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Using Empirical (real-world) Transportation Data to Extend Travel Demand Model Capabilities

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Beyond Peak Hour Volume-to-Capacity: Developing Hours of Congestion

Mike Mauch
DKS Associates
Presentation Overview

- Introduction to the Hours of Congestion (HOC) project
- Data sources – PORTAL and tube counts
- Observed trends in the count data
- HOC model goodness of fit
- Peak Spreading
- Observed trends and forecasting “hours of congestion”
- Concluding Remarks
How Can Transportation Decisions Be Made When Standards Are Not Meaningful?

- What does it mean when peak hour volume to capacity (v/c) ratios far exceed 1.0?
- What is the difference between a peak hour v/c ratio of 1.3 and 1.6? How much worse is congestion on the facility?
- Evaluating only peak hour level-of-service (LOS) provides myopic understanding of congestion.
- A performance measure of the “duration” of congestion is needed to evaluate networks in these conditions.
Current Regional Travel Demand Models Are Not Built To Predict Congestion Duration & Peak-Spreading

- Trips are developed for daily trip purposes
- Peak period trip tables are built with fixed time-of-day factors
  - **Portland Metro Model Time Periods**
    - AM Peak (7AM - 9AM, 2 hours)
    - Midday Peak (Noon - 1PM, 1 hour)
    - PM Peak (4PM - 6PM, 2 hours)
- Network congestion affects trip distribution, mode choice, and assignment, but excess demand is not forced into shoulder periods
Congestion Duration Analysis Can Provide Decision Makers Insight Into the Reality of Congestion

- If financial constraints, land use forecasts, and policies on facility sizing = severe peak hour failure, how many hours of the day are congested?
Hours of Congestion (HOC) Approach: Data Mining to Build a Travel Demand Model Post-Processing Tool

Data Mining Sources

- PORTAL Data (Database of Freeway Loop Detectors) – 4 yrs of data
- ATR Data (Database of Permanent Count Recorders) – 4 yrs of data
- Roadway Tube Counts (Sample Daily Hourly Profiles) – 100+ data points
- Bus GPS Records (Database of Corridor Travel Speed) – 6 weeks of data
Data Mining Must Include Data Cleaning

- Data Screening Process
  - Identify Locations of Interest
  - Filter to General Purpose Lanes
  - Remove weekends and holidays
  - Review data quality diagnostics and filter out “suspect” data

665 Loop Detector Locations

- 455 Valid Detectors
Step #1: Can Daily Traffic Volume Be Predicted From Peak Period & Midday Data Points?

\[
ADT = 1.30 \times Vols_{AM-2} + 10.67 \times Vols_{Midday-1} + 1.58 \times Vols_{PM-2}
\]
Step #1: Can Daily Traffic Volume Be Predicted From Peak Period & Midday Data Points?

> summary(lm(ADT~AM2+Midday1+PM2+(-1), data=ODOT))

Call: lm(formula = ADT ~ AM2 + Midday1 + PM2 + (-1), data = ODOT)

Residuals:

                Min       1Q   Median       3Q      Max
-5696.49   -97.86   578.70  1183.60  4131.34

Coefficients:

            Estimate Std. Error t value Pr(>|t|)
AM2      1.30360    0.07008   18.60   <2e-16 ***
Midday1  10.66800    0.20618   51.74   <2e-16 ***
PM2      1.57994    0.05039   31.35   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1544 on 579 degrees of freedom
Multiple R-squared: 0.9987,     Adjusted R-squared: 0.9987
F-statistic: 1.465e+05 on 3 and 579 DF,  p-value: < 2.2e-16

\[ ADT = 1.30 \cdot Vols_{AM-2} + 10.67 \cdot Vols_{Midday-1} + 1.58 \cdot Vols_{PM-2} \]
Step #2: Can Hourly Traffic Volume Be Predicted With Daily, Peak Period & Midday Data Points?
Step #2: Can Hourly Traffic Volume Be Predicted With Daily, Peak Period & Midday Data Points?

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>f(ADT)</th>
<th>f(AM-2hr)</th>
<th>f(MD-1hr)</th>
<th>f(PM-2hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midnight - 1 AM</td>
<td>0.059</td>
<td>-0.121</td>
<td>-0.391</td>
<td>-0.091</td>
</tr>
<tr>
<td>1 - 2 AM</td>
<td>0.048</td>
<td>-0.085</td>
<td>-0.342</td>
<td>-0.081</td>
</tr>
<tr>
<td>2 - 3</td>
<td>0.054</td>
<td>-0.078</td>
<td>-0.464</td>
<td>-0.109</td>
</tr>
<tr>
<td>3 - 4</td>
<td>0.044</td>
<td>-0.051</td>
<td>-0.329</td>
<td>-0.088</td>
</tr>
<tr>
<td>4 - 5</td>
<td>0.061</td>
<td>-0.019</td>
<td>-0.480</td>
<td>-0.138</td>
</tr>
<tr>
<td>5 - 6</td>
<td>0.110</td>
<td>0.089</td>
<td>-0.928</td>
<td>-0.283</td>
</tr>
<tr>
<td>6 - 7</td>
<td>0.077</td>
<td>0.457</td>
<td>-0.916</td>
<td>-0.195</td>
</tr>
<tr>
<td>7 - 8</td>
<td></td>
<td></td>
<td>0.523</td>
<td></td>
</tr>
<tr>
<td>8 - 9</td>
<td></td>
<td></td>
<td>0.477</td>
<td></td>
</tr>
<tr>
<td>9 - 10</td>
<td>0.029</td>
<td>0.205</td>
<td>0.252</td>
<td>-0.113</td>
</tr>
<tr>
<td>10 - 11</td>
<td>0.026</td>
<td>0.076</td>
<td>0.551</td>
<td>-0.105</td>
</tr>
<tr>
<td>11 - Noon</td>
<td>0.010</td>
<td>0.039</td>
<td>0.835</td>
<td>-0.053</td>
</tr>
<tr>
<td>Noon - 1 PM</td>
<td></td>
<td></td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>1 - 2 PM</td>
<td>0.012</td>
<td>-0.044</td>
<td>0.841</td>
<td>0.032</td>
</tr>
<tr>
<td>2 - 3</td>
<td>0.017</td>
<td>-0.103</td>
<td>0.676</td>
<td>0.150</td>
</tr>
<tr>
<td>3 - 4</td>
<td>0.010</td>
<td>-0.058</td>
<td>0.172</td>
<td>0.411</td>
</tr>
<tr>
<td>4 - 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 - 7</td>
<td>0.046</td>
<td>-0.139</td>
<td>0.168</td>
<td>0.138</td>
</tr>
<tr>
<td>7 - 8</td>
<td>0.069</td>
<td>-0.236</td>
<td>0.159</td>
<td>-0.044</td>
</tr>
<tr>
<td>8 - 9</td>
<td>0.072</td>
<td>-0.241</td>
<td>0.034</td>
<td>-0.066</td>
</tr>
<tr>
<td>9 - 10</td>
<td>0.085</td>
<td>-0.265</td>
<td>-0.111</td>
<td>-0.102</td>
</tr>
<tr>
<td>10 - 11</td>
<td>0.089</td>
<td>-0.231</td>
<td>-0.307</td>
<td>-0.141</td>
</tr>
<tr>
<td>11 - Midnight</td>
<td>0.082</td>
<td>-0.195</td>
<td>-0.422</td>
<td>-0.123</td>
</tr>
</tbody>
</table>
Result: A Tool That Can Estimate & Graphically Display Hourly Volume Profiles
Result: A Tool That Can Estimate & Graphically Display Hourly Volume Profiles

[Graph showing estimated and empirical volume profiles for US-99 E -- SE McLoughlin Blvd N/O SE Park Ave, Year 2005. The graph displays hourly volume data from midnight to 11 midnight, with estimated and empirical curves.]
Step #3: Accounting For Peak “Spreading”

Table 4: PM Peak Spreading Factors

<table>
<thead>
<tr>
<th>Time</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 – 3 PM</td>
<td>16.0%</td>
</tr>
<tr>
<td>3 – 4 PM</td>
<td>17.4%</td>
</tr>
<tr>
<td>4 – 5 PM</td>
<td>25.0%</td>
</tr>
<tr>
<td>5 – 6 PM</td>
<td>20.1%</td>
</tr>
<tr>
<td>6 – 7 PM</td>
<td>16.0%</td>
</tr>
<tr>
<td>7 – 8 PM</td>
<td>5.0%</td>
</tr>
</tbody>
</table>
The Hours of Congestion Tool Helps Identify and Assess Locations for Operations Improvements

Lower Boones Ferry Road (northbound), 2035
The results of the Hours of Congestion sample corridor analysis reasonably match empirical data considering the accuracy of raw model data.

The network plots generated with the Hours of Congestion results are easy to graphically present and explain.

The Hours of Congestion application is flexible enough to be applied to more focused corridor studies with post-processed volume data used as inputs.
The Hours of Congestion data and network plots should be viewed critically, as queue spillbacks and the corridor-wide impact on hours of congestion is not captured with this link specific application. This is similar to conducting traffic signal analysis using isolated HCM methodology instead of coordinated corridor analysis in Synchro, or looking at traditional model link v/c plots where congestion does not impact upstream or downstream results.

Overall, the link-based application is recognized as not being as robust as a trip-table based Dynamic Traffic Assignment (DTA) or activity based modeling tool, but it is reasonable as an interim analysis tool applied to four-step travel model volumes over the next few years as Metro develops a more robust travel model. Even though the results of the Hours of Congestion analysis does not adjust trip tables and/or reassign traffic, the resulting application is quite useful at a macroscopic level as a prioritization and general policy tool, providing valuable information on levels (hours) of congestion not otherwise available.
Introducing Hours of Congestion Into the Transportation Planning Process

Legend

Hours of Congestion

V/C > 1.00

- 0 hours
- 1 - 2 hours
- 3 - 6 hours
- 7 - 12 hours
- 13 - 15 hours

2035 Hours of Severe Congestion (V/C > 1.00)
Forecasting the Duration of Congestion Improves Regional Transportation Discussions

- Hours of Congestion provides a duration measure for congested urban networks
- Hours of Congestion adds a new dimension to understanding key regional bottlenecks
- Hours of Congestion helps identify and assess locations for operations improvements
- Hours of Congestion provides a comparison to known nationwide severely congested corridors
Hours of Congestion provides a duration measure for congested urban networks.
Hours of Congestion adds a new dimension to understanding key regional bottlenecks
Hours of Congestion helps identify and assess locations for operations improvements
Hours of Congestion provides a comparison to known nationwide severely congested corridors

<table>
<thead>
<tr>
<th>Location</th>
<th>Corridor</th>
<th>Year</th>
<th>Hours of Congestion per Weekday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland, OR</td>
<td>I-5 south of Columbia River</td>
<td>2009</td>
<td>4 to 5</td>
</tr>
<tr>
<td>Portland, OR</td>
<td>I-5 between I-405 and I-84</td>
<td>2035</td>
<td>12 to 14</td>
</tr>
<tr>
<td>New York, NY</td>
<td>I-95</td>
<td>2009</td>
<td>15</td>
</tr>
<tr>
<td>Chicago, IL</td>
<td>I-90/I-94</td>
<td>2009</td>
<td>14</td>
</tr>
<tr>
<td>Los Angeles, CA</td>
<td>US-101</td>
<td>2009</td>
<td>14</td>
</tr>
</tbody>
</table>

HOC – implemented as an embedded model script or post model run Excel-based application
HOC methodology successfully applied to other models – SACOG’s SACMET Model
Questions?

Developing an Empirical Tool for Estimating Duration of Congestion

Questions?