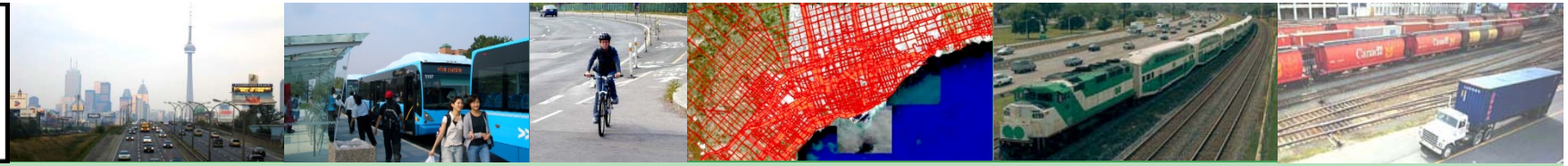
Modelling Transportation in the Greater Golder Horsehoe: Lessons and Challenges

Jesse Coleman, IBI Group

Ontario EMME Users Group Spring Meeting
Toronto, Ontario
May 16, 2008

Outline

- GGH Model project overview
- Model structure
  - Tours and journeys
  - Land use
  - Networks
  - Model process & four stages
- Model application
- Lessons and challenges

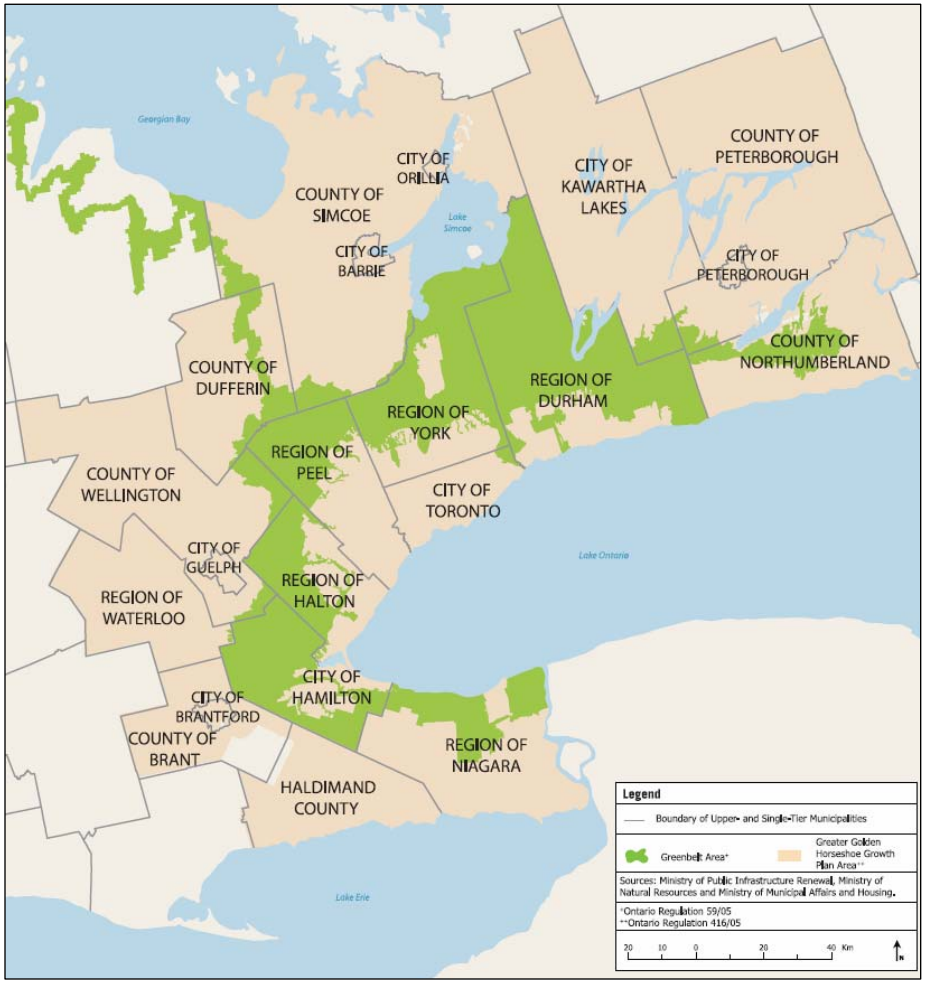


Project Overview

- Goal is to develop transportation and land use forecasting tools for the MTO to be used for all major Ministry planning studies and environmental assessments (EA)
- The model must be sensitive to Growth Plan land use changes and be able to capture the impacts of major public transit investments
- Model is being used as a sketch planning tool in developing the Metrolinx Regional Transportation Plan (RTP) for the Greater Toronto and Hamilton Area (GTHA)

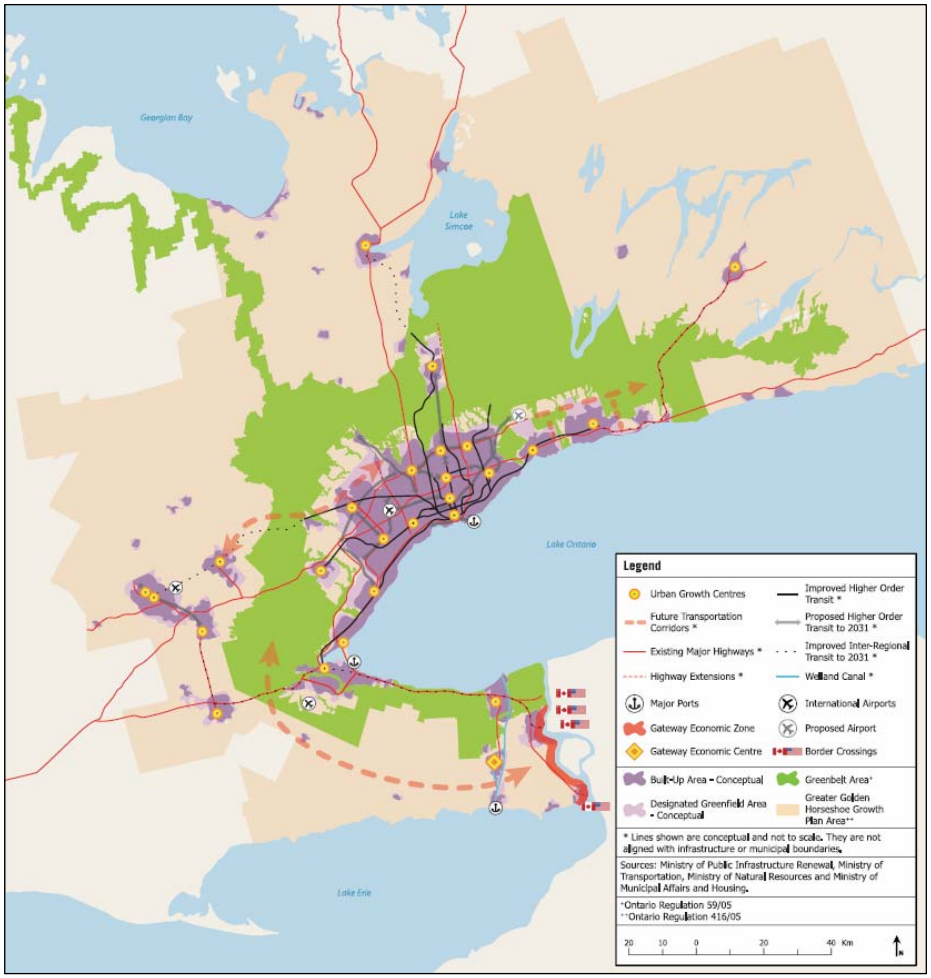
Study Area Overview

- The Growth Plan for the Greater Golden Horseshoe "Places to Grow" was created as a blueprint on how to accommodate new growth in the GGH.
- Population projected to grow by 48% from 7.79 million in 2001 to 11.5 million in 2031
- Employment projected to grow by 46% from 3.81 million in 2001 to 5.56 million in 2031
- Covers a total land area of 33,400 sq. km.



Places to Grow

- GGH Model created to be sensitive to changes in land use policies specified in the Growth Plan.
- Allocate growth to built up areas where the capacity exists to best accommodate population and employment growth, while providing strict criteria for settlement boundary expansions
- Promote transit supportive densities and a healthy mix of residential and employment land uses



GGH Model Overview

- State-of-practice tour-based a.m. and p.m. peak hour model
- Trips purposes:
  - Home-Work Journeys (HBW)
  - Home-Post Secondary School Journeys (HBPostSec)
  - Home-Elementary / Secondary School Journeys (HBSch)
  - Non Work-School Journeys (NWS)
  - Non-Home Based (NHB)

GGH Model Overview (cont'd)

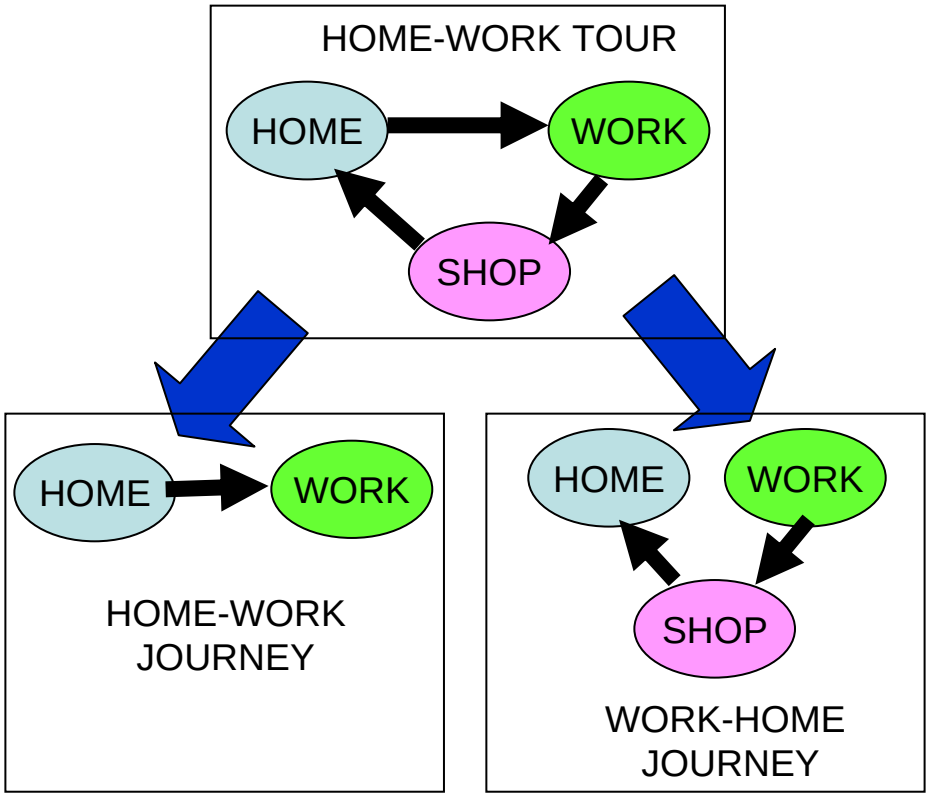
- Common assumptions/techniques applied throughout the regions allowing projects to be compared on a consistent basis:
  - Population, employment and land use by traffic zone (Growth Plan)
  - Road classification and volume-delay functions
  - Common transportation network assumption for base year and future years
  - Municipalities consulted to obtain most current information available

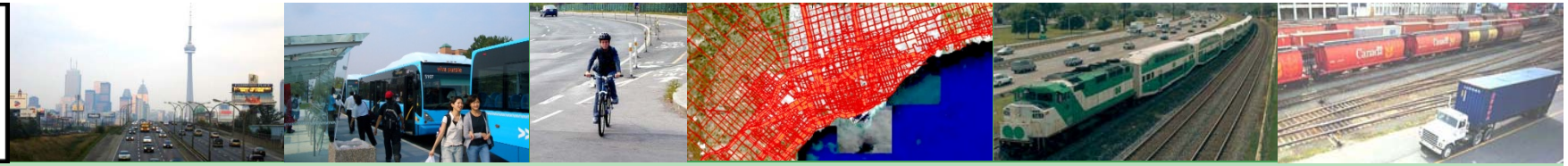
GGH Model Overview (cont'd)

- Ability to test Growth Plan directions and policies, and sustainable transportation modes/initiatives:
  - Socioeconomic/demographic sensitive:
    - Age, job type, household structure, income, auto ownership
  - Level-of-service sensitive:
    - Logit mode choice, gravity trip distribution, equilibrium assignment with feedback mechanisms
  - Land use sensitive:
    - Spatial distribution affects trip length, travel self-containment
    - Land use typology defined for each zone
    - Walk time to transit, road speed/capacity, trip generation differs based on land use

Terminology: Journeys and Tours

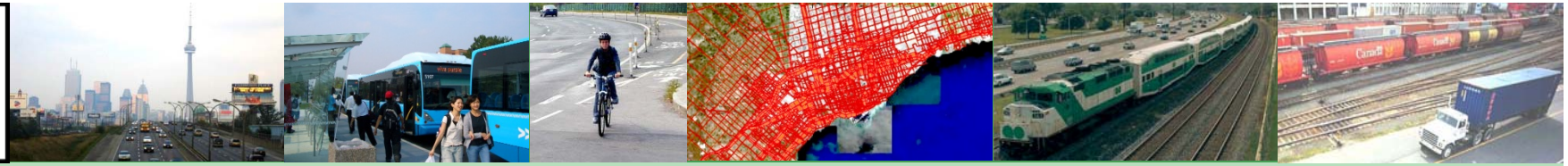
- A tour is a complete movement leaving home and returning home again
- A journey is one half of a tour, which is the movement from the primary origin to the primary destination





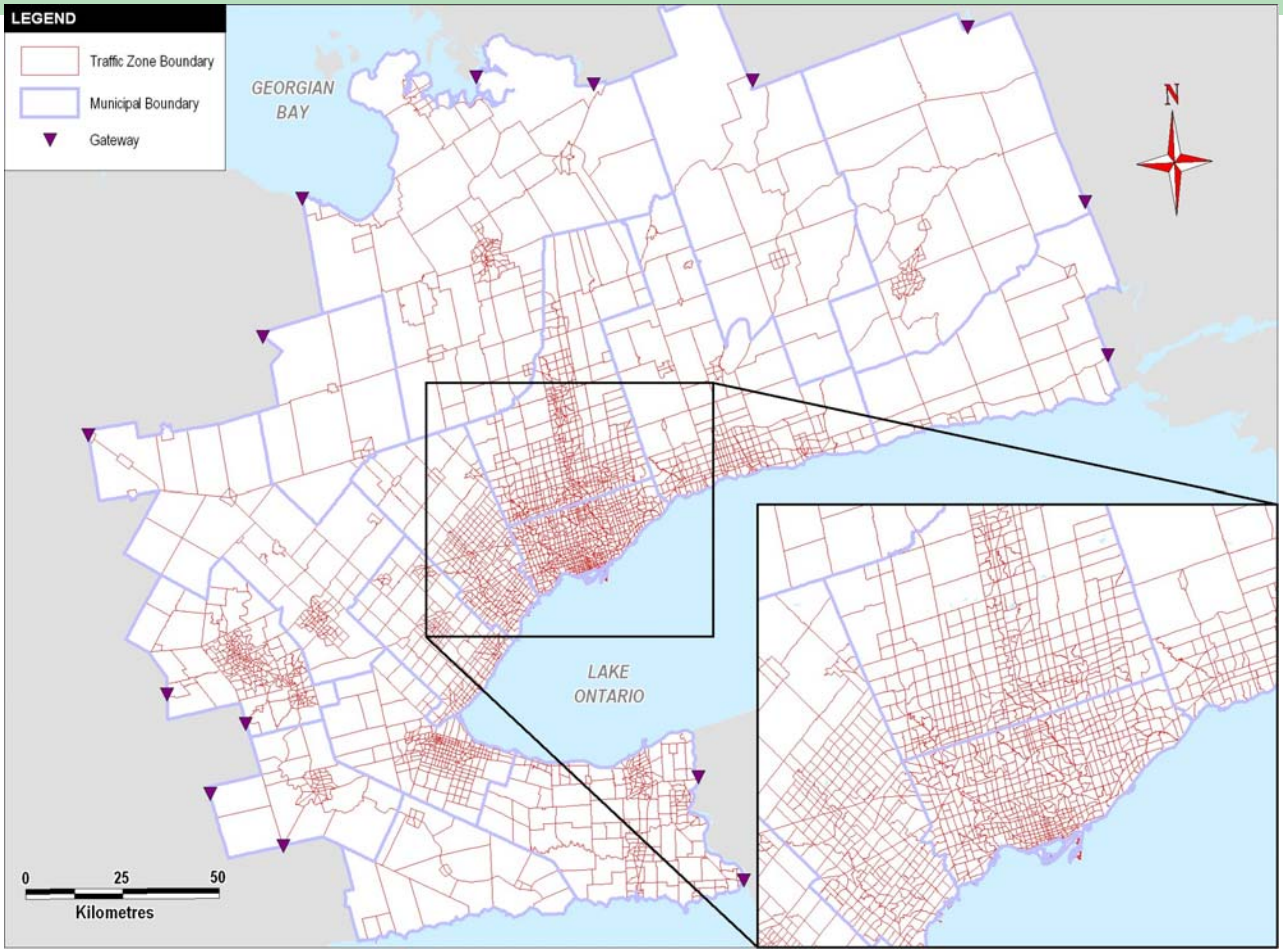
Why tour-based?

- Focuses analysis on the primary movement that generates the trip (i.e. work or school), while filtering out the noise of relatively unimportant stops within the journey
- As a result, provides significantly more explanatory power relative to conventional trip-based models
- Need to model both a.m. and p.m. peak per
- Can be a precursor to more complex activity-based model systems



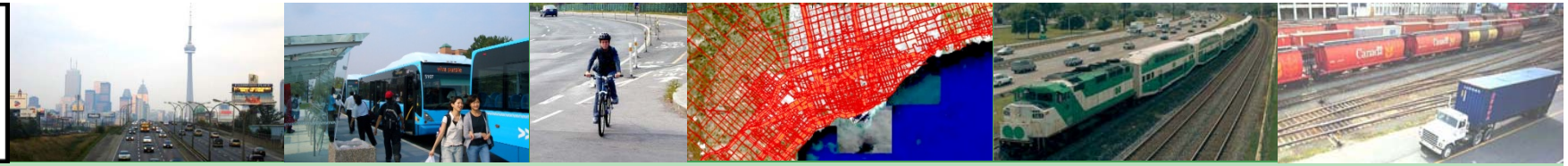
GGH Model Traffic Zone System

- Approximately 3,000 zones defined for GGH
- Based on municipal, census and transportation (road/rail boundaries), geographic feature, land use, etc.
- Includes representation of urban growth centres



Land Use / Socio-economic Inputs

- For the GGH Model, information and forecasts include:
  - Population
    - Age
    - household structure
    - Employment status
    - Labour force participation by occupation
  - Employment
    - Number of jobs by job category
    - Full time/part-time

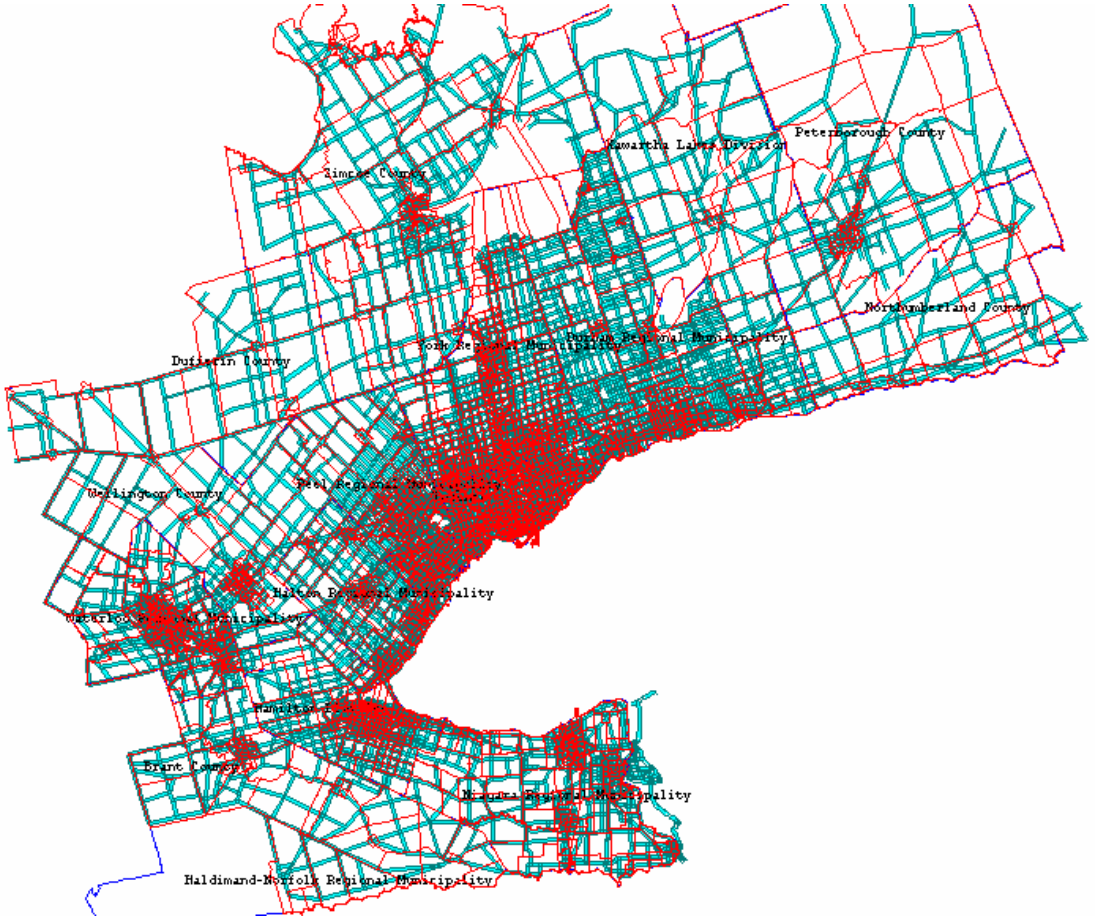


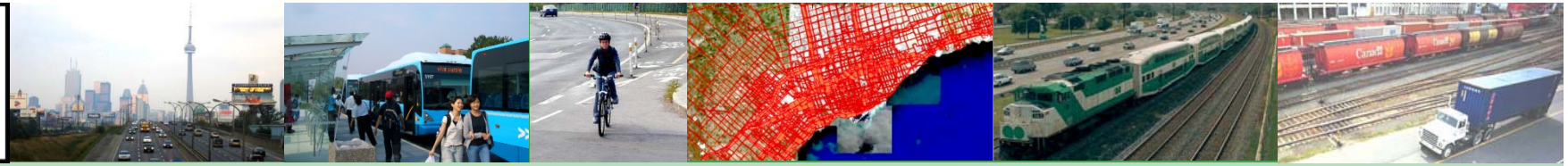
Future Land Use

- Detailed to 3,000 traffic zones; corresponds to Growth Plan targets by municipality
- Achieves Growth Plan targets for urban growth centres, built-up areas, designated greenfield areas
- Reflects future trends:
  - Age distribution of the population will change significantly
  - Dwelling preferences changes by age of household
  - Growth Plan imposed shifts in structural types permitted
  - Employed by industry mix will change significantly

Road Networks

- Network coding standards revised/enhanced and consistently applied across GGH
  - Consistent with DMG standards and linked to functional class, area type and adjacent land use
  - More accurate speed and capacity representation
- Calibration of volume-delay functions
- 18,000 regular nodes and 64,000 links





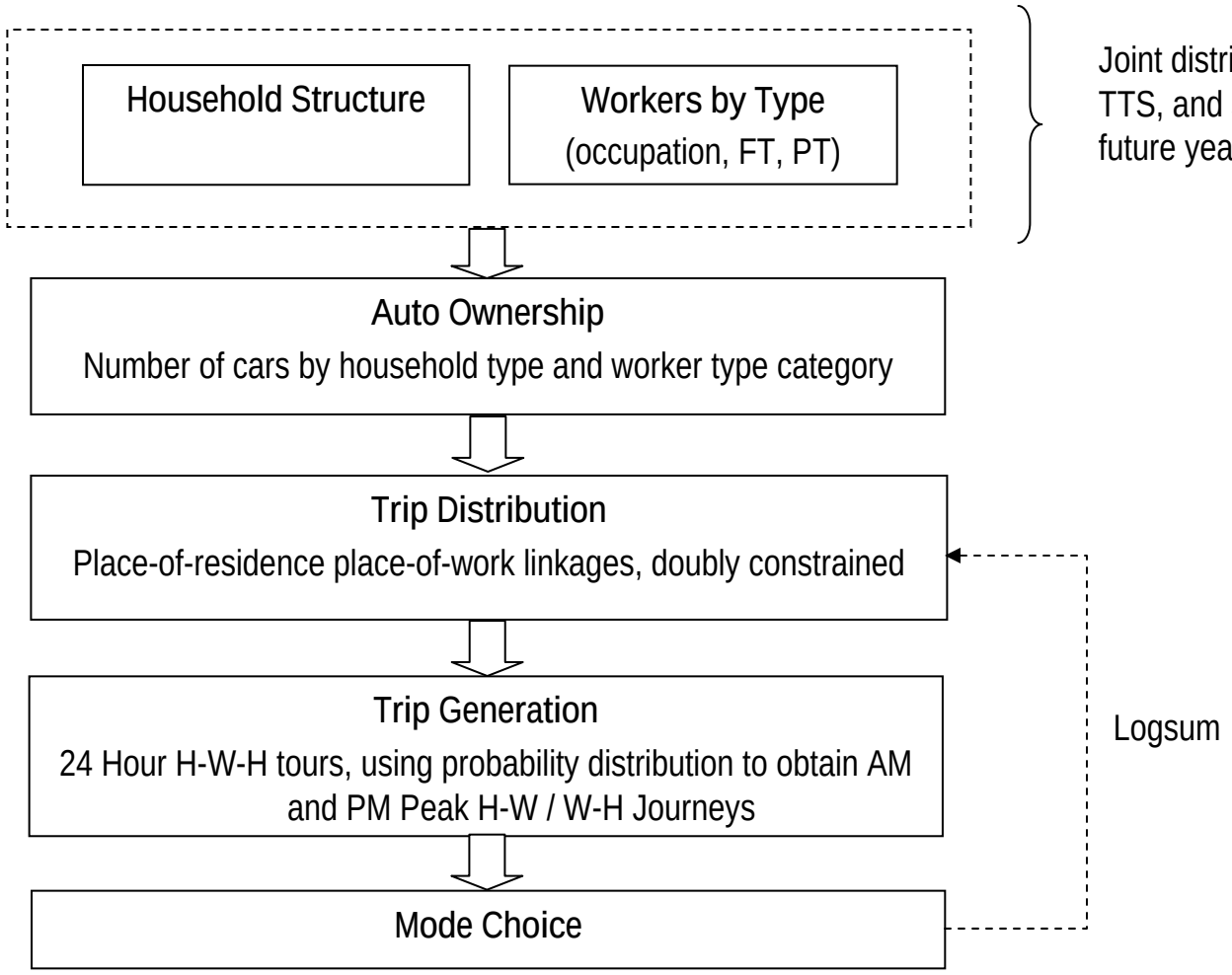
Transit Networks

- Improved estimation of walk access times
  - Eliminate zone size bias
  - Based on land use / street layout
- Enhanced transit time function
  - Sensitive to traffic congestion; no longer fixed constant speed over entire length of route
  - Estimated as a function of auto travel time, number of stops and dwell time
- 1450 one-way transit lines with 42,000 segments

Model Process

- Trip Generation & Auto Ownership:
  - Trip rates or regression equations by purpose with segmentations by household structure, job type, auto ownership
- Trip Distribution
  - Gravity model segmented by occupation (4 categories)
  - Log-sum based on utilities of logit model
- Model Split
  - Nested logit model
- Trip assignment
  - User equilibrium

Home-Work Model Sub-system



Home-PostSecSchool Model Sub-System

Household Structure

Students by Type
(age group)

Joint distribution based on TTS, and synthesized for future years.

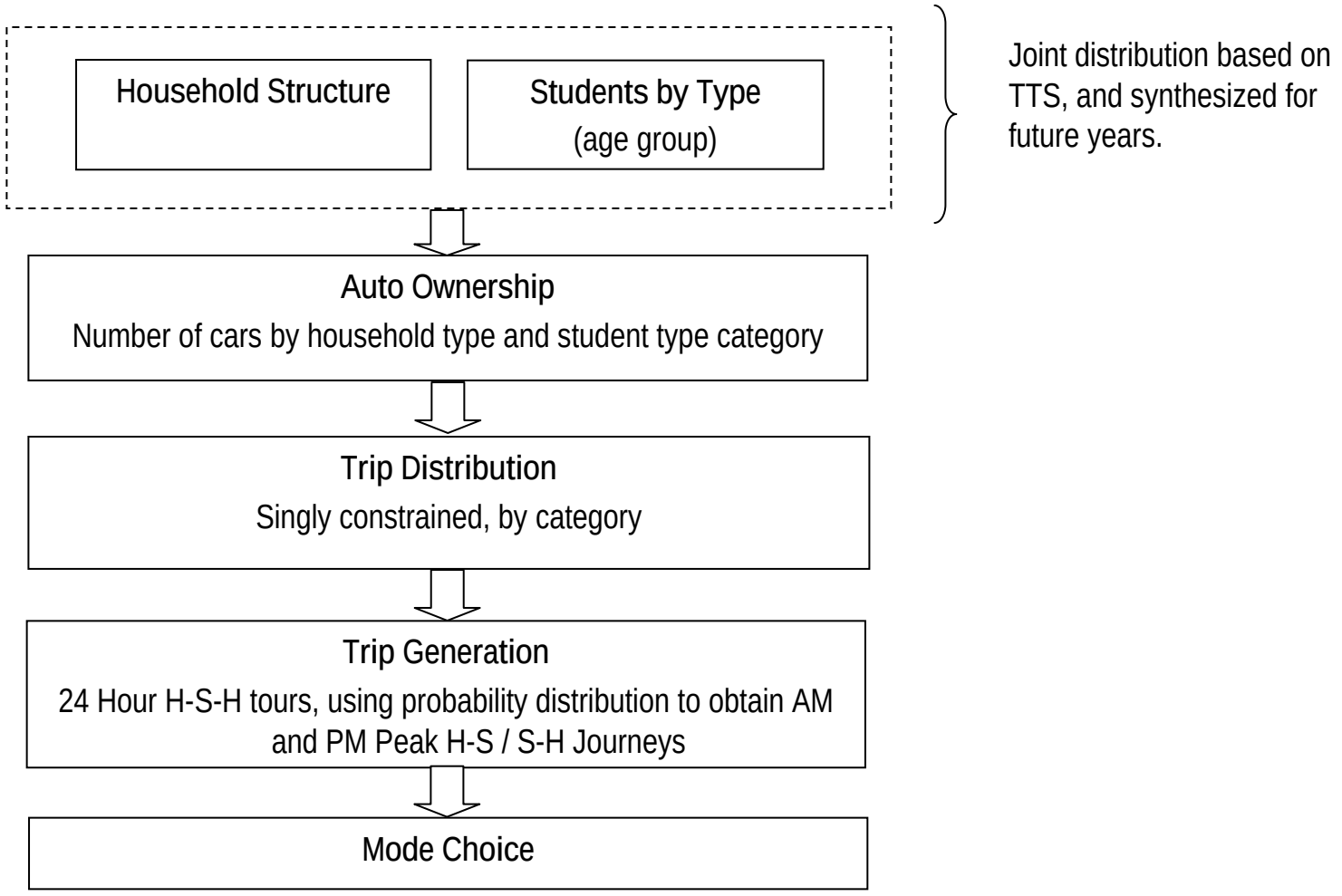
Auto Ownership
Number of cars by household type and student type category

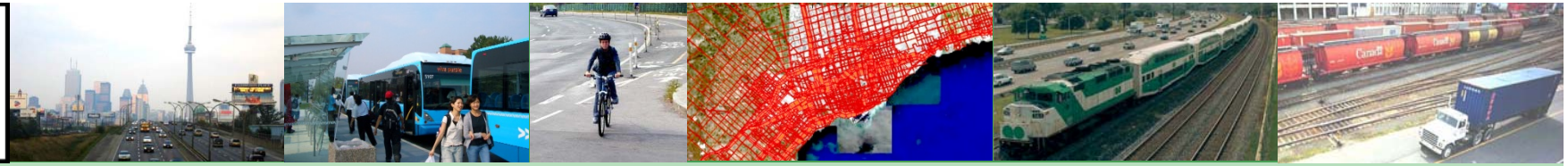
Trip Distribution
Place-of-residence place-of-school linkages, doubly constrained

Trip Generation
24 Hour H-S-H tours, using probability distribution to obtain AM and PM Peak H-S / S-H Journeys

Mode Choice

Home-School Journey Model Sub-System





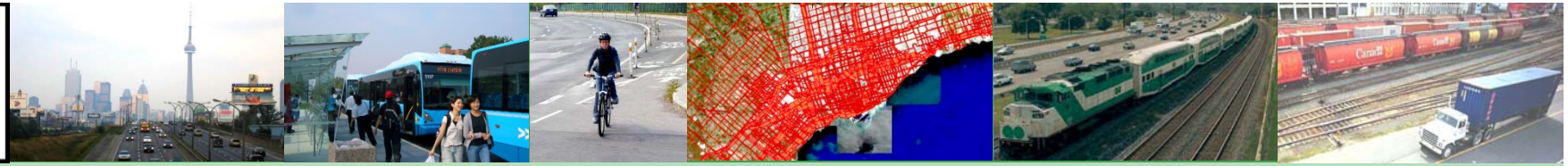
Linkage & Journey Generation

2 Step process:

- Daily linkages generated by household type (i.e single parent or two parent 3 child households), person type (i.e. worker/student, full time/part time) & auto ownership segment.
- After trip distribution is complete, the daily linkages are factored to become daily tours that occur within one or both peak periods
- After mode choice is complete, the daily tours are factored to become a.m. and p.m. peak period journeys

Linkage Distribution

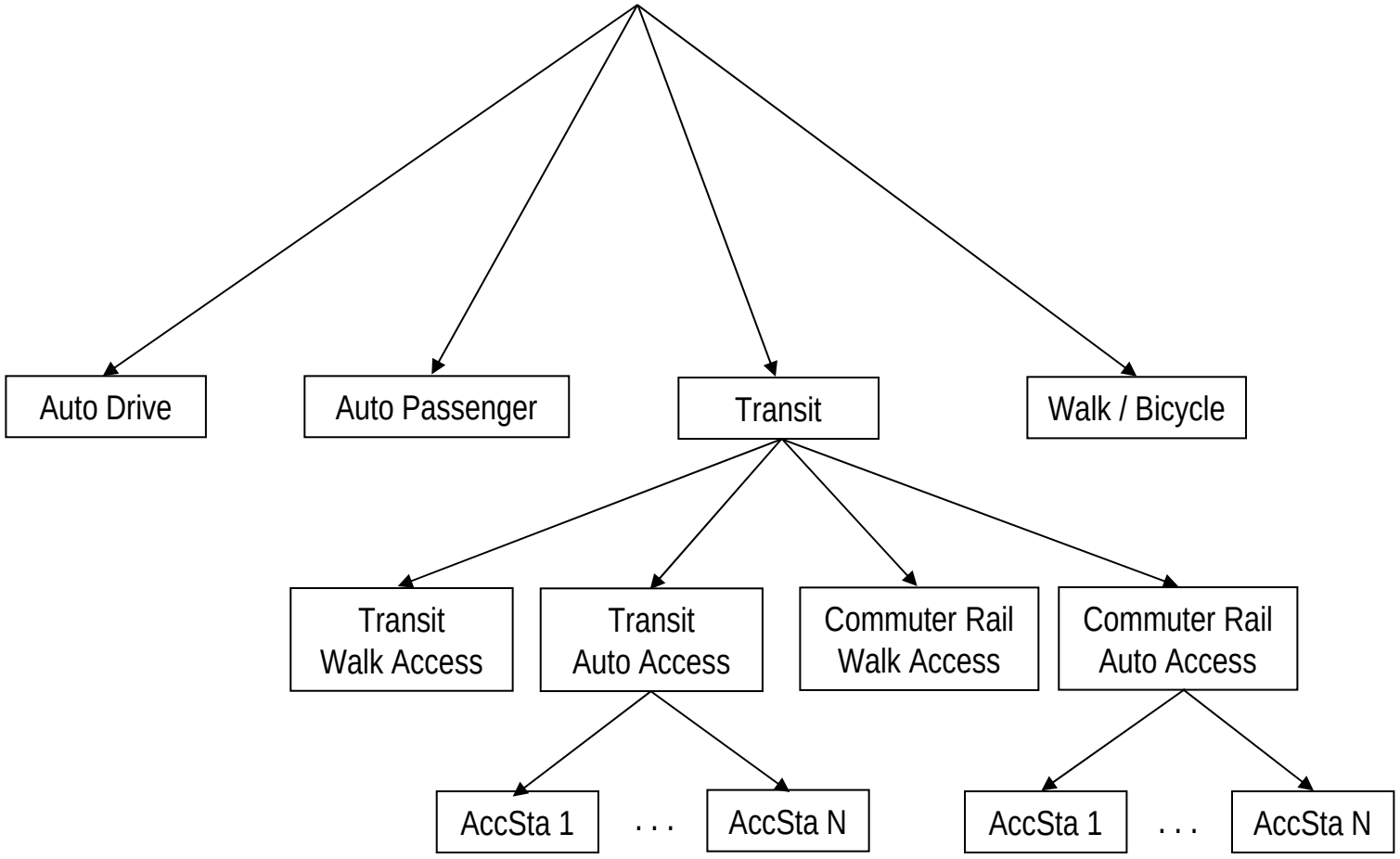
- Work purposes
  - Gravity model segmented by occupation (4 categories)
  - Impedence from mode choice logit model Log-sum
- Secondary School
  - Gravity model using same logsum term as the work model
- Elementary & Secondary Schhol
  - Singly constrained logit destination choice models
- Other, Shopping & Non Home Based
  - Trip-based approach, using a fratar distribution



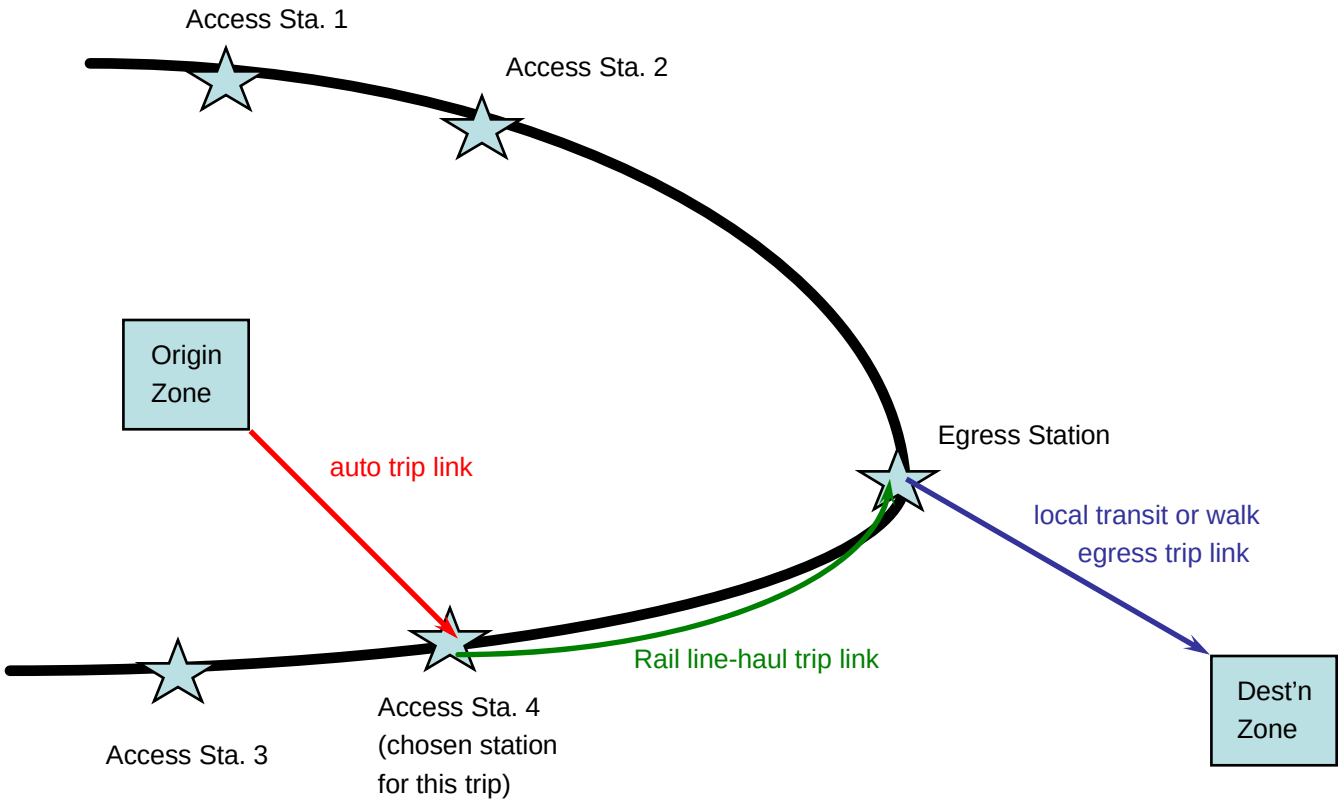
Mode Choice

- Models the home-destination-home tour holistically as a joint mode choice across the two time periods, using service levels for the two peak periods in an integrated manner.
- Nested logit model for work and post-secondary school purposes
- Multinomial logit models for other purposes
- Range of level of service and spatial/land use variables are included to maximize explanatory power and sensitivity
- Park and ride station choice model

Work Tour Mode Choice

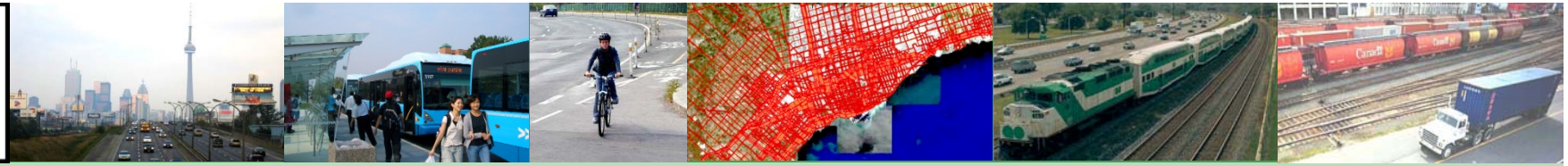


Park and Ride Station Choice



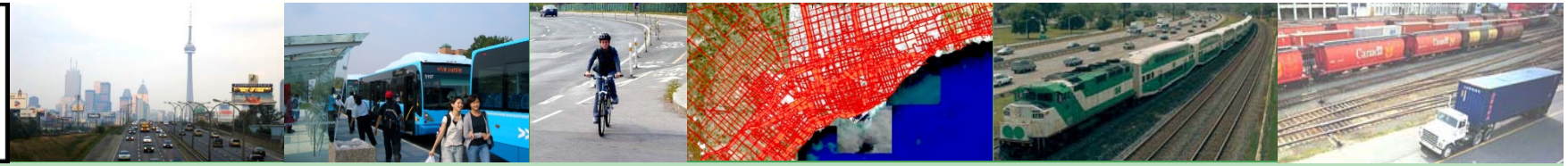
Trip Assignment

- EMME user equilibrium auto and transit assignments
- Matrix convolution used to assign auto and transit portions of park and ride trips to/from the chosen station.
- Future integration with commercial vehicle model, running PCE assignments.



Model Application

- Implemented entirely in EMME using macros/scripts
- Travel times averaged between cycles to aid convergence
- 4.8 GB databank
  - 2 scenarios (a.m. & p.m. road and transit integrated networks) + 2 working copies
  - 135 full matrices, 999 mo vectors
- Four-stage full model runs converge after 4 cycles, each taking ~7 hours (~28 hours total)



Lessons and Challenges

- Model very complex, resulting in very long cycle times (6-7 hours).
- 7 hour cycle times means that models can no longer be run overnight
- Investigating ways of freezing certain model elements to test minor network changes without needing a full model run (i.e freezing trip distribution)
- Tour based mode choice approach computationally intensive as both a.m. and p.m. matrices need to be stored concurrently. Is this gain in explanatory power worth the computational burden?
  - Looking into methods to run the model on one time period only as an option to save time

Question for INRO?

- As regional models become increasingly complex, what steps are INRO planning to keep computational demands under control:
  - Support for multicore processors, or parallel computing?
  - Other ideas?