Integrating EMME/2 and Micro-simulation for HOV Forecasting on GTA Highways

Presented by:

Goran Nikolic P.Eng.

(MTO Traffic Office)

Rob Pringle P.Eng.

(McCormick Rankin Corporation)

Ontario

EMME/2 CONFERENCE

OCTOBER 2007

MRC

What this presentation will cover…

- **Context**
- Enhancements to the EMME/2 model
- Development of an incremental model relating changes in proportion of HOV's to changes in travel time for HOV's relative to SOV's
- Integration of macro and micro modeling

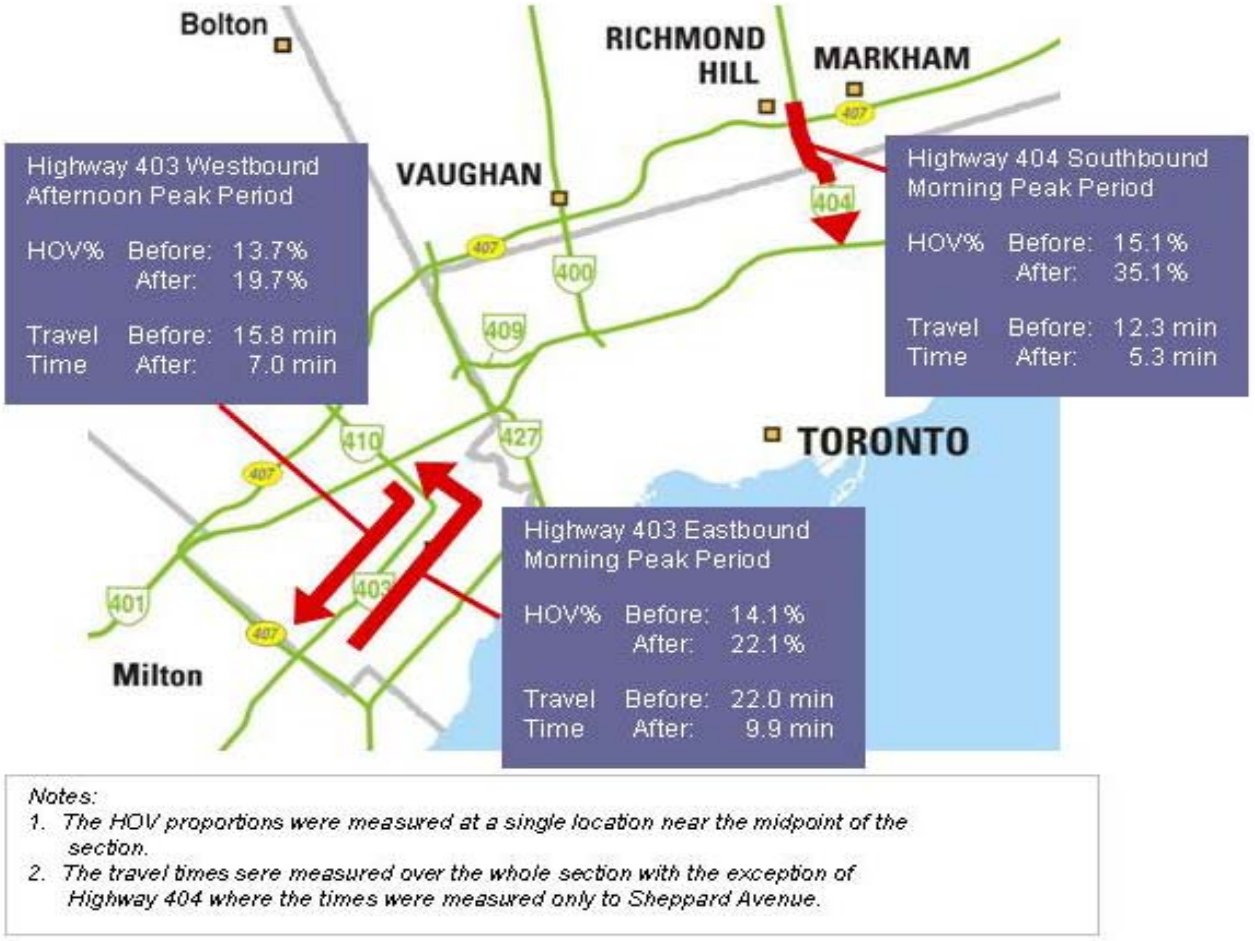
Auto occupancy has declined

- Between 1996 and 2001, the average auto occupancy for morning peak-period commuting trips originating in the Greater Toronto Area (GTA) dropped from 1.135 to 1.120 persons/vehicle
- This means that transporting 1,000 commuters required 21 more single-occupant vehicles (SOV) while the number of high-occupancy vehicles (HOV) decreased by 10, for a net increase of 11 vehicles

Initial success for HOV lanes on Ontario highways

- In response to the need to reverse this trend, the Ministry of Transportation of Ontario (MTO) implemented HOV lanes on Highways 403 (eastbound and westbound) and 404 (southbound only) in late 2005
- Within 6 months, the proportion of HOV's in peak-period, peak-direction traffic had increased from 14% to 21% on Highway 403 and from 15% to 35% on Highway 404
- At the same time, average travel times for HOV's on these sections of highway were reduced by more than 50%

Initial success (cont'd)



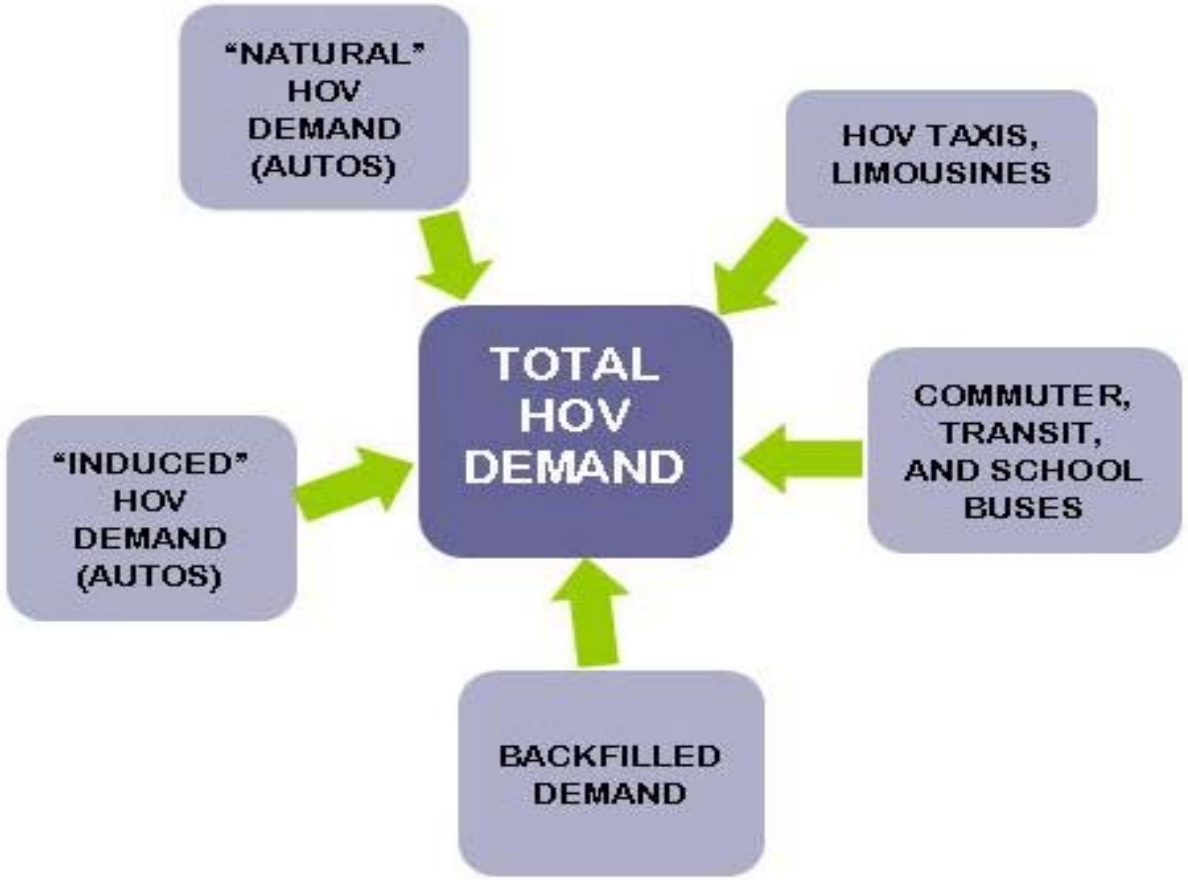
Notes:

1. *The HOV proportions were measured at a single location near the midpoint of the section.*
2. *The travel times sere measured over the whole section with the exception of Highway 404 where the times were measured only to Sheppard Avenue.*

The GTA HOV network studies

- To follow up on the success of the HOV lanes on Highways 403 and 404, MTO commissioned two studies - GTA West (Earthtech) for Peel and Halton and GTA East (MRC) for York, Toronto, and Durham with the following general objectives:
  - Assess feasibility of implementing HOV lanes on the 400-series highways in the GTA
  - Forecast utilization of potential future HOV lanes.
  - Assess synergies of different HOV lane combinations/networks
  - Evaluate HOV lane implementation priorities.

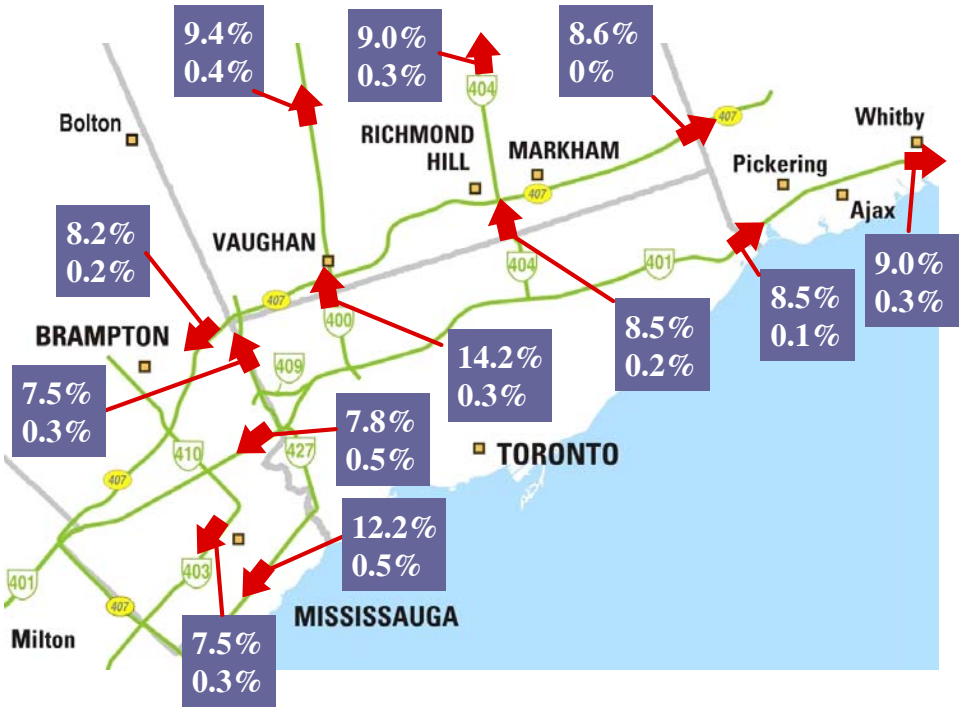
The components of the HOV market



Natural demand: Existing HOV use of highways

- Natural demand occurs today without HOV lanes
- Some auto passengers are captive (have no alternative)
- Others do so to save money or in response to ridesharing programs or other incentives

Existing HOV proportions on GTA highways



Induced demand: impact of HOV lanes

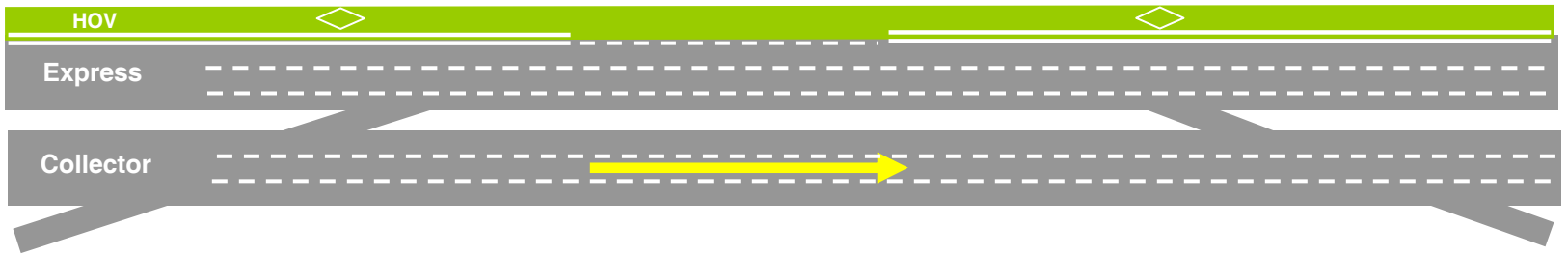
- Induced demand consists of the additional (new) HOV trips that result from the implementation of HOV lanes in a corridor and the associated savings in commuting time.
- Includes:
  - Conversion - of existing SOV's in the corridor to HOV's
  - Diversion of existing HOV's from other corridors
  - Combination – conversion of existing SOV's in other corridors to HOV's and diversion to the corridor of interest

- Context
- **Enhancements to the EMME/2 model**
- Development of an incremental model relating changes in proportion of HOV's to changes in travel time for HOV's relative to SOV's
- Integration of macro and micro modeling

Enhancements to the EMME/2 model

1. *Separation of express and collector lanes*

- EMME/2 models of the GTA road network have generally not separated express and collector lanes (eg. Highway 401, Highway 427 south of Highway 401, other local situations)
- Since HOV lanes are located in the express lanes, the ability of HOV's to use HOV lanes and the length used depends in part on the location of express/collector transfers relative to the ramps used to enter and exit from the highway



EMME/2 enhancements (cont'd)

2. Coding of HOV lanes and access zones

- Proposed HOV lanes on GTA highways were coded based on best practices and design guidelines prepared previously by MRC
- Appropriate access zones were coded, connecting the HOV lane to the general-purpose lanes - located to
  - provide convenient access
  - avoid the need for "abrupt" lane-changes to reach access zone from an on-ramp or an off-ramp from the access zone
- HOV lane capacity reduced from 1,800 to 1,600 to reflect reduced passing opportunities and the desire to retain a high level-of-service
- Modified volume/delay functions for HOV lanes

- Enhancements to the EMME/2 model
- **Development of an incremental model relating changes in proportion of HOV's to changes in travel time for HOV's relative to SOV's**
- Integration of macro and micro modeling

Incremental model for HOV forecasting

- The parallel HOV West study utilized a logit mode-split model developed in Minnesota
- Without a purpose-designed survey, it is not possible to develop a trip-based model from GTA data
- The current study was able to utilize local experience in the form of before/after observations bracketing the implementation of HOV lanes on Highways 403 and 404
- The localized nature of this data (volumes and travel times) and a desire to incorporate information on existing HOV proportions led to consideration of an incremental model – one that estimates changes in HOV use relative to changes in travel time
- The incremental approach allows unchanging variables (eg. carpool formation times) to be typically ignored
- The model that results can be thought of in the same way as the more traditional diversion curve.

The incremental model (cont'd)

- The before/after data for the new (as of December 2005) HOV lanes on Highways 403 and 404 included:
  - HOV and SOV volumes for all on and off-ramps and selected mainline sections
  - Travel times on the HOV and general purpose lanes by section
- To relate changes in travel times to changes in HOV use, it was necessary to estimate the actual "intermediate" origins and destinations within the study section of highway. This was accomplished using HOV and SOV traversal matrices from EMME/2 as "seed" matrices and then factoring (FRATAR) these to the on and off-ramp control volumes
- It was then possible to create a series of data points for different trip interchanges within the study section relating changes in HOV and SOV travel times to changes in HOV proportions
- Note that HOV2 and HOV3+ have been combined due to the small proportion of HOV3+ vehicles.

The incremental model (cont'd)

- Various functional forms were considered:
  - incremental logit, linear, power, etc.
  - Different formats for independent variables (travel times)
- Due to the form of the equation (incorporating existing HOV proportion), it was necessary to use "brute force" to calibrate – different forms/coefficients were tried and the optimum based on the lowest sum of squared errors AND (subjectively) lack of error biases
- The most logical form and best fit was obtained with the following function:

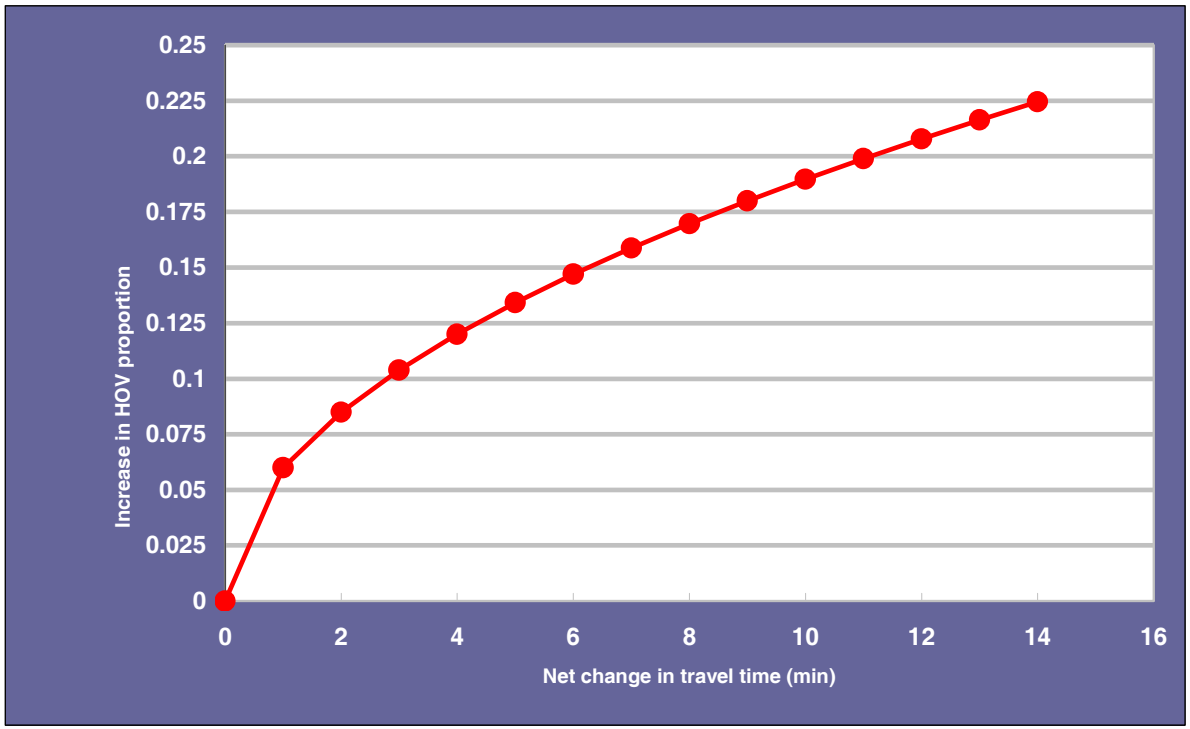
$$P_{HOV,after} = P_{HOV,before} + 0.06\ ((tt_{HOV,after} - tt_{HOV,before}) - (tt_{SOV,after} - tt_{HOV,before}))^{0.5}$$

where: ***P*** *= proportion of HOV's in total autos*

tt *= travel time through the study section*

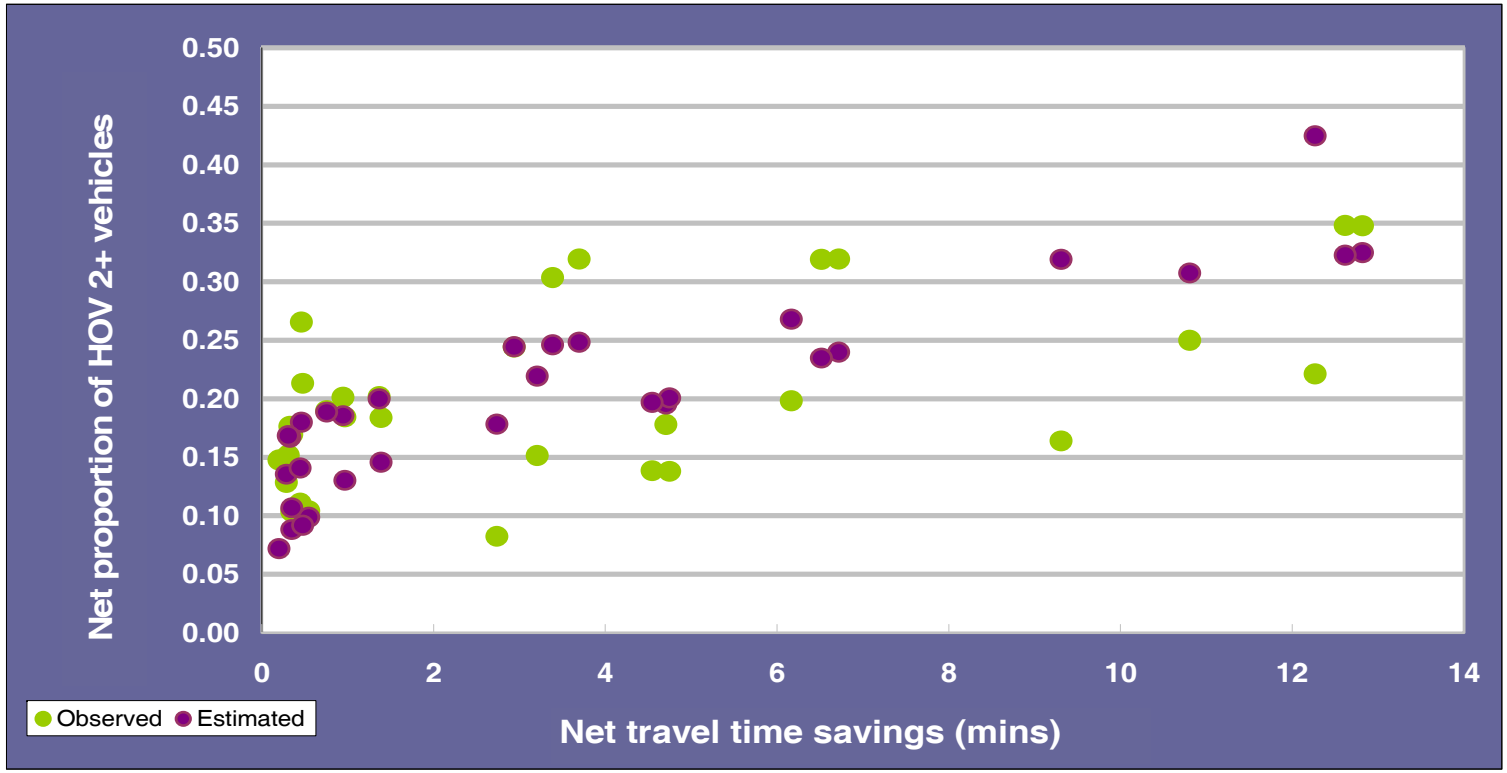
The incremental model (cont'd)

- This graph represents the "raw" functional form with zero existing HOV proportion – proportionally higher "reaction" rate to the HOV lanes at low values of time savings perhaps represents the "novelty" aspect



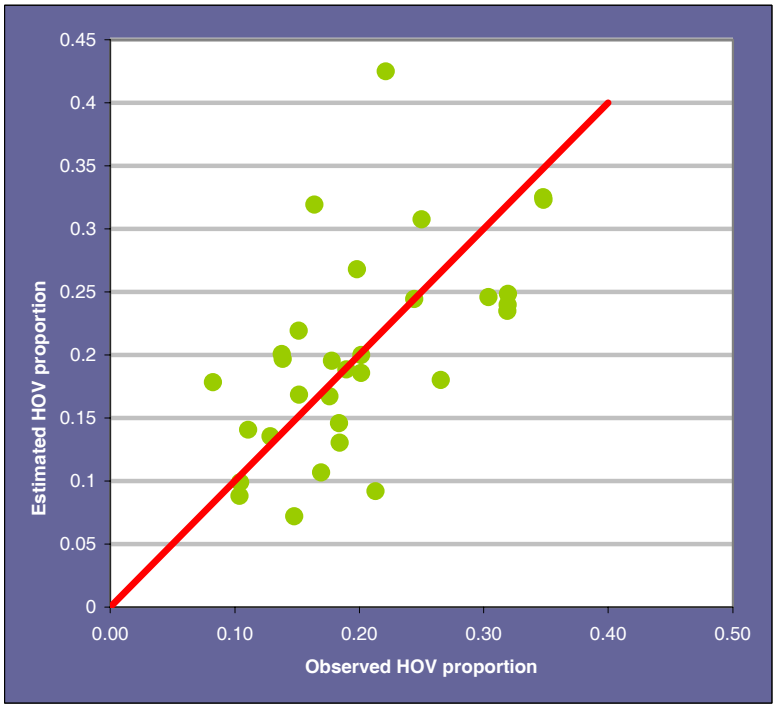
The incremental model (cont'd)

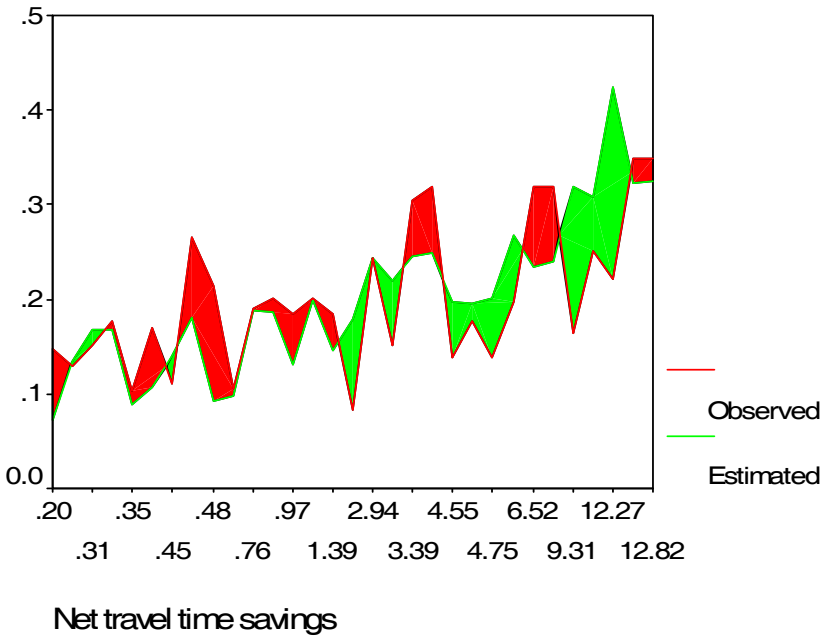
- This graph compares the HOV proportions predicted by the model with the "after" observations for Highways 403 and 404



The incremental model (cont'd)

- The estimation errors, or differences between the estimated and the observed HOV proportions, were reviewed.





- Enhancements to the EMME/2 model
- Development of an incremental model relating changes in proportion of HOV's to changes in travel time for HOV's relative to SOV's
- **Integration of macro and micro modeling**

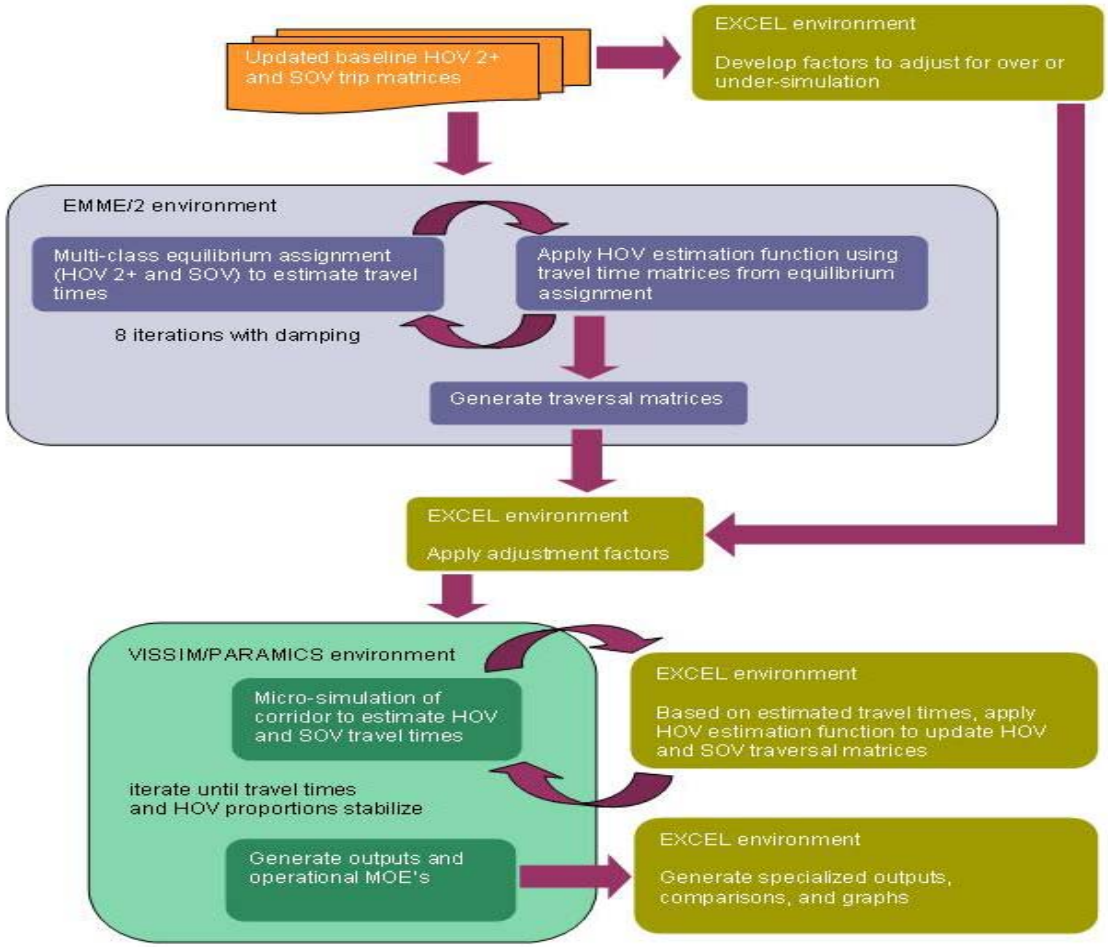
Enhanced estimation of travel time differences

- To operationalize the HOV estimation model, it is necessary to have reliable information on the differences between HOV and SOV travel times
- In its normal state, the EMME/2 framework relies on volume/delay functions (VDF) that are suitable for strategic analysis but less suitable for this study
- The original idea was to develop new VDF's using micro-simulation and use these within the EMME/2 framework – but this may affect the relative attractiveness of highways and surface streets – disturbing the "balance" in the current model

Enhanced estimation of travel time differences

- Instead, it was decided to use EMME/2 in sequence with micro-simulation to achieve a similar objective
- After EMME/2 was applied iteratively with the estimation model (incorporated within a macro), VISSIM/PARAMICS simulation models of the primary HOV corridors were applied iteratively with the same estimation model in spreadsheet form
- The EMME/2 component will allow for rerouting of trips into the corridor to make use of the HOV lanes – the micro-simulation component will simply refine the HOV proportions within the corridor
- It was necessary to adjust the damping (weights on previous and current assignments to 75% and 25% respectively) for both micro and macro modeling to avoid undesirable oscillation and ensure convergence
- Equilibrium was assumed to be achieved when the change in HOV proportion matched with the change in relative travel times before and after a given iteration.
- A secondary benefit of this approach was the availability of detailed operational MOE's from the simulation models

HOV estimation framework



Backfilling and taxis/buses/limos

- With the addition of new lanes for HOV use, the improvement in overall level-of-service may re-attract tripmakers who may have switched to a different route or trip departure time (backfilling)
- Although this model does not consider changes in trip departure times, a comparable equilibrium is assumed to be achieved through consideration of route diversion alone.
- Taxi and bus use of HOV lanes are evaluated on the basis of current conditions, past trends, and planned future service expansion – these vehicles represent a small proportion (less than 1% of traffic overall)

Summary

- Local data from HOV lane implementation on Highways 403 and 404 was used to develop an incremental HOV estimation model.
- The EMME/2 travel demand model is being used in tandem with micro-simulation to refine the estimation of HOV proportions based on travel time differences.
- This study demonstrates the potential for strategic models (eg. EMME/2) and operational models (eg. VISSIM/ PARAMICS) to be used together to improve the reliability of estimating HOV lane utilization.