Modeling for Managed Lane Traffic and Revenue Forecasting

North Carolina Model Users Group

CDM Smith

19 November 2015

Agenda

- General concepts of modeling for managed lanes
  - Managed lanes vs. general tolls
- Managed Lane Model Development
  - Modifications to the Travel Demand Model
  - Replicating future year bottleneck conditions with microsimulation
- Forecasting revenue
  - Static approximation of dynamic tolling
- Special considerations in managed lane modeling

Managed Lane Modeling for Traffic and Revenue

CDM Smith's Managed Lane Forecasting Model

- Adaptation of a standard regional Travel Demand Model
- Focused heavily on a single highway corridor (or network of corridors)
  - Surrounding region is included to allow for alternative route diversion

Model Functionality

- Built to forecast 'typical' traffic and revenue conditions
- Estimates typical tolls for model periods
  - Hourly during peaks
  - Period-wise during off peaks

Levels of Managed Lane Study

Level 1 (Sketch Level)

- High-level traffic and revenue estimates
- May use spreadsheet model as an alternative to a traditionsal TDM

Level 2 (Planning Level)

- Employs travel demand model with volume and speed calibration

Level 3 (Investment Grade)

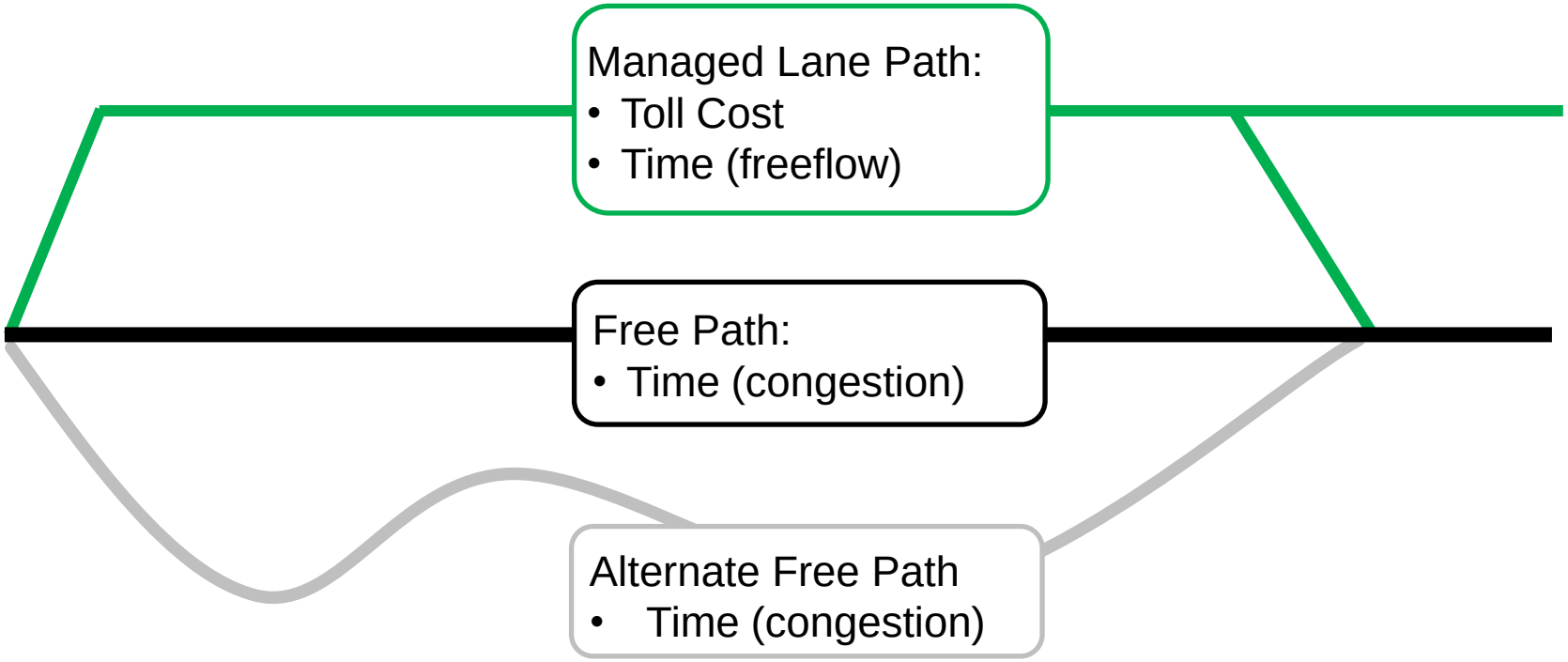
- Requires independent economist to validate model growth
- Employs SP surveys to estimate model parameters (e.g. VOT, toll decision equation, eligible managed lane users)
- May require risk analysis or sensitivity testing

Covered in Presentation

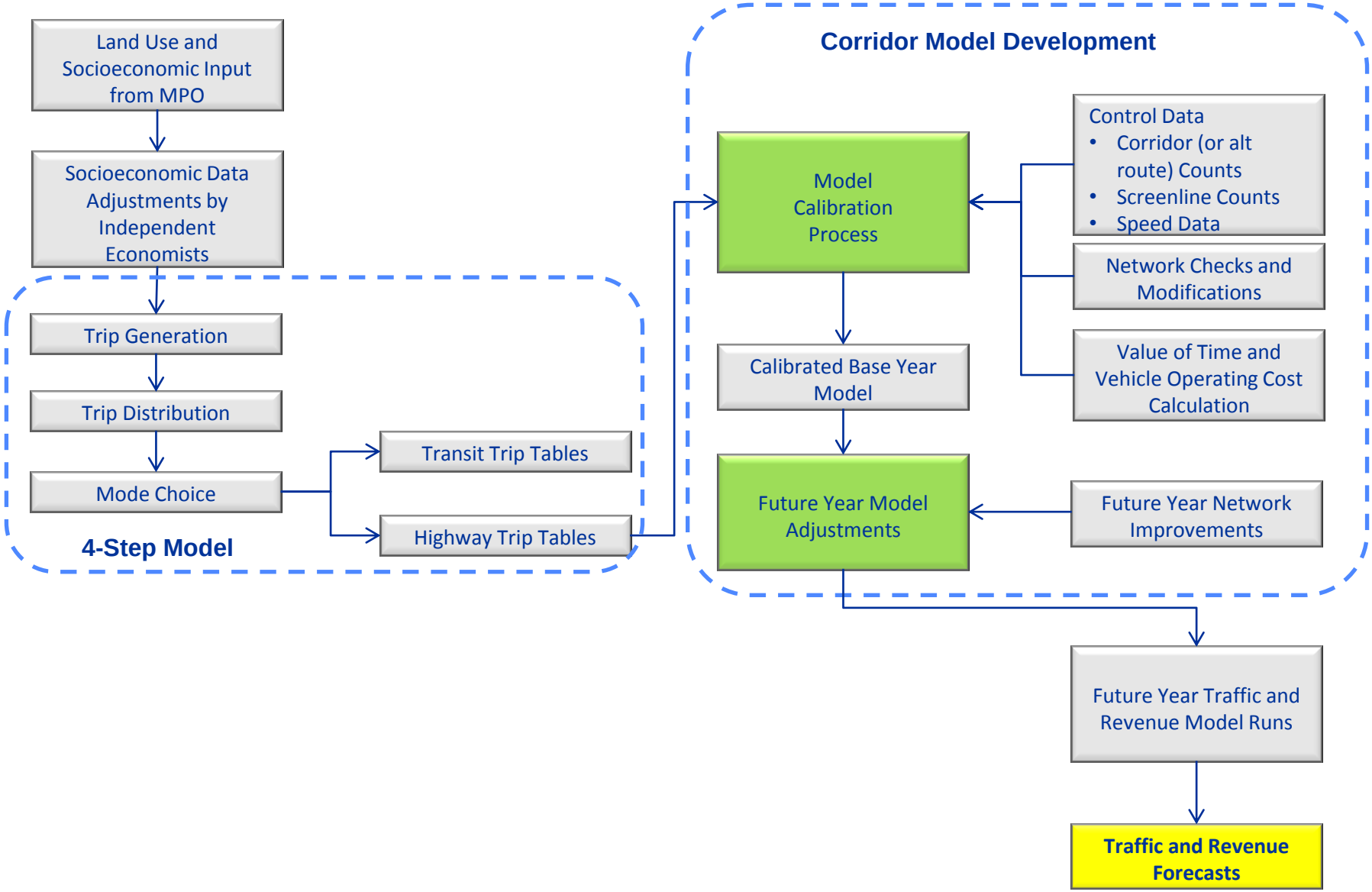
General Toll Decision Model

$P = \exp(b_0 + b_1x + b_2x2 + \dots)$

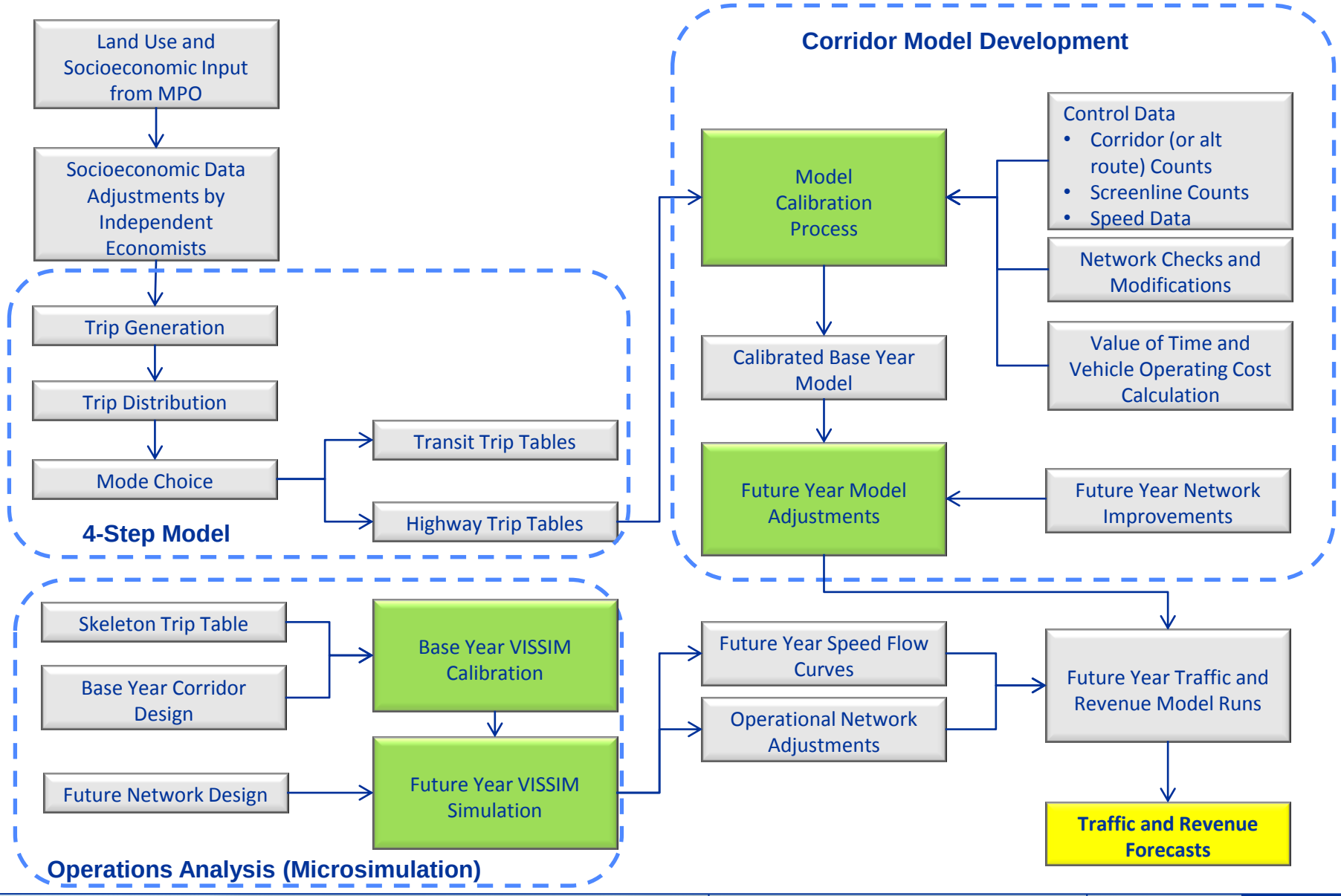
Managed Lane Choice Model



General Toll Modeling Process



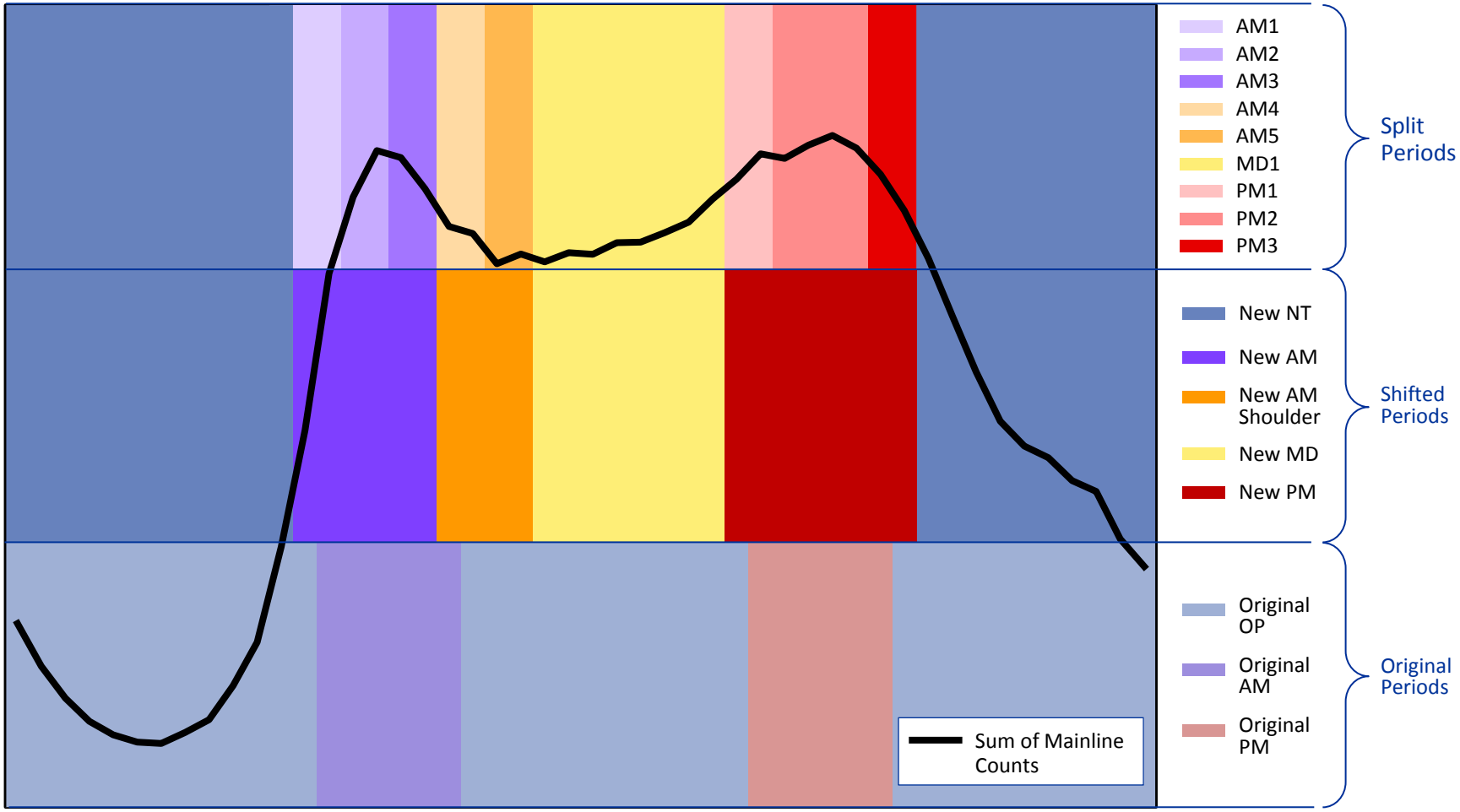
Managed Lane Modeling Process



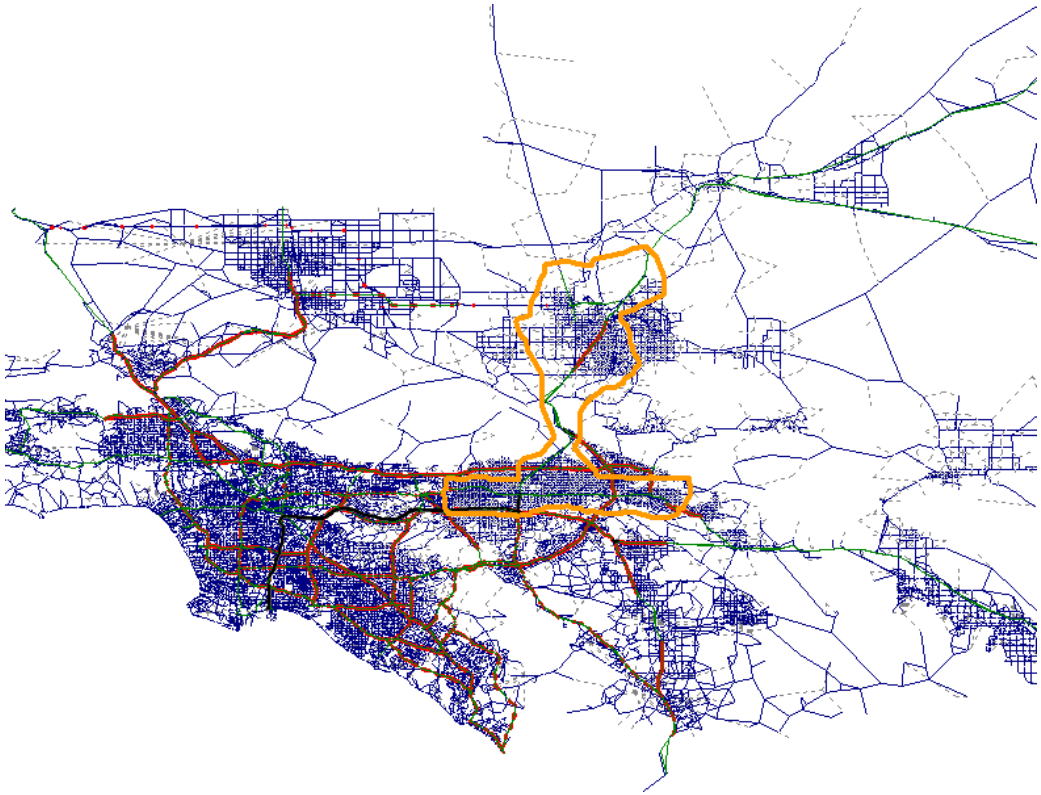
Managed Lane Sensitivity

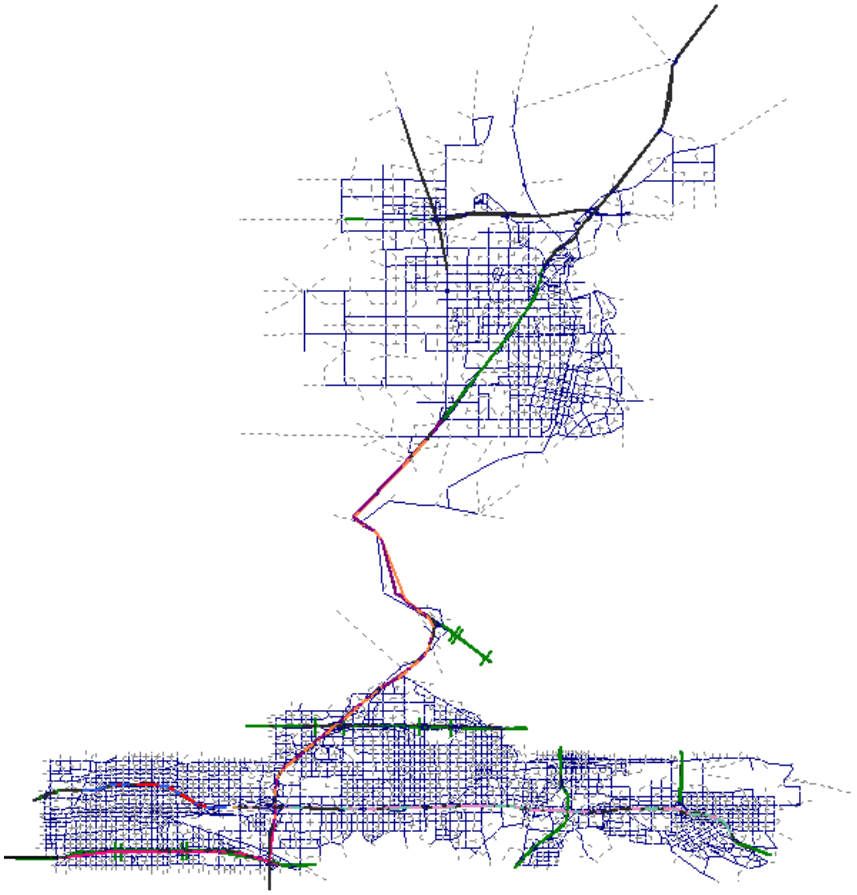
Corridor Speed	• Well-Calibrated Travel times are critical on corridor • Simulating and replicating bottleneck conditions is necessary
Peak Hour Condition	• Necessary to model a peaking condition • Replicate queue building across periods
Traffic Management	• Dynamic pricing on managed lanes to maintain freeflow conditions

Modifications for the Managed Lane Model: Refining Model Periods



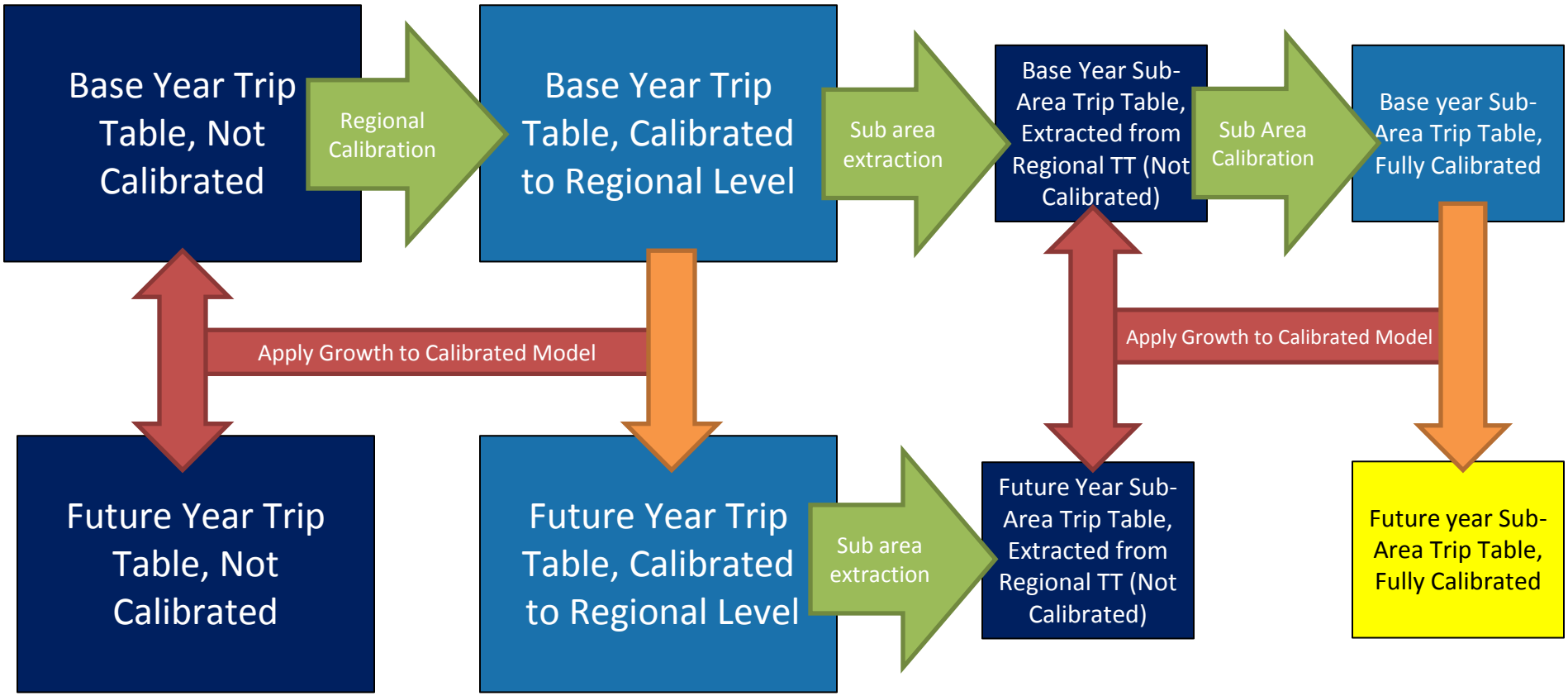
Modifications for the Managed Lane Model: Sub-Area Extraction





FROM 3,774 ZONES TO 1,621 ZONES

Modifications for the Managed Lane Model: Sub-Area Extraction



Modifications for the Managed Lane Model: Replicating Bottleneck Conditions

Freeway Traffic Congestion Realms

Handled by TDM	THROUGHPUT Actual Traffic Equal to Demand?	TRAVEL TIME Travel Time near Free Flow Time?
Uncongested Operations	Yes	Yes
Metered Flow	No	Yes
Stable Congestion	Yes	No
Queuing Capacity Reduction	No	No

Calibrating Future Year Speeds

Naïve method (consistent with base year VDF)

- Only accurate if travel patterns remain consistent across corridor and additional capacity does not create new bottlenecks

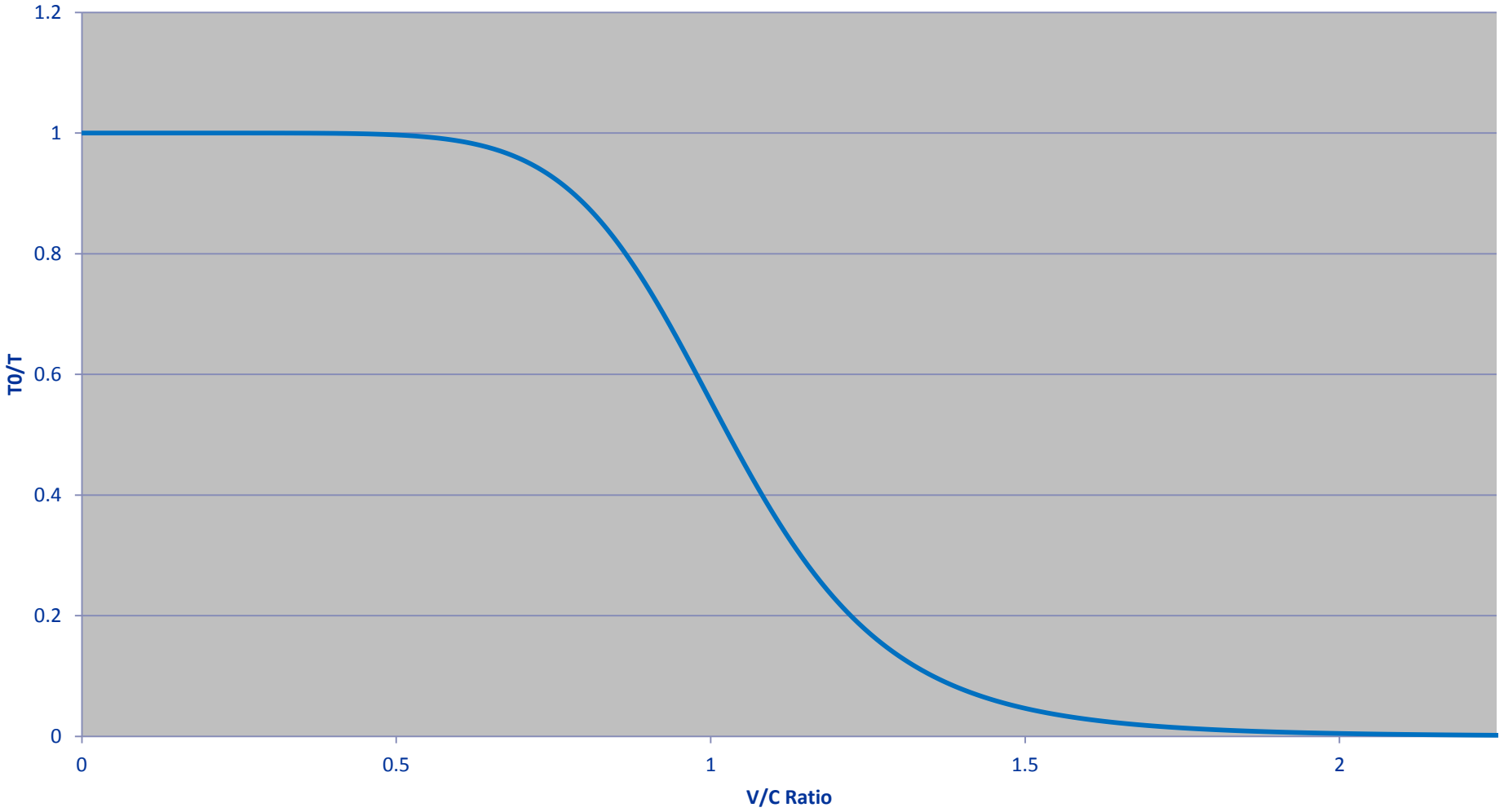
HCM analysis

- Load future year demand, calculate bottlenecks across time periods based on demand and capacity of new network
- Use several loading combinations to determine shape of speed flow curves

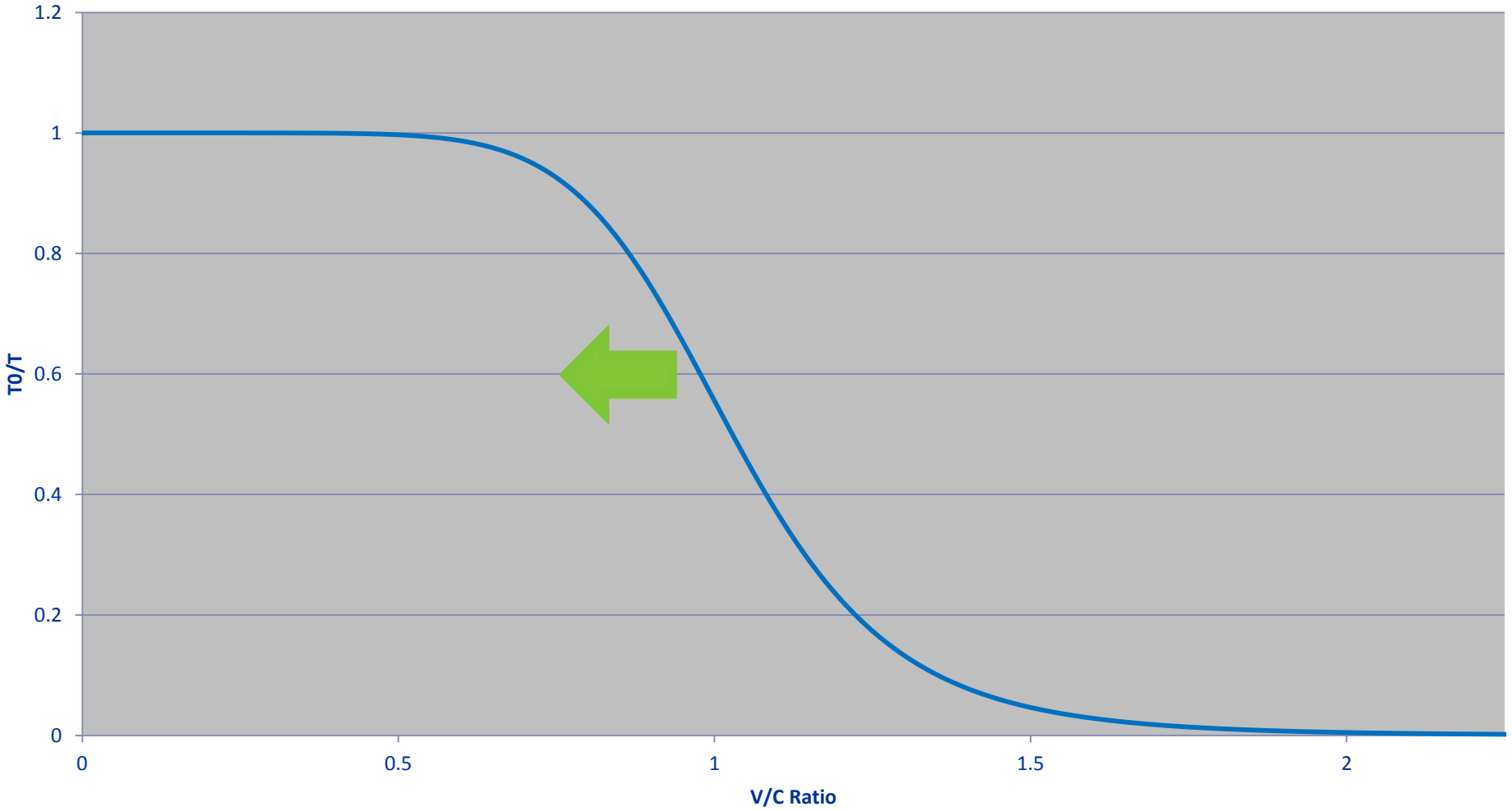
VISSIM analysis (most accurate method)

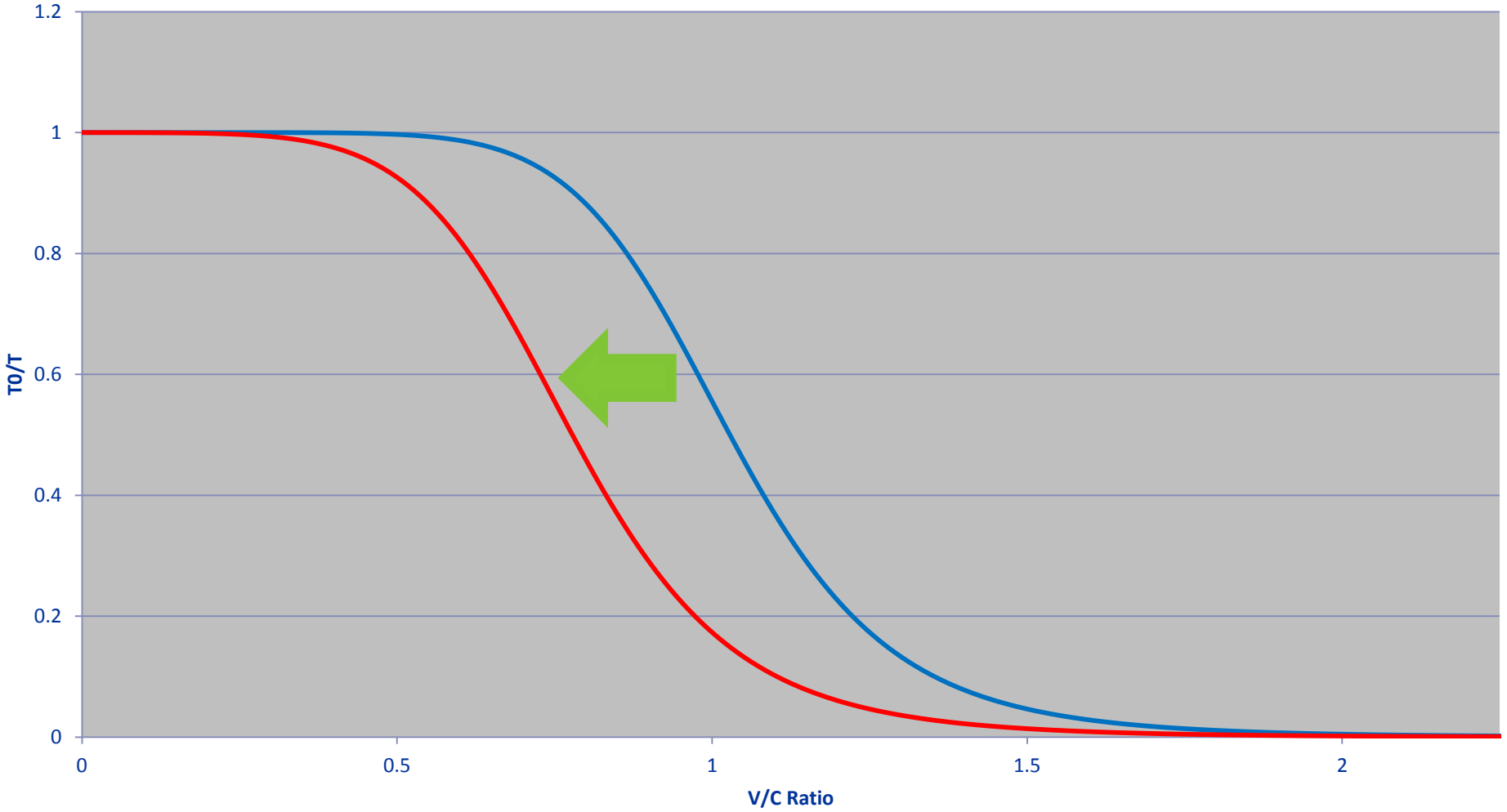
- Build and calibrate base-year VISSIM network
- Create future year network and loading conditions on calibrated sim
- Load microsimulation for peak periods to determine new VDF curves

Calibrating Future Year Speeds

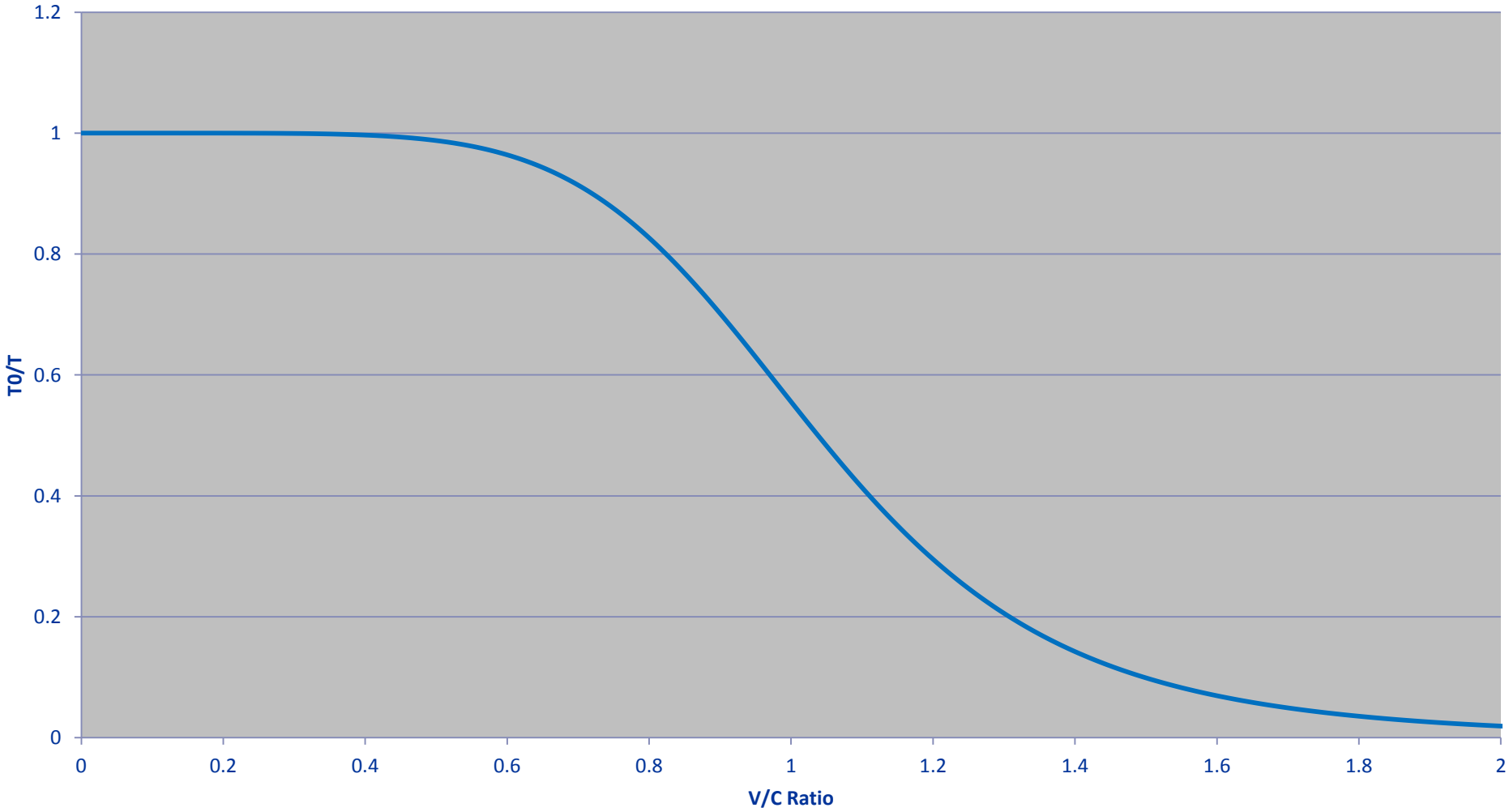


Calibrating Future Year Speeds




1.2
1
0.8
0.6
0.4
0.2
0
T0/T
0
0.5
1
1.5
2
V/C Ratio

Calibrating Future Year Speeds



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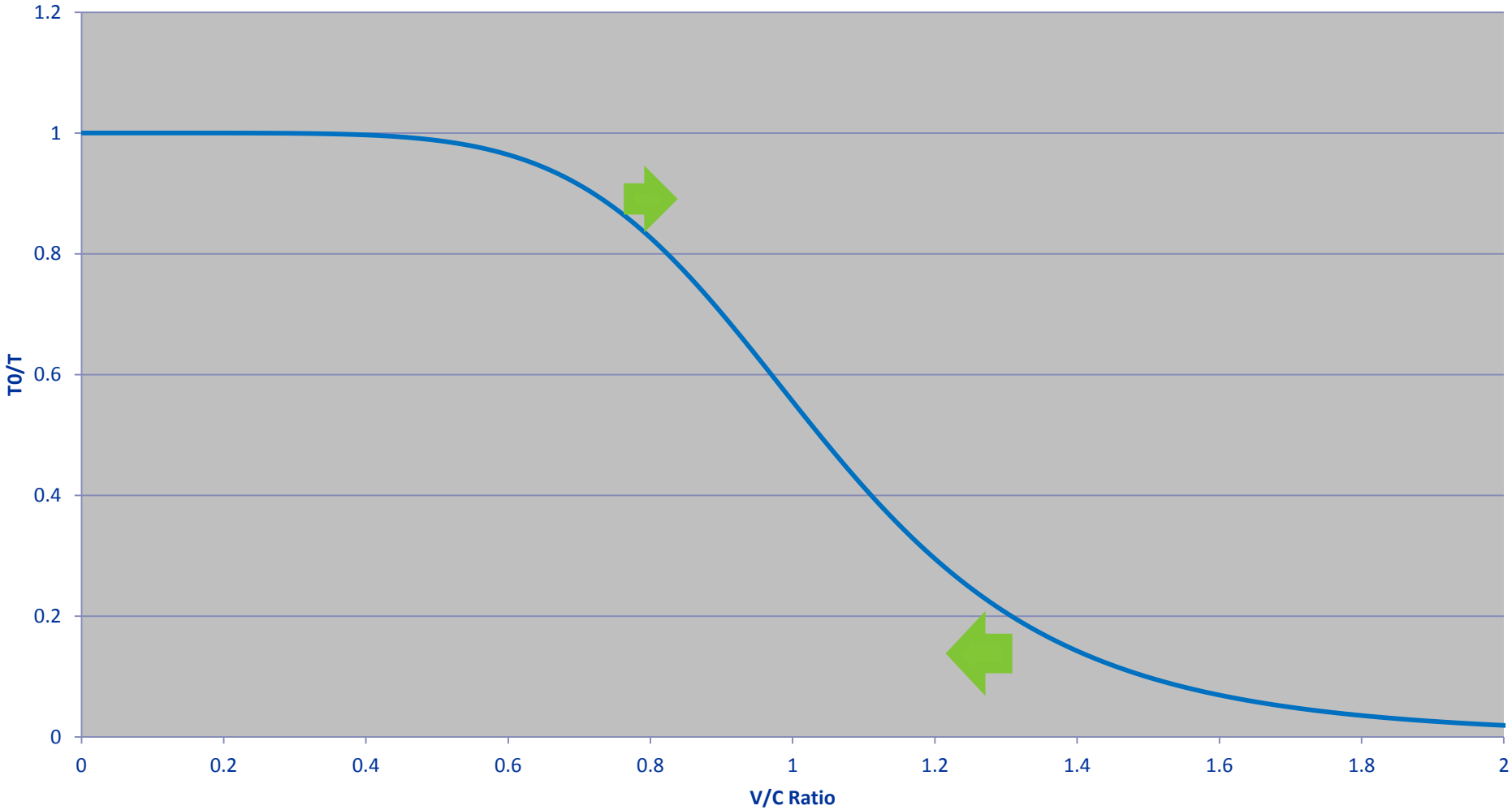
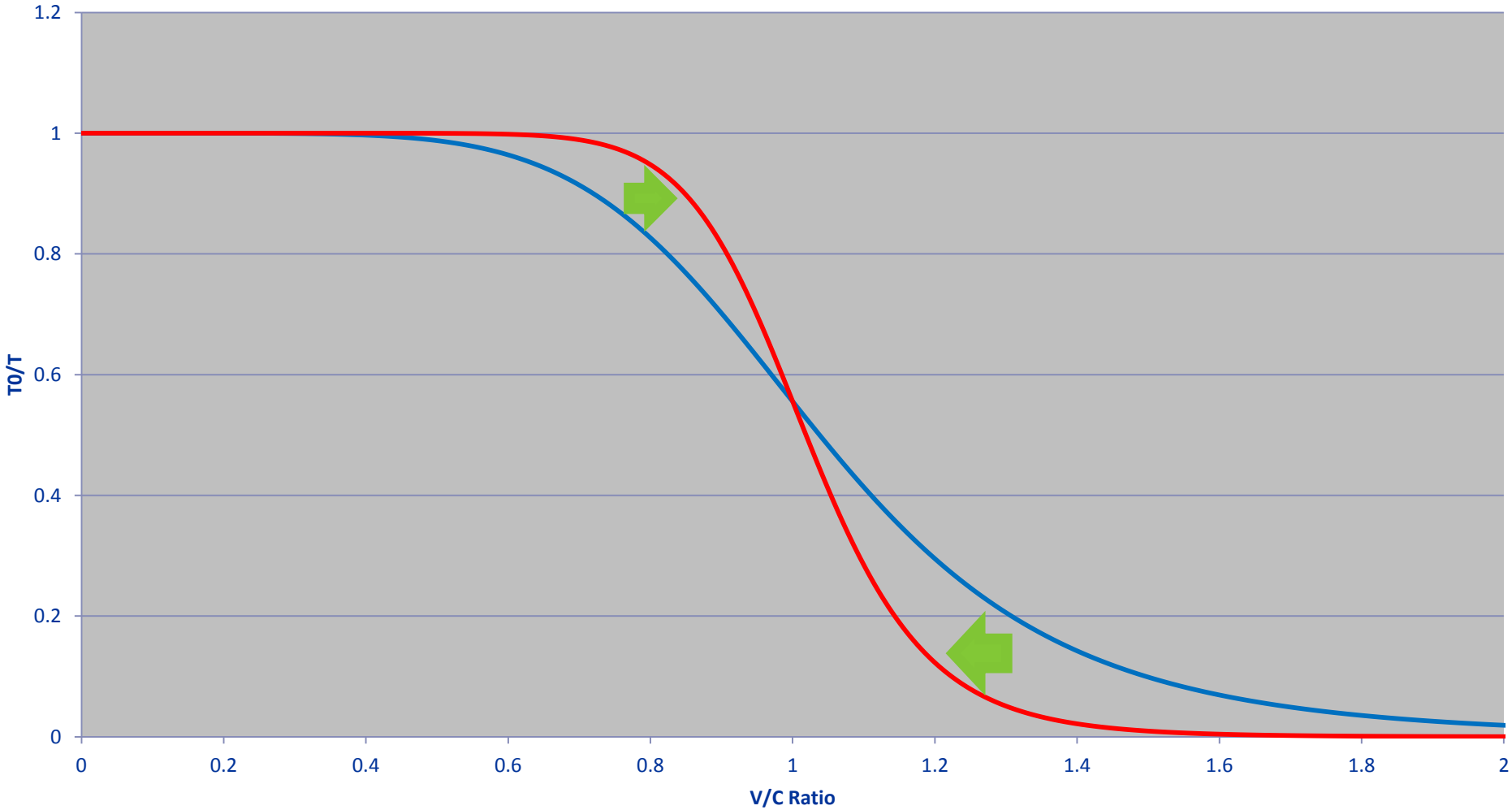
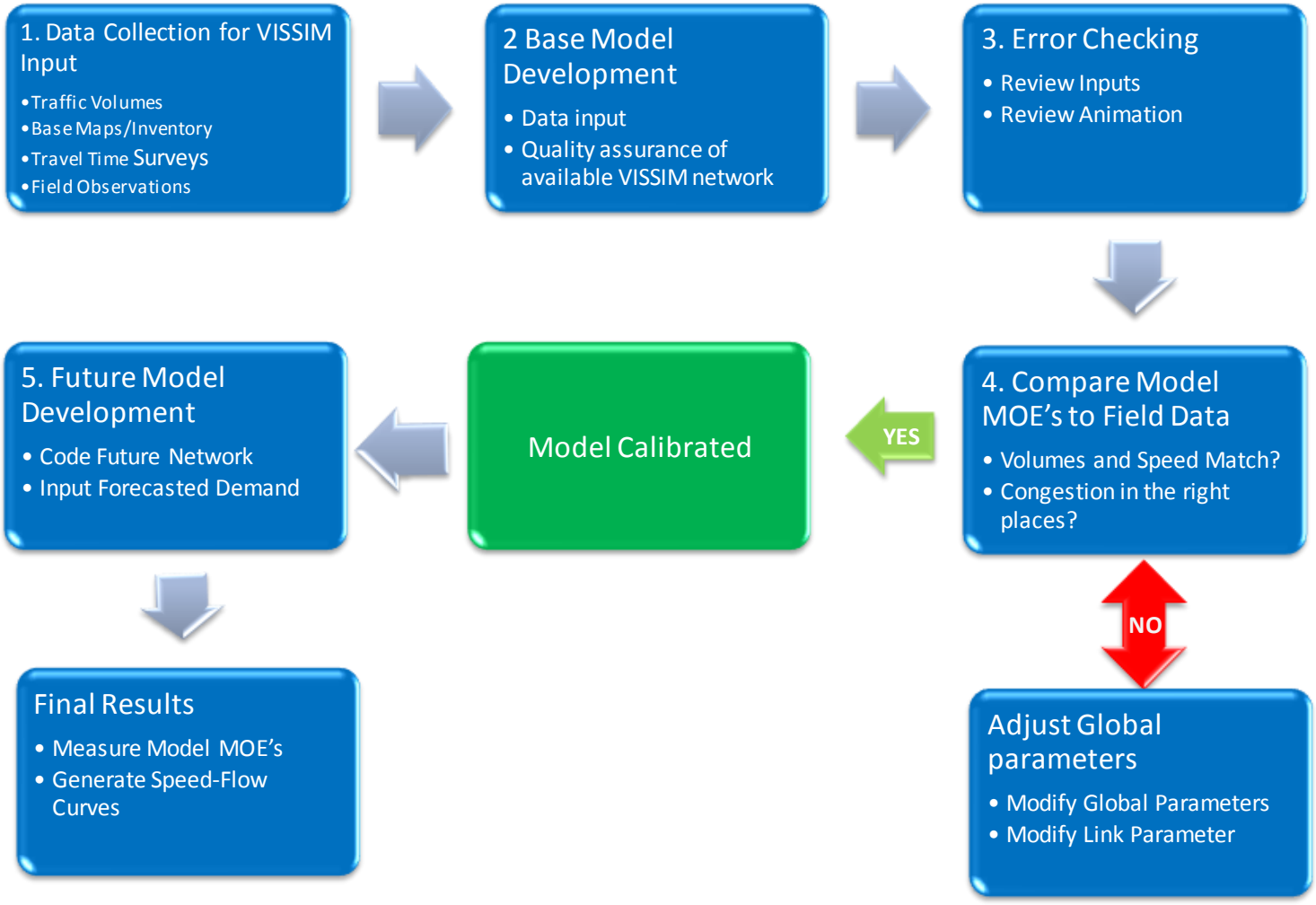


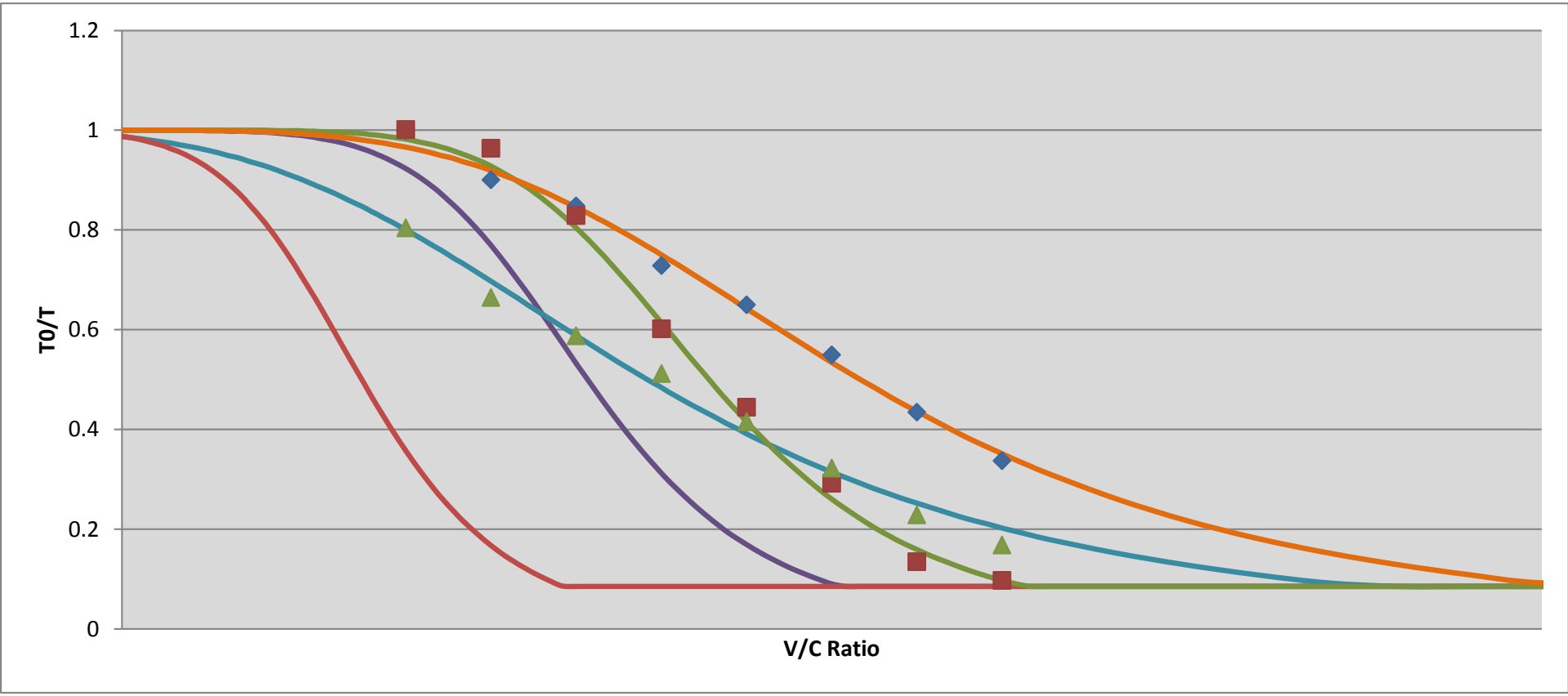
Calibrating Future Year Speeds



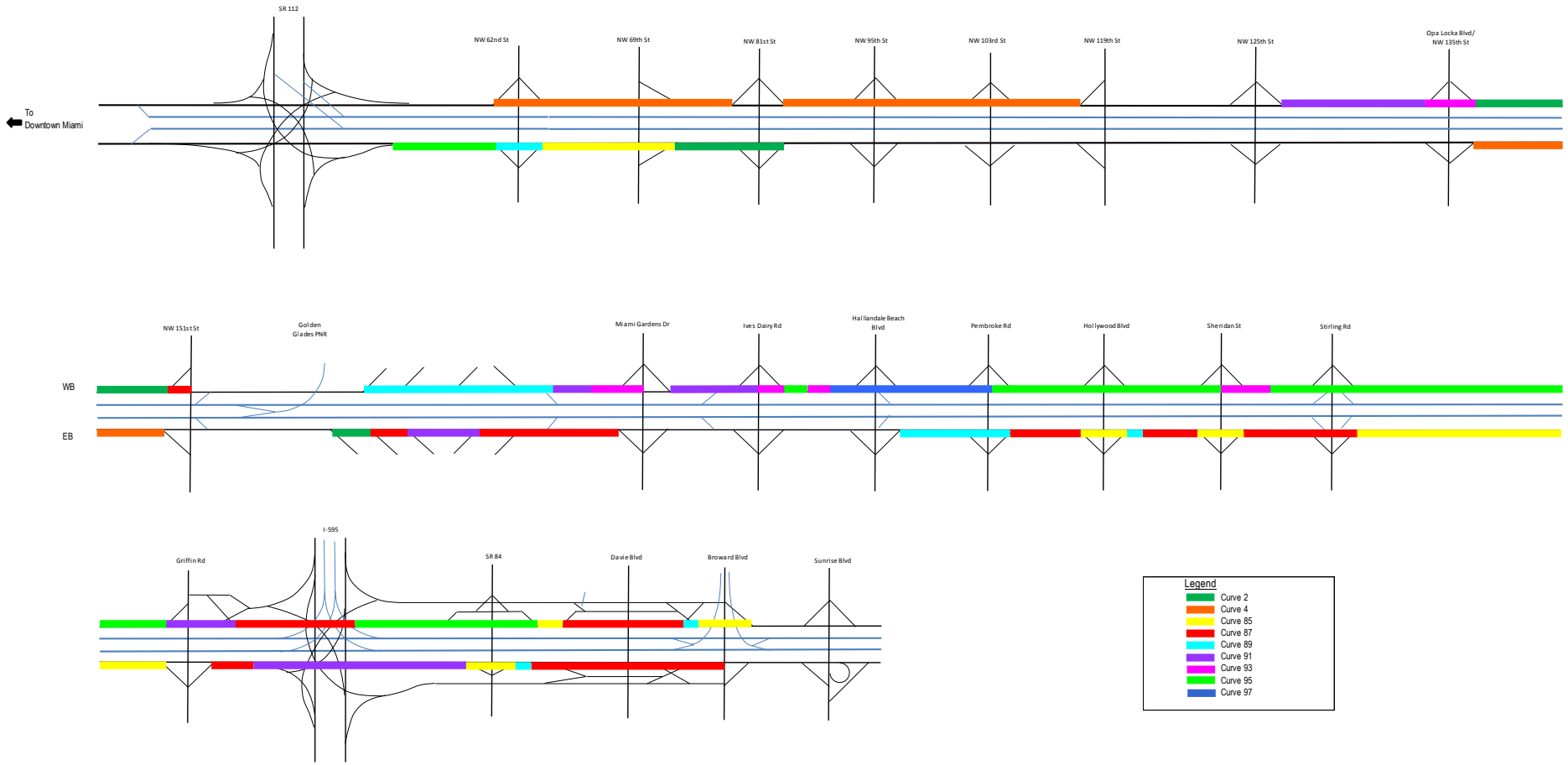
Vissim Model Development and Calibration Process



Sample Results from Vissim Load Sets
Modified Speed-Flow Curves



Modifications for the Managed Lane Model: Modified Speed-Flow Curve Example



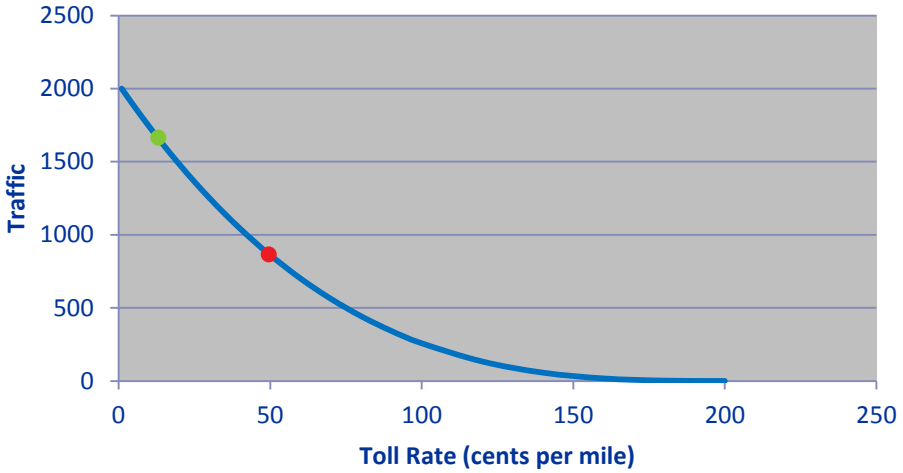
Static Approximation of Dynamic Tolling

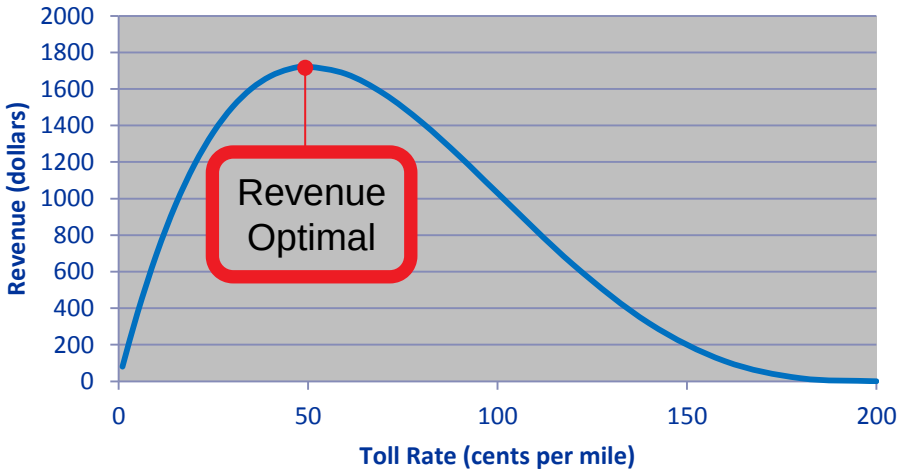
- Given:
  - Calibrated Base Year Model
  - Modified future VDF curves for links
  - Accurate coding of proposed future year managed lane configuration(s)
- We want to estimate how much revenue the managed lanes will generate
- Considerations:
  - What optimization point will we use?
    - Maximize traffic flow
    - Optimize revenue
  - Specific toll agency requirements (minimum toll, trip reconstruction)

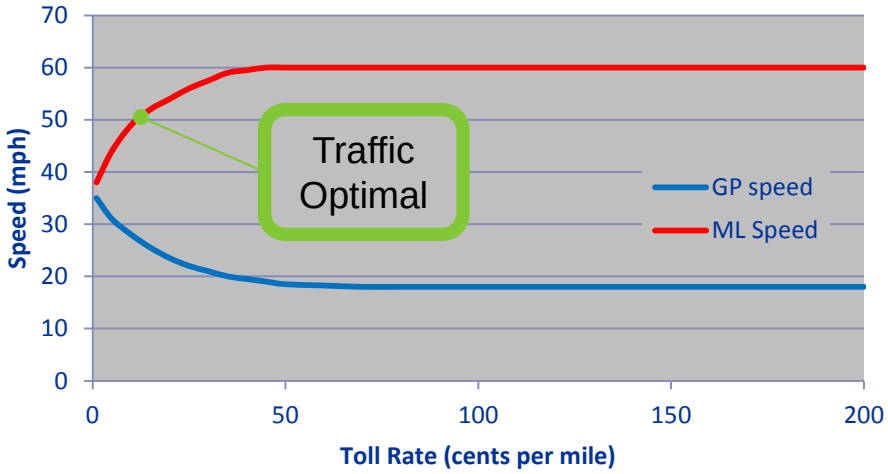
Typical Traffic Conditions

- Dynamic traffic pricing – will adjust automatically (or manually depending on toll agency) to retain near free-flow speed in managed lanes
- Model estimates are static (within standard TDM)
- Model itself represents a typical weekday traffic condition
  - Interpretation of final traffic is that this would be the expected toll necessary to maintain traffic flow in lanes

Toll Sensitivity and Optimization Points







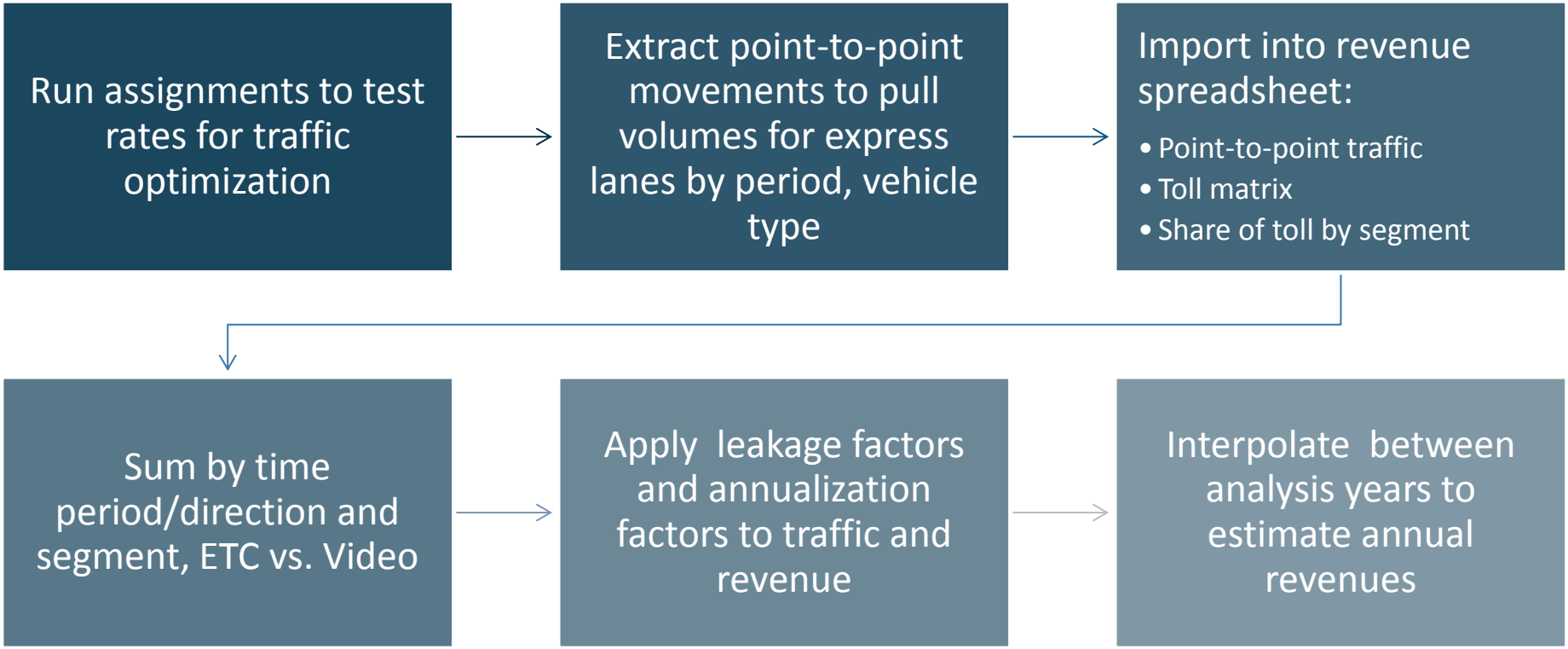
Revenue Optimization

- Maximize the revenue generated at a toll gantry or for multiple toll movements

Traffic Optimization

- Maximize the **uncongested** traffic in managed lanes
  - 50 miles per hour minimum speed
  - Achieved in the model through a maximum **traffic** threshold (typically about 1600 vplph)

Post-processing and Revenue Calculations



Special Considerations

Multiple Decision Points	• Multinomial/Nested Decision Structure • Time Penalties • Depends heavily on configuration of decision points
Fully Constrained Sections (no alt route)	• Limit minimum volume on roadways • Trip suppression/time of day shifting in outer years
Operations Analysis of Managed Lane Access	• Strict calibration of microsimulation model • Reconfiguration of access point design
Sensitivity Testing & Risk Analysis	• 'Stress-testing' model with specific input parameters • Statistical simulation

Important Considerations of Managed Lanes

- Managed lanes are fully dependent on growth
  - Managed lanes to solve problems of reasonably congested GP lanes
    - Will make gp lanes freeflow (in many cases) for opening years
  - Managed lanes in extreme congestion must be carefully planned
    - If complete breakdown of lanes (demand > C*1.4), access points may exacerbate queues
- Managed lanes should not be seen as a method for fully funding construction
  - ML construction rarely breaks even in a typical roadway lifespan
- Most important model consideration is to benchmark forecasts against managed lanes that are currently operating