An Integrated Modeling Approach for 95 Express Phase 3

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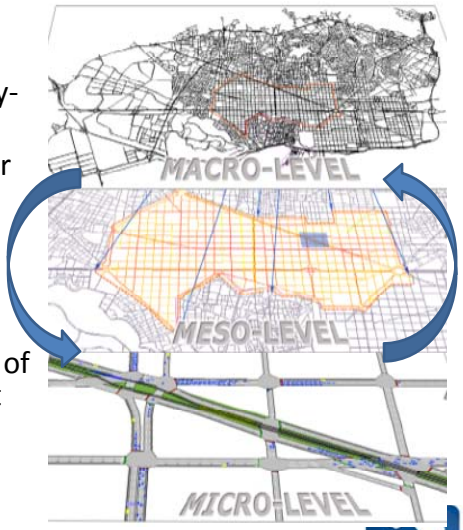
Agenda

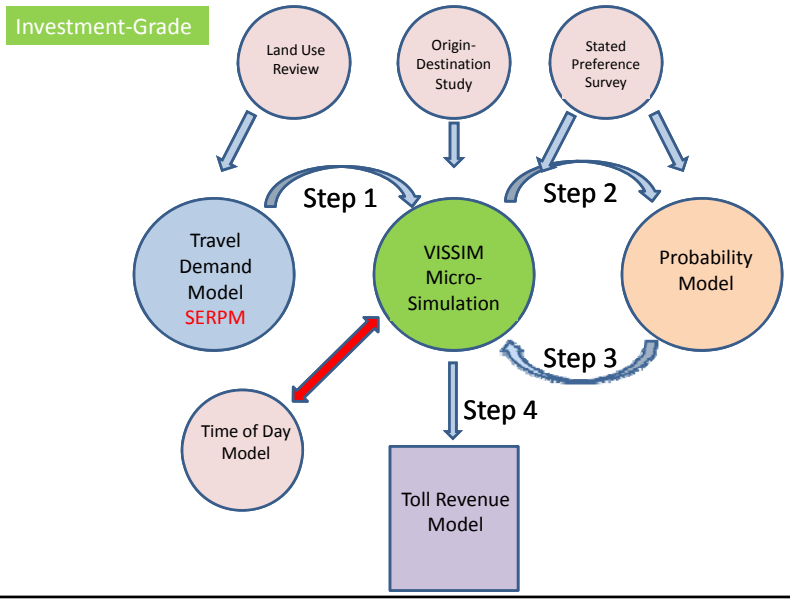
- Overview of Traffic Forecasting and Analysis Process
- SERPM Corridor Demand Estimation
  - Toll Choice Model Customization
  - Post-Processing Methods
  - Project Model Validation
- VISSIM Model Integration
  - Model Development and Calibration
  - Managed Lane Module Customization

Simulation Methods

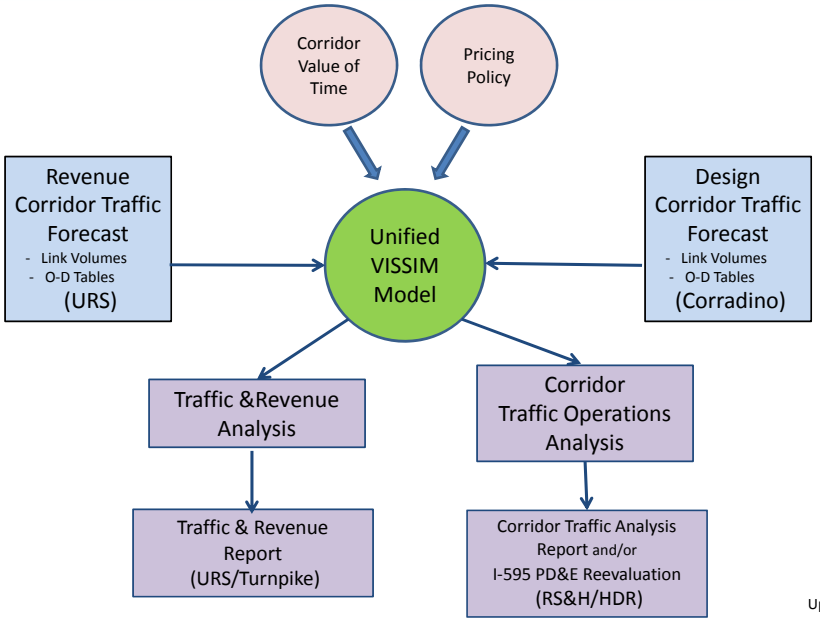
- **Macroscopic (SERPM)**
  - Simulation of flow, speed, and density made on a segment-by-segment basis
  - Enhanced toll choice model for route assignment
- **Microscopic (VISSIM)**
  - Simulates detailed movement of individual vehicles throughout the network
  - VISSIM offers dynamic lane choice model (DTA)



Traffic and Revenue Approach

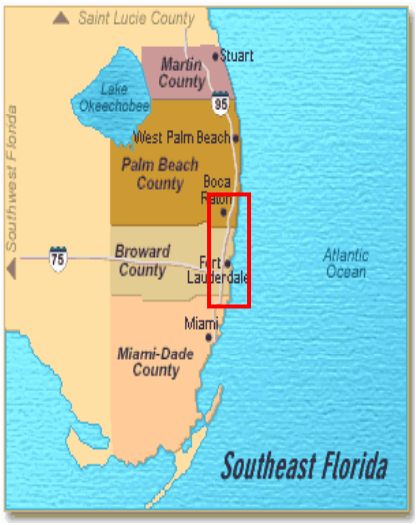


Traffic Analysis Process



Updated: 8/19/13

I-95 Express Phase 3 Forecasting Case Study



Outline of Demand Forecasting

- Design Traffic Forecasting Needs
- Traditional Approach
- Manual Post-Processing Issues
- Journey to an Alternate Approach
- I-95 Express Phase 3 Forecasting Case-Study

Design Traffic Forecasting Needs

- AADT
- DDHV
- Traffic Factors, K and D

$$DDHV = AADT*K*D$$

Traditional Approach

- Select a Travel Demand Model
- Perform Subarea Validation
- Develop Forecasts
- Apply Traffic Factors
- Ad hoc, NCHRP 255-style Post-Processing
- Develop Design Traffic

Traditional Approach Issues

- Manual Errors in Large-Scale projects
- Forecasting Consistency Issues
- Heavy Relying on Traffic Factors- K, D
- Issues with Managed Lanes Modeling Projects
  - Daily-to-Peak Correspondence is Different (K)

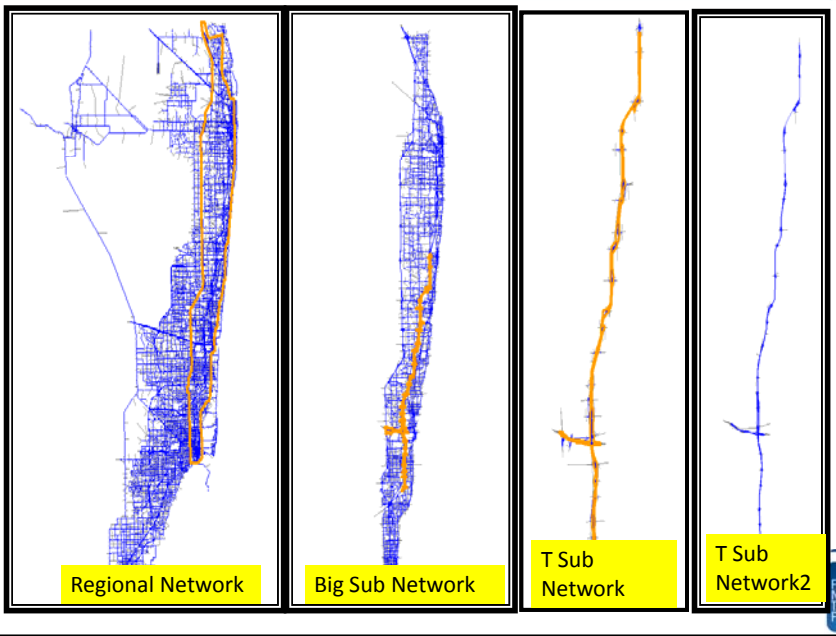
Journey to an Alternate Approach

- Use of Peak-Period Model Estimates
- Use of Diurnal Factors (Peak Period-to-Peak Hour)
- Use of CUBE Analyst Matrix Estimation Process
- Increased Confidence in Turning Movement Forecasts

Analysis Years and Alternatives

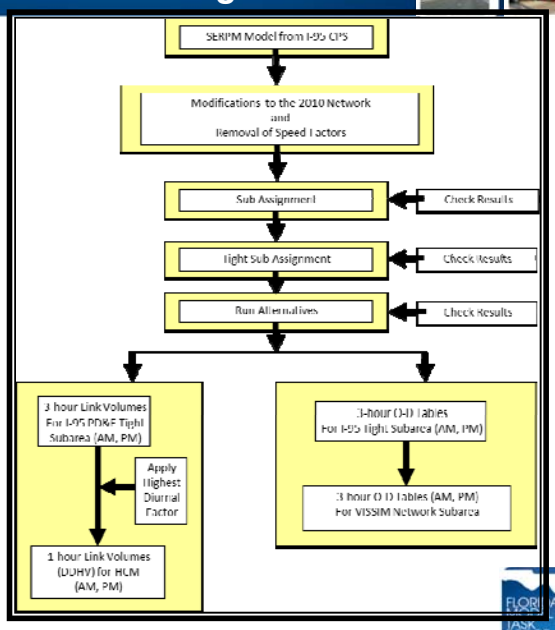
- 2010/11 – Base and Validation Year
- 2040 – Design Year
  - No-Build
  - Build Phase 3
- 2020 – Opening Year
  - Build with Phase 3A

Corridor Subarea Extraction

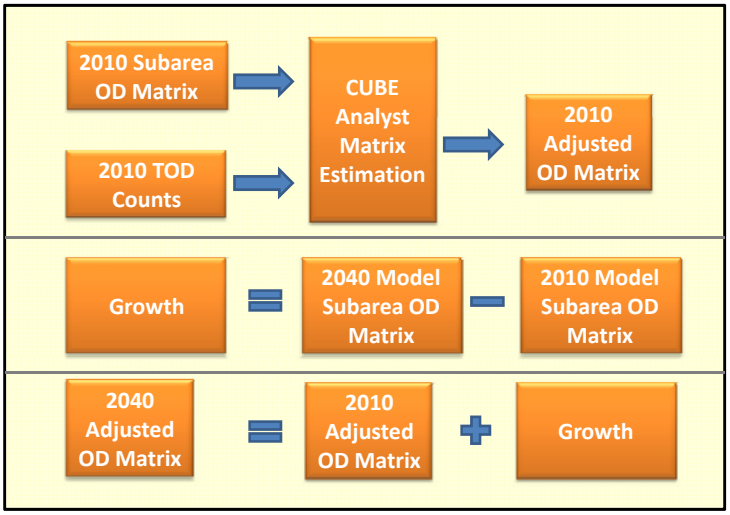


Overview of Subarea Forecasting

- SERPM6.5 Regional Model (3 Counties)
- Toll Choice Model Enhancement for I-95 "Big Subarea"
- Tight Subarea Validation for Corridor Demand
- Tight Subarea2 extraction for VISSIM integration



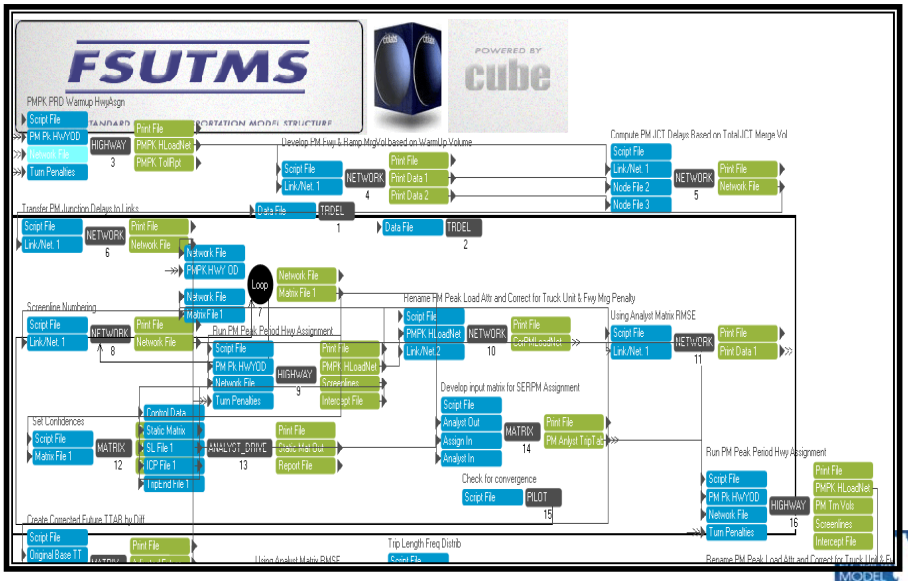
Methodology



2010 CUBE Analyst Matrix Estimation

- 2010/11 TOD Traffic Counts-As screenlines
- 2010/11 Prior Tsub Model OD Matrix
- Review Link-Level and Turning Movement-Level Assignment
- Review Trip Lengths Before and After
- Several Iterations of Validation

Iterative Matrix Estimation Process



2010 Validation Statistics

AM Model Validation Statistics

Volume Group	Count Range	Model RMSE (%)	Max Allowable RMSE	Volume	Count	Volume/Count	Number of Links
1	1 5,000	21.9%	45 55%	1,253,856	1,220,769	1.03	436
2	5,000- 10,000	6.2%	35 - 45%	805,582	805,989	1	129
3	10,000 20,000	3.1%	27 35%	759,243	748,096	1.01	48
4	20,000- 30,000	1.8%	24 - 27%	243,106	240,733	1.01	11
ALL	1-500,000	11.6%	32 - 39%	3,061,787	3,015,587	1.02	624

PM Model Validation Statistics

Volume Group	Count Range	Model RMSE (%)	Max Allowable RMSE	Volume	Count	Volume/Count	Number of Links
1	1 5,000	27.1%	45 55%	1,079,395	1,060,066	1.02	373
2	5,000 10,000	5.4%	35 45%	1,213,963	1,202,777	1.01	189
3	10,000 20,000	3.9%	27 35%	693,214	675,227	1.03	42
4	20,000 30,000	3.3%	24 27%	472,056	459,360	1.03	20
ALL	1-500,000	12.1%	32 - 39%	3,458,628	3,397,430	1.02	624

Daily Model Validation Statistics

Volume Group	Count Range	Model RMSE (%)	Max Allowable RMSE	Volume	Count	Volume/Count	Number of Links
1	1 5,000	54.2%	45 55%	192,932	155,943	1.24	44
2	5,000- 10,000	31.5%	35 - 45%	796,307	751,670	1.06	99
3	10,000 20,000	30.8%	27 35%	3,094,156	2,872,637	1.08	188
4	20,000- 30,000	8.8%	24 - 27%	4,498,990	4,299,674	1.01	177
5	30,000- 40,000	6.1%	22 - 24%	653,006	631,808	1.03	19
6	40,000 50,000	8.5%	20 22%	421,858	408,393	1.05	9
7	50,000- 60,000	4.1%	18 - 20%	216,024	211,699	1.02	4
8	60,000 70,000	2.4%	17 18%	208,840	204,873	1.02	3
9	70,000- 80,000	4.9%	16 - 17%	767,773	741,279	1.04	10
10	80,000 90,000	6.0%	15 16%	921,143	905,350	1.02	11
11	90,000-100,000	6.8%	14 - 15%	1,071,357	1,050,015	1.02	11
12	100,000-500,000	8.7%	11 14 %	2,898,427	2,943,538	0.98	26
ALL	1-500,000	15.2%	32 - 39%	15,590,767	15,171,879	1.03	601

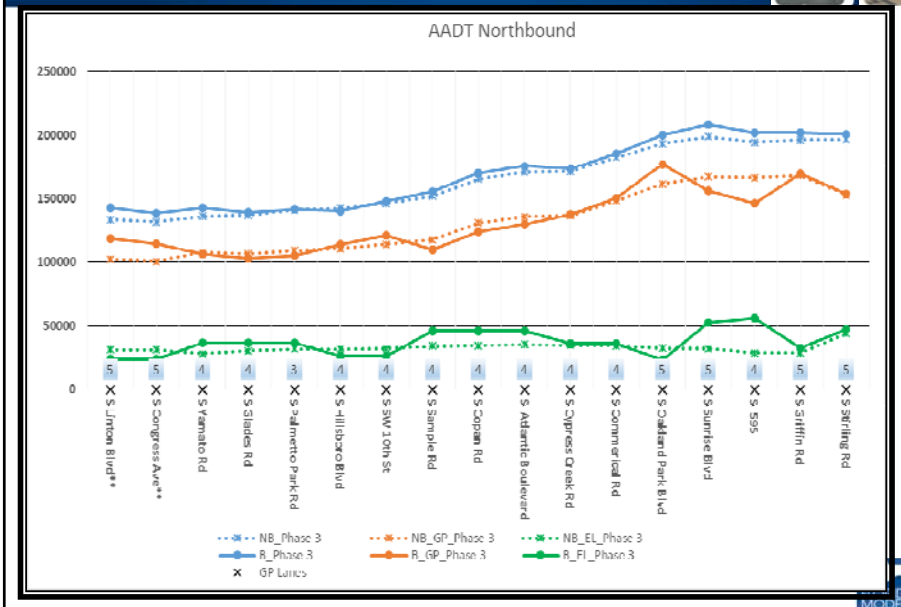
2040 Forecasts Development

- Main goals
  - Develop O-D matrices for AM and PM
  - Develop DDHV Volumes for Operational Analyses
  - Integrate Forecasts with Micro-Simulation
- Inputs
  - Model Subarea 2040 O-D Matrix (2040 Raw O-D)
  - Model Subarea 2010 O-D Matrix (2010 Raw O-D)
  - Growth = (2040 Raw O-D) – (2010 Raw O-D)
- Target
  - Adjusted 2040 O-D Matrix: 2010 "Validated" O-D + Growth

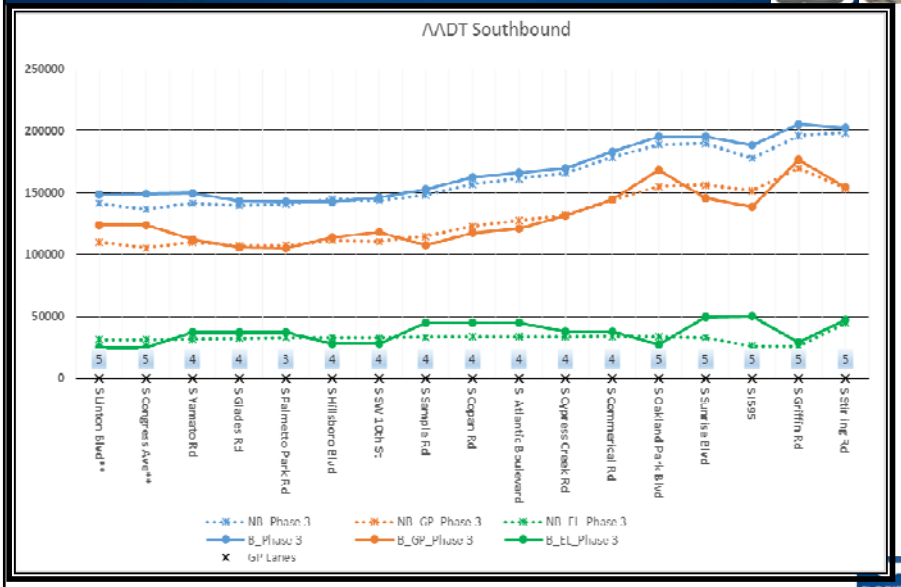
QC Process

- Independent Peer Review
- Reasonableness Checks
  - Historical Trends and Growth Rates
  - Past Studies and Relevant Corridor Experience
  - Inconsistencies

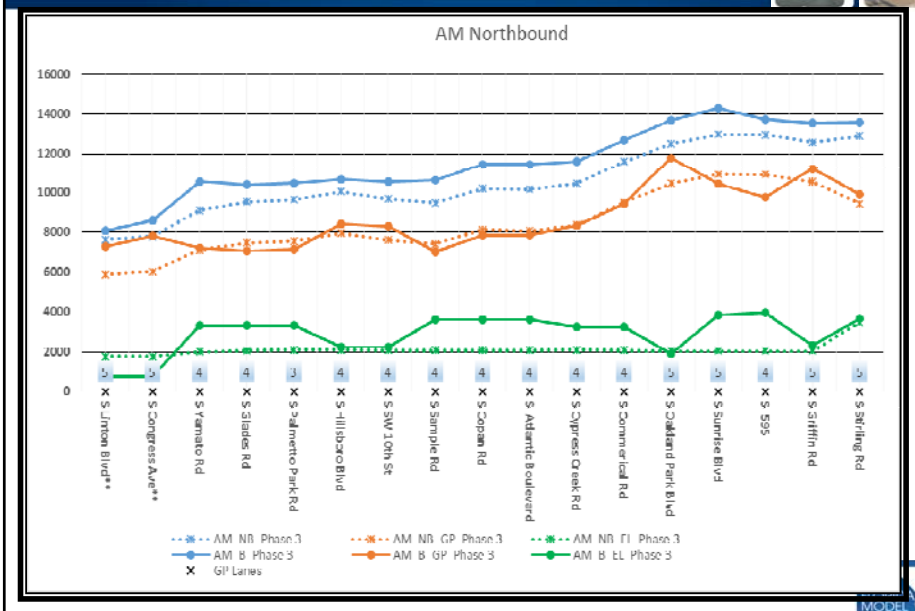
2040 Build vs. No-Build AADT Northbound



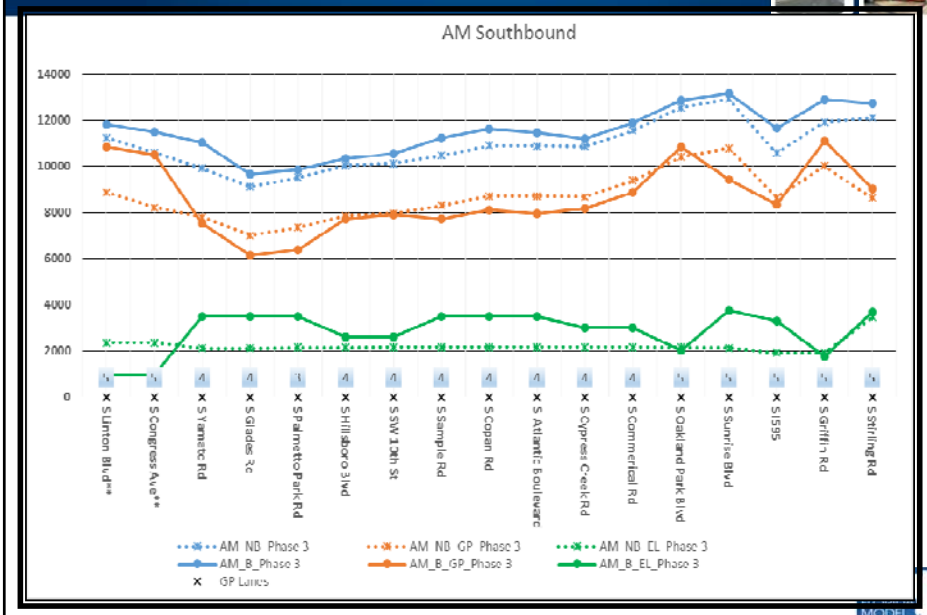
2040 Build vs. No-Build AADT Southbound



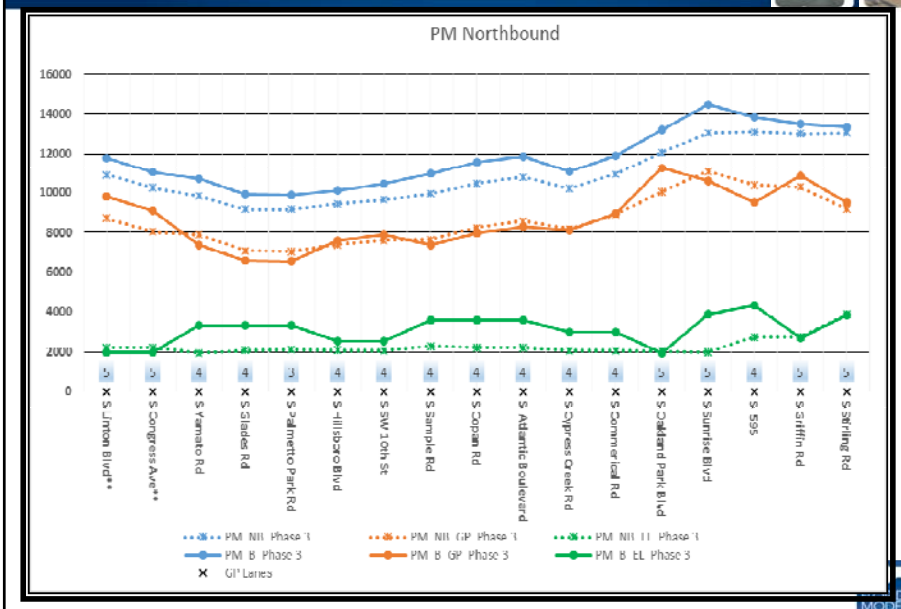
2040 Build vs. No-Build AM Northbound



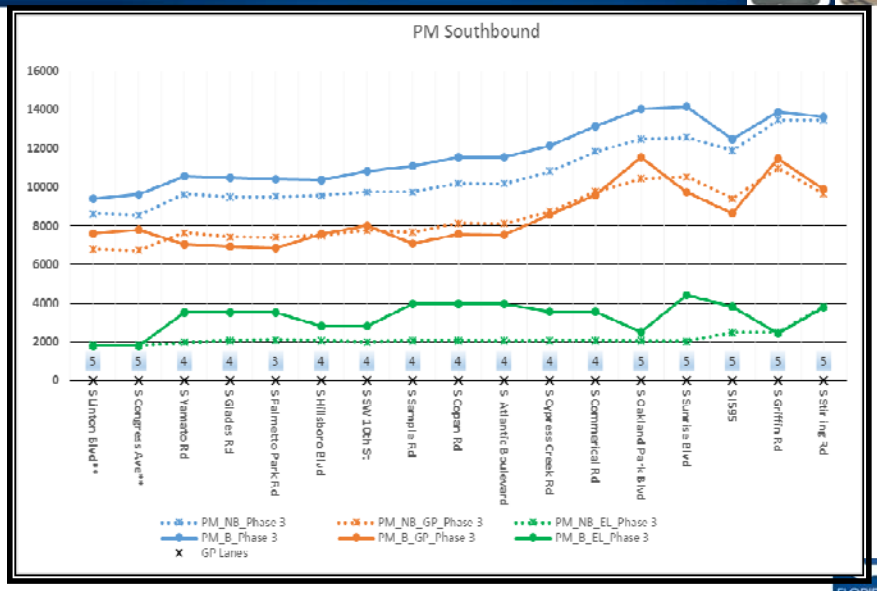
2040 Build vs. No-Build AM Southbound



2040 Build vs. No-Build PM Northbound



2040 Build vs. No-Build PM Southbound

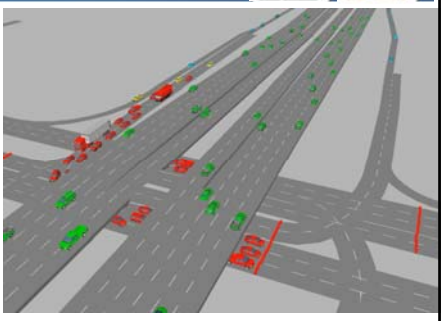


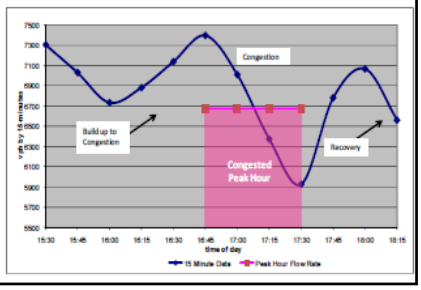
Summary and Lessons Learned

- Demand Matrices Extraction for Micro-Simulation
- Streamlined Forecasting Approach to Minimize Manual Post-Processing
- Savings in Time and Resources
- Consistency in Forecasts among Alternatives
- Ability to Test Several Alternatives and Develop Design Traffic Forecasts

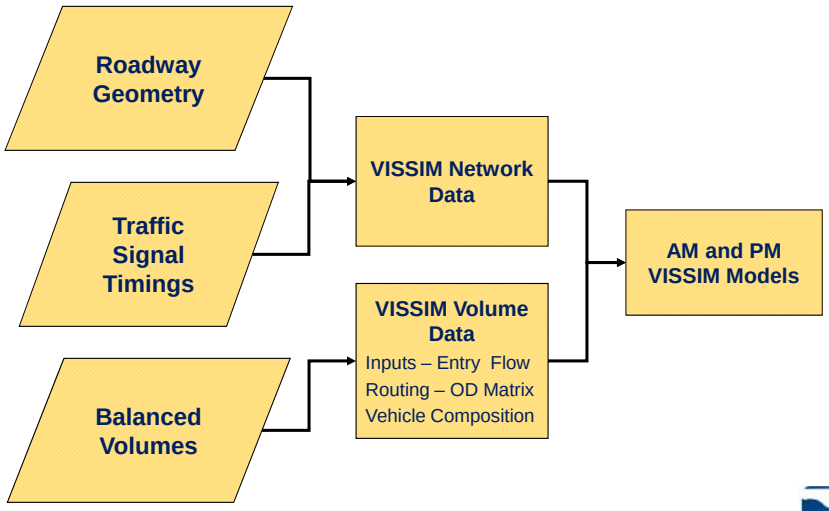
I-95 VISSIM Model Features

- **Network**
  - 33 Miles of Mainline
  - 24 Existing Interchanges
  - 45 Signalized Intersections
- **Simulation Periods**
  - AM and PM – 4.5 Hours Each
  - Existing - 2011
  - Future - 2020 and 2040
- **Vehicle Classes**
  - Existing – SOV, HOV, Trucks
  - Future – Pay, Exempt, Trucks
    - Exemptions – HOV 3+, Hybrids, Buses, Motorcycles, Non-Revenue



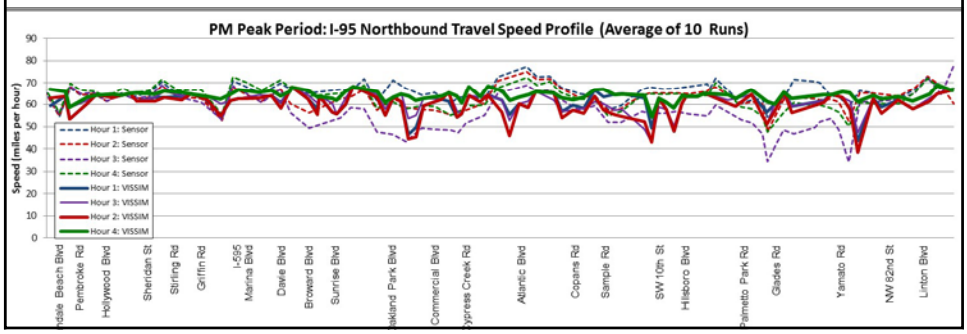


Model Development



I-95 VISSIM Calibration Challenges

- Freeway and arterial congestion
- Extended periods of oversaturation
- Closely spaced interchanges
- Model sensitivity



I-95 VISSIM Model Calibration

Volume Comparison

GEH Summary $GEH = \sqrt{\frac{2(M-C)^2}{M+C}}$	Northbound		Southbound	
	AM Peak Period	PM Peak Period	AM Peak Period	PM Peak Period
Mainline	2.6	1.6	1.4	0.6
Off-ramps	1.0	0.7	1.3	0.8
On-ramps	0.5	0.6	0.6	0.3

Travel Time Comparison

Overall Travel Time	AM Peak Period	PM Peak Period
Northbound I-95	**- 4%**	**- 2%**
Southbound I-95	**0 %**	**- 4%**

VISSIM Managed Lane Components

- Managed Lane Facility Definition
  - General Use Lanes: no toll, no restrictions
  - Managed Lanes: toll and/or occupancy restrictions
- Pricing model
  - Typically depends on dynamic traffic conditions
  - Traffic Responsive
  - COM Script
- Decision model
  - Discrete choice model
  - Utility of the toll computed from travel time savings and current price
  - Logit decision function: 50% on toll lane if utility = 0
  - Unique user classes react differently to same toll

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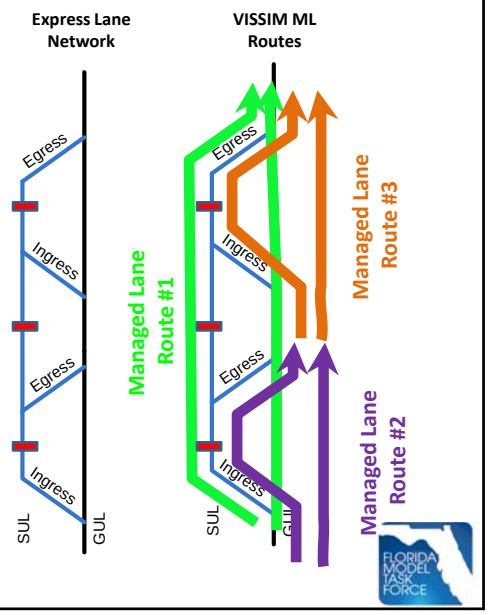
Express Lane Routes

- Route for each ingress and egress pair
- Consists of a express lane route and a general purpose route
- Referenced to a Express Lane Facility
  - Pricing model
  - Decision model
- Choice is made at point of entry



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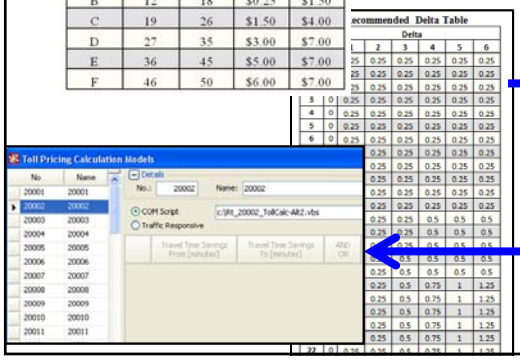
Pricing Model

- COM Script
  - External scripting via VBA
  - VISSIM object links and evaluation metrics accessible
  - User defines pricing logic (speed, volume, density)

Level of Service	Traffic Density Min	Traffic Density Max	Rate Min	Rate Max
A	0	11	$0.25	$0.25
B	12	18	$0.25	$1.50
C	19	26	$1.50	$4.00
D	27	35	$3.00	$7.00
E	36	45	$5.00	$7.00
F	46	50	$6.00	$7.00




```
'95 Express Phase 3 COM Script

'Array of minimum toll rate based on LOS
Dim minLOStoll(6)
minLOStoll(0) = 0.15
minLOStoll(1) = 0.15
minLOStoll(2) = 0.17
minLOStoll(3) = 0.28
minLOStoll(4) = 0.66
minLOStoll(5) = 1.43

'Array of maximum toll rate based on LOS
Dim maxLOStoll(6)
maxLOStoll(0) = 0.15
maxLOStoll(1) = 0.16
maxLOStoll(2) = 0.23
maxLOStoll(3) = 0.56
maxLOStoll(4) = 1.38
maxLOStoll(5) = 2.00


'toll division
tdiv = 1

'toll segment length
tlength = 2.6

'update interval in seconds
t_val = 900

'actual toll round value in dollars
toll_round = 0.05

'required minimum toll, regarless of segment length
reqmintoll = 0.25

iteration = iteration + 1

simtime = iteration * t_val

'Step 1:  Calculate change in traffic density

D_avg = 0
curDensity = 0
numlanes = 0

'Identify density at each cross section

For i = 0 To a 'In mldcs array
  numvehseg = 0
  S_temp = 0
  D_temp = 0
  For j = 0 To b  'in mldcs array
     SET ml = dc.GetDataCollectionByNumber(mldcs(i,j))
     numvehseg = ml.GetResult("NVEHICLES", "SUM", 0)
     S_temp = ml.GetResult("SPEED", "MEAN", 0)
```

95 Express Pricing Algorithm

- Table lookup based on vehicle density in the express lanes
- Sample Toll Calculation
  - Toll (T_{t-1}) = $4.00,
  - TD_{t-1}= 27, $TD_t = 29$
  - ΔTD of +2 Yields ΔR of +$0.50
  - $R_t = R_{t-1} + \Delta R$ = $4.00 + $0.50 = $4.50
  - Check Range in LOS Table

Delta Table

Traffic Density	Δ Traffic Density 0	1	2	3
27	$0.00	$0.25	$0.50	$0.75
28	$0.00	$0.25	$0.50	$0.75
29	[illegible]	[illegible]	**$0.50**	$0.75
30	$0.00	$0.25	$0.50	$0.75
31	$0.00	$0.25	$0.50	$0.75
32	$0.00	$0.25	$0.50	$0.75

Level of Service	Traffic Density Min	Traffic Density Max	Rate Min	Rate Max
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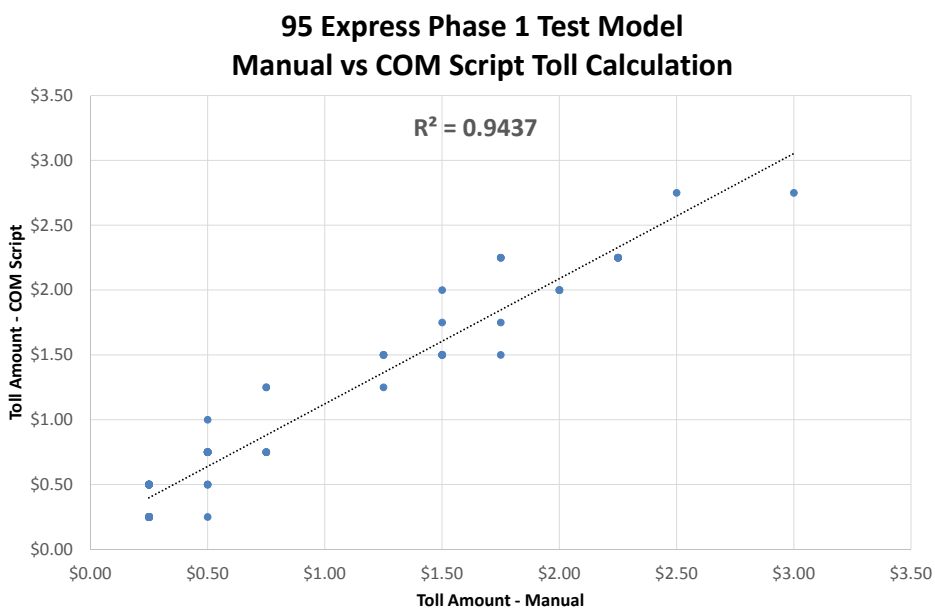
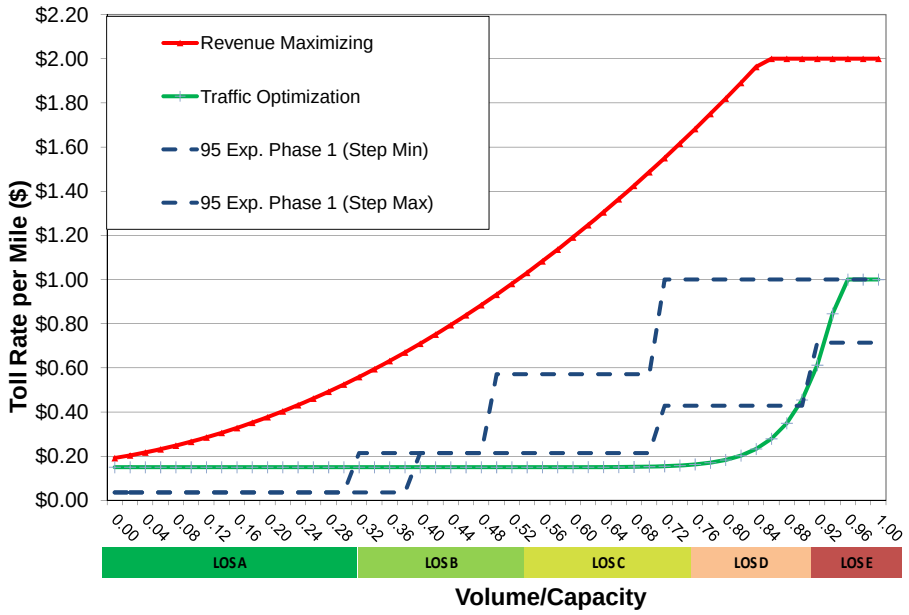
95 Express Phase 1 Test Model



95 Express Phase 3 Toll Escalation Policy

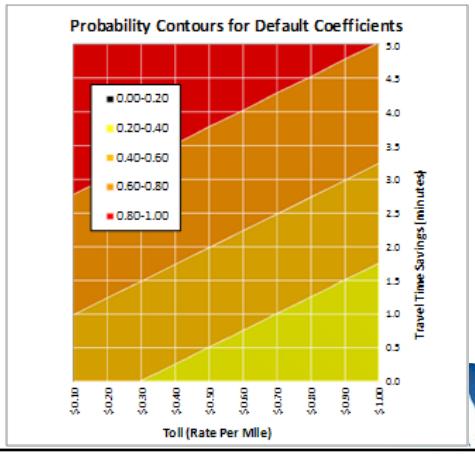


Lane Decision Model

$$P_{(Managed)} = 1 - \frac{e^{\alpha * U_{(Managed)}}}{e^{\alpha * U_{(Managed)}} + e^{\alpha * U_{(Unmanaged)}}} = 1 - \frac{1}{1 + e^{\alpha * \Delta U}}$$

$$U_{(Managed)} = (Cost\ Coefficient * \triangle\ Toll) + (Time\ Coefficient * \triangle\ Time\ Saving) + Constant$$

- Alpha value
- Time coefficient
- Cost coefficient
- Toll Constant (Intercept)
- Decision model is needed for both Traffic Responsive and COM script toll models



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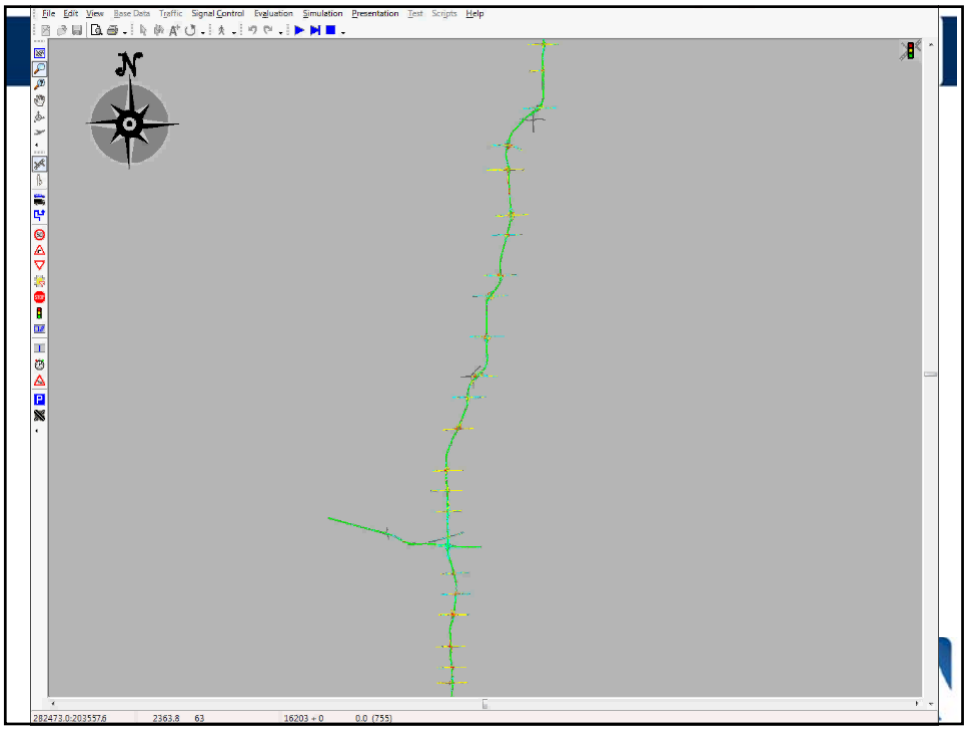
BUILD VISSIM SAMPLE OUTPUT


Segment		Northbound (5:30 pm – 6:30 pm)			
#	Description	GUL	ML	ML Share	Toll
3	Griffin Road to I-595	7,422	2,113	22%	$0.40

Segment		Southbound (5:30 pm – 6:30 pm)			
#	Description	GUL	ML	ML Share	Toll
3	Griffin Road to I-595	5,732	2,522	31%	$0.41



Summary

- Coordination with T&R effort can add value
- Understand that pricing policy can affect operations
- VISSIM managed lane function achieves interim goal for dynamic assignment
- DUE or constrained demand methods could be beneficial

Questions & Answers