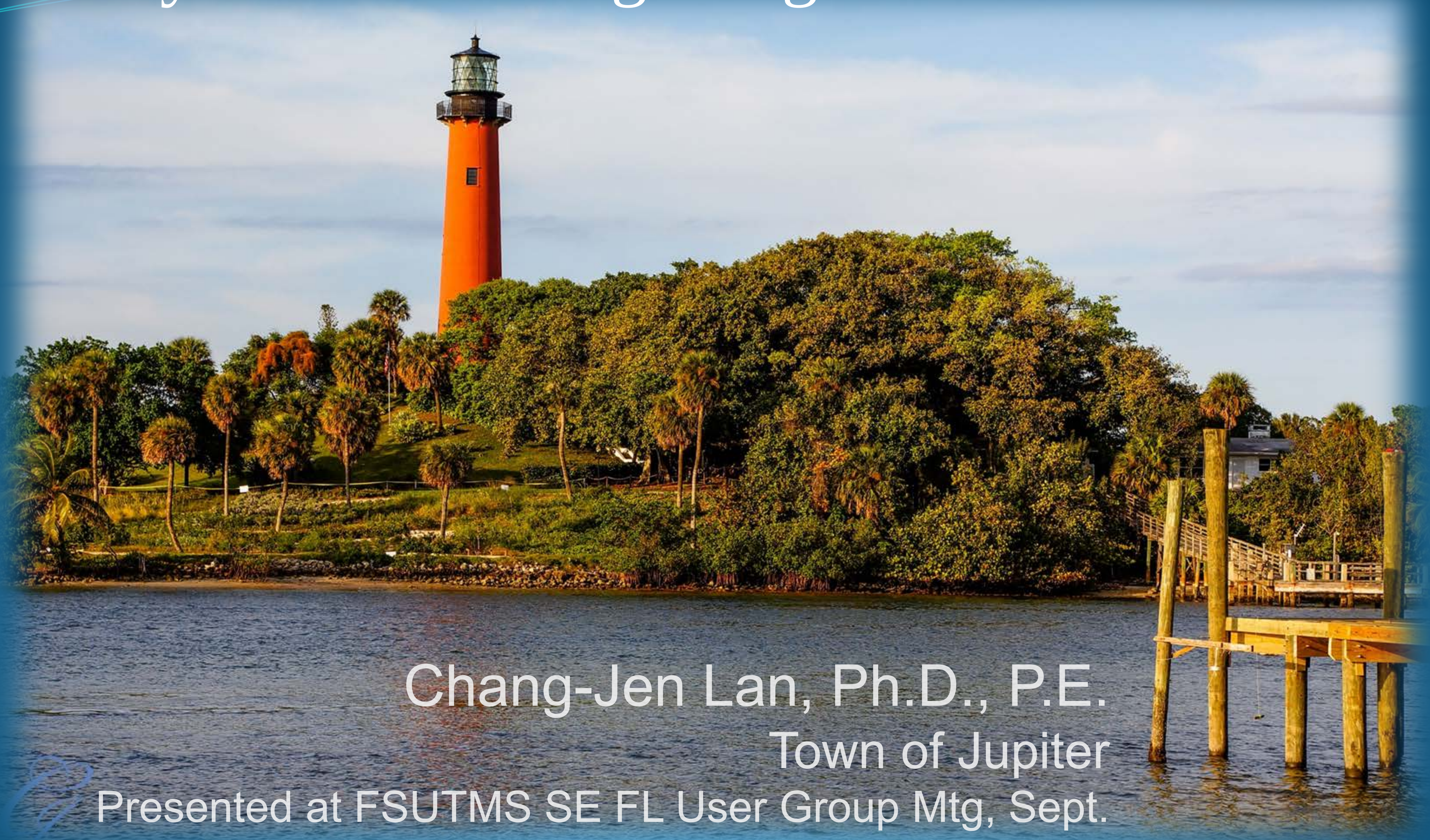
Synthesis of Long Range Demand Forecasts



Chang-Jen Lan, Ph.D., P.E.

Town of Jupiter

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Introduction

- Travel demand forecasting is an important element for developing the long-range transportation plan (LRTP) and EAR-based comp plan amendments
- Significant efforts were devoted to migrate the traditional four-step, trip-based model to tour-based, activity-based model (ABM)
- Expectations planning agencies have on an advanced demand forecasting model
  - To replicate the base year condition well
  - To be sensitive to the policies being tested
  - To respond logically to changes in model inputs
- If the base-year modeled counts do not meet the validation accuracy standard, it is questionable whether the forecasts made in future years are reliable

Introduction

- The ABM is sensitive to a broad range of planning policies as well as the impact from emerging technologies, but does not replicate ground counts well in the base-year condition
- To that end, ITE two-step model and logistic growth model that utilize extensive temporal traffic volume information to achieve higher validation accuracy were introduced
- The proposed logistic growth model portrays a more realistic flattening growth curve when traffic approaches roadway capacity
- The logistic model could also characterize the impact of events or policy intervention on traffic growth due to, for example, great depression and pandemic outbreak
- Model outputs were synthesized to improve reliability of future demand forecasts

SERPM (SE Regional Planning Model) *8*

- Disaggregate behavior models are created to simulate travel induced activity and choices at personal and household levels
- Updates the base year from 2010 (used by SERPM 7) to 2015
- Certain systematic biases were often found in the model outputs
- Adjusted SERPM outputs (by PBC TPA) to account for systematic biases

$$\widehat{c_{15}} = r_{15}\frac{c_{10}}{r_{10}}, \quad \text{if } 0.8 \le \frac{c_{10}}{r_{10}} \le 1.2 \text{ or } r_{15} + (c_{10} - r_{10}) < 0$$

$$= r_{15} + (c_{10} - r_{10}), \quad \text{otherwise}$$

Estimated count in ‘15

Raw output ‘15

- Adjusted Root Mean Square Error, RMSE%, or coef. of variation

$$\text{RMSE\%} = \frac{\sqrt{\dfrac{\sum_i \left(ADT_i - \widehat{ADT_i}\right)^2}{N-1-p}}}{\dfrac{\sum_i ADT_i}{N}}$$

where N = sample size; p = no. of parameters;

SERPM 8

- RMSE% for SERPM

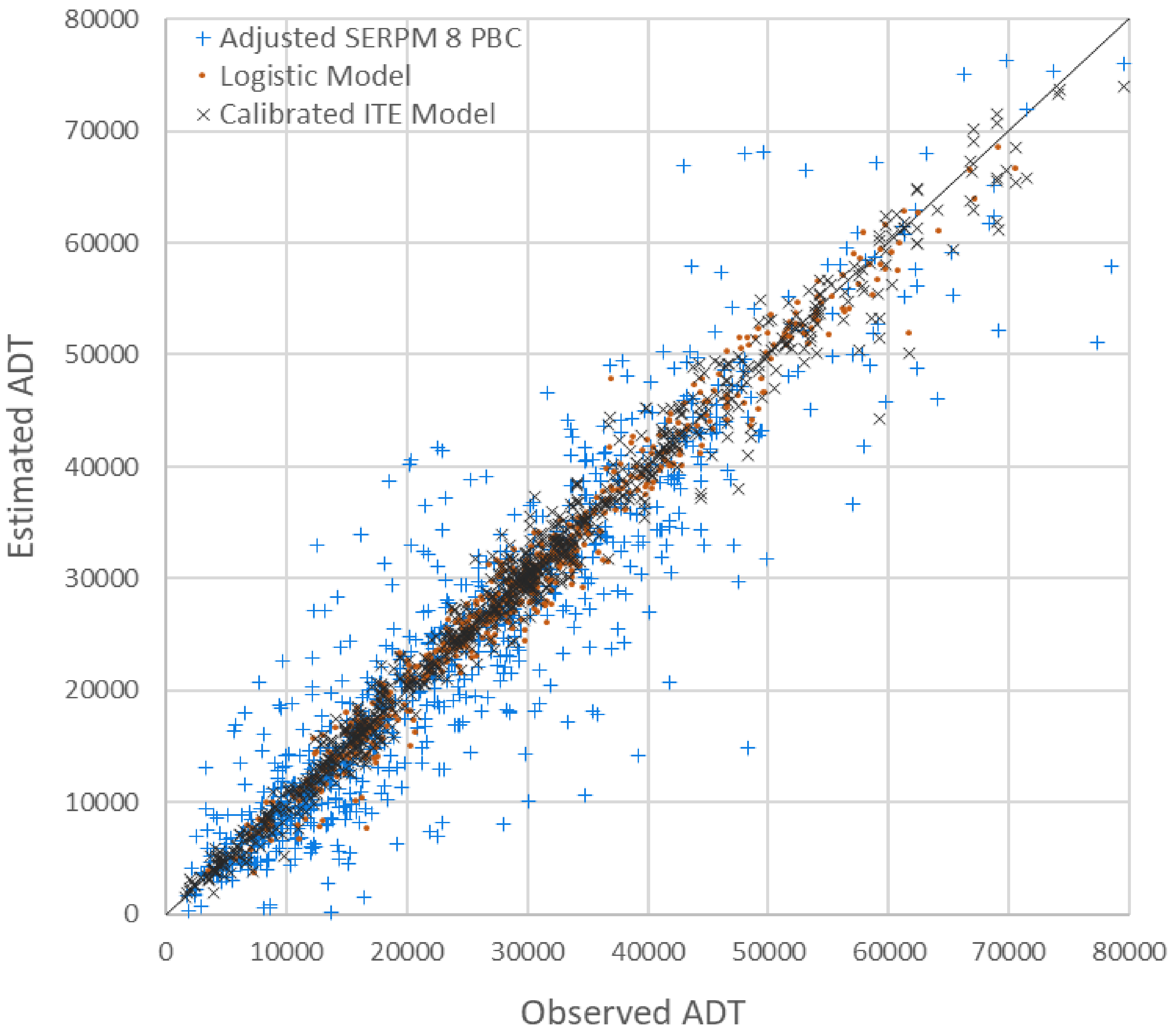
Table 1. Estimation errors (RMSE%) from original and adjusted SERPM

<table>
<tr><th rowspan="2">AADT</th><th rowspan="2">SERPM 8 PBC model (%)</th><th rowspan="2">Adjusted SERPM model (%)</th><th colspan="3">Allowable error limit (%) on 4-step forecasting model</th></tr>
<tr><th>FHWA</th><th>MDOT</th><th>FDOT BD-432[1]</th></tr>
<tr><td>≤1,000</td><td>167 (4)[2]</td><td>NA</td><td>60</td><td>200</td><td>150</td></tr>
<tr><td>>1,000–2,500</td><td>129 (20)</td><td>108.6 (6)</td><td>47</td><td>100</td><td>100</td></tr>
<tr><td>>2,500–5,000</td><td>88 (77)</td><td>74.6 (27)</td><td>36</td><td>50</td><td>65</td></tr>
<tr><td>>5,000–10,000</td><td>57 (152)</td><td>48.4 (111)</td><td>29</td><td>25</td><td>45</td></tr>
<tr><td>>10,000–15,000</td><td>50 (145)</td><td>39.5 (127)</td><td rowspan="2">25</td><td rowspan="2">20</td><td>35</td></tr>
<tr><td>>15,000–25,000</td><td>45 (213)</td><td>32.4 (190)</td><td>25</td></tr>
<tr><td>>25,000–50,000</td><td>29 (326)</td><td>19.8 (303)</td><td>22</td><td>15</td><td>15</td></tr>
<tr><td>>50,000</td><td>22 (88)</td><td>18.1 (73)</td><td>21</td><td>10</td><td>10</td></tr>
<tr><td>All Groups</td><td>36.8 (1025)</td><td>27.1 (837)</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Notes: [1] Lan et al. [7]; [2] No. of samples (in parenthesis)

SERPM 8

- Estimated vs Observed counts comparison for
  (1) adjusted SERPM
  (2) ITE two-step model
  (3) Logistic model



Pragmatic Implications

- Consequences and negative impacts due to inaccurate predictions
  (1) Road sections might be programmed into unnecessary improvements because of over-estimated traffic → wasted capital investment
  (2)Road sections might be excluded from necessary improvements due to underestimation in traffic → congestion cost
- There are some tolerances however, i.e.,
  - The 1st consequence will not occur as long as the overly projected traffic does not exceed the existing capacity;
  - The 2nd consequence will not occur if the underestimated traffic also exceeds the existing capacity
- In PBC, 6.7% and 5% roadway sections are likely affected by these consequences based on the original and adjusted SERPM outputs

ITE Two-Step Model

- Contains only vehicular trip generation and trip distribution steps
  - ITE trip generation rates → Internalization deduction → Pass-by deduction → double-counting deduction → net external traffic
  - Trips are distributed based on local knowledge, survey, TMC or four-step model
- The total traffic at the target year

$$T_t = \underbrace{T_b(1+\alpha gI - r(1-I))^t}_{\text{(base-yr traffic + background growth)}} + \underbrace{\beta T_d}_{\text{(unbuilt develop-ment trips)}}$$

NLS estimated $\beta = 0.319$ ($t = 11.2$), $r = 1.13\%$ ($t = 7.8$)

- The net external development trips can be obtained from PBC TPS database, which is in turn established based on applicant's traffic impact studies

Corridor	Traffic growth multiplier, α	Annual population growth rate, g
Indiantown Rd	1.002	1.324% (Town of Jupiter)
Donald Ross Rd	1.521	
Alt A1A	1.154	
Military Trail	0.567	
US 1	0.509	
Central Blvd	1.717	
Center St	0.368	
A1A	-0.984	
Frederick Small Rd	0.801	
Island Way North	3.328	
I-95	1.577	1.039% (PBC)

ITE Two-Step Model

- Adjusted *RMSE%* for ITE
  - Even the original ITE model outperforms the adjusted ABM

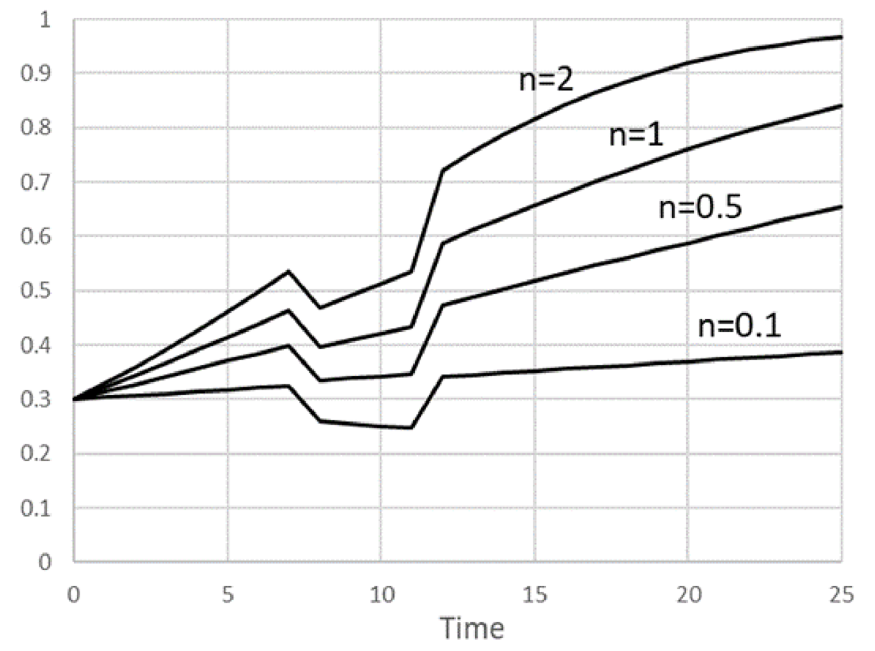
<table>
<tr><th rowspan="2">AADT</th><th rowspan="2">Original ITE model (%)</th><th rowspan="2">Calibrated ITE model (%)</th><th colspan="3">Allowable error limit (%) on 4-step forecasting model</th></tr>
<tr><th>FHWA</th><th>MDOT</th><th>FDOT BD-432[1]</th></tr>
<tr><td>≤1,000</td><td>NA</td><td>NA</td><td>60</td><td>200</td><td>150</td></tr>
<tr><td>>1,000–2,500</td><td>76.1 (8)</td><td>32.3 (8)</td><td>47</td><td>100</td><td>100</td></tr>
<tr><td>>2,500–5,000</td><td>44.6 (32)</td><td>18.4 (32)</td><td>36</td><td>50</td><td>65</td></tr>
<tr><td>>5,000–10,000</td><td>19.0 (58)</td><td>16.1 (58)</td><td>29</td><td>25</td><td>45</td></tr>
<tr><td>>10,000–15,000</td><td>16.1 (81)</td><td>10.1 (81)</td><td rowspan="2">25</td><td rowspan="2">20</td><td>35</td></tr>
<tr><td>>15,000–25,000</td><td>15.1 (187)</td><td>7.6 (187)</td><td>25</td></tr>
<tr><td>>25,000–50,000</td><td>12.1 (413)</td><td>6.2 (413)</td><td>22</td><td>15</td><td>15</td></tr>
<tr><td>>50,000</td><td>10.0 (106)</td><td>7.8 (106)</td><td>21</td><td>10</td><td>10</td></tr>
<tr><td>All Groups</td><td>13.3 (885)</td><td>8.4 (885)</td><td>-</td><td>-</td><td>-</td></tr>
</table>

The Proposed Logistic Model

- Derived from a generalized differential equation $\frac{dX_t}{dt} = \gamma X_t \left(1 - \left(\frac{X_t}{X_\mathrm{m}}\right)^n\right) - \varphi X_t$
- Estimated volume-to-capacity ratio of road section *i* in year *t*

$$\hat{X}_{i,t} = \frac{X_m (1 - c_i I_t)^{1/n} \left(1 + d_i g_{i,t}\right)}{\left[1 + \left(\left(\frac{X_m}{X_{i,0}}\right)^n (1 - c_i I_t) - 1\right) exp\left[-n b_i S_{i,t-1}(1 - c_i I_t)t\right]\right]^{1/n}} + k\left(\frac{T_{d(i,t)}}{C_i}\right) + a_i \varepsilon_{t-1}$$

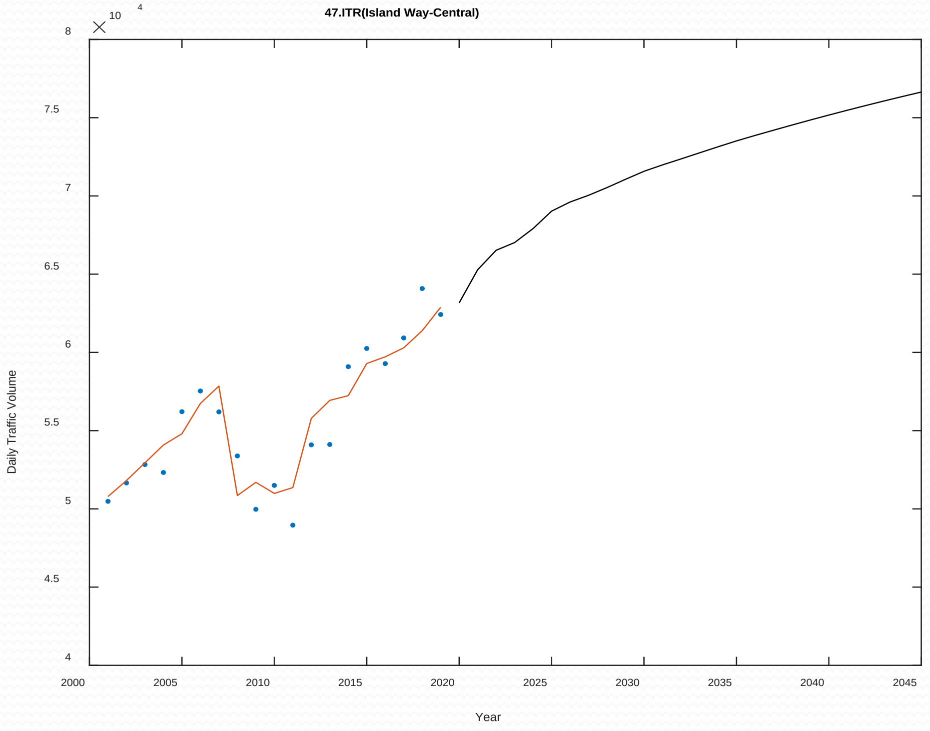
- Advantages:
  - c_i reflects intervention under the impact of great recession
  - Accounts for the effects of population growth and development trips
  - Structured as a nonlinear MA(1) time series model, while maintaining the property of flattening growth pattern when reaching or exceeding roadway capacity



The Proposed Logistic Model

- The adjusted RMSE%

AADT	Adjusted SERPM model (%)	Calibrated ITE model (%)	Proposed Logistic model (%)
≤1,000	NA	NA	NA
>1,000–2,500	108.6 (6)	32.3 (8)	NA
>2,500–5,000	74.6 (27)	18.4 (32)	13.9 (2)
>5,000–10,000	48.4 (111)	16.1 (58)	20.2 (17)
>10,000–15,000	39.5 (127)	10.1 (81)	19.4 (38)
>15,000–25,000	32.4 (190)	7.6 (187)	10.4 (136)
>25,000–50,000	19.8 (303)	6.2 (413)	6.9 (324)
>50,000	18.1 (73)	7.8 (106)	4.4 (53)
All Groups	27.1 (837)	8.4 (885)	7.5 (570)



Synthesis of Model Outputs

- The model assigned volumes are synthesized using the weights determined by the adjusted RMSE% from each volume group
- Weights for three model outputs were calculated as the inverse of the adjusted RMSE%
- Depending on the volume group, these weights were determined as 10%-16% for ABM model, 32%-55% for ITE two-step model and 31%-54% for the logistic model

AADT	RMSE (%)			Weights		
	SERPM	ITE	Logistic	SERPM	ITE	Logistic
≤1,000	NA	NA	NA	1/3	1/3	1/3
>1,000–2,500	108.6	32.3	NA	0.129	0.435	0.435
>2,500–5,000	74.6	18.4	17.4	0.107	0.433	0.46
>5,000–10,000	48.4	16.1	21.0	0.158	0.476	0.365
>10,000–15,000	39.5	10.1	17.9	0.14	0.55	0.309
>15,000–25,000	32.4	7.6	11.0	0.122	0.519	0.359
>25,000–50,000	19.8	6.2	7.2	0.144	0.462	0.394
>50,000	18.1	7.8	4.7	0.139	0.322	0.539

Conclusions

- The TPA adjustment logic reduces the overall RMSE% from 36.8% for the original SERPM down to 27.1% for the adjusted SERPM, their RMSE% in every volume group still fail to meet the accuracy standard
- the logistic model outperforms the ITE model by a small margin (7.5% vs 8.4%), with higher accuracy found in the large volume group
- Despite of being more advantageous than the ABM in terms of count reconciliation, the ITE and logistic models should never be intended to be a replacement. They can be valuable supplemental tools to enhance the count accuracy through the synthesizing method introduced here
- Use the discrepancy between the actual and modeled link counts as a "direct" criterion to be minimized in the calibration process; migrate the capacity-restrained UE assignment algorithm to SUE counterpart; etc.
- Incorporate rich temporal traffic information / model into SERPM

Questions?
Comments?

Chang-Jen Lan, Ph.D, P.E.
cjl@jupiter.fl.us; 561-741-2538