2019 WORK ZONE SAFETY CONFERENCE
(Presented to NJDOT April 11, 2019)

MAKING WORK ZONES SMARTER-
DATA DRIVEN DECISION MAKING

Tom Brennan
Associate Professor, The College of New Jersey
brennant@tcnj.edu
PURPOSE

- **Overall Objective:** Data Driven Management
- **Objective:** Review current processes, present common issues, and assess future decisions that agencies will need to make
- Lead to a series of case studies on “Smart Work Zone” Management

Source: http://workzone.eng.wayne.edu/

“If you can’t measure it, you can’t manage it”

Peter Drucker
Probe Data Overview

Archived Data Provides
Game Changing
Opportunities for
Agencies
CASE STUDY DESIGN

1. Gather Construction Information
2. Determine Analysis Type
3. Select Performance Metrics
4. Download Retrieve Probe Data
5. Define Performance Thresholds
6. Perform Calculations
7. Interpret Results
8. Intervention/Project Analysis
9. Report
10. Document
CONSTRUCTION INFORMATION

Varies from Agency to Agency

• Work Zone Exposure Data
• Boundaries of Work Zone
  ▪ Advanced and Transition Area
  ▪ Work Zone Activity
  ▪ Post Activity
• Dates Ranges
  ▪ Construction Dates
  ▪ Timeframe for Historical Dates

Source: MUTCD
PERFORMANCE MEASURE SELECTION

Based on Agency Goals

Mobility Performance Measures

- Delay
- Queuing
- Reliability
- Speed
- User Cost
PERFORMANCE MEASURE SELECTION

Also Determine Visualizations
PERFORMANCE THRESHOLDS
Based on Agency Objectives

- Pass/fail State Agency Goal
  - no more than 15 minutes of additional delay
- Regional Level Threshold
  - 20% increase in delay system wide
  - Categories (minor; moderate; and severe)
- Delay acceptable to drivers
  - WZ vs. Non-Work Zone
- Policy
  - Respond to traveler complaints within 24 hours
PERFORM CALCULATIONS

Turn Data into Information

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<th>Jan</th>
<th>Feb</th>
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Avg. $11,050,000
2016 $7,055,000
## Work Zone Mobility Audit

### What is necessary?

| Traffic Flow Data:          | • Probe data; National Performance Measurement Research Data Set (NPMRDS), agency provided data sets: HERE, INRIX, TomTom, etc.  
|                            | • Other agency data: continuous count station data, dedicated counts, etc. (NJ Agencies have Access to INRIX)  |
| Work Zone Activity Data:    | • Project characteristics  
|                            | • Work zone activity information (location, duration, etc.)  
|                            | • Work zone impacts to base roadway conditions (lanes closed, speed limit reductions, etc.)  |
| Data Storage and Analysis Tools: | • Algorithms / process to develop work zone exposure metrics from traffic flow and work zone activity data.  
|                                | • Database/server capable of storing large quantities of data  
|                                | • Data analysis software or proprietary dashboards |
Work Zone Mobility Audit

What is necessary?

Step 1: Determine the Performance Measures of interest for use in your agency or district

Step 2: Acquire the probe data from a public or commercial vendor

Step 3: Compile the collected data using Excel or other preferred analysis tool

Step 4: Create appropriate graphics for quick reference

Step 5: Document and Archive Performance Measures for Future Decision Making

<table>
<thead>
<tr>
<th>Work Zone Traffic Mobility Performance Measures</th>
<th>Delay</th>
<th>Queue</th>
<th>User Cost</th>
<th>Reliability</th>
<th>Resiliency</th>
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<td>Total Delay</td>
<td>Max. Queue Length</td>
<td>Passenger Vehicle Cost</td>
<td>LOTTR</td>
<td>Time to Recover</td>
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<td>Delay per Vehicle</td>
<td>Max. Queue Duration</td>
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<td>Buffer Index</td>
<td>Volume to Capacity</td>
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<td>Delay per VMT</td>
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- Delay
- Total Delay
- Delay per Vehicle
- Delay per VMT

- Queue
- Max. Queue Length
- Max. Queue Duration
- Total Queue Duration

- User Cost
- Passenger Vehicle Cost
- Commercial Vehicle Cost

- Reliability
- LOTTR
- Buffer Index
- Planning Time Index

- Resiliency
- Time to Recover
- Volume to Capacity
Travel Time Distribution Plots

Shows the distribution of travel times in the observation period captured for work year and year prior.

Position of work year line (2015) compared to prior year shows an increase or decrease in travel time.

Increase in travel time
Congestion “Volcano” Plots
Also available for Queue

Shows congestion levels at various points in the work zone corridor progression based on TMC.

Different colors represent different months of the analysis year.

Wider bands show where and when congestion was more significant for further investigation.
## Summary Statistics

<table>
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<th>Summary Statistics</th>
<th>Year prior</th>
<th>Year of</th>
<th>Net change</th>
<th>% change</th>
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<td>Queue Minutes per mile per day</td>
<td>1.2</td>
<td>10.7</td>
<td>+ 9.5</td>
<td>+ 792%</td>
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<td>Minutes of queuing per day</td>
<td>10.1</td>
<td>57.7</td>
<td>+ 47.6</td>
<td>+ 471%</td>
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<td>Congestion Minutes per mile per day</td>
<td>75.1</td>
<td>103.5</td>
<td>+ 28.4</td>
<td>+ 38%</td>
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<td>Delay Minutes per mile per day</td>
<td>43.7</td>
<td>101.8</td>
<td>+ 58.1</td>
<td>+ 133%</td>
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</table>

- Queues are identified by travel speeds less than 15 mph
- Congestion is identified by travel speeds between 15 and 45 mph
- Delay incorporates all travel speeds that are less than the posted speed limit
Determine if there is an issue

- Are any performance thresholds exceeded?

Intervene, if problems are discovered

- Real Time Probe Data: modify WZ configuration/hours
- Historical: Revisit specifications and revise

Document all changes (successes and failures)

- Document WZ successes and failures
- Create reference of historical WZ to prevent Institutional turnover loss.
Document Conditions/Manage Events
Mobility Report Performance Measures

Hours of speed < 45 mph

Almost 2600 hours in a year
Mobility Report Performance Measures

2011 Congestion Hours
Mobility Report Performance Measures

2012 Congestion Hours
Regional Mobility Performance Measures
2017 Bridge Closure

- **Camden County**
  - TMCs
    - Local = 615
    - NJDOT = 404

- **Mercer County**
  - TMCs
    - Local = 615
    - NJDOT = 404

- **Burlington County**
  - TMCs
    - NJDOT = 388

- **I-276 Bridge Closure** (1/20/17)
  - US-1 & Calhoun Bridge
  - NJ-413 Bridge
  - NJ-73 Bridge
  - Betsy Ross Bridge
  - I-676 Bridge

- **Philadelphia, PA**
  - Camden County TMCs
    - NJDOT = 358

- **New York, NY**

- **Burlington**
  - Burlington County TMCs
    - NJDOT = 388

- **US-130**

10 Miles
Regional Mobility Performance Measures
2017 Mean Increase in Percent Travel Time – 3 Counties

Day of the Year January 1 – March 31 (2017)
Regional Mobility Performance Measures
2017 Mean Increase in Percent Travel Time – Roadway Type

Day of the Year January 1 – March 31 (2017)
Regional Mobility Performance Measures
2017 Mean Increase in Percent Travel Time – Roadway Type

Increased Average MTT During Bridge Closure (AM Peak)
Peak at 8:15 AM
Increased Average MTT During Bridge Closure (PM Peak)
Peak at 5:30 PM
Peak at 5:45 PM
Peak at 8:30 AM
Regional Mobility Performance Measures
2017 Mean Increase in Percent Travel Time – Roadway Type
Regional Mobility Performance Measures
2017 Mean Increase in Percent Travel Time – Roadway Type

24-Hours (15-Min Bins)

Winter Storm January 22-24
July 4th Weekend
Memorial Day Weekend
Congestion Extended Past PM Peak in Summer Months

0:00 23:45 12:00

Day of the Year 2016

0 >0 2.5 5 >5

January 22-24
July 4th Weekend
Labor Day Weekend
December 25

Only 614 TMCs used in the Study Area
Study Region
Baseline Corridor Assessment (Needs to be done Statewide)  
2013 I-80

- ~68 Miles of Interstate Highway Crossing NJ
- 166 Traffic Message Channels (TMCs)
- ~90 million 1-minute anonymous probe vehicle speed records analyzed
Baseline Corridor Assessment (Needs to be done Statewide)
2013 I-80

INDIANA MOBILITY REPORTS

2012 Indiana Mobility Report: Full Version

Steve M. Remias, Purdue University
Thomas M. Brennan Jr., Purdue University
Christopher M. Day, Purdue University
Hayley Summers, Purdue University
Edward Cox, INDOT
Deborah Horton, Purdue University
Baseline Corridor Assessment (Needs to be done Statewide)
2013 I-80

**Figure 18.**
Top 20 travel time deficit (TTD) segments throughout the Indiana interstate system.
Baseline Corridor Assessment
2013 I-80

Hours of Increased Travel Time

Mile Markers (East Bound →)

- High Travel Times in December
- Recurring periods of High Travel Times Dropping Off Where I-80 Express Begins ~ MM 60.0

Mile Markers (← West Bound)

- High Travel Times in October
- High Travel Times in January, May, and June
- Recurring periods of High Travel Times Starting Where I-80 Express Ends ~ MM 63.8
- High Travel Times in October/December
Baseline Corridor Assessment
2013 I-80

15-minute Bins (24- Hours)
Baseline Corridor Assessment (Different Perspective)
2013 I-80

Minutes of Delay

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

January 2013
Baseline Corridor Assessment (Different Perspective)
2013 I-80

AM Peak EB Congestion

Minutes of Delay

15 MINUTE BINS IN 24-HOURS

33.4 to 33.7
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

33.7 to 34.5
Baseline Corridor Assessment (Different Perspective)
2013 I-80

AM Peak EB Congestion

15 MINUTE BINS IN 24-HOURS

34.5 to 34.9
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

Minutes of Delay

January 2013

34.9 to 35.0
Baseline Corridor Assessment (Different Perspective)
2013 I-80

AM Peak EB Congestion

15 MINUTE BINS IN 24-HOURS
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

37.7 to 38.1
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

Minutes of Delay

January 2013

38.1 to 39.3
Baseline Corridor Assessment (Different Perspective)
2013 I-80

AM Peak EB
Congestion

15 MINUTE BINS IN 24-HOURS

39.3 to 39.9
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion
0.1 Miles

TCNJ
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Baseline Corridor Assessment (Different Perspective)
2013 I-80

AM Peak EB
Congestion

15 MINUTE BINS IN 24-HOURS
Minutes of Delay

15 MINUTE BINS IN 24-HOURS

Minor Congestion

Baseline Corridor Assessment (Different Perspective)

2013 I-80
Baseline Corridor Assessment (Different Perspective)

2013 I-80

15 MINUTE BINS IN 24-HOURS

Weather Related Delays

Minutes of Delay

January 2013

41.8 to 42.3
Baseline Corridor Assessment (Different Perspective)

2013 I-80

15 MINUTE BINS IN 24-HOURS

42.3 to 42.6
Baseline Corridor Assessment (Different Perspective)
2013 I-80

Weather Related Delays

Minutes of Delay

January 2013

15 MINUTE BINS IN 24-HOURS

42.6 to 43.2
Baseline Corridor Assessment (Different Perspective)
2013 I-80

Minutes of Delay

Weather Related Delays
Incident

15 MINUTE BINS IN 24-HOURS

43.2 to 45.3
Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

AM Peak EB Congestion

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Baseline Corridor Assessment (Different Perspective)
2013 I-80

15 MINUTE BINS IN 24-HOURS

48.3 to 48.6
Baseline Corridor Assessment (Different Perspective)
2013 I-80

Weather Related Delays

15 MINUTE BINS IN 24-HOURS

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Baseline Corridor Assessment (Different Perspective)
2013 I-80

Weather Related Delays

15 MINUTE BINS IN 24-HOURS

56.7 to 63.6

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80
Baseline Corridor Assessment (Different Perspective)
2013 I-80
Baseline Corridor Assessment (Different Perspective)

2013 I-80

Sum =
Baseline Corridor Assessment (Different Perspective)

2013 I-80: 6 months

Westbound Mile Markers 52.5 – 39.6

Feb 9-10 Snow Storm
Baseline Corridor Assessment (Different Perspective)
2013 I-80: 6 months

Westbound Mile Markers 52.5 – 39.6
Mobility Report Performance Measures (Specific Construction)

Outer Loop

460 Hours of Congestion / yr.
Mobility Report Performance Measures

Outer Loop

Congestion Reduced by 200 hours / yr.
Mobility Report Performance Measures

Outer Loop

Congestion Reduced by 200 hours / yr.
I-465 Projects in 2012 (reduced congestion)

- I-74: 200 hours
- Allisonville Rd.: 50 hours
- Sam Jones Exp.: 170 hours
- Sam Jones Exp.: 100 hours
Probe Data Case Studies

1. Typical Work Zone Analysis
2. Assessment of New Work Zone Strategies
3. Improvement of Detour Routes
4. Work Zone Mobility Audits
CONSIDER RECORDS FROM PROBE DATA: RECORDS PER HOUR

Distribution

7.3 Miles
CR 541

NB/SB
4-Months Corridor
Records per Hour
STATISTICS OF ANONYMOUS PROBE DATA: REPORTING DATA

- 9-12 Hrs
- 6-9 Hrs
- 3-6 Hrs
- 0-3 Hrs
- 0 Hrs

14% Not Reporting

0.1% Not Reporting

Hurricane

Recovery
STATISTICS OF ANONYMOUS PROBE DATA: SPEED BINS CAPTURED

4-Months Corridor Travel Speeds

Establishing Speed a Benchmark
Probe / Crash Data (5 miles I-69 Indian)

Transition Into Construction Begins May 1
MOT Plan Changes July 1

Average 1 Crash / Week
Average 6.1 Crashes / Week
Average 0.9 Crashes / Week

4.5 to 5.4
2.9 to 4.5
2.3 to 2.9
1.3 to 2.3
0.9 to 1.3
0.4 to 0.9

Week of
Weighted Congestion Hours

Number of Crash Types
THOUGHTS FOR DISCUSSION

Numerous decisions will need to be made at the agency level

• Work Zone Exposure Data Collection Strategy
• Mobility Data Collection (NPMRDS, Detector-Based, Third Party)
• Performance Measure Strategies
  • Whether to do it or not?
  • What types of Work Zones to monitor/measure?
  • What Performance Measure(s) will you use?
  • What Thresholds will you set?
  • What level of detail will you monitored/measured?
  • What frequency will you monitor/measure?
  • How will a poor performing work zone be managed?

• Higher Level Strategies
  • How will you archive the information?
  • How will you use it in planning future work zones?
  • Will you develop agency-wide performance measures/standards?
  • Will you incentivize/disincentivize contractors based on mobility data?
  • How do you quantify the benefit of performance measurement?
Conclusions & Next Steps

- **Overall**
  - Probe Data has numerous potential work zone applications
  - It can be a tool to improve performance
- **Discussion is still needed on numerous items including:**
  - Activity Data
  - Performance Thresholds
  - Real-Time vs. Archived Data Benefits
  - Mapping these tools into regular operations
- **Research Needed**
  - Investigate Different Work Zone Types: Lane Closures, Patching, Shoulder Closures, Ramp Closures, etc.
  - Investigate and Develop some threshold recommendations
  - Develop base line report ([https://docs.lib.purdue.edu/imr/4/](https://docs.lib.purdue.edu/imr/4/))
  - Create a series of Case Studies using both NPMRDS Data and Third-Party Data