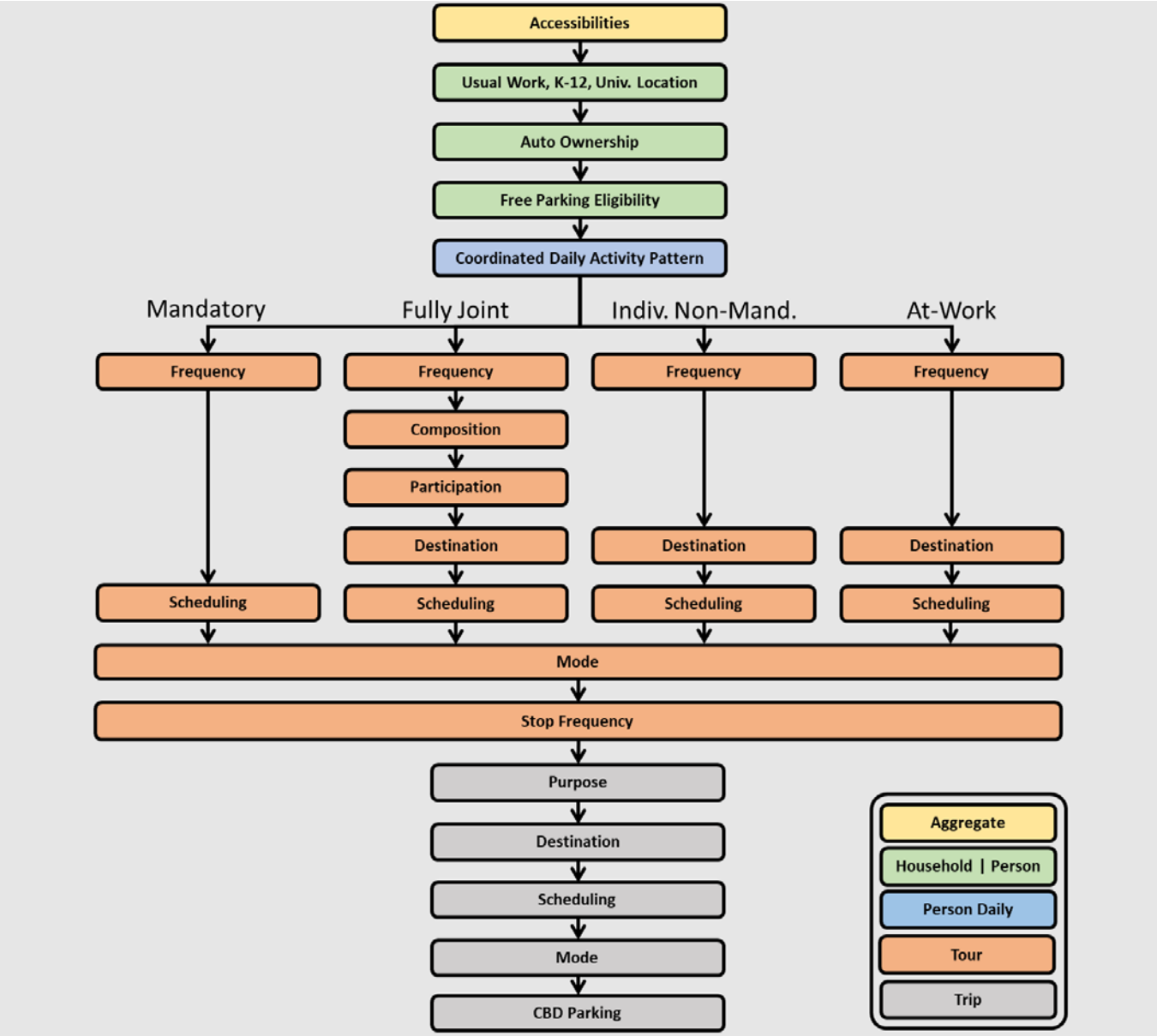
Recommended Gen3 Model – ActivitySim

- Mature, proven activity-based model
  - Based on the Coordinated Travel-Regional Activity-Based Modeling Platform (CT-RAMP)
  - Same structure used by Atlanta, SF Bay Area, San Diego, Miami, Chicago, Portland MPOs
- Professionally engineered and maintained open-source Python software
- Supported by AMPO consortium

Features of ActivitySim

- Uses ***tours*** for the generation of travel and to ensure consistency across trips within a tour
- Uses ***micro-simulation*** for modeling travel choices
- Includes household-level and person-level travel choices
  - Limited ***intra-household interactions*** between household members
- Schedules tours into ***time-windows*** to ensure there are no overlapping travel episodes

Existing ActivitySim Design



How does proposed Gen3 design meet objectives?

- State-of-the-practice activity-based model
- Addresses key aggregation biases noted in current model deficiencies
- Addresses key policies of interest
  - Non-motorized travel, TNCs, AVs, telecommuting, employer-based transit subsidies
- Meets most pressing regional transportation issues facing Washington, DC region
  - Same model has been used for RTP updates, policy analysis and project applications in Atlanta, SF Bay Area, San Diego, Chicago, Miami, etc.

Gen3 Development Plan

Phase I: Existing ActivitySim model

- Includes core functionality and features contributed by other agencies
- July 2020 through September 2021

Phase II: Enhanced ActivitySim model

- Includes MWCOG-specific enhancements and locally estimated models
- Fully-calibrated, validated, documented
- Training for MWCOG and partner agencies
- July 2021 through December 2022

COG/TPB Staff Perspective and Review of the Report

COG staff perspective (1)

- Modeling needs: “Product Requirements Document for the TPB Travel Demand Forecasting Model, Generation 3, the Next-Generation Model.” NCRTPB/MWCOG, May 25, 2018
- RSG recommendation: COG should move from its current, aggregate, trip-based travel demand model to a disaggregate, simplified activity-based model (ABM), implemented in an open-source travel demand modeling software platform known as ActivitySim.

COG staff perspective (2)

- COG/TPB staff generally agree with the broad lines of the RSG proposal.
- Obviously, with such a large undertaking, there are details that may need tweaking and adjustment as we move through the two phases of calibration and validation.
- It is also understood that any large software development project carries many risks, but, based on the experience of the consulting team, COG/TPB staff believes that the risks are manageable and that the benefits of the new model will outweigh the costs.

Review process for the report

- Three levels of review
  - COG travel demand modeling staff (early May)
  - Other COG staff (late May)
    - RSG revisions to draft report (early June)
  - Travel Forecasting Subcommittee (mid June)
    - RSG finalized report (late June)

TFS review

- Several TFS members requested copies of the COG staff ABM training that was conducted in May
- One member expressed interest, but did not have time to review
- Three TFS members provided written comments
  - Ms. Nazneen Ferdous, Travel Demand Modeler, Jacobs
  - Ms. Lisa Shemer, P.E., Chief, Travel Forecasting and Analysis Division, MDOT, State Highway Administration (SHA)
  - Ms. Yuanjun Li, PTP, Planner Coordinator, Maryland-National Capital Park & Planning Commission (M-NCPPC), Montgomery County Planning Department (MCPD)

TFS review

- Over 50 questions/comments
- Each is addressed in a memo dated 6/30/20
- Some were substantive comments; others were more minor, such regarding typos or omissions
- In many cases, feedback resulted in updates to the report, which improved the report
- Next few slides present some examples of TFS comments and COG and/or RSG responses

TFS review: Example comment/response

- Comment #1 (Jacobs): The proposed Gen3 Model seems to represent only fully joint tours, not partially joint tours.
- COG/TPB staff response #1: We agree. As currently planned, Gen3 Model would explicitly represent only fully joint tours, not partially joint tours in the Daily Activity Pattern (DAP) model. RSG's proposal is that the Gen3 Model would be a simplified ABM, built upon a simplified CT-RAMP platform. As such, it would not implement the more advanced CT-RAMP features such as the explicit modeling of in-household activity coordination that forms partially joint tours in the DAP.

  The mode choice model of the Gen3 Model will be calibrated to the observed data: specifically, the 2017-18 COG/TPB Regional Travel Survey (RTS) and on-board transit survey data. This means that, although partially joint tours (such as picking up or dropping off household member) are not explicitly modeled in the DAP model, the shared-ride travel associated with those activities will be modeled in Gen3 (we just would not know if a shared ride coming out of mode choice results from the carpooling of household members on a fully or partially joint tour or from an outside-the-home carpool arrangement).
- RSG response #1: Nothing to add.

TFS review: Example comment/response

- Comment #1 (MDOT SHA): We are generally supportive of this effort to move towards an activity-based model platform for MWCOG.
- COG/TPB staff response #1: Great!
- RSG response #1: Nothing to add.

TFS review: Example comment/response

- **Comment #2 (MDOT SHA)**: We are thinking that, even with the new Gen3 Model, our current approach at MDOT SHA of using the "best model for the project" will continue. For example, MD projects within the MWCOG region would use the MWCOG model; whereas projects which may overlap MPO boundaries may use either the MSTM or one of the MPO models, whichever best represents the situation.
- **COG/TPB staff response #2**: That seems reasonable to us.
- **RSG response #2**: Nothing to add.

TFS review: Example comment/response

- Comment #8 (MDOT SHA): Will there be any changes in the current socio-economic data or zone structure (i.e. employment categories) anytime soon?
- COG/TPB staff response #8: This is not planned for the Gen3 Model, but could be considered for the Gen4 Model.
- RSG response #8: There are only minor changes suggested to current socio-economic data. For example, we recommend the use of enrollment data by TAZ for school and university destination choice models. We will develop a set of population synthesis controls from Census data that can either be held constant (proportional to household/population forecasts) into the future or adjusted to reflect assumed changes in socio-demographic groups into the future.

TFS review: Example comment/response

- **Comment #6 (M-NCPPC)**: Page 10 could also list parking needs and impacts (by IoT, environmental requirements, and PNR for transit), which is an important policy measure, not just parking pricing. (FYI, in the County General Plan Update, "Thrive Montgomery 2050," the proposed policies are aimed for greatly reducing auto trips and reducing parking, including converting current parking lots and PNR lots in urban areas)
- **COG/TPB staff response #6**: See RSG response.
- **RSG response #6**: We have added a bullet item on p. 10 to address this issue.

TFS review: Example comment/response

- Comment #12 (M-NCPPC): Page 26 “We propose to add a telework frequency model in Phase II” It’s a good idea to add a telework frequency model in Phase II. I hope that the 2017-18 RTS can provide more data for that. If not, then there may be a need for an additional workplace/employer survey.
- COG/TPB staff response #12: Noted.
- RSG response #12: Nothing to add.

TFS review: Example comment/response

- Comment #35 (M-NCPPC): Page 72 AV: Yes, it's a must! AV allows 0-occ, and may affect household vehicle ownership (needs and affordability), parking, AV delivery, etc. May also set a "switch" - what if assuming all autos are AVs.
- COG/TPB staff response #35: Noted. Defer to RSG regarding setting a switch.
- RSG response #35: In other models, we have allowed the user to specify the percent of the private fleet that is AV. Alternative-specific constants are "turned on" or "turned off" in the auto ownership model that replicates this percentage. If the user sets the percentage to 100%, then alternatives with human-driven vehicles are unavailable.

Acknowledgements

- Consultant team
  - RSG, especially, Joel Freedman, Binny Paul, Albab Noor
  - BMG, especially, Mushtaq Rahman
- COG/TPB Travel Forecasting Subcommittee
- COG/TPB Travel Forecasting and Emissions Analysis (TFEA) Team
  - Model Development Group: Feng Xie, Meseret Seifu, Jian (Jim) Yin, Ray Ngo, Sanghyeon Ko
  - Model Application Group, especially Dusan Vuksan and Jane Posey

Phase I Deployment

Phase I Task Order (03)

TASK	DESCRIPTION
0	Project Management
1	Population Synthesis
2	Data Development
3	Phase I ActivitySim Deployment
4	Phase I Model Estimation
5	Calibration and Validation
6	Sensitivity Testing

Population Synthesis

PURPOSE

Generate household and person files used in ActivitySim

TASKS

- Design control variables and data sources
- Build base and future year synthetic populations using PopulationSim
- Document

Data Development

PURPOSE

Develop required observed data for use in model calibration and validation

TASKS

- Code 2017/18 RTS in ActivitySim format (tours, stops, etc.)
- Code and expand (if necessary) on-board surveys
- Assign OBS data to transit network to test coverage, network quality, and transit assignment parameters
- Document

Phase I ActivitySim Deployment

PURPOSE

Stand up initial ActivitySim model

TASKS

- Adjust Cube scripts to generate required ActivitySim input skims
- Adjust Cube scripts to replace trip-based model output with ActivitySim output
- Implement and integrate initial ActivitySim model
- Implement visualizer to compare model results to observed data
- Document

Phase I Model Estimation

PURPOSE

Estimate tour mode and destination choice models

TASKS

- Generate input files in ActivitySim estimation format
- Run ActivitySim in estimation mode and estimate models
- Apply estimated models
- Document

Phase I Model Calibration and Validation

PURPOSE

Adjust model network, parameters, constants, skimming and assignment procedures to improve goodness-of-fit

TASKS

- Iteratively run and analyze model results
- Fix model input and specification errors if necessary
- Implement automated calibration procedures
- Make informed and reasonable parameter adjustments
- Document

Phase I Sensitivity Testing

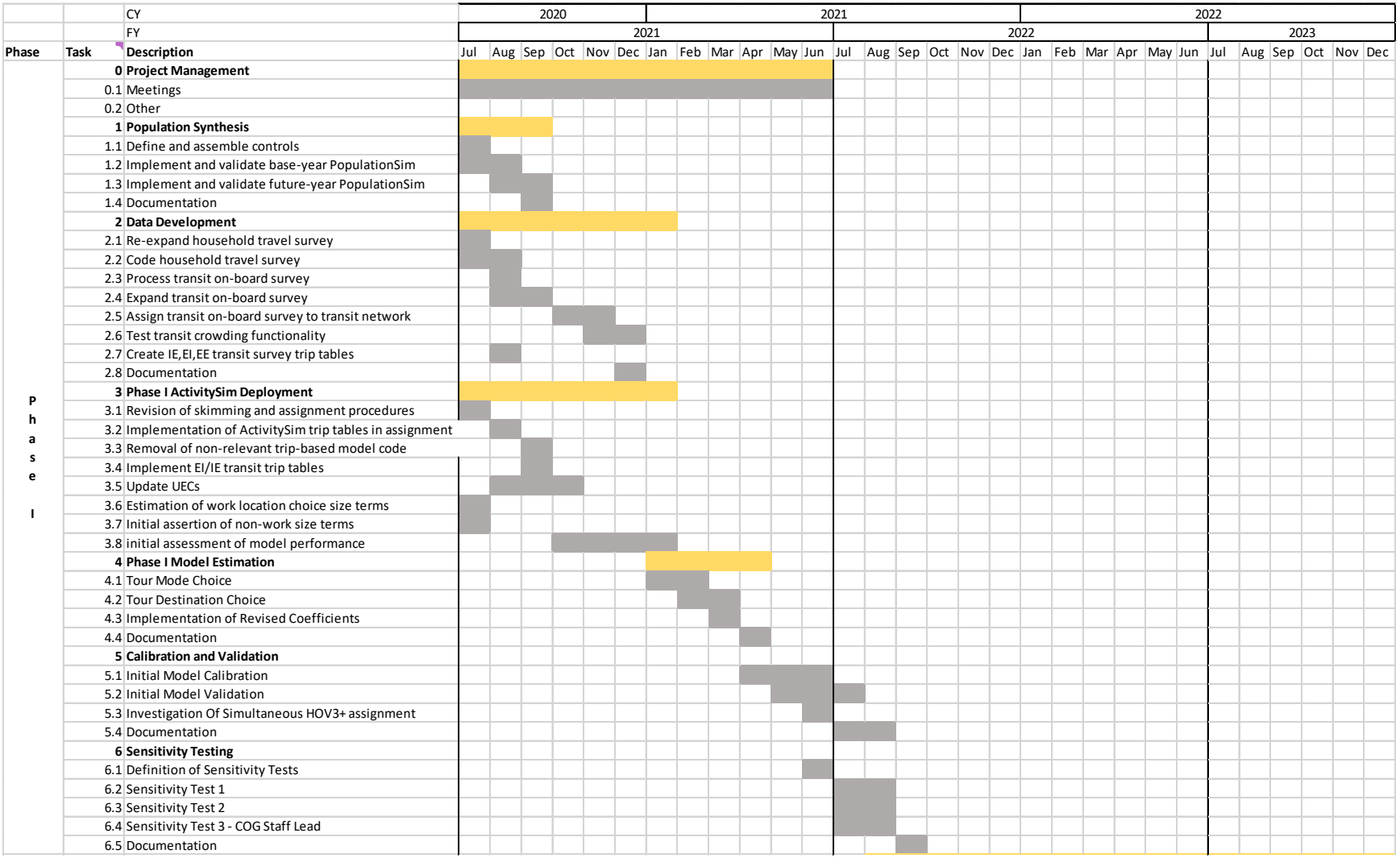
PURPOSE

Perform dynamic validation of Phase I Models

TASKS

- Define sensitivity tests
- Code sensitivity tests
- Run sensitivity tests and generate useful outputs to glean insights from model results
- Make informed and reasonable input and/or parameter adjustments if necessary
- Document

Phase I Deployment Schedule



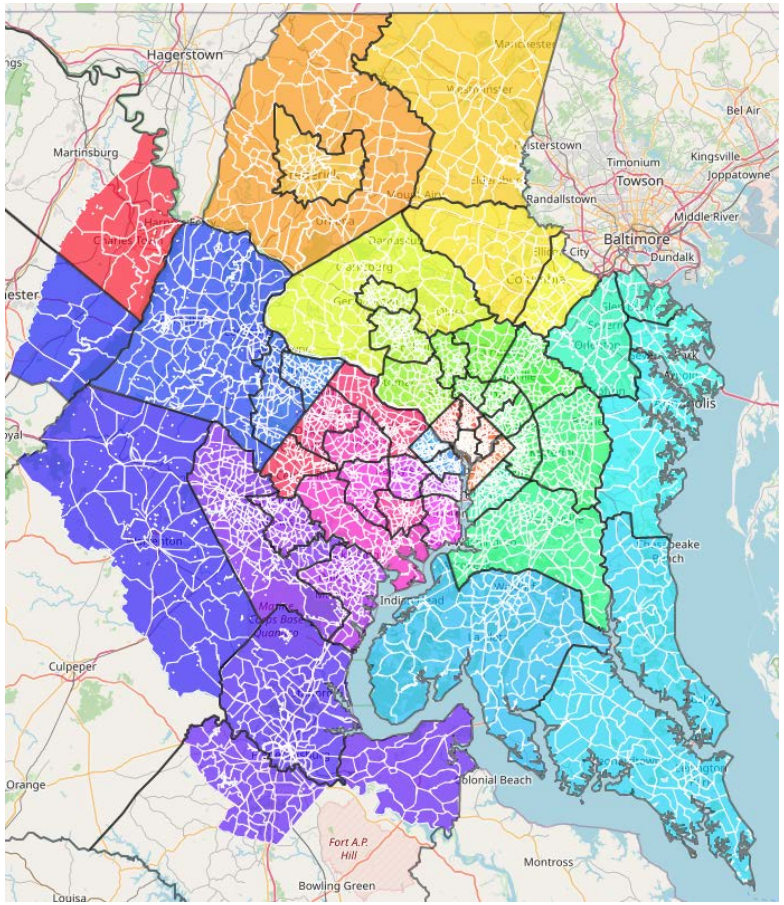
2017/18 Regional Travel Survey Re-expansion

Regional Travel Survey Reweighting

- Describe the methodology used to reweight the RTS data using interim survey data
- Used an entropy-based list-balancing approach
  - Implemented in Population Sim
- Comparisons to:
  - Modified PUMS data used as controls
  - Previous weights
- Discuss briefly how to use PopulationSim for survey expansion
  - PopulationSim setup can be rerun by COG/TPB staff

Control Totals

- Began with 2018 1-year PUMS data
  - Excluded group quarters
  - Counts at the PUMA-level
- PUMA-level counts scaled to 2018 TAZ household and person totals
  - Base year model totals
  - Used TAZ-to-PUMA correspondence provided by MWCOG
- Household and person controls were used



TAZ-to-PUMA correspondence

Control Variables

VARIABLE	CATEGORIES
Household Size	1-person 2-person 3-person 4-person 5-person or more
Income	Under $25,000 $25,000 - $49,999 $50,000 - $99,999 $100,000 - $149,999 $150,000 or more
Workers	0 workers 1 worker 2 workers 3 workers or more
Vehicles	0 vehicles 1 vehicle 2 vehicles 3 vehicles or more
Presence of Kids	0 kids 1 or more kids
Total Households	-

VARIABLE	CATEGORIES
Gender	Male Female
Age	Under 5 years 5 – 15 years 16 – 17 years 18 – 34 years 35 – 49 years 50 – 64 years 65 years or older
Worker Status	Worker Non-worker
University Student Status	University student Non-university student
Race	Hispanic only Black only Asian only White only Other/multiple races
Area Type	Not in Activity Center In RTS Activity Center (TPB/ARL) In MTS HighTransit Commute Area Type (BMC) In MTS Hard to Reach Households Area Type (BMC) In MTS Lower Density Area Type (BMC)
Total Persons	-

Survey Data

- Expanded interim dataset delivered on 15 June
  - MWCOG is still performing some review of RTS data
  - Current data does not include Maryland overlap areas in both MWCOG and BMC
- Existing imputation was used
  - Income, age, gender, race/ethnicity
- R script to reformat data for PopulationSim

Expansion Routine Setup

- Used the survey expansion functionality within PopulationSim
- Existing expansion factors were used to seed the list-balancing algorithm
- New factors were bounded between 0.25 and 5 times the existing factors
- Expansion was done at the PUMA level (no aggregation was performed)
  - 53 PUMAs across DC, MD, VA, and WV

Expansion Results

- The majority of geographies do reasonably well matching PUMS controls
  - +/- 10% of targets
- Mean expansion factors range from ~80 to ~450 by geography
- However, we do recommend some aggregation once the survey sample is finalized
  - We recommend aggregating PUMAs with the worst match
  - These tend to be geographies with the smaller sample sizes (in this case the MD PUMAs)

Expansion Results

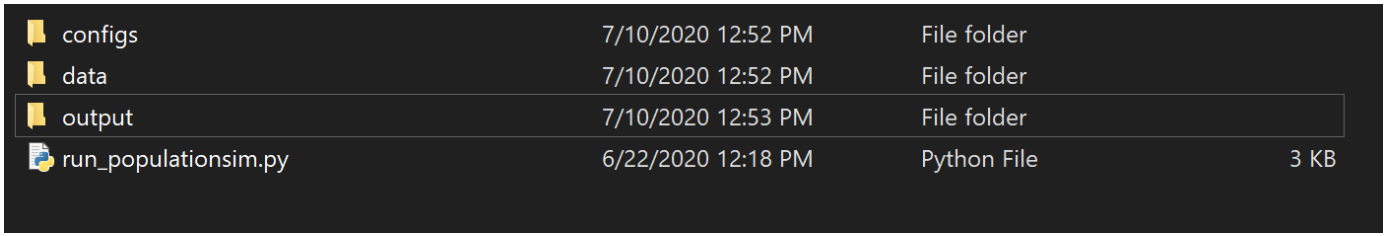
- RSG compared new expansion factors to previous factors
- In general, new expansion factors match control targets much better than previous

SOURCE	HOME_STATE_COUNTY_FIPS	H_WORKER_0	H_WORKER_1	H_WORKER_2	H_WORKER_3+
1_RSG	24013	24%	26%	38%	11%
2_PUMS18	24013	23%	27%	39%	12%
3_MWCOG	24013	20%	24%	46%	9%
4_PUMS17	24013	21%	31%	38%	10%
1_RSG	24021	18%	35%	38%	9%
2_PUMS18	24021	18%	35%	38%	9%
3_MWCOG	24021	19%	39%	36%	6%
4_PUMS17	24021	19%	34%	38%	10%

- Memo has been provided to COG/TPB staff for review.

Using PopulationSim

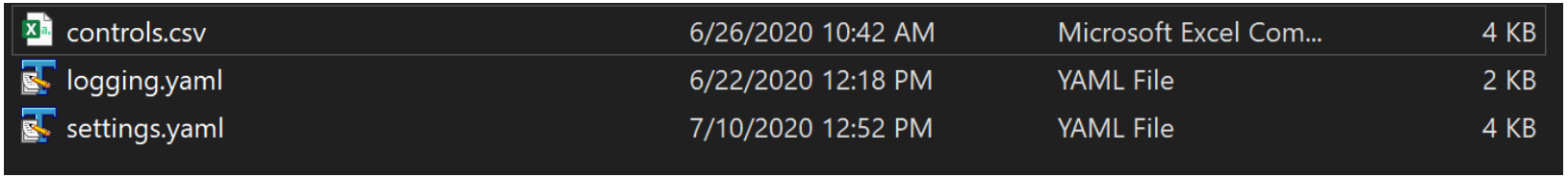
- Install PopulationSim
  - https://activitysim.github.io/populationsim/getting_started.html
- Download folder from box



- run_populationsim.py runs PopulationSim

Using PopulationSim

- configs folder

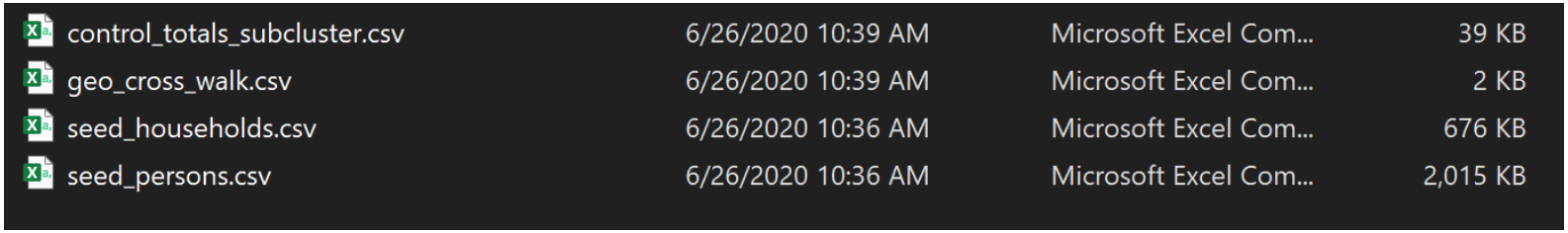


- controls.csv provides mapping between survey data and control totals using a pandas-based expression
  - also allows for importance and geography setting

target	geography	seed_table	importance	control_field	expression
h_income_0k_25k	SUBREGCluster	households	10000	h_income_0k_25k	households.HH_INCOME_DETAILED == 1
h_income_25k_50k	SUBREGCluster	households	10000	h_income_25k_50k	households.HH_INCOME_DETAILED == 2
h_income_50k_100k	SUBREGCluster	households	10000	h_income_50k_100k	households.HH_INCOME_DETAILED == 3
h_income_100k_150k	SUBREGCluster	households	10000	h_income_100k_150k	households.HH_INCOME_DETAILED == 4
h_income_150k_200k	SUBREGCluster	households	10000	h_income_150k_200k	households.HH_INCOME_DETAILED == 5
h_income_200k_plus	SUBREGCluster	households	10000	h_income_200k_plus	households.HH_INCOME_DETAILED == 6

Using PopulationSim

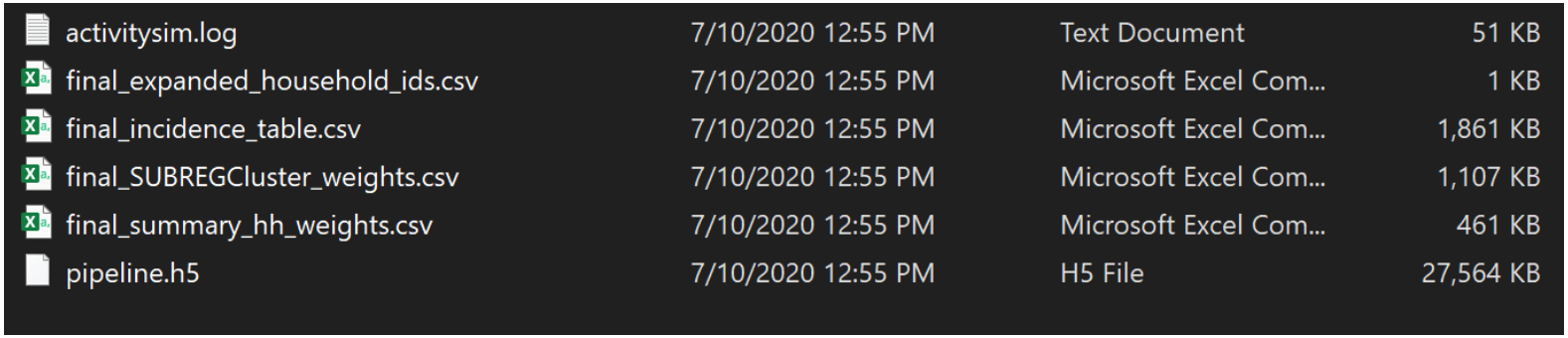
- data folder



- survey and control data
- geography crosswalk

Using PopulationSim

- output folder



activitysim.log	7/10/2020 12:55 PM	Text Document	51 KB
final_expanded_household_ids.csv	7/10/2020 12:55 PM	Microsoft Excel Com...	1 KB
final_incidence_table.csv	7/10/2020 12:55 PM	Microsoft Excel Com...	1,861 KB
final_SUBREGCluster_weights.csv	7/10/2020 12:55 PM	Microsoft Excel Com...	1,107 KB
final_summary_hh_weights.csv	7/10/2020 12:55 PM	Microsoft Excel Com...	461 KB
pipeline.h5	7/10/2020 12:55 PM	H5 File	27,564 KB

- final_summary_hh_weights.csv has the new expansion factors

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