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Think Forward

FY 2017 Short Term Model Improvements Task Order

Status Update

presented to
Travel Forecasting Subcommittee

presented by
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May 19, 2017

Task Order 17.2 Short-Term Model Improvements

- Overview of the Improvements

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Short-Term Model Improvements

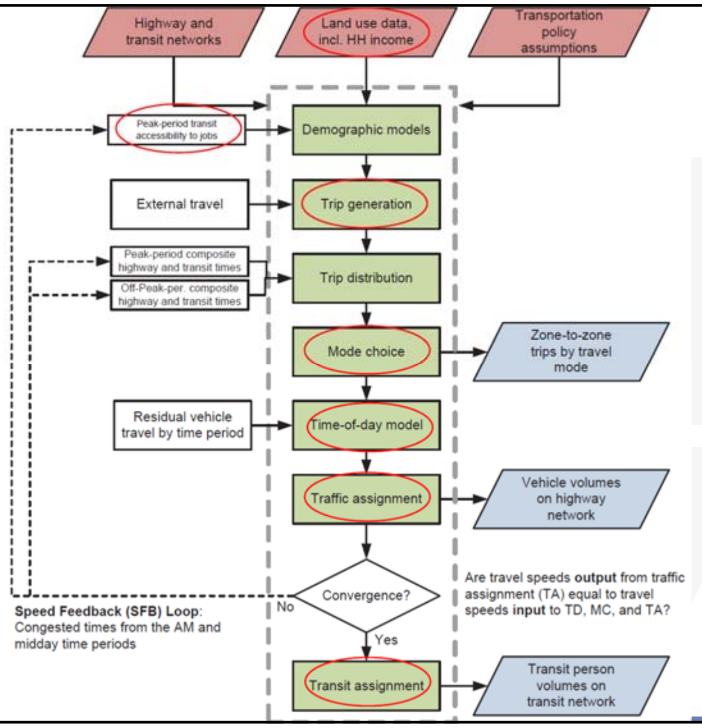
- Short-term model improvements reflect the priorities expressed in the stakeholder survey/outreach
  - Improved transit modeling
  - Improved non-motorized modeling
  - Improved managed lanes/pricing
  - Maintain model usability

Short-Term Model Improvements

- Calibration/Validation Year 2014
- Model application in Cube scripts
  - Maintain the existing model run procedures
  - Change related components

Model Flowcharts

- Component Changes



Work Plan

- Key Dates Recap
  - » January/February – Data processing and integration
  - » March/April – Model estimation
  - » April/May – Model implementation in Cube
  - » May/June – Model calibration, validation, and documentation

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Task Order 17.2 Short-Term Model Improvements

- PT Migration

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Status of PT Migration

- Application process has been developed, tested, and validated
- Application scripts have been implemented and verified
- Readily integrated into the existing COG/TPB model process
- Skim results are compatible with those from the existing process
- Validation of PT assignment process to be conducted with estimated trip tables generated from updated mode choice model

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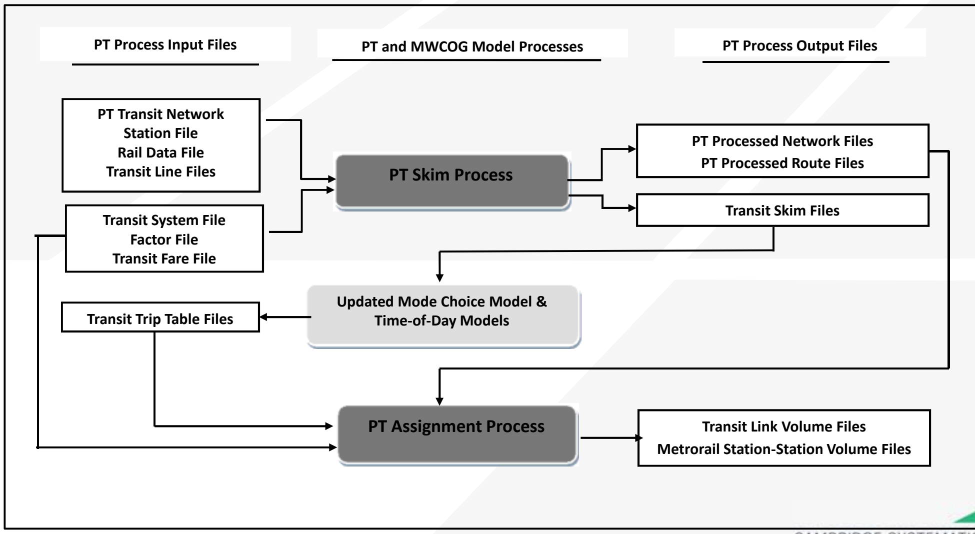
PT Skim and Assignment Process



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Main Differences in Skimming/Assignment Process between PT and TRNBUILD

- Skimming/assignment process stratification:
  - By time period and access mode (6 combinations) in PT
  - By time period, access mode and transit submode (22 combinations) in TRNBUILD
- Mode-specific IVT weight factors
- Consider transit fare in path choice process
- Creates processed network and route files for later uses - to save run times in transit assignment process and perform in-depth analyses (e.g., tracing paths of specific i-j pairs)

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Differences/Similarities between PT and TRNBUILD Inputs

- Similar basic input data
  - » Background highway network (including transit links)
  - » Transit line files
  - » Station file
- Pre-process to create "NT legs" of transit network (e.g., links for walk access/egress, drive access, transfers, etc.)
- Transit system file to specify transit operators and link modes in the PT network
- Transit fare functions for path choice process
- Different weight factors in path choice process

PT Major Path Building Parameters and Weighting Factors

Travel Time Weights

Travel Time Type	Mode	Weight
In-Vehicle Time	Auto modes	1.00
	Local bus	1.00
	Express bus	1.00
	Commuter rail	0.85
	Metrorail	0.90
Out-of-Vehicle Time	Auto terminal time	2.50
	Walk times for transit	2.50
	Drive access to transit	1.50
	Initial Wait (first 7 minutes)	2.50
	Other Wait	1.50

Transit Boarding Penalties

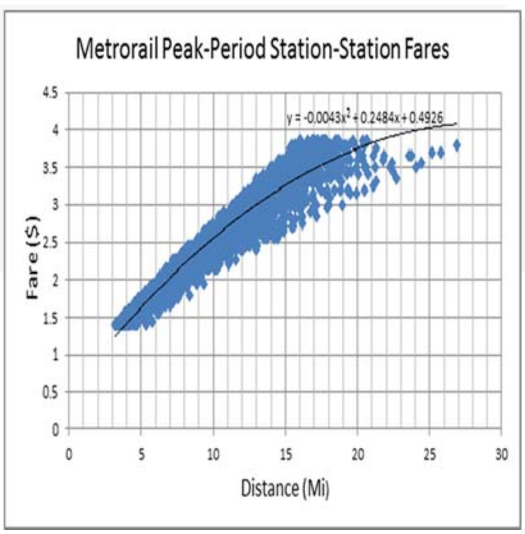
Transit Mode	IVT Equivalent (in min)
Local Bus	15
Express Bus	13
Commuter Rail	5
Metrorail	3

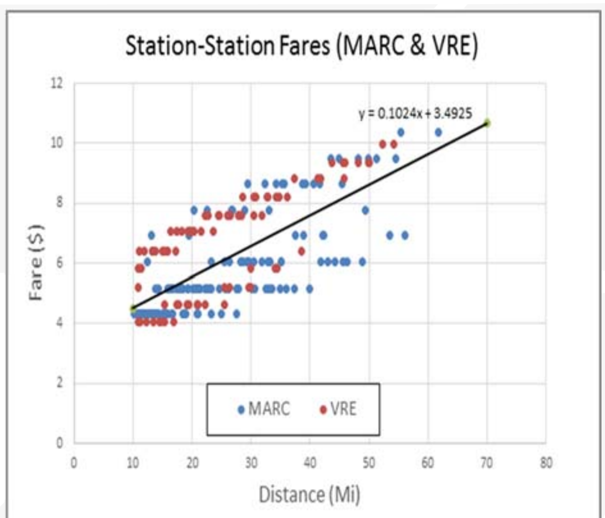
Note: Preliminary values that are being refined during the final validation process

Fare Functions in Path Choice Process

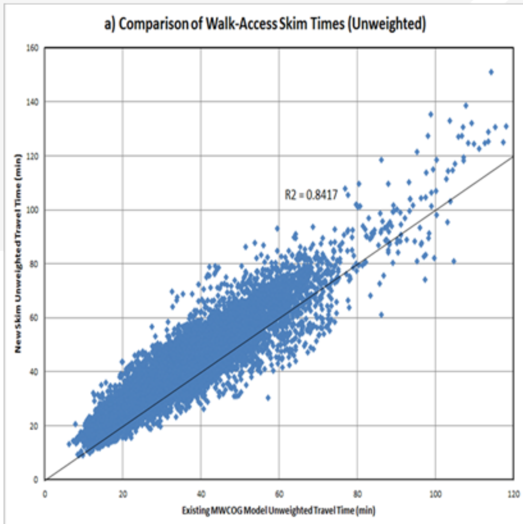
- Two types of fare functions
  - » Flat fare for bus
  - » Distance based fare for Metrorail and commuter rail
- Consider transfer discounts
- Applied in path choice process only
- MFARE programs are still used to develop fare matrices

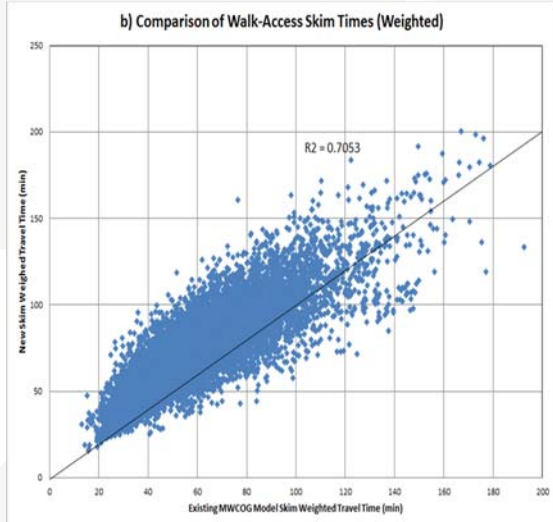
Station-Station Fare Functions





Comparison of Skim Times between PT and TB processes





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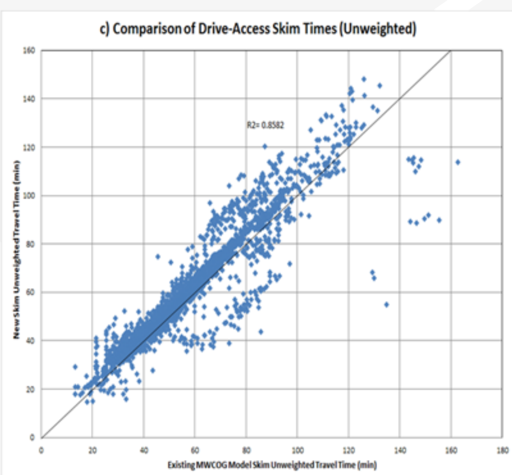
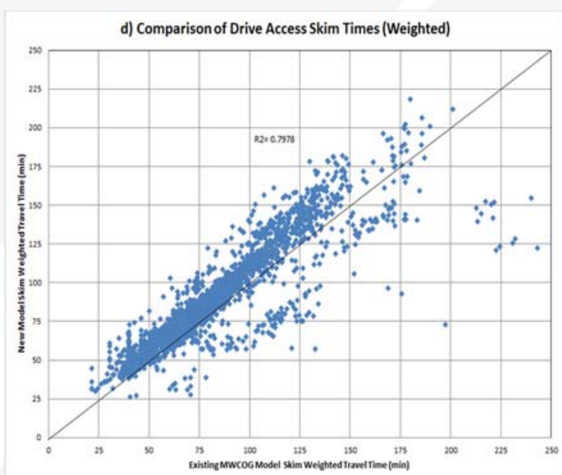
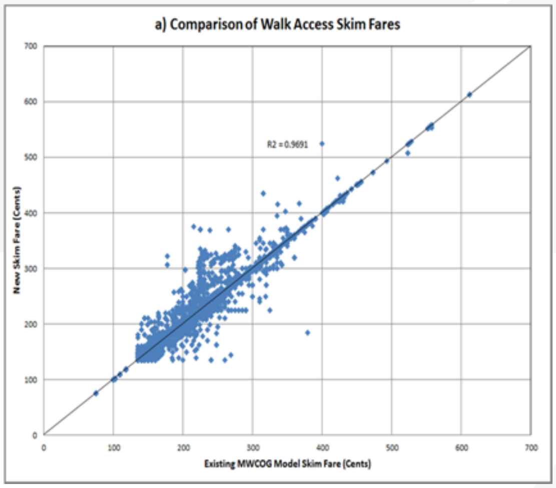
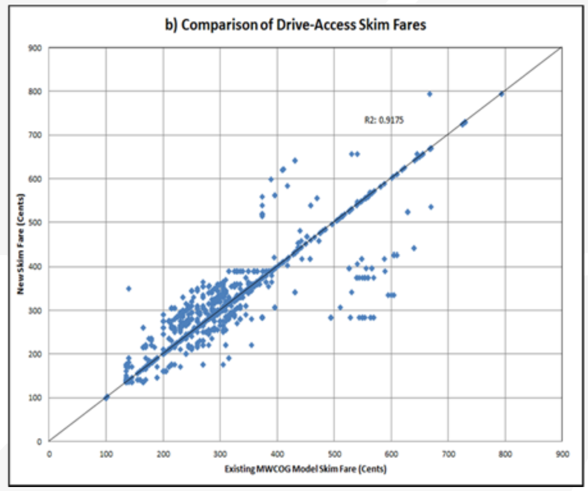




Comparison of Skim Fares between PT and TB Processes





Integrating PT Skim Process

- Uses similar inputs as existing TB process (with updated path-building weight factors)
- Applied by access mode and time period (6 combinations)
- Generates skim matrices files with similar format as TB process
- Generates Metrorail boarding/alighting station matrices (for MFARE program to generate fare matrices)
- Also generates processed network and route files (for transit assignment process and path-tracing analysis)
  - » Network file – consists of all transit links and NT legs
  - » Route file – stores “enumerated” transit paths between i-j pairs

Integration of PT Assignment Process

- Input trip tables generated by the updated mode choice model and time-of-day process (by time period and access mode)
- Use the PT network and route files generated in the skimming process
  - » Reduce computer run times in assignment process
  - » Ensure the compatibility between path-choice, skimming and assignment results
- Generate similar outputs as the TB process
  - » Transit link volume data
  - » Metrorail station-station passenger volume matrices

Transit Path-Building and Assignment

- Evaluated the consistency of PT and TB assignment results (by applying the same trip tables in both processes)

Transit Main Mode	Trips - Existing Procedure	Trips – New Procedure	Difference	% Difference
Local Bus	603,227	582,553	-20,674	-3.4%
Exp Bus	83,562	88,680	5,118	6.1%
Metro	997,821	1,019,597	21,776	2.2%
Commuter Rail	29,535	36,942	7,407	25.1%
Total	**1,714,145**	**1,727,772**	**13,627**	**0.8%**

- Further validation to be conducted with estimated trip tables generated from the updated mode choice model

Task Order 17.2 Short-Term Model Improvements

- Non-Motorized Model Enhancements

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Non-Motorized Model Structure

- Binary logit model for non-motorized modal splits at trip generation
  - » Productions and attractions
  - » Non-motorized modal shares as dependent variables
  - » Trip purposes (HBW, HBS, HBO, NHW, NHO)
- A disaggregate model estimation, with the objective of making the model
  - » More responsive to planning variables
  - » Seamless integration with the existing framework

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Non-Motorized Model Outputs

- Non-motorized trip productions by trip purposes
- Non-motorized trip attractions by trip purposes

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Non-Motorized Model Data

- Integrated Survey Data
  - » HTS data (2007-08 plus the 2011, 2012 Geo-Focused Surveys)
- Socioeconomic and built environment variables at block and TAZ level

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Non-Motorized Model Data

- Variables
  - » Trip-maker socioeconomic characteristics
  - » Built environment variables (floating land use density, land use diversity (entropy and Simpson's diversity index, urban design such as intersection density by types)
  - » Accessibility (access to transit stops/station)

Non-Motorized Model Estimation

- In general, the TAZ-level and block-level model estimation results are quite similar, with a few cases where the block-level models are slightly better than the TAZ-level models
- In most cases, estimated parameters for urban design and built environment variables such as density, diversity and design were consistent with our hypotheses on their significance in explaining the non-motorized modal shares

Non-Motorized Model Estimation

- Significant Variables
  - Population and employment floating density variables
  - Entropy and Simpson index
  - Intersection floating density for 3- or 4- legs and cul-de-sac
  - Transit stop floating density

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Non-Motorized Model Estimation

- In the non-motorized modal share models for productions, home-based work (HBW) trips are likely to have higher non-motorized shares where there is high employment, more diverse land uses, more 3- or 4-leg intersections, and fewer cul-de-sac streets
- In general, the model estimation results for the attraction-side variables are similar to those for the production-side variables. Employment density variables are not significant or with wrong signs in home-based trip purposes.

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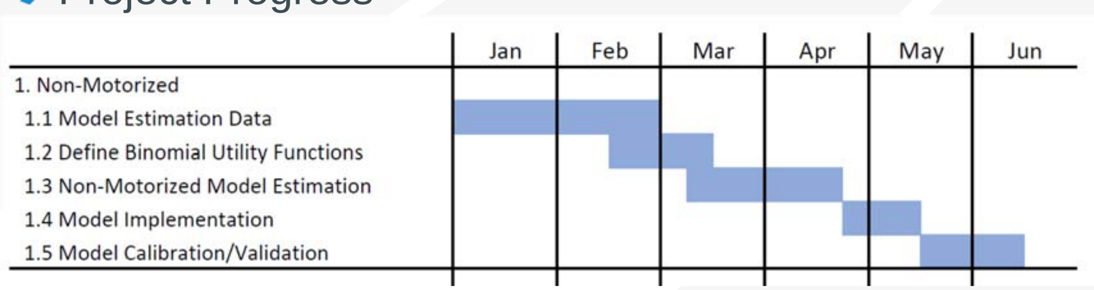
Non-Motorized Model Application/Calibration

- Implemented in TripGeneration.s
  - Changes in input file (Zone.dbf)
- Comparison with the results from the existing procedure
- Comparison with observed non-motorized modal shares by trip purposes
- Comparison with observed non-motorized modal shares by area types

Short-Term Model Improvements

- Project Progress



Task Order 17.2 Short-Term Model Improvements

- Mode Choice Model Enhancements

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Mode Choice Model Structure

- Modes
  - » Auto – single occupant
  - » Auto – double occupant
  - » Auto – three or more occupants
  - » Transit – park-&-ride access
  - » Transit – kiss-&-ride access
  - » Transit – walk access
- Trip purposes (separate models estimated for each)
  - » Home-based work (HBW)
  - » Home-based shopping (HBS)
  - » Home-based other (HBO)
  - » Non-home-based work (NHBW)
  - » Non-home-based other (NHBO)

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Mode Choice Data

- Household travel surveys
  - Regional household travel survey (2007/08)
  - Geo-focused survey (2011)
  - Geo-focused survey (2012)
- Transit on-board surveys
  - Metrorail survey (2008)
  - MARC survey (2007/08)
  - Bus survey (2008)
  - VRE survey could not be incorporated
- Survey data merged and reweighted for model estimation

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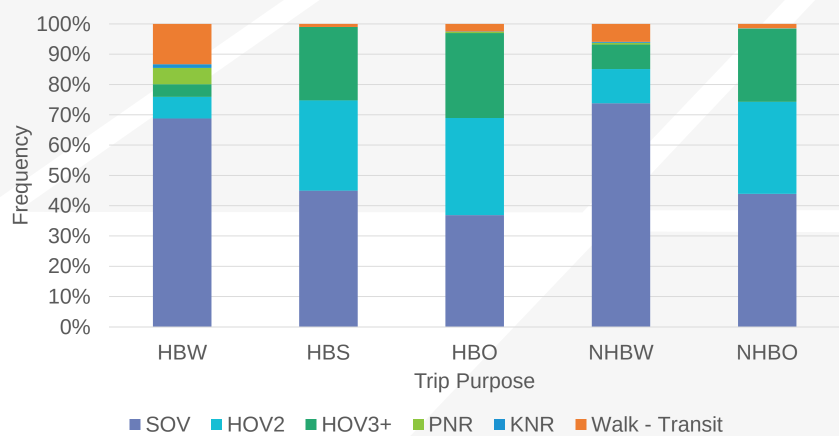
Mode Choice (weighted) Frequencies



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Value of Time Segmentation (refresher)

- To improve representation of managed lane facilities, value of time (VOT) segmentation is being implemented in the model
- Traveler VOT cannot be observed directly, and must be inferred
- Composition of VOT segments and average VOTs for each segment were derived from several data sources
- Three VOT segments considered:
  - **Low ($2.70/hr); Medium ($8.29/hr); High ($27.36/hr)**
- VOT is used by the model in two ways:
  - Average VOTs for each segment are used in highway skimming procedures
  - VOT segment composition informs how trips by income category get assigned to each VOT segment (low income households tend to be low VOT)

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VOT Segmentation and Mode Choice Model Estimation

- VOT of each respondent represents a “latent”, or unobserved, attribute
  - Not observed whether individual is from low, medium, or high VOT category
  - Special modeling procedures are required to appropriately generate model probabilities for model estimation
- VOT segmentation assumptions
  - Development of VOT segments used data from other sources and implied certain relationships between travelers’ time & cost sensitivities
    - Cost sensitivities by income category
    - VOTs by VOT category
  - Those relationships were tested in mode choice model estimation (to test for consistency)

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Mode Choice Model Variables

- **Level of service variables**
  - Cost
  - Travel time (sensitivities vary by type of travel time)
  - Transit boardings
- Income constants
- **Transit accessibility** – measured at the zonal level
- **Zonal diversity** – measure of relative employment to population in zone
- **Cul-de-sacs** – measure of street connectivity
- Final models have **Multinomial Logit (MNL)** form
  - Nested logit models were tested and rejected on basis of inconsistency with theory

Key Findings

- Implied VOTs estimated to be lower than our assertions
- Estimated VOT levels by VOT segment were close to our assertions
- Ultimately, we chose to constrain most of the level-of-service relationships
  - This is not uncommon for mode choice models estimated using revealed preference survey data
    - Many travelers “captive” in their mode choices
    - Correlation across level-of-service attributes
  - Given level of effort to identify relationship prior to model estimation, constraining model results viewed as better option than deviating from assertions
  - One variable NOT constrained
    - Scale of model sensitivity to level of service variables

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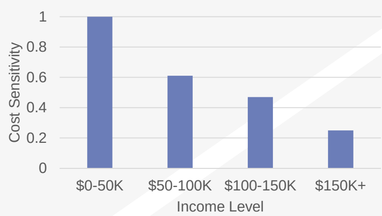
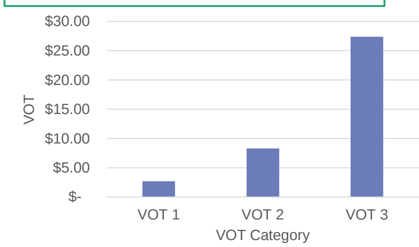
Key Relationships in Final Models

Relative Cost Sensitivities



Values of Time



Travel Time Weights

Travel Time Type	Mode	Weight
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Transit Boarding Penalties

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Additional Results

- Transit accessibility (at zonal level)
  - Important positive impacts on walk access/egress ends of transit trips
  - Suggests that perception of a location as having transit access is important (in addition to measurable transit connectivity between one's origin & destination, which is measured by level of service variables)
- Zonal diversity had small positive impacts on transit utility
- Cul-de-sacs negatively associated with transit usage

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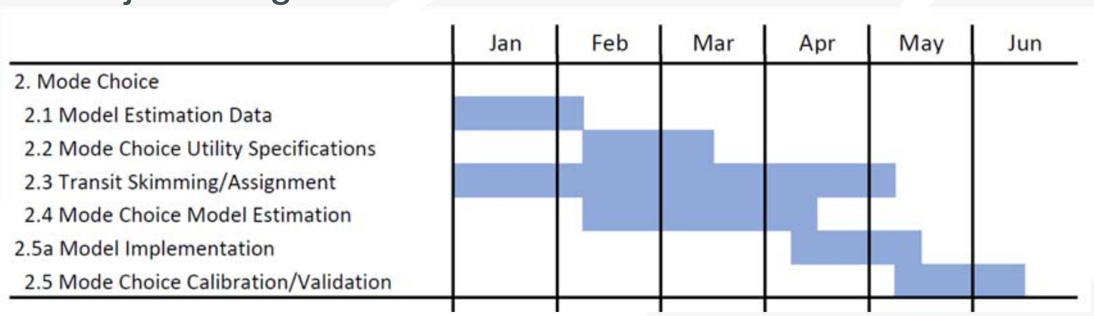
Model Choice Model Application/Calibration

- Implemented in Cube scripts
  - » Replace the existing mode choice procedure
  - » Inputs and outputs will be changed
- Comparison with the observed by trip purposes, household income categories, and geographic segments
- Model parameters will be adjusted to achieve a satisfactory match between estimated and observed data

Short-Term Model Improvements

- Project Progress



Task Order 17.2 Short-Term Model Improvements

- Traffic Assignment Enhancements

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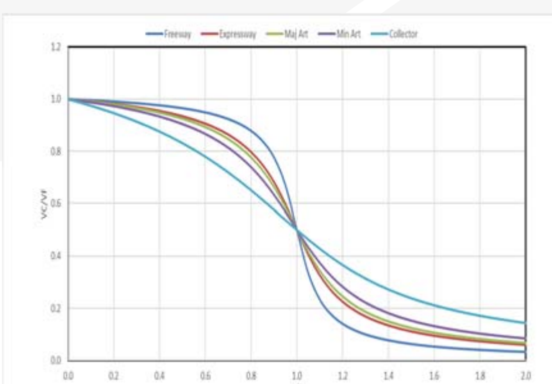
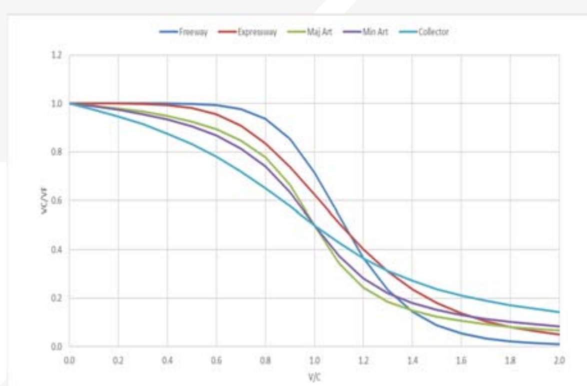
Revised Volume Delay Functions

- Replaced the existing Conical functions with BPR functions for Freeway and Expressway facilities





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Updated Highway Assignment Process

- Stratify vehicle trip tables by value of time (VOT) segment, with 12 vehicle types in each assignment process
  - SOV (3 VOT segments)
  - HOV2 (3 VOT segment)
  - HOV3 (3 VOT segment)
  - Commercial vehicle
  - Truck
  - Airport
- Revised link impedance calculation of vehicle loading process *(for 12 vehicle classes instead of existing 6 classes)*
- Same "2-step" process for peak period assignments, with 6 assignment runs (e.g., am non-hov3, am hov3, pm non-hov3, pm hov3, midday, night-time)

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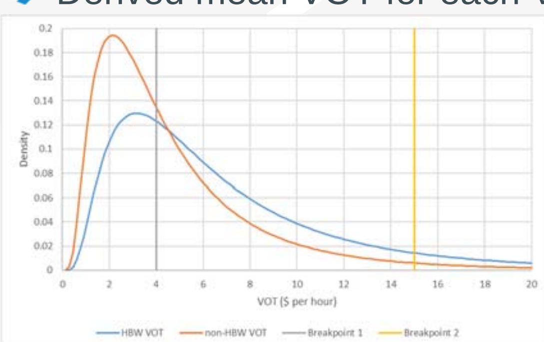
Development of VOT Segments

- Based on VOT distributions of specific income groups and trip types
- Derived mean VOT for each VOT segment



VOT Groups	VOT Lower Bound	Mean VOT ($/Hr)
VOT1	0.00	2.70
VOT2	4.00	8.29
VOT3	15.00	27.36

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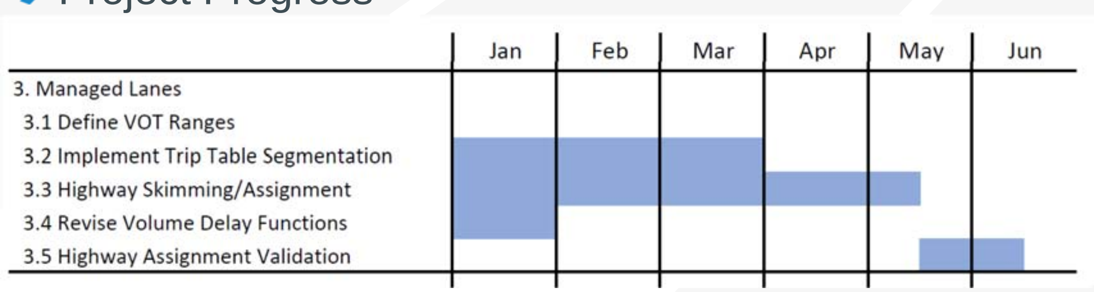
Outputs of Updated Highway Assignment Process

- Similar combined loaded network as existing process
  - Vehicle volumes (aggregating all VOT segments) by time period and vehicle type
  - Operation data (v/c, congested speeds, VMT, etc.) by time period
- More link volume fields (by VOT segment) in the loaded networks of individual assignment runs
- Process of select-link analysis needs to be revised accordingly
- Process of toll analysis (e.g., toll-setting procedure) also needs to be updated

Short-Term Model Improvements

- Project Progress



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Next Steps

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Next Steps

- Model calibration and validation
- Model documentation

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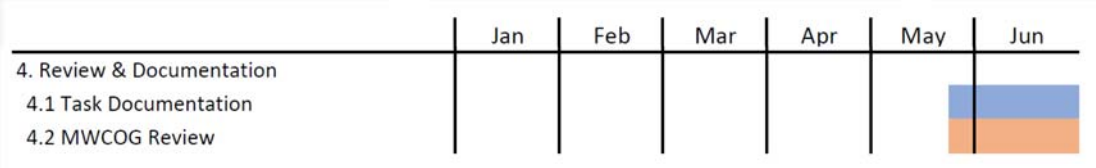
Short-Term Model Improvements

Project Progress



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