INDOT Traffic Forecasting Tool
Online R-Based Version

presented to
Southeast Florida Model Users Group

Presented by
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March 15, 2019
TFT Introduction

- A customized R application to facilitate INDOT’s long range traffic forecasting activities at project level
- Earlier TFT – developed in 2006.
- Existing TFT v3.0 – developed in 2017
  - GISDK based post-processor
  - TransCAD license required to use the post-processor
  - Input data in native TransCAD format (DBD, BIN)
  - Up to 15 links for analysis at a time
  - Reports & graphs in BIN format
TFT Introduction (Cont.)

- TFT v4.0 *(for this presentation)* – This is currently a working version and INDOT hasn't made decision regarding the official final version
  - Interactive online tool
  - Easy to access and use by every individual with access to internet
  - Customized base year & future year for analysis
  - Latest traffic counts throughout Indiana
  - Utilization of the latest ISTDM
  - Various traffic forecasting methods
  - Analysis of multiple links at a time *(No limit)*
  - Enhanced output visualization (powered by R)

- Minimizes staff requirements, reduces potential method & calculation errors

- Evolved version based on tools for Kentucky and Tennessee
Why R?

- An open-source & emerging programming language for travel demand modeling
- Efficient data management of multiple links at a time
- Powerful graphing capability for better output visualization
- “Live” graphs
- .HTML output files – extremely convenient for info dissemination
ISTDM 8*

- 4-step model (TransCAD 7)
- Coverage – entire IN + partial IL, KY, MI, OH
- 4,915 zones & 61,410 links
- Modes
  - auto, freight, LD transit
  - tolling
- Model years 2015 – 2045 with 10-year increment

* This version is currently under development and the specific info provided here might change
Traffic Data

- INDOT’s Traffic Count Database System (TCDS)
- Use recent data (2001 – 2015)
- Tag INDOT’s Traffic Section & count stations GIS layers to ISTDM 8 network
- Cover all segments of state owned roads
Forecasting Fundamentals

- **Traffic Estimation/Forecast Methods**
  - Linear
  - Regression
  - Exponential (Annual Growth Factor)
  - Adjusted Exponential (Indiana Traffic Growth Profile)
  - NCHRP 255 Calibration Procedure: average of difference and growth factor methods.

**Used Data**
- 2001 – 2015 traffic counts (as many as 15 data points per location)
- ISTDM8 model volume (2 data points per location – base year & future year)

- **Capacity Estimation (by Level of Service)**
Linear Model

\[ P_t = P_b + s(t - b) \]

Where,

\[ P_b = \text{traffic volume in year } b \]
\[ P_t = \text{traffic volume in year } t \]
\[ s = \text{annual growth increment, which is defined as } s = \frac{P_t - P_b}{t - b} \]

\[ s = \frac{46561 - 31123}{2016 - 2002} = 1102.71 \]

<table>
<thead>
<tr>
<th>Year</th>
<th>AADT</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>31,123</td>
</tr>
<tr>
<td>2003</td>
<td>33,288</td>
</tr>
<tr>
<td>2004</td>
<td>31,753</td>
</tr>
<tr>
<td>2005</td>
<td>33,231</td>
</tr>
<tr>
<td>2006</td>
<td>33,611</td>
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<tr>
<td>2007</td>
<td>33,403</td>
</tr>
<tr>
<td>2008</td>
<td>35,688</td>
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<td>2009</td>
<td>41,020</td>
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<td>2010</td>
<td>40,435</td>
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<td>2011</td>
<td>41,041</td>
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<tr>
<td>2012</td>
<td>41,246</td>
</tr>
<tr>
<td>2013</td>
<td>41,455</td>
</tr>
<tr>
<td>2014</td>
<td>42,447</td>
</tr>
<tr>
<td>2015</td>
<td>42,998</td>
</tr>
<tr>
<td>2016</td>
<td>46,561</td>
</tr>
</tbody>
</table>

\[ Y = 31123 + 1102.71 (X - 2002) = -2176502.42 + 1102.71 X \]
Regression Model

\[ \hat{P}_t = a + b \times t \]

Where,

\( \hat{P}_t \) = traffic volume in year \( t \)

\( a \) = intercept

\( b \) = slope

\( a = -1986759.17 \)

\( b = 1008.04 \)
Exponential Model

\[ P_t = P_b \times (1 + r)^{t-b} \]

Where,

\( P_b \) = traffic volume in year \( b \)
\( P_t \) = traffic volume in year \( t \)

\( r \) = annual growth rate, which is defined as \( r = \left(\frac{P_t}{P_b}\right)^{\frac{1}{t-b}} - 1 \)

\[ r = \left(\frac{46561}{31123}\right)^{\frac{1}{2016-2002}} - 1 = 2.92\% \]
Indiana Traffic Growth Profile

- Sometimes, it’s necessary to adjust abnormal annual growth rate for long range traffic forecasting, due to raw data deficiency
  - Insufficient historical counts
  - Significant short-term variations caused by transient local event (e.g., land use development, new roadway projects)
Indiana Traffic Growth Profile

- Use Q-Q plot to filter outliers (normally distributed data should follow a straight line with correlation coef. = 1.0).
- Find & delete the outliers from the analysis (Excel-based).

Example: Rural Interstate (raw data)

Example: Rural Interstate (cleaned data)

![Q-Q Plot](chart1.png)

- correlation coef. = 0.89

![Q-Q Plot](chart2.png)

- correlation coef. = 0.99
## Indiana Traffic Growth Profile (cont.)

### Cleaned Data

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Rural</th>
<th></th>
<th></th>
<th>Urban</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Mean</td>
<td>Upper</td>
<td>Lower</td>
<td>Mean</td>
<td>Upper</td>
</tr>
<tr>
<td>1 - Interstate</td>
<td>0.46%</td>
<td>0.88%</td>
<td>1.31%</td>
<td>1.04%</td>
<td>1.28%</td>
<td>1.52%</td>
</tr>
<tr>
<td>2 - Other Freeway or Expressway</td>
<td>0.88%</td>
<td>1.89%</td>
<td>2.90%</td>
<td>0.59%</td>
<td>1.13%</td>
<td>1.67%</td>
</tr>
<tr>
<td>3 - Other Principal Arterial</td>
<td>0.07%</td>
<td>0.26%</td>
<td>0.46%</td>
<td>-0.02%</td>
<td>0.13%</td>
<td>0.29%</td>
</tr>
<tr>
<td>4 - Minor Arterial</td>
<td>-0.08%</td>
<td>0.08%</td>
<td>0.25%</td>
<td>0.45%</td>
<td>0.57%</td>
<td>0.70%</td>
</tr>
<tr>
<td>5 - Major Collector</td>
<td>-0.06%</td>
<td>0.02%</td>
<td>0.10%</td>
<td>0.07%</td>
<td>0.33%</td>
<td>0.60%</td>
</tr>
<tr>
<td>6 - Minor Collector</td>
<td>-1.61%</td>
<td>-0.61%</td>
<td>0.39%</td>
<td>0.57%</td>
<td>0.84%</td>
<td>1.11%</td>
</tr>
<tr>
<td>7 - Local</td>
<td>-1.39%</td>
<td>-0.56%</td>
<td>0.26%</td>
<td>1.01%</td>
<td>1.44%</td>
<td>1.87%</td>
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</table>
## Indiana Traffic Growth Profile (cont.)

### Cleaned Data

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Rural</th>
<th>99% CI - Lower</th>
<th>Mean</th>
<th>99% CI - Upper</th>
<th>Urban</th>
<th>99% CI - Lower</th>
<th>Mean</th>
<th>99% CI - Upper</th>
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<td>0.29%</td>
</tr>
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<td></td>
<td>-0.08%</td>
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<td></td>
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<td>1.11%</td>
</tr>
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<td></td>
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<td>-0.56%</td>
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<td></td>
<td>1.01%</td>
<td>1.44%</td>
<td>1.87%</td>
</tr>
</tbody>
</table>

### Raw Data

<table>
<thead>
<tr>
<th>Functional Classification</th>
<th>Rural</th>
<th>Min</th>
<th>Mean</th>
<th>Max</th>
<th>Urban</th>
<th>Min</th>
<th>Mean</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Interstate</td>
<td></td>
<td>-42.53%</td>
<td>0.83%</td>
<td>39.31%</td>
<td></td>
<td>-34.31%</td>
<td>1.21%</td>
<td>33.52%</td>
</tr>
<tr>
<td>2 - Other Freeway or Expressway</td>
<td></td>
<td>-10.65%</td>
<td>1.89%</td>
<td>14.98%</td>
<td></td>
<td>-46.94%</td>
<td>0.54%</td>
<td>41.54%</td>
</tr>
<tr>
<td>3 - Other Principal Arterial</td>
<td></td>
<td>-26.08%</td>
<td>-0.22%</td>
<td>23.11%</td>
<td></td>
<td>-65.92%</td>
<td>-0.06%</td>
<td>57.37%</td>
</tr>
<tr>
<td>4 - Minor Arterial</td>
<td></td>
<td>-64.81%</td>
<td>0.00%</td>
<td>33.51%</td>
<td></td>
<td>-65.32%</td>
<td>0.33%</td>
<td>46.55%</td>
</tr>
<tr>
<td>5 - Major Collector</td>
<td></td>
<td>-58.93%</td>
<td>-0.50%</td>
<td>62.66%</td>
<td></td>
<td>-79.46%</td>
<td>0.35%</td>
<td>112.86%</td>
</tr>
<tr>
<td>6 - Minor Collector</td>
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<td>-32.24%</td>
<td>-0.46%</td>
<td>68.87%</td>
<td></td>
<td>-46.31%</td>
<td>-1.29%</td>
<td>17.75%</td>
</tr>
<tr>
<td>7 - Local</td>
<td></td>
<td>-56.53%</td>
<td>-1.26%</td>
<td>45.97%</td>
<td></td>
<td>-52.38%</td>
<td>-0.07%</td>
<td>10.66%</td>
</tr>
</tbody>
</table>
### Indiana Traffic Growth Profile (cont.)

**Cleaned Data**

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<td>1.44%</td>
<td>1.87%</td>
</tr>
</tbody>
</table>

\[
GF_{adj} = \begin{cases} 
  CI_{99\%,l}, & \text{if } GF < CI_{99\%,l} \\
  GF, & \text{if } CI_{99\%,l} \leq GF \leq CI_{99\%,u} \\
  CI_{99\%,u}, & \text{if } GF > CI_{99\%,u} 
\end{cases}
\]
NCHRP 255 Adjustment Procedure

- **Ratio adjustment**
  \[ A_{ratio} = \frac{COUNT}{A_b} \times A_f \]

- **Difference adjustment**
  \[ A_{difference} = (COUNT - A_b) + A_f \]

- **Final adjustment**
  \[ RA_f = \frac{A_{ratio} + A_{difference}}{2} \]

where:

- \( COUNT \) = base year traffic count
- \( A_b \) = base year model volume
- \( A_f \) = future year model volume
- \( A_{ratio} \) = future year volume based on ratio adjustment
- \( A_{difference} \) = future year volume based on difference adjustment
- \( RA_f \) = final adjusted future year volume
Capacity Estimation (by LOS)

- **LOS E Capacity:**
  - ISTDM8 daily capacity estimates

- **LOS A-D Capacity**
  - LOS E Capacity × reduction factor
  - Reduction factor: Highway Capacity Manual (HCM) Level of Service criteria by facility type & speed
  - Widely used by Indiana Department of Transportation (INDOT)
Data

- All the required data is deployed to the hosting server along with the R scripts and related files
- The files are not visible to the users
- Any changes needed should be made by the admin and then redeployed to the hosting server
Data (cont.)

- ISTDM8 Loaded Network (Base Years) – shapefiles

Count Station ID added in network to join with Historical Data
• **Historical Data – CSV file**

- **AADT counts for the most recent 15 years (2001, 2002 ... 2015)**

- K- Factor

- Area Type and Functional Classification

- Truck Percentage

- Count

- Station ID
Data (cont.)

- Future year total volumes by link ID – CSV file

<table>
<thead>
<tr>
<th>Network Link ID</th>
<th>Total Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>28574</td>
<td>16101.43</td>
</tr>
<tr>
<td>28580</td>
<td>2035.799</td>
</tr>
<tr>
<td>28586</td>
<td>2035.799</td>
</tr>
<tr>
<td>28644</td>
<td>16101.43</td>
</tr>
<tr>
<td>28738</td>
<td>4085.333</td>
</tr>
<tr>
<td>29380</td>
<td>16101.43</td>
</tr>
<tr>
<td>29405</td>
<td>9425.651</td>
</tr>
<tr>
<td>29437</td>
<td>13975.56</td>
</tr>
<tr>
<td>29526</td>
<td>2035.799</td>
</tr>
<tr>
<td>29541</td>
<td>11939.76</td>
</tr>
<tr>
<td>29547</td>
<td>11701.58</td>
</tr>
<tr>
<td>29564</td>
<td>2732.19</td>
</tr>
<tr>
<td>29583</td>
<td>2732.19</td>
</tr>
<tr>
<td>29606</td>
<td>9425.651</td>
</tr>
<tr>
<td>29631</td>
<td>2732.19</td>
</tr>
</tbody>
</table>
Online TFT Application Tabs
“Quick Guide” Tab

- Brief step-by-step instructions on how to use the online tool (There will be detailed documentation on all the steps and analysis of the outputs)

1. **Preprocess Data**
   - a. Select the desired base and future year. At this point please only select 2015 for base year and 2035 for future year for the demo purposes.
   - b. Click the Pre-Process Data button and wait for a message stating the completion of the process.

2. **Select Links**
   - It may take up to a minute or two for the map to load! Do not switch among tabs before the map is loaded.
   - a. Select the County where the desired roadway exists.
   - b. Zoom in and pan around to find the exact link of interest (only Green links have available counts).
   - c. Click on the desired Green links in the map to select them. You should see a list of the selected link IDs appear below the map, click again on the same link to remove it from the selected links list.
   - d. Once you are done selecting Desired links you can move to the next tab. Note that you can come back to this tab at any time to select more links.

3. **Historical Data**
   - a. Select a link ID and click the button below it. A table will be displayed below the button with available Historical count data for the link.
   - b. Change the link ID from the dropdown window and click the button again to update the table with the info for the new selected link.

4. **Estimate**
   - a. Select a link ID and click the button below it. A table and a graph will be displayed below the button with Estimation data for the link (it may take a few seconds for the data to appear).
   - b. Change the link ID from the dropdown window and click the button again to update the table and graph with the info for the new selected link.

5. **Forecast**
   - a. Select a link ID and click the button below it. A table and a graph will be displayed below the button with Forecast data for the link (it may take a few seconds for the data to appear).
   - b. Change the link ID from the dropdown window and click the button again to update the table and graph with the info for the new selected link.
“Preprocess” Tab

Select desired base and future year scenarios

- Note that additional scenarios can only be added by the admin
Click “Pre-process Data” button to process data for each link:

- Estimate capacities by LOS
- Join Base Year model network with historical traffic counts and the future link volume data
- A message will pop up to confirm the completion of pre-processing data.
“Select Links” Tab (cont.)

- *It may take up to a minute or two for the map to load! Do not switch among tabs before the map is loaded*

- A dropdown menu is provided for easier navigation through the network by choosing the County where desired roadway exists

- The highlighted green links are the ones with available historical count data *(the final version will cover all state-owned roads)*

- Once clicked, the link will be highlighted red and link ID of the selected link will be displayed at the bottom of the page
“Select Links” Tab (cont.)

- Clicking the non-highlighted links will trigger a warning message

Message

There is no available data for link 110009889! Please only select highlighted green links
“Select Links” Tab (cont.)

- Selected links can be individually unselected by re-clicking them or can be unselected all at once by clicking the “Clear All Selected Links” button.
“Historical Data” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Historical Data Report” to generate the table with historical information
“Estimation” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Estimate Report” to generate the estimate graph and table
“Estimation” Tab

• All the selected link IDs can be seen in the dropdown menu
• User can select the desired link ID and then click “Generate Estimate Report” to generate the estimate graph and table
“Estimation” Tab (cont.)

“Report and Graph” HTML Report

• Download Estimation Graphs (By default will be saved under the browser’s main download folder)
  • Static jpg, png, or pdf file

Select desired format and click the “Download the plot” button to save the chart

💡 “Estimate Graphs – Link XXX.jpg” → XXX is the link ID
“Estimation” Tab (cont.)

“Report and Graph” HTML Report

• Save the entire HTML file to Dropbox
  • The saved HTML file has live charts and can be shared with others (they only need a web browser to open the file)

💡 “EstimateReport_LinkXXX.html” → XXX is the link ID
“Report and Graph” HTML Report

- Saved HTML file inside Dropbox folder (still "live" plots)
“Forecast” Tab

- All the selected link IDs can be seen in the dropdown menu.
- User can select the desired link ID and then click “Generate Forecast Report” to generate the forecast graph and table.
“Forecast” Tab

- All the selected link IDs can be seen in the dropdown menu
- User can select the desired link ID and then click “Generate Forecast Report” to generate the forecast graph and table
“Forecast” Tab (cont.)

“Report and Graph” HTML Report

- Download forecasting plot as .JPG, PNG, or PDF
- Save the entire HTML file (inside Dropbox folder)

Select desired format and click the “Download the plot” button to save the plot

Click the “Save HTML file” button to save the entire report as HTML file

“ForecastReport_LinkXXX_.html” ➔ XXX is the link ID
Acknowledgements

- Johnny Han (jhan@corradino.com) – Corradino Indianapolis.
- Roy Nunnally, Greg Katter, Korey Chu – Indiana DOT
Questions ?