I-95 Corridor Coalition

NJ Pilot Study Testing Potential MAP-21 System Performance Measures Webcast

January 29, 2014

www.I95Coalition.org
Housekeeping Items

For Greatest Participation

– Keep your phone muted until asking a question or speaking (press *6 to mute/unmute individual phone lines)

– Please do not place call “on hold” as your hold music may be heard by the group

– John & Keith will pause and take questions at strategic points in this presentation

– Please state your name and agency before asking your question
Housekeeping Items (continued)

Additional Webcast & Audio Information

– Call 610-662-5569 for difficulties with the web or audio application.

Presentation

• Today’s presentation will be posted to the I-95 Corridor Coalition website on the VPP Feature Page (Project Presentations tab)

• NJDOT & NJTPA are preparing a report detailing this effort. A link to this report will be on the Coalition website when it becomes available.

• Contact Information will be available at the end of this presentation
Welcome

Marygrace Parker
I-95 Corridor Coalition

www.I95Coalition.org

I-95 Corridor Coalition

January 29, 2014
Objectives for Today

1. Give Coalition members an opportunity to ask questions on the potential MAP-21 system performance measures.

2. Provide an opportunity for NJDOT/NJTPA to get feedback on the methodology from Coalition members.
New Jersey Pilot Study
Testing Potential MAP-21 System Performance Measures

John Allen
New Jersey Department of Transportation

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North Jersey Transportation Planning Authority

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New Jersey Department of Transportation

MAP-21
Moving Ahead for Progress in the 21st Century

New Jersey Pilot Study
Testing Potential MAP-21 System Performance Measures
An In-Depth Discussion with the VPP Team

January 29, 2014
Agenda

- Project Approach
- Pilot Corridors
- Data Sources
- Data Gathering & Processing
- Performance Measure Calculations
- Issues & Challenges
- Suggested Next Steps/Additional Considerations

(Note: The ! icon indicates a specific issue/consideration)
Project Approach

- Test AASHTO’s system-level performance measure methodologies for two NJ corridors:
  - Use proposed, as well as alternate formulations & thresholds for delay and reliability
  - Evaluate aggregation methods
  - Assess results - what the values are telling us
  - Note barriers, challenges, assumptions, workarounds

- Develop a Summary Report
  - Provide step-by-step procedures, results, “lessons learned” and recommendations

- Research ways to standardize data analyses and reduce manual processing where possible
Pilot Corridors

Chosen based on regional importance, unique features and familiarity

**Interstate; rural to urban; portion with local & express lanes; toll & free**

- Entire length – 67.8 miles
- Divided into 4 sub-corridors:
  - PA border to I-287 (30.8 miles)
  - I-287 to GSP (22.6 miles)
  - GSP to NJ Tpk (5.4 miles)
  - NJ Tpk to Holland Tunnel (9.0 miles)

**NHS freeway & arterial; limited access & traffic signals; urban, commercial, semi-rural**

- Entire length – 45.3 miles
- Divided into 4 sub-corridors:
  - NJ 138 to GSP (14.3 miles)
  - GSP to US 9 (16.1 miles)
  - US 9 to NJTPK (9.5 miles)
  - NJTPK to Hoes Lane (5.4 miles)
Data Sources

■ Travel Time (Speed) Data
  - Vehicle Probe Project (VPP) Suite
    - Massive Raw Data Downloader
    - Five-minute average
    - Hourly average

■ Vehicle/Truck/Bus
  - NJDOT CMS
  - NJ TRANSIT GTFS
  - Weigh-in-motion (WIM) data

■ Vehicle Occupancy
  - Plan4Safety
  - NJ TRANSIT
Data Gathering & Processing

TRAVEL TIME DATA (VPP SUITE)
Download Raw Probe Data

5-min data for reliability measures; hourly data for delay measures
Import Raw Data Into Access

Use smallest appropriate data types to minimize file size.
Note that timestamp field needs to be imported as Text field.

<table>
<thead>
<tr>
<th>tmc code</th>
<th>measurement tstamp</th>
<th>average_speed</th>
<th>reference_speed</th>
<th>travel time minutes</th>
<th>confidence score</th>
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<td>65.000000000000000</td>
<td>0.05740728476821120800</td>
<td>10.00000000000000</td>
</tr>
</tbody>
</table>
Primary keys help to speed up queries and joins. This table should have only one record for any Timestamp for any TMC.
Convert measurement_tstamp to Date_Time

Timestamp was imported as Text, so need to convert to Date/Time data type via Append Query

Expr1: CDate(Left([measurement_tstamp],19))
“Append” Errors Due to Time Change

- On November 4, 2012 (end of DST), 1:00-1:59 AM occurs twice
- Access does not allow duplication in “Primary Key” fields
- Causes “key violations” in Access
- This is not a cause for concern

![Microsoft Access error message](image)
Access Has 2 Gigabyte File Size Limitation

- Compact your database often!

- Use multiple databases with linked tables
- Alternatively, use another DBMS (e.g., SQL Server, Oracle, mySQL)
Access Is Missing Percentile Function

- Modified one found on the Internet
- Function works with a criteria (similar to “DSum” in Excel)
- Can be called from Totals queries

Function DPercentile(PV As Single, expr As String, domain As String, Optional criteria As String) As Double
'Uses linear interpolation method for percentile values.
Dim dbs As Database
Dim rst As Recordset
Dim lowIndex As Long
Dim numberOfRecords As Long

Set dbs = CurrentDb
If Len(criteria) <> 0 Then
    Set rst = dbs.OpenRecordset("select " & expr & " from " & domain & _
    " where " & criteria & " order by " & expr)
Else
    Set rst = dbs.OpenRecordset("select " & expr & " from " & domain & _
    " order by " & expr)
End If
If rst.EOF Then
    numberOfRecords = 0
Else
    rst.MoveNext
    numberOfRecords = rst.RecordCount
End If

If numberOfRecords = 0 Then
    DPercentile = 0
ElseIf numberOfRecords = 1 Then
    DPercentile = rst(expr)
Else
    trueIndex = (PV / 100 * numberOfRecords) + 0.5
    lowIndex = Int(trueIndex)
    rst.MoveFirst
    rst.Move (lowIndex - 1)
    DPercentile = rst(expr)
    If lowIndex <> trueIndex Then
        rst.MoveNext
        DPercentile = DPercentile + (trueIndex - lowIndex) * _
        (rst(expr) - DPercentile)
    End If
End If

Conflate Volume Segments and TMC Links

- NJCMS uses Standard Route Identifier (SRI) & Milepost
- Need to get SRIs and Mile Posts for TMC links
- ArcGIS tools: Feature Vertices to points, Split Line at Points, Spatial Join, Locate Features Along Routes

### Table

<table>
<thead>
<tr>
<th>Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TMC Codes</strong></td>
</tr>
<tr>
<td>Beginning and ending mileposts</td>
</tr>
</tbody>
</table>

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**January 29, 2014**

New Jersey Pilot Study
Identify Corresponding NJCMS and TMC Links

- CMS links and TMC links are not coincident
- Case 1: Multiple TMC links completely within one CMS link
- Case 2: Multiple CMS links in one TMC link
- Start & Finish Mileposts

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New Jersey Pilot Study
Transfer NJCMS Volumes to TMC Links

- Calculate volume on segment based on the amount of segment corresponding to the TMC link
  - \[ \text{CMSVol} \times (\frac{[\text{Final End MP}] - [\text{Final Start MP}]}{[\text{MP End2}] - [\text{MP Start2}]}) \]
- Sum for each TMC
- End up with database of average day hourly volumes by TMC
Convert Auto Volumes to Passenger Volumes

- Use Average Vehicle Occupancy (AVO) from Plan4Safety crash data

<table>
<thead>
<tr>
<th>Sub-corridor</th>
<th>2008-2010 Vehicles</th>
<th>2008-2010 Occupants</th>
<th>AVO</th>
</tr>
</thead>
<tbody>
<tr>
<td>78A</td>
<td>4,202</td>
<td>5,958</td>
<td>1.42</td>
</tr>
<tr>
<td>78B</td>
<td>4,987</td>
<td>6,542</td>
<td>1.31</td>
</tr>
<tr>
<td>78C</td>
<td>3,075</td>
<td>4,248</td>
<td>1.38</td>
</tr>
<tr>
<td>78D</td>
<td>2,280</td>
<td>3,198</td>
<td>1.40</td>
</tr>
<tr>
<td>18A</td>
<td>781</td>
<td>990</td>
<td>1.27</td>
</tr>
<tr>
<td>18B</td>
<td>755</td>
<td>965</td>
<td>1.28</td>
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<tr>
<td>18C</td>
<td>3,424</td>
<td>4,673</td>
<td>1.36</td>
</tr>
<tr>
<td>18D</td>
<td>1,546</td>
<td>2,015</td>
<td>1.30</td>
</tr>
</tbody>
</table>

- Multiply by Vehicle Volumes
- Results in Passenger Volumes (Auto)
  - Contributes to Annual Person Hours of Delay
Convert NJ TRANSIT buses to Passenger Volumes

- Use NJ TRANSIT GTFS (general transit feed specifications) files
  - Routes & Shapes (Used DisplayGTFSRouteShapes tool)
  - Trips (Individual buses)
  - Stop times (arrival/departure times)
  - Stops (bus stop locations)
- Resultant database of hourly volumes by TMC and day of week

- Multiply by typical bus load factors
  - 45 passengers/bus peak period (peak direction)
  - 20 passengers/bus off-peak
- Results in Passenger Volumes (NJT Buses)
  - Contributes to Annual Person Hours of Delay
Process Truck and Private Bus Volumes

- Use Weigh-in-Motion (WIM) sites
  - Limited availability (4 WIM sites on NJ 18, 3 WIM sites on I-78)
  - Processed to yield hourly truck and bus volumes by day of week
  - Assigned to Sub-corridors
  - WIM sites predominantly in locations without NJ TRANSIT service
    - Bus counts assumed to be private buses

- Results in database of truck/bus volumes

- Truck volumes
  - Used for Truck Delay measure (Annual Hours of Truck Delay)

- (Assumed) Private Bus volumes
  - Added to NJ TRANSIT buses
  - Used for Bus Delay measure
  - Converted to passenger volumes for Annual Person Hours of Delay
Performance Measure Calculations

ANNUAL HOURS OF DELAY

New Jersey Pilot Study

January 29, 2014
AASHTO’s Standing Committee on Performance Management (SCOPM) Formulation for AHD

- Compare hourly travel times with predetermined threshold travel time
- Use hourly travel times for an “Average week”

\[
\text{Delay}_{hr \text{ of day}, \text{day of week}} = \text{Vol}_{hr \text{ of day}} \times \max \left(0, \left(\text{TT}_{hr \text{ of day}, \text{day of week}} - \text{Threshold} \ \text{TT}_{hr \text{ of day}, \text{day of week}}\right)\right)
\]

- \( AHD = 52 \times \left(\sum_{\text{day of week}=1}^{7} \left(\sum_{\text{hr of day}=0}^{23} (\text{Delay}_{hr, \text{day of week}})\right)\right) \)
- Volumes can be for vehicles, persons, trucks, buses, etc.
- Threshold is “agency-specified”
“Average Week” Not Defined by SCOPM

Two Options Considered:

- Find “Example/Typical” week
  - Consider holidays, vacations, events, weather, etc.
- Calculate (“synthetic”) average of hourly travel times by day of week over entire year

Choice: Synthetic average week

- Reproducible annually
- Avoids dealing with above “considerations” of “Example/Typical” week

Example Synthetic Average Week

(TMC 120+04411)

Average travel time

Day of week and hour of day
Range of Threshold Variations Considered

- Freeflow travel time
  - Issues with INRIX “reference speed” values
    - Not fixed throughout 2012
    - Some questionable values discovered
  - Use calculated 15th percentile travel time (using 5-minute data)
    - Same as travel time at 85th percentile speed

- Median travel time over all days
  - Single value

- Median travel time by day of week and hour of day
  - Reflective of “expected” conditions
  - May be more appropriate for reliability threshold

- Maximum throughput travel time (at 85% of the posted speed)
  - Based on Washington State DOT practice

- “Acceptable” travel time
  (at percentage of free-flow travel time that varies based on area type and time of day)

<table>
<thead>
<tr>
<th>Area Type</th>
<th>Peak</th>
<th>Off-peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>167%</td>
<td>133%</td>
</tr>
<tr>
<td>Suburban</td>
<td>133%</td>
<td>118%</td>
</tr>
<tr>
<td>Rural</td>
<td>111%</td>
<td>105%</td>
</tr>
</tbody>
</table>
Threshold Variation Graphical Comparison

Example Link A
(TMC 120+04411)

Average TT
Freeflow TT
Median TT, all days
Maximum Thruput TT
"Acceptable" TT
Median TT, day/hr

Travel time, min

Day of week and hour of day

Sun 12 AM Mon 12 AM Tue 12 AM Wed 12 AM Thu 12 AM Fri 12 AM Sat 12 AM Sun 12 AM

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AHD Visualization for I-78 (TMC-level)

- Shown in Person-Hours of Delay/mile
  - Hourly Person Volume x Travel Time above threshold
  - Person Volume = Vehicle Volume x $AVO_{Subcorr}$ + Bus Passengers
  - Over all days

- Varying Threshold Travel Time Creates Different AHD Results
  - Free-flow travel time
  - Maximum “thru-put” travel time (85% of posted speed)
  - Additional thresholds not shown
    - Yearly median
    - Day/Hour median
    - “Acceptable” travel time
AHD Visualization for NJ 18 (TMC-Level)

Legend
APHD/mile (Freeflow Threshold)
0 - 25,000
25,000 - 50,000
50,000 - 100,000
100,000 - 339,000

Legend
APHD/mile (Max Thruput)
0 - 25,000
25,000 - 50,000
50,000 - 100,000
100,000 - 266,000

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AHD – Threshold Variation Results

- Varying Threshold Travel Time…
  - Free-flow travel time
  - Median travel time (over entire year)
  - Median travel time (for each day of week and hour of day)
  - Maximum throughput (at 85% posted speed)
  - At “acceptable” speeds (based on area type and time of day)

...has resulted in different outcomes

- Each Threshold option has unique policy implications

### Annual Person-Hours of Delay per mile

<table>
<thead>
<tr>
<th>Route</th>
<th>Miles (Both Dir.)</th>
<th>Free-flow</th>
<th>Yearly Median</th>
<th>Day/Hr Median</th>
<th>Max Throughput</th>
<th>&quot;Accept.&quot; Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 Corridor</td>
<td>76.4</td>
<td>21,800</td>
<td>16,000</td>
<td>3,130</td>
<td>12,600</td>
<td>8,950</td>
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<tr>
<td>18A</td>
<td>17.6</td>
<td>2,290</td>
<td>1,050</td>
<td>203</td>
<td>18</td>
<td>0</td>
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<tr>
<td>18B</td>
<td>32.7</td>
<td>190</td>
<td>165</td>
<td>138</td>
<td>68</td>
<td>96</td>
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<td>17.9</td>
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<td>31,400</td>
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<td>73,500</td>
<td>65,200</td>
<td>13,100</td>
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<td>21,800</td>
<td>11,300</td>
<td>19,100</td>
<td>9,480</td>
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<td>61.4</td>
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<td>6,030</td>
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<td>6,080</td>
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<td>18.2</td>
<td>124,000</td>
<td>94,100</td>
<td>26,900</td>
<td>104,000</td>
<td>54,400</td>
</tr>
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</table>
AHD – Alternate Formulation

- SCOPM’s use of an “average week” might underestimate actual annual delay
  - Delay is only counted when below threshold
  - Average may be below threshold, but individual values above threshold

- Using actual hourly data may give a fuller, more accurate accounting of delay
  - Uses all available hourly data

\[
AHD = \sum_{t=12AM \ Jan \ 1}^{11PM \ Dec \ 31} (Vol_{hr \ of \ day} \times \max (0, (TT_t - \text{Threshold } TT_{hr \ of \ day, day \ of \ week})))
\]
AHD – Alternate Formulation Results

- Using all hourly data instead of an hourly data for a calculated “average week” increases the amount of delay
  - Comparing average to threshold is different than comparing individual values to threshold
  - 2012 was a leap year and thus had 366 days vs. 52x7 = 364 days
  - Calculation does take a bit longer
  - Makes comparisons across years somewhat tricky (leap years, “extra” days fall on different days of the week)

### Annual Person-Hours of Delay per mile

<table>
<thead>
<tr>
<th>Route</th>
<th>Miles (Both Dir.)</th>
<th>Calculation Variations (free-flow threshold)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Week</td>
<td>All Hourly Data</td>
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<tr>
<td>18 Corridor</td>
<td>17.6</td>
<td>21,800</td>
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<tr>
<td>18A</td>
<td>17.6</td>
<td>2,290</td>
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<td>52,900</td>
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<tr>
<td>78D</td>
<td>18.2</td>
<td>124,000</td>
</tr>
</tbody>
</table>

New Jersey Pilot Study

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Performance Measure Calculations

RELIABILITY INDEX
RI$_{80}$ SCOPM Formulation

- **Travel Time Multiplier needed to be on time 80 percent of the time**
  - If you happen to be traveling in the five-minute period of the day with the highest 80$^{th}$ percentile travel time
  - Compared to a threshold travel time for that segment, regardless of time of day

- **SCOPM Method**
  - Divide the day into 288 five-minute intervals
  - For each five-minute interval (e.g., 8:00-8:05AM), calculate 80$^{th}$ percentile travel time (TT$_{80}$), across all days (either calendar days or workdays)
  - From the 288 values of TT$_{80}$, select highest value over the entire day (or just over the peak period)
  - $RI_{80} = \frac{\text{Maximum TT}_{80}}{\text{Threshold TT}}$
RI$_{80}$ User-defined Threshold Variations

- **Varying Threshold Travel Time Creates Different RI$_{80}$ Results**
  - Free-flow travel time
  - Yearly Median travel time
  - Maximum Throughput travel time (85% of posted speed)

- **Extreme values**
  - Values under 1.0
    - Worst 80th percentile TT < threshold TT
    - Not a logical multiplier
  - Values above 7.0
    - Worst 80th percentile TT > seven times threshold TT!
Reliability – Alternate Formulation ($TTR_{\text{Max}}$)

- For each of the 288 five-minute intervals
  - Calculate the 80th and 50th percentile travel times, (either over all calendar days or just workdays)
    - $TT_{80}$ and $TT_{50}$
  - Calculate Travel Time Ratio ($TTR_t$)
    - $TTR_t = \frac{TT_{80}}{TT_{50}}$
- Use maximum value of $TTR_t$ ($TTR_{\text{Max}}$)
- Travel Time Multiplier needed to be on time 80 percent of the time
  - If you happen to be traveling in the most unreliable five-minute period of the day
  - Compared to a median travel time for that segment for that five-minute period
- Gives less extreme values
TTR_{\text{Max}} Example – TMC Location
**TTR\textsubscript{Max} Example – TMC Travel Times**

Max TT80 = 4.19 min (7:50AM)
Free-flow TT = 0.56 min
Annual Median TT = 0.59 min
RI\textsubscript{80} = 7.1 or 7.5

Max TT50 = 1.73 min (7:55AM)

TTR\textsubscript{Max} = 4.8 (8:55AM)
Maximum unreliability is not at same time as maximum travel time

New Jersey Pilot Study
Draft – Subject to Change
**TTR_{Max} – Results Visualization**

- More moderate values
  - None < 1.0
  - Max value of 4.8

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**Legend**
- < 1.0
- 1.0 - 1.2
- 1.2 - 1.5
- 1.5 - 2.0
- > 2.0

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**Draft – Subject to Change**
Reliability – Sub-corridor Aggregation

- There are many **Weighting Factor Options** for sub-corridor aggregation:
  - TMC length
  - TMC travel time
    - Freeflow
    - Average
    - Median
    - 80th percentile
  - Vehicle volume (daily)
  - Passenger volume (daily)
  - Vehicle miles traveled (daily)
  - Passenger miles traveled (daily)
  - Vehicle hours traveled (daily)
  - Passenger hours traveled (daily)

- Still work in progress
Issues & Challenges

- **General**
  - Manual conflation of TMCs (for volumes) tedious and time-consuming
    - Hopefully a one-time process
  - Missing hourly volumes by day of week, especially weekends
    - Currently assuming average weekday hourly volumes apply to all 7 days
  - Determining how to “aggregate up” TMCs for “telling the story,” particularly for reliability

- **NJ-Specific**
  - Adjusting average vehicle occupancy with transit ridership is problematic:
    - Tedious process to use GTFS tables to get number of NJ TRANSIT buses on each TMC during each hour for weekday and weekends
    - Applying typical peak/off-peak loading factors to get number of passengers
    - Using WIM data as surrogate for private and university bus data
  - Lacking traffic volume data in NJCMS for 128 miles of the enhanced NHS (need to find out coverage of INRIX and Nokia/NAVTEQ data)
Suggested Next Steps

- Look at multiple years to see what changes in PMs occur (temporally/spatially)

- Test corridors/years where there have been recently completed projects (“telling the story” re: project effectiveness)

- Have other States and MPOs run through similar tests (varying levels of resources, tools, etc.)

- Test the PM methodologies using NPMRDS datasets
Additional Considerations

- Challenge to ascertain *WHY* PM changes occur (a project, background traffic growth, economy, gas prices, etc.?) in assessing multi-year and/or project-related comparisons – may also affect or guide target-setting

- Complex issues re signalized arterial operations data (multiple speed curves, side friction, signal density) – UMD multi-state validation report forthcoming

- Consider more critical thinking re: “agency-determined threshold travel times”

- Analytical tools – to automate the processes and create *consistent* summary output (tables, graphs, visualizations) – are **highly** desirable
Wrap Up

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Thank You