Enhancing Analysis with Probe-Based Data

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Kimley-Horn and Associates, Inc.
June 26th, 2018
ITE Joint Western & Texas District Meeting
BIG DATA

• How can we use BIG DATA to enhance traditional analysis?
• Leverage rich data sources instead of manual collection
• Increase statistical significance, reliability, and usability for future applications
Background
Austin TMC

- Kimley-Horn staffs and operates the Austin TMC
  - Provide daily staffing
  - Detect and respond to equipment malfunctions
  - Work daily with signal timing engineers
  - Support the effort to track and report on system performance
By The Numbers:
AS OF JANUARY 2017

- 998 Traffic Signals
- 140 Travel Time Detection Units
- 576 School Zone Flashers
- 53 Pedestrian Hybrid Beacons
- 291 Monitoring Cameras
- 13 Dynamic Message Boards

City of Austin Traffic Management Center
Austin TMC Performance Measures

- Collect
- Analyze
- Report

- How can we leverage BIG DATA?
Procurement Objectives

• Analyzing travel-related information along City of Austin arterials.
• Identifying trends in traffic flow along arterials using historical data.
• Supporting freeways and arterial traffic operations.

• Collecting and analyze traffic volume data.
• Using data to report performance.
Mining Data On The Road

We use a connected network of sensors, devices, car and drivers to develop robust insights.
Mining Data On The Road

We use a connected network of sensors, devices, car and drivers to develop robust insights.
INRIX Data Process

Normalize
- GPS Vehicle Probe
- Mobile Probe
- Driver Generated Report
- Road Sensor
- Traffic Camera
- Incidents

Map Matching
- Provider Health Processing

Speed Estimation
- Filter points based on location, heading, speed
- Locate points within a road segment

Statistical Refinement
- INRIX FUSION ENGINE
- Filtering
- Spatial Inference
- Temporal Inference
- Optimization
- Bayesian Analytics
- SOE Real-time, historical & predictive blending

Aggregate Speed Data from Probes & Sensors
- Collect data from 400+ sources
- Monitor to ensure proper data point - timely and valid
- Place valid data points on a specific road
- Sensor and Provider Health Processing

Snap Probe Data to Road Network
- Outlier detection to remove statistical anomalies
- Weight data based on source and latency
- Apply “Adaptive Spatial Resolution” to optimize accuracy and relevance

Compute Speed Value Based on Data from Over 15 Mins
- Leverage real-time where possible
- Enhance data to leverage road closures
- Process less than ideal real-time estimates with typical and predictive forecasts

Enhance Precision of Result & Calculate Confidence Factor
Available Data & Metrics

**Data**
- Speed
- Travel Time
- Reference Speed
- Historic Average Speed
- Comparative Speed
- Congestion
- Historic Average Congestion

**Metrics**
- Speed
- Travel Time
- Travel Time index
- Buffer Time
- Buffer Index
- Planning Time
- Planning Time Index
- User Delay Cost
Available Tools

• Congestion Scan
• Bottleneck Ranking
• User Delay Cost Analysis
Congestion Scan
## Bottleneck Ranking

### Summary Table

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Road Name</th>
<th>Intersection</th>
<th>Direction</th>
<th>Impact Factor</th>
<th>Occurrences</th>
<th>Avg Max Duration (min)</th>
<th>Average Max Length (miles)</th>
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<tr>
<td>NB RM 2222</td>
<td>RM-2222 / Ranch Road 2222 / RM 2222 / W Koenig Ln</td>
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<td>RM-2222 / City Park Rd</td>
<td>E</td>
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<td>RM-2222 / Mount Bonnell Rd</td>
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1 to 5 of 11 Entries

### Occurrences

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<th>Max Duration (min)</th>
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<td>11-06</td>
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<td>18</td>
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<tr>
<td>3.86</td>
<td>10-16</td>
<td>18</td>
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</table>

Show 24 hour view
## User Delay Cost

| User Delay Cost | 1 AM | 2 AM | 3 AM | 4 AM | 5 AM | 6 AM | 7 AM | 8 AM | 9 AM | 10 AM | 11 AM | 12 PM | 1 PM | 2 PM | 3 PM | 4 PM | 5 PM | 6 PM | 7 PM | 8 PM | 9 PM | 10 PM | 11 PM | Daily Total |
|-----------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----------|
| User Delay Cost | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K | $2.2K |

### Delay Cost Summary
- **Total Delay Cost:** $2.2K
- **Total Delay Time:** 1 hour
- **Average Delay Cost per Hour:** $2.2K
- **Hourly Delay Cost:** $2.2K

### Notes
- **User Delay Cost:** Calculated based on user data and traffic conditions.
I-95 Corridor Coalition

INRIX Real-Time and Historic Traffic Flow

LIVE NOW
For Roadway Performance Planning: INRIX was chosen as the most accurate, affordable, and comprehensive real-time traffic provider by the I-95 Corridor Coalition.

HIGHLIGHTS:
• Covered 40,000 centerline miles of roadway (8,000 freeway) across 11 states.
• Exceeded all 42 validation checks throughout 11 states and a full range of scenarios.
• INRIX continuously improved data quality across the 6 year span of the VPP.
Data Accuracy

- Other studies have found probe-based data to be similarly accurate to Bluetooth probe data.
- $\Delta$ of more interest than absolute values.
Applications

- Comparing signal timing efforts with before/after studies
  - Monitoring the system in real time
  - Evaluating impacts of TMC operations
  - Identifying trends
  - Analyzing queues
  - Quantifying benefits and costs

- Quantifying delay in terms of costs
- Deep statistical analysis (e.g. reliability)
- Supplementing or replacing travel time runs
- Speed studies
- Other metrics that can be used to communicate effectively with the public or decision-makers
Applications in Austin

Before & After Studies
Austin’s Retiming Effort

- Retime signals every 3 years
  - ~350 signals/year
- Standard Goal – 5% reduction in travel time
  - Improve progression
  - Minimize side street delay
Methodology

• Goals
  • Estimate signal performance before and after
  • Determine success of retiming effort
  • Quantify benefits
• Old way – floating car travel time runs
  • 3 weekday peaks
  • 5 runs each peak each direction
  • 4 MOEs (TT, Speed, Stops, Delay)
• New way – probe-based data
  • 3 weekday peaks
  • 2 months of data
  • 10 MOEs
Measures of Effectiveness

Traditional MOEs
- Travel time (seconds)
- Speed (miles per hour)
- Travel time index
- Delay

Advanced
- Travel Time Confidence Interval
- Speed Confidence Interval
- Travel Time Index Confidence Interval
- Buffer Time
- Planning Index
- User Delay Cost
RM 2222 Corridor
1.8 miles
7 intersections
Retiming Effort

- City of Austin Staff implemented January 2018
- Balanced delay among all approaches
- Maximized progression on RM 2222
- Optimized sequences
- Weekday peaks only
- Existing cycle lengths maintained
Analysis Periods

Before
- October 16th – November 17th, 2017
- One full month
- Prior to implementation
- Avoided
  - Thanksgiving (November 23rd, 2017)
  - Christmas (December 24th & 25th, 2017)
  - New Year’s Eve (December 31st, 2017)
  - New Year’s Day (January 1st, 2018)
- University of Texas in session
- Austin ISD in session

After
- January 22nd – February 23rd, 2018
- One full month
- After implementation
- University of Texas in session
- Austin ISD in session
Analysis Periods

• Weekends are excluded from the City’s annual signal retiming project.

• The City of Austin’s standard assumed peak hours were used for analysis:
  • AM peak period: 6:30 AM - 9:00 AM
  • MD peak period: 9:00 AM – 3:30 PM
  • PM peak period: 3:30 PM - 7:00 PM
Analysis and Results – Traditional MOEs

- Travel Time
- Speed
- Travel Time Index
- Delay
AM Peak Southbound (Peak Direction)
6:30 AM - 9:00 AM
150-second CL
Travel Time -13%
AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL
AM Peak Southbound (Peak Direction)
6:30 AM - 9:00 AM
150-second CL

Delay 48%
PM Peak
Northbound (Peak Direction)
3:30 PM - 7:00 PM
150-second CL

Travel Time -5%
PM Peak Northbound (Peak Direction)
3:30 PM - 7:00 PM
150-second CL

Speed +4%
PM Peak
Northbound
(Peak Direction)
3:30 PM - 7:00 PM
150-second CL

Delay
-15%
Advanced MOEs

- Deeper analysis of signal retiming efforts
- Signal retiming can also improve reliability
- Δ confidence intervals (CI) of the MOEs
- CI = 95\textsuperscript{th} percentile - 5\textsuperscript{th} percentile.
Analysis and Results – Advanced MOEs

- Travel Time Confidence Interval
- Speed Confidence Interval
- Travel Time Index Confidence Interval
- Buffer Time
- Planning Index
Travel Time Index

\[ \text{Travel Time Index} = \frac{\text{Travel Time}}{\text{Free - Flow Travel Time}} \]
Planning Time Index

Planning Time Index = \frac{95\% \text{ Travel Time}}{\text{Free – Flow Travel Time}}

Time: 07:45
2017-10-16 – 2017-11-17 (Mo,Tu,We,Th,Fr): 1.88

SB RM 2222
Buffer Time

Buffer Time = 95% Travel Time - Average Travel Time
AM Peak
Southbound
(Peak Direction)
6:30 AM - 9:00 AM
150-second CL

Travel Time CI
-41%
AM Peak
Southbound (Peak Direction)
6:30 AM - 9:00 AM
150-second CL

Speed CI
-23%
AM Peak
Southbound (Peak Direction)
6:30 AM - 9:00 AM
150-second CL

Buffer Time
-36%
PM Peak Northbound (Peak Direction)
3:30 PM - 7:00 PM
150-second CL

Travel Time CL -30%
PM Peak Northbound (Peak Direction)
3:30 PM - 7:00 PM
150-second CL
PM Peak Northbound (Peak Direction)

3:30 PM - 7:00 PM
150-second CL

Buffer Time -34%
Analysis and Results – User Delay Costs

• Combines probe speed data with volume data provided by the Texas Transportation Institute to estimate the cost of delay experienced by drivers as a result of congestion.
## User Delay Cost

<table>
<thead>
<tr>
<th>Date</th>
<th>AM 1</th>
<th>AM 2</th>
<th>AM 3</th>
<th>AM 4</th>
<th>AM 5</th>
<th>AM 6</th>
<th>AM 7</th>
<th>AM 8</th>
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<th>AM 10</th>
<th>AM 11</th>
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<th>PM 6</th>
<th>PM 7</th>
<th>PM 8</th>
<th>PM 9</th>
<th>PM 10</th>
<th>PM 11</th>
<th>Daily Total</th>
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</tr>
</tbody>
</table>

**Daily Total: $101,903.71**
Monthly User Delay Costs
AM Peak

$23,800+
Monthly User Delay Costs
PM Peak

Overall UDC $98,800+
Analysis Conclusions

• Overall, the RM 2222 retiming effort was a success.
• Travel time was reduced 5% in peak direction AM & PM
• Operations made more reliable/less variable overall
• Significant UDC savings for the City of Austin
• Explosive population growth in Central Texas
Lessons Learned
Before & After Studies
Crowd-Sourced vs. Floating Car

**Crowd-Sourced Data**
- Massive data set
  - Up to years of data
  - 24 hours of data
- Flexible
- Historical
- Continuous
- Collection of links
- Normal day?

**Floating Car TTR**
- Limited data set
  - 5 runs per direction per peak
- Stops
- Context
  - Weather
  - Construction
- Full corridor
- Labor intensive
Benefits of Probe-Based Data

- As accurate as Bluetooth
- No infrastructure investment
- Historical data available
- Large data set
- 24-hr continuous data set
- No additional labor for collection
- No local storage
- Advanced metrics
Challenges of Probe-Based Data

- No stop information
- Lack of context
  - Weather
  - Special events
  - Incidents
  - Temporary lane closures
  - Operational issues
- Combination of links
Questions

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