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New Methods for Improving Non-Home-Based Trips In Trip-Based Models

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Overview

RSG work on new methods for improving non-home-based (NHB) trips in trip-based models:

- Iowa Statewide Model
- TMIP How-to Guide (*forthcoming*) with pilot for Salt Lake City, UT
- Anchorage, AK Model
- Tennessee Statewide Model
- Anderson, IN (*implementing in-house*)
- Now under consideration in Virginia and Vermont





Goals

The Problem with NHB trips

AN OLD PROBLEM

- When four-step models evolved in the 1950s & 1960s, NHB trips only accounted for ~15% of trips
- According to surveys, NHB trips now account for $\geq 30\%$ of all trips
- By definition, NHB trips are **disconnected** from the households that make them and, thus, from the other HB trips made by the household
- This disconnect affects all dimensions of travel – location, mode, & time – therefore, NHB trips respond in the wrong places, in the wrong modes, and at the wrong times
- NHB trips are like **noise** in most models – pumped up to produce the right amount of overall volume – but adding error to results



Spatial Problems with NHB Trips

NHB trip patterns in four-step models can be physically impossible, implying that travelers/vehicles appear and disappear, making trips between places they never went in the first place

NHB trips can respond in illogical ways (e.g., new homes can generate new NHB trips in remote locations they almost never visit on home-based trips)

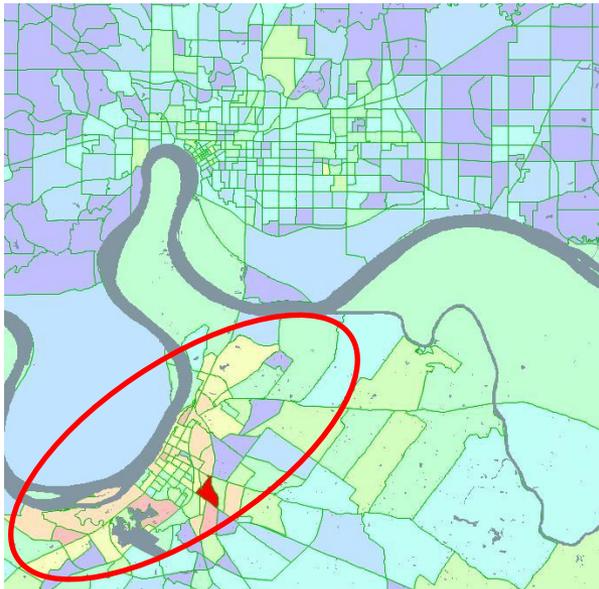


Figure 1 Home-based trips

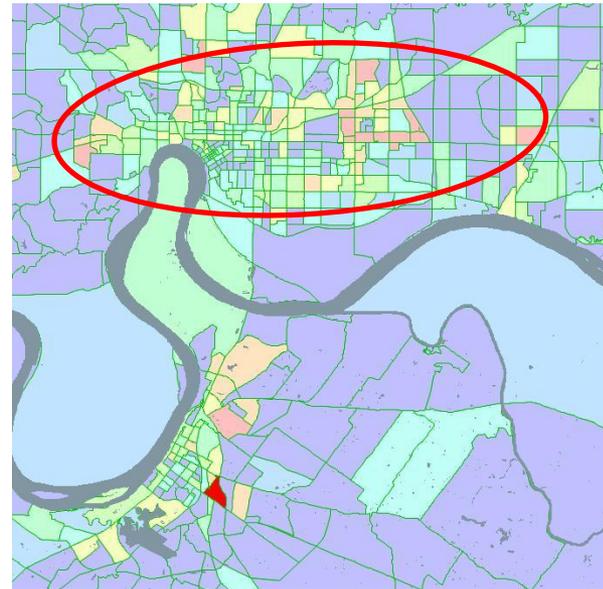


Figure 2 Non-home-based trips

Other Problems with NHB Trips

Mode and time of NHB trips are very difficult to model in the traditional four-step framework

NHB trip modes are conditional on HB trip mode choice, but not modeled this way in the four-step procedure

For example:

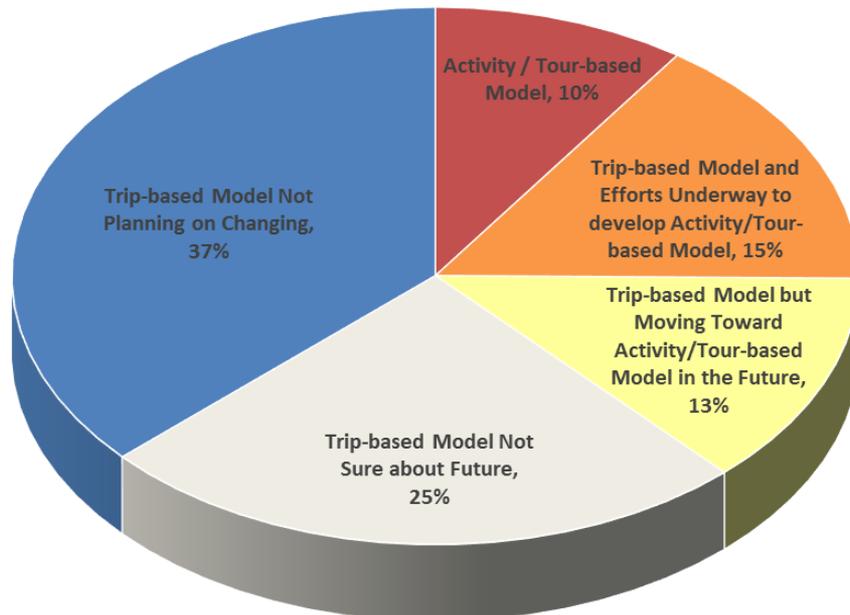
- In traditional four-step framework, transit improvements shift both HB and NHB trips to transit
- and **decrease** HB & NHB walk trips
- In reality, more HB transit trips can lead to **more** NHB walk trips

Options for Agencies

IS THE ONLY OPTION TO DEVELOP AN ENTIRELY NEW ACTIVITY-BASED MODEL?

According to a TMIP survey at the end of 2013:

- Near term, 3/4 of agencies will not have an activity-based model
- Long term, 1/3 – 2/3 of agencies will stay with trip-based models



As TRB Special Report 288 states: *“there is no single approach to travel forecasting or set of procedures that is ‘correct’ for all applications or all MPOs.”*

TMIP's Objective

OBJECTIVE:

- Provide more **options** to agencies for addressing issues related to non-home-based trips by:
 - providing **inexpensive** enhancements to existing trip-based models
 - that can be **implemented quickly** as part of a model update without requiring the development of a whole new model
 - that **improve** the model's ability to represent **non-home-based trips**





Methods

Understanding the Problem

THE PROBLEM:

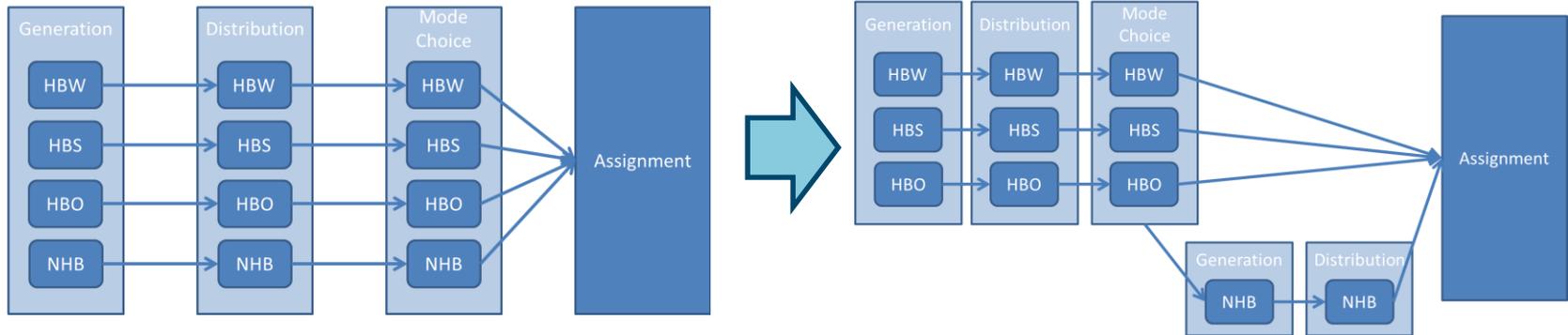
- Four-step models represent all trips through two component models – trip generation and trip distribution
 - These correspond to the decision of whether/how frequently to make a trip and where to go (destination)
- These two models cannot (properly) define a NHB trip
- A NHB trip requires a third piece of information/decision: an origin, where to visit the destination from
 - In other words, two spatial (distribution) models are necessary to represent a NHB trip because neither its origin or destination are known and thus both trip ends have to be modeled



A Simple Solution

SOLUTION

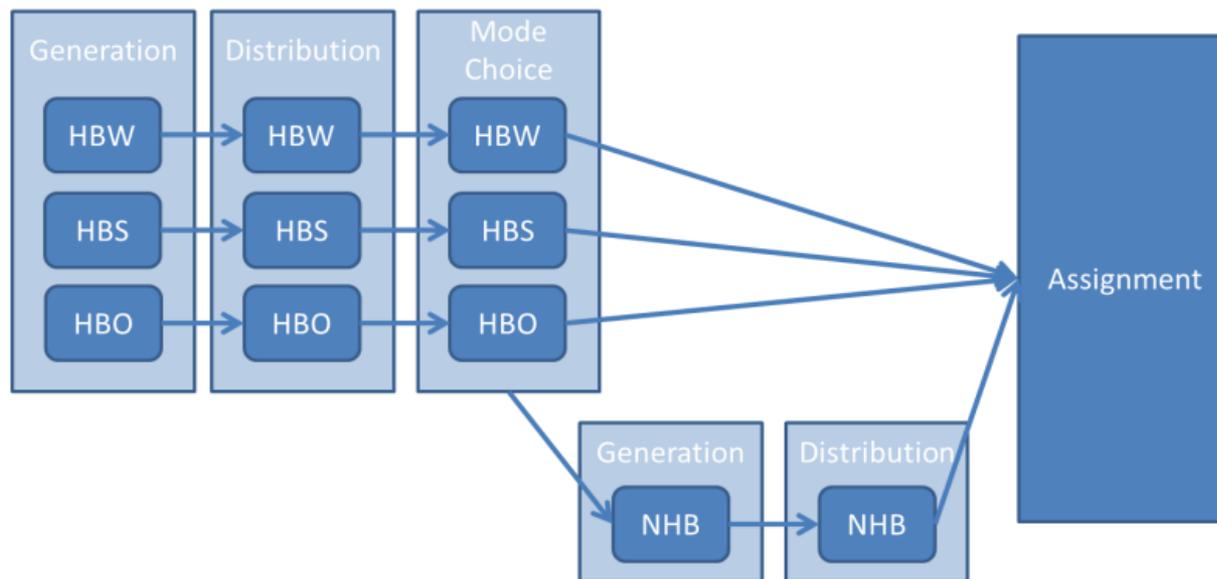
- Simplest solution is by linking and running NHB distribution in series rather than in parallel with the HB distribution models
- Sequenced and linked in this way, HB & NHB distribution can assign both the origin and destination to NHB trips
- This solution requires no changes to the HB model components



A Few Details

METHOD 1 DETAILS

- Generation of NHB trips is done by mode, as a simple function of the HB attractions to that zone by each mode
- Mode choice is therefore unnecessary

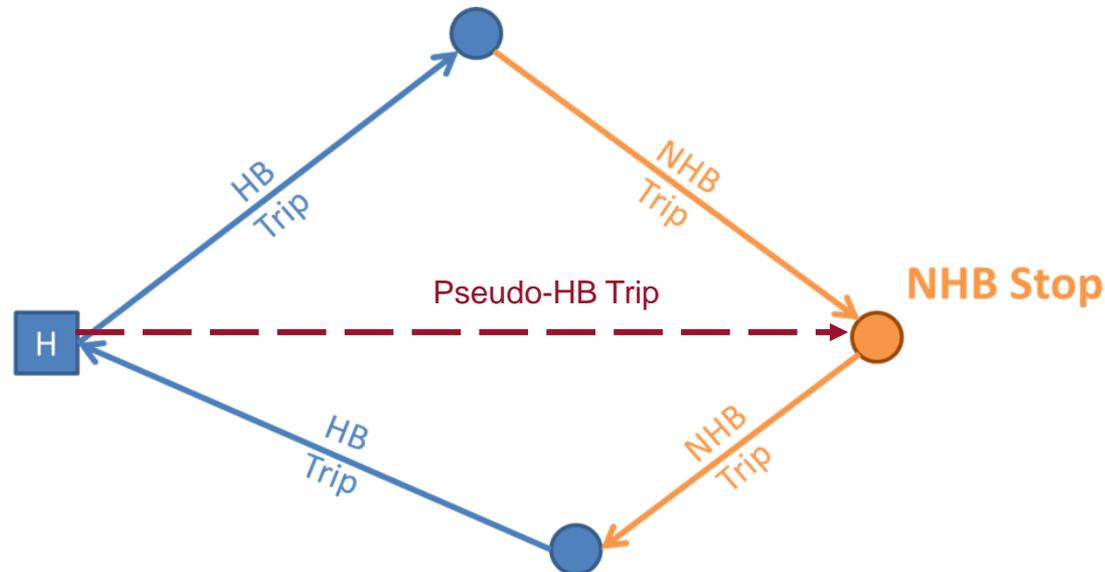


One complication

NHB STOPS

Method 1 treats all NHB trips as if both trip ends were HB trip attractions (only 1 NHB trip per tour)

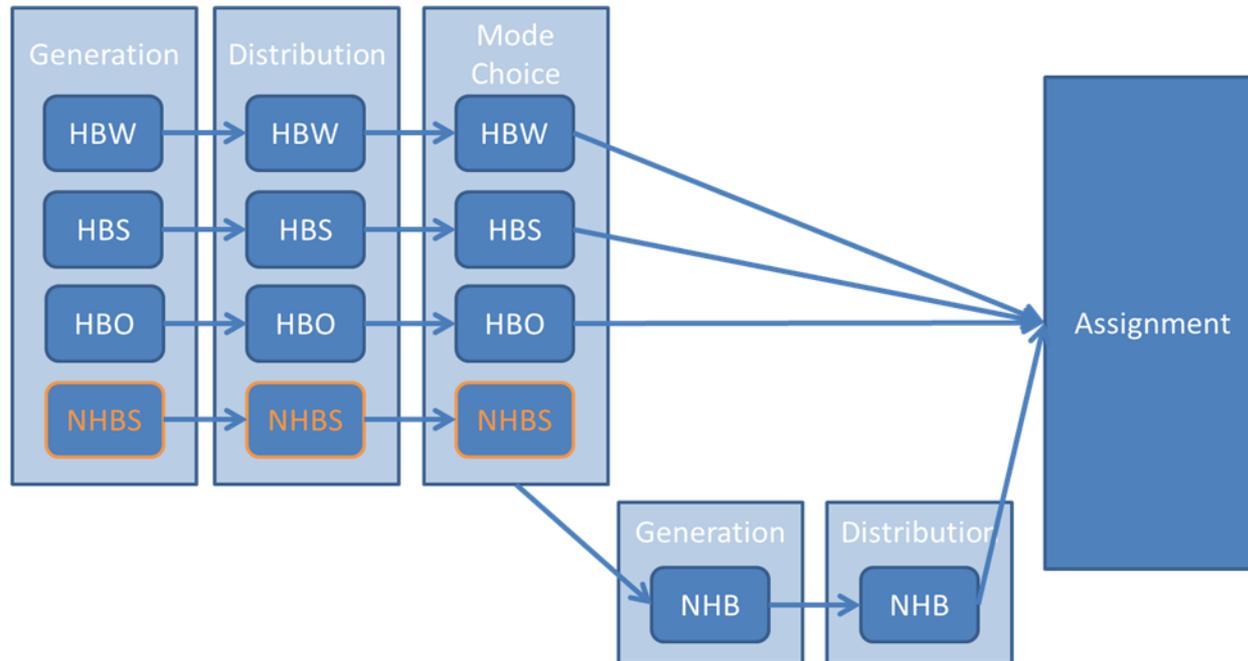
This is true for a large portion of NHB trips, but there are still many NHB stops



Another Simple Solution

METHOD 2

Generating and distributes NHB stops (or pseudo-HB trips)





Testing

Pilot: Salt Lake City

Each of the three methods were implemented and tested using the Wasatch Front Regional Council (WFRC)'s model

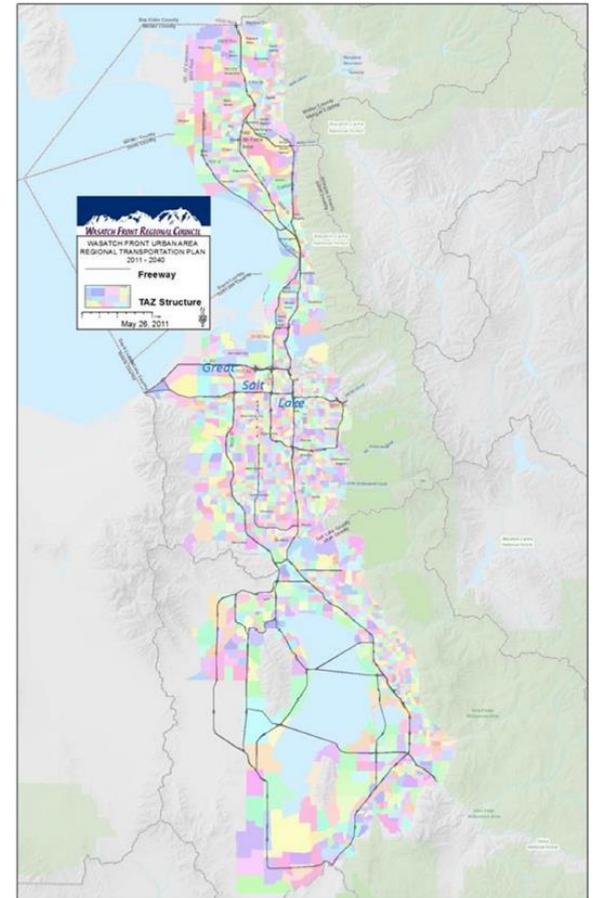
1.7 million population

Large transit ridership

Recent household and on-board survey data

Reasonably typical four-step model:

- 2,200 TAZ
- 6 trip purposes (HBW, HBC, HBSch, HBO, NHBW, NHBW)
- 6 modes (DA, HOV2, HOV3, SB, TR, NM)
- Auto ownership, mode choice, & feedback
- No destination choice, etc.



Method 1 NHB Trip Generation Results

Simple regression models from household survey data

Extremely plausible, intuitive results

Example results:

NHBW HOV2

| Coefficient | Estimate | t value |
|-------------|----------|---------|
| HBW_HOV2 | 0.2840 | 32.7 |
| HBW_HOV3 | 0.0862 | 7.8 |
| HBW_DR | 0.0808 | 24.4 |
| HBW_TR | 0.0534 | 3.4 |
| HBW_NM | 0.0326 | 2.5 |
| HBO_HOV2 | 0.0173 | 4.7 |

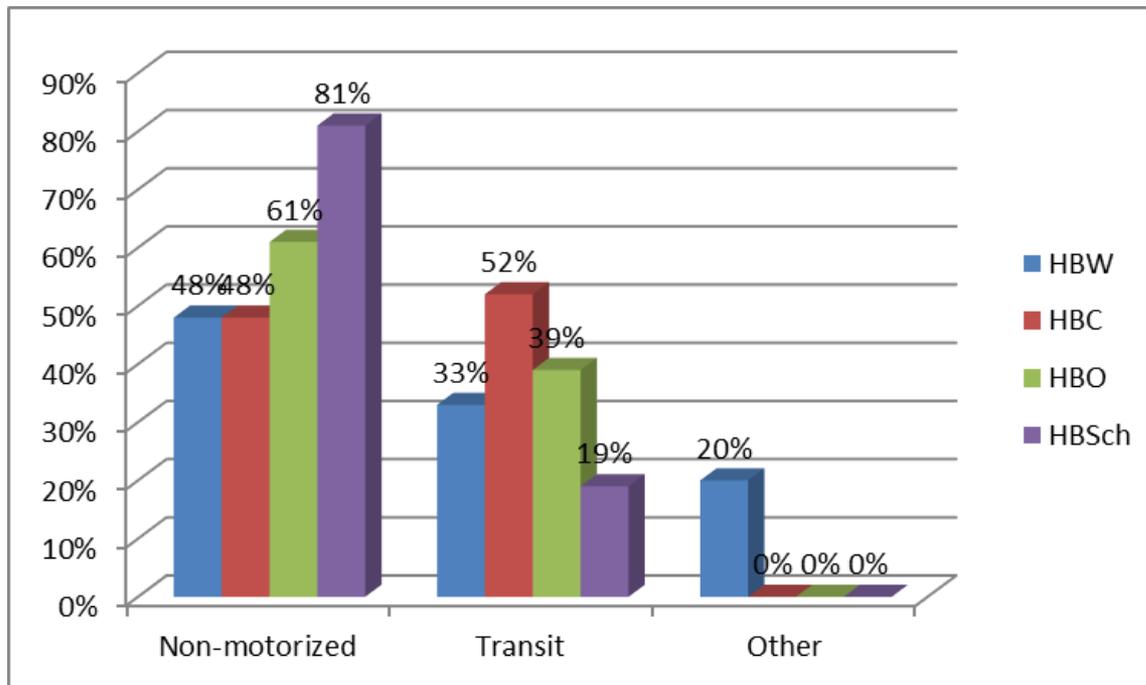
NHBNW NM

| Coefficient | Estimate | t value |
|-------------|----------|---------|
| HBO_TR | 0.4071 | 19.5 |
| HBC_TR | 0.1261 | 4.7 |
| HBO_NM | 0.1200 | 26.8 |
| HBC_NM | 0.0980 | 5.0 |
| HBSch_NM | 0.0656 | 6.7 |
| HBSch_DR | 0.0291 | 2.7 |
| HBO_HOV2 | 0.0208 | 6.3 |
| HBO_DR | 0.0185 | 6.2 |
| HBO_HOV3 | 0.0116 | 4.2 |
| HBSch_HOV3 | 0.0112 | 2.0 |

Clear Linkage between Transit and Walking

Transit HB trips more likely to generate non-motorized NHB trips than transit NHB trips

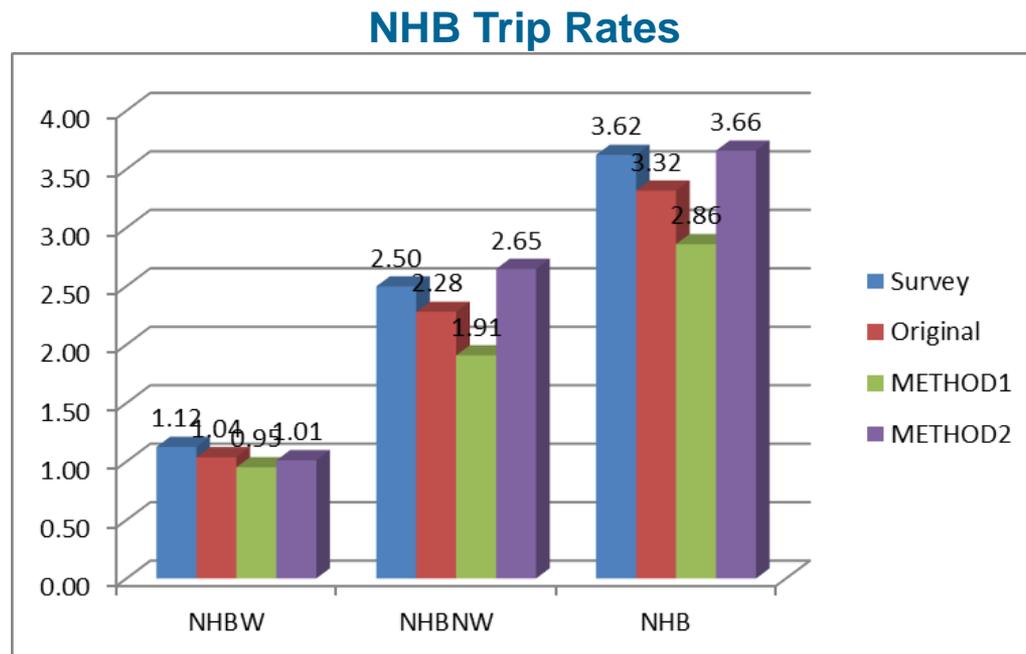
Mode Shares of NHB Trips Generated by Transit HB Trips



Calibration Comparisons - Generation

Estimated Method 1 NHB generation models are slightly worse than the original four-step model's and would require modest calibration adjustments to match survey rates

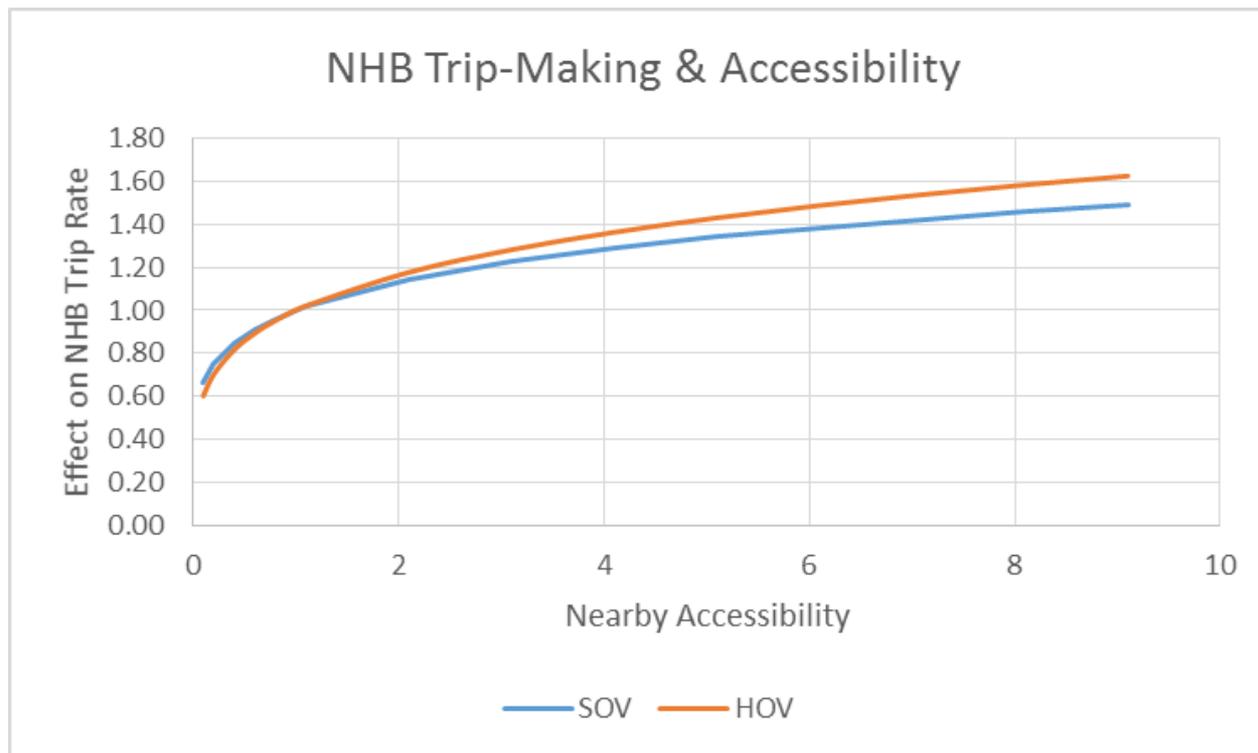
Estimated Method 2 NHB generation models match survey rates better than the original model and would require no calibration adjustment



Incorporating Accessibility

In more recent applications, such as TN, accessibility has also been incorporated as a factor in NHB trip generation from HB trip attractions

NHB Trip Rates vs. Accessibility

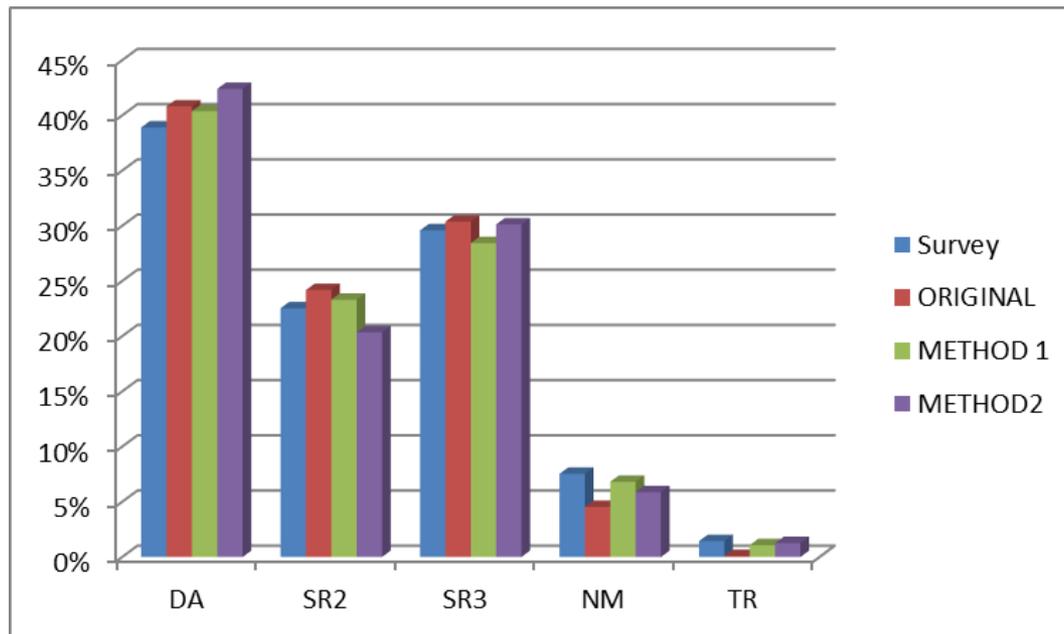


Calibration Comparisons – Mode Shares

Resulting mode shares from Methods 1 & 2 estimated models agree with survey data better than the original, calibrated model

- especially for transit and non-motorized modes
- with no calibration (alternative specific constants)

NHB Mode Shares



Calibration Comparisons – Distribution

TLFD can be calibrated to match observed distribution for either four-step or enhanced models, so not much basis for comparison

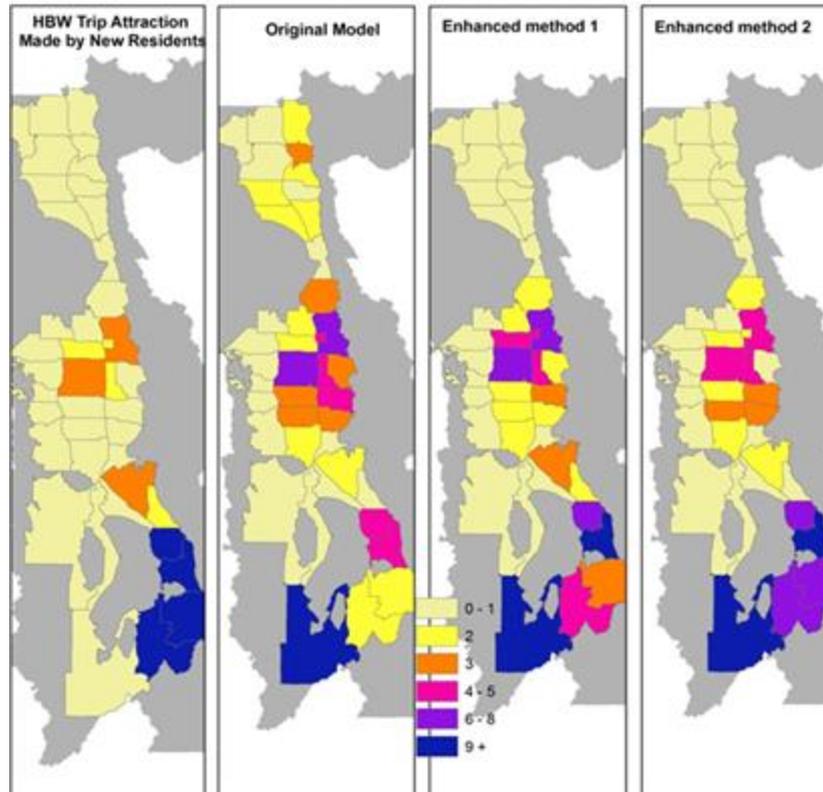
Actual agreement of the overall OD pattern between the models and the observed patterns for autos from the HH survey and for transit from the on-board survey was calculated using a ρ^2 statistic

| | Rho-Squared |
|--------------------------|-------------|
| Original Model | 0.294 |
| Enhanced Method 1 | 0.328 |
| Enhanced Method 2 | 0.323 |
| Enhanced Method 3 | 0.310 |

The enhanced models offer statistically significant (10% for Method 1) improvement in goodness-of-fit (using Horowitz's Non-Nested Hypothesis Test) and are better able to replicate the observed OD pattern of NHB trips than the original four-step model

Sensitivity Test: New Residential Development

Enhanced methods showed much better consistency between new HB trips generated by new development and new NHB trips generated by new development



**Percent Change
in NHBW Trip
Attractions**

Also revealed significance of balancing procedures in results

Sensitivity Test: Enhanced Transit Service

Original four-step model shows very large (>30%) increase in NHB trips by transit

Enhanced models show much more modest (~5%) increase in NHB trips by transit

Actual before and after study would be required to prove which is right, but enhanced model seems more plausible



Conclusions

Conclusions

ENHANCED METHODS PERFORM BETTER THAN THE ORIGINAL FOUR-STEP MODEL

- Produce significantly more reasonable responses to hypothetical new residential growth and more plausible mode shifts in response to hypothetical enhanced transit service
- Better able to replicate observed NHB trip rates, mode shares and OD patterns with less calibration
- Make clearer, more intuitive and reasonable connections between NHB and HB modes
- Allows demographic market segmentation of NHB trips for toll modeling or equity/EJ analysis, etc.





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