MAP-21 PM3 Performance Measure Calculations: A Tutorial
Subparts E, F, & G from the NPRM

A Tutorial on Calculating the Current Proposed PM3 Measures
Overview: We’re here to help www.cattlab.umd.edu/MAP-21

- Explore the NPMRDS
- Work with other data sources
- Give guidance and feedback
- Test hypothesis/alternatives
- A forum for discussion
- A place to ask question
- How to provide us your volume and speed limit data
- What else can we do for you?
Overview: Today’s Objective

• A Tutorial on calculating the performance measures behind Suparts E, F, and G
• The sample data set and detailed instructions for how to calculate these measures can be found in the “So you want to do this on your own?” section of our website www.cattlab.umd.edu/MAP-21 towards the bottom of the page.
The sample data was compiled for six reporting TMC segments from the December 2015 NPMRDS. The segments are located on I-66 in northern Virginia near the Capital Beltway.

- **MAP-21_Sample_Data_Set_TMC.csv**
  - Basic reporting segment (TMC) metadata including road name, segment length, and direction of travel
- **MAP-21_Sample_Data_Set_TT.csv**
  - 34,082 individual travel time records for December 2015, referenced by TMC code
  - Includes travel times for “all vehicles” as well as passenger vehicles and truck vehicles individually, when available
Subpart E consists of four performance measures:
1. Percent of the Interstate System providing for Reliable Travel Times
   • Based on the Level of Travel Time Reliability (LOTTR) metric
2. Percent of the non-Interstate NHS providing for Reliable Travel Times
   • Based on the Level of Travel Time Reliability (LOTTR) metric
3. Percent of the Interstate System where Peak Hour Travel Times Meet Expectations
   • Based on the Peak Hour Travel Time Ratio (PHTTR) metric
4. Percent of the non-Interstate NHS where Peak Hour Travel Times Meet Expectations
   • Based on the Peak Hour Travel Time Ratio (PHTTR) metric
Data requirements

- **Geographic range**: all mainline highways on the Interstate System and non-Interstate NHS for an entire state
- **5-minute average travel times for entire reporting period**
  - Use “all vehicles” value from the NPMRDS
  - Fill in missing and “0” or null travel times with travel time at the posted speed limit
- Four time period bins:
  - Weekday 6:00 AM – 10:00 AM (Weekday AM)
  - Weekday 10:00 AM – 4:00 PM (Weekday Midday)
  - Weekday 4:00 PM – 8:00 PM (Weekday PM)
  - Weekend 6:00 AM – 8:00 PM (Weekend)
Calculating LOTTR

- For every reporting segment and every time period bin, LOTTR is calculated using the following formula:

\[
\text{Level of Travel Time Reliability} = \frac{\text{80th percentile travel time}}{\text{50th percentile travel time ("normal travel time")}}
\]
Calculating LOTTR (continued…)

- Calculate the system-level performance measure, 
  Percent of the [Interstate | non-Interstate] System providing for Reliable Travel Times

\[
\text{Percent of the System Providing for Reliable Travel Times} = 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}
\]

where
- \( i \) = a reporting segment
- \( R \) = total number of reporting segments where all four LOTTR values are < 1.50
- \( T \) = total number of reporting segments
- \( SL_i \) = length of reporting segment \( i \)

The summation of acceptable reporting segment lengths divided by the summation of all reporting segment lengths
Step 1. Prepare data
- Group travel time readings into the four time period bins for each reporting segment
  - Throw out any travel times of “0” or null here as they will be replaced

Using the sample data set, we will end up with 24 travel time sets
(6 reporting segments × 4 time period bins = 24)
Step 1. Prepare data (continued)

- Fill in missing readings with the travel time at the posted speed limit
- Find travel time at posted speed limit for each reporting segment

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Travel Time, in seconds, at Speed Limit (55 mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.30804</td>
<td>20</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.86218</td>
<td>122</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.08511</td>
<td>136</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.24972</td>
<td>82</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.81046</td>
<td>53</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.76393</td>
<td>115</td>
</tr>
</tbody>
</table>

- Calculate expected number of readings for each time period bin
  - Weekday AM = (23 weekdays × 4 hours × 12 readings per hour) = 1104
  - Weekday Midday = (23 weekdays × 6 hours × 12 readings per hour) = 1656
  - Weekday PM = (23 weekdays × 4 hours × 12 readings per hour) = 1104
  - Weekend = (8 weekend days × 14 hours × 12 readings per hour) = 1344
Step 1. Prepare data (continued…)

- Fill in missing readings with the travel time at the posted speed limit (continued…)
  - Add appropriate number of readings with travel times at the posted speed limit to the travel time sets built previously

- **Example:** The sample data set contains 536 travel time readings for reporting segment 110N04173 during the “Weekday AM” time period bin (6:00 AM – 10:00 AM). There are an expected 1104 readings for this time period bin, so an additional 568 travel times will be added with a value of 20 seconds.

\[
1104 \text{ expected} - 536 \text{ available} = 568 \text{ missing}
\]
Step 2. Calculate LOTTR values for every reporting segment and time period bin

Level of Travel Time Reliability = \[
\frac{80\text{th percentile travel time}}{50\text{th percentile travel time}}
\]

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Time period</th>
<th>80th percentile travel time</th>
<th>50th percentile travel time</th>
<th>LOTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>Weekday AM</td>
<td>26</td>
<td>20</td>
<td>1.30</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>20</td>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>121</td>
<td>20</td>
<td>6.05</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>20</td>
<td>20</td>
<td>1.00</td>
</tr>
<tr>
<td>110N04174</td>
<td>Weekday AM</td>
<td>130</td>
<td>120</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>122</td>
<td>112</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>193</td>
<td>122</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>122</td>
<td>122</td>
<td>1.00</td>
</tr>
<tr>
<td>110N04175</td>
<td>Weekday AM</td>
<td>225</td>
<td>164</td>
<td>1.37</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>174</td>
<td>142</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>167</td>
<td>141</td>
<td>1.18</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>170</td>
<td>136</td>
<td>1.25</td>
</tr>
<tr>
<td>110P04173</td>
<td>Weekday AM</td>
<td>82</td>
<td>76</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>81</td>
<td>76</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>82</td>
<td>82</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>82</td>
<td>78</td>
<td>1.05</td>
</tr>
<tr>
<td>110P04174</td>
<td>Weekday AM</td>
<td>53</td>
<td>53</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>56</td>
<td>53</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>54</td>
<td>53</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>53</td>
<td>53</td>
<td>1.00</td>
</tr>
<tr>
<td>110P04175</td>
<td>Weekday AM</td>
<td>118</td>
<td>110</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>Weekday Midday</td>
<td>121</td>
<td>111</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>Weekday PM</td>
<td>165</td>
<td>117</td>
<td>1.41</td>
</tr>
<tr>
<td></td>
<td>Weekend</td>
<td>115</td>
<td>109</td>
<td>1.06</td>
</tr>
</tbody>
</table>
Subpart E – LOTTR sample calculation

Step 3. Calculate Percent of the System Providing for Reliable Travel Times

\[
\text{Percent of the System Providing for Reliable Travel Times} = 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}
\]

• Summary of LOTTR values previously calculated, with values ≥ 1.50 highlighted

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>LOTTR</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Weekday AM</td>
<td>Weekday Mid</td>
<td>Weekday PM</td>
</tr>
<tr>
<td>110N04173</td>
<td>0.308</td>
<td>1.30</td>
<td>1.00</td>
<td>6.05</td>
<td>1.00</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.862</td>
<td>1.08</td>
<td>1.09</td>
<td>1.58</td>
<td>1.00</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.085</td>
<td>1.37</td>
<td>1.23</td>
<td>1.18</td>
<td>1.25</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.249</td>
<td>1.08</td>
<td>1.07</td>
<td>1.00</td>
<td>1.05</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.810</td>
<td>1.00</td>
<td>1.06</td>
<td>1.02</td>
<td>1.00</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.763</td>
<td>1.07</td>
<td>1.09</td>
<td>1.41</td>
<td>1.06</td>
</tr>
</tbody>
</table>

\[
\text{Percent of the System Providing for Reliable Travel Times} = 100 \times \frac{2.085 + 1.249 + 0.810 + 1.763}{0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763} = 100 \times \frac{5.907}{8.077} = 73.1\%
\]
Data requirements

- **Geographic range**: all mainline highways on the Interstate System and non-Interstate NHS within the boundary of urbanized areas with a population over one million
  - Boundaries proposed to be based on most recent decennial census, but adjustments may be approved
- **5-minute average travel times for all non-holiday weekdays**
  - Use “all vehicles” value from the NPMRDS
  - Remove travel times representing speeds less than 2 mph or greater than 100 mph
  - NO GAP FILL
  - Six peak hour time period bins:
    - 6:00 AM – 7:00 AM
    - 7:00 AM – 8:00 AM
    - 8:00 AM – 9:00 AM
    - 4:00 PM – 5:00 PM
    - 5:00 PM – 6:00 PM
    - 6:00 PM – 7:00 PM
Subpart E – PHTTR data requirements

Data needed (continued…)

- **Agency-defined Desired Peak Period Travel Time**
  - Coordinate between State DOTs, MPOs, and any applicable operating agencies
  - Defined for every reporting segment
  - Separate values for AM and PM periods
Calculating PHTTR

- For every reporting segment and every peak hour time period bin, calculate the Average Travel Time:

\[
\text{Average Travel Time} = \frac{\sum_{1}^{N} \text{Travel Time}}{N}
\]

where: \( N = \) number of travel times recorded within the time period bin

- For every reporting segment, calculate the Peak Hour Travel Time:

\[
\text{Peak Hour Travel Time} = \text{Max}_{j=1}^{6} \{ \text{Average Travel Time}_j \}
\]

where: \( j = \) peak hour time period bin

\[
\text{Average Travel Time}_j = \text{Average Travel Time for time period } j
\]
Calculating PHTTR (continued…)

• For every reporting segment, calculate the *Peak Hour Travel Time Ratio*:

\[
\text{Peak Hour Travel Time Ratio} = \frac{\text{Peak Hour Travel Time}}{\text{Desired Peak Period Travel Time}}
\]
Calculating PHTTR (continued…)

• Calculate the system-level performance measure,

Percent of the [Interstate | non-Interstate] System where Peak Hour Travel Times Meet Expectations

\[ \text{Percent of the System where Peak Hour Travel Times Meet Expectations} = 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i} \]

where

- \( i \) = a reporting segment
- \( R \) = total number of reporting segments where PHTTR < 1.50
- \( T \) = total number of reporting segments
- \( SL_i \) = length of reporting segment \( i \)

The summation of acceptable reporting segment lengths divided by the summation of all reporting segment lengths
Step 1. Prepare data

- Group travel time readings into the six peak hour time period bins for each reporting segment
  - Weekdays only!
  - Ignore travel times occurring on a holiday
    - The sample data set includes Christmas Day (December 25, 2015), so we will ignore all readings from this day
  - Ignore travel times representing speeds less than 2 mph or greater than 100 mph
  - Define upper and lower travel time limits for each reporting segment

Using the sample data set, we will end up with 36 travel time sets (6 reporting segments × 6 peak hour time period bins = 36)
Step 1. Prepare data (continued...)
- Define *Desired Peak Period Travel Times* for each reporting segment
  - For this example:
    - AM period = 80% of the posted speed limit travel time
    - PM period = 60% of the posted speed limit travel time

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Desired Travel Time AM (80% of Speed Limit = 44 mph)</th>
<th>Desired Travel Time PM (60% of Speed Limit = 33 mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.30804</td>
<td>25</td>
<td>34</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.86218</td>
<td>152</td>
<td>203</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.08511</td>
<td>171</td>
<td>227</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.24972</td>
<td>102</td>
<td>136</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.81046</td>
<td>66</td>
<td>88</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.76393</td>
<td>144</td>
<td>192</td>
</tr>
</tbody>
</table>
Step 2. Calculate Average Travel Time

- Calculate the *Average Travel Time* for each reporting segment and peak hour time period bin

\[
\text{Average Travel Time} = \frac{\sum_{1}^{N} \text{Travel Time}}{N}
\]

### Reporting Segment

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>6:00 AM – 7:00 AM</th>
<th>7:00 AM – 8:00 AM</th>
<th>8:00 AM – 9:00 AM</th>
<th>4:00 PM – 5:00 PM</th>
<th>5:00 PM – 6:00 PM</th>
<th>6:00 PM – 7:00 PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>38</td>
<td>21</td>
<td>27</td>
<td>106</td>
<td>142</td>
<td>131</td>
</tr>
<tr>
<td>110N04174</td>
<td>161</td>
<td>120</td>
<td>129</td>
<td>335</td>
<td>411</td>
<td>362</td>
</tr>
<tr>
<td>110N04175</td>
<td>191</td>
<td>200</td>
<td>187</td>
<td>146</td>
<td>196</td>
<td>183</td>
</tr>
<tr>
<td>110P04173</td>
<td>74</td>
<td>76</td>
<td>83</td>
<td>76</td>
<td>77</td>
<td>87</td>
</tr>
<tr>
<td>110P04174</td>
<td>51</td>
<td>51</td>
<td>52</td>
<td>60</td>
<td>58</td>
<td>56</td>
</tr>
<tr>
<td>110P04175</td>
<td>111</td>
<td>115</td>
<td>114</td>
<td>209</td>
<td>218</td>
<td>164</td>
</tr>
</tbody>
</table>

Step 3. Find the Peak Hour Travel Time

- Select the maximum *Average Travel Time* for each reporting segment

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Peak Hour</th>
<th>Peak Hour Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>5:00 PM – 6:00 PM</td>
<td>142</td>
</tr>
<tr>
<td>110N04174</td>
<td>5:00 PM – 6:00 PM</td>
<td>411</td>
</tr>
<tr>
<td>110N04175</td>
<td>7:00 AM – 8:00 AM</td>
<td>200</td>
</tr>
<tr>
<td>110P04173</td>
<td>6:00 PM – 7:00 PM</td>
<td>87</td>
</tr>
<tr>
<td>110P04174</td>
<td>4:00 PM – 5:00 PM</td>
<td>60</td>
</tr>
<tr>
<td>110P04175</td>
<td>5:00 PM – 6:00 PM</td>
<td>218</td>
</tr>
</tbody>
</table>
### Subpart E – PHTTR sample calculation

#### Step 4. Calculate Peak Hour Travel Time Ratio

- Calculate the *Peak Hour Travel Time Ratio* for each reporting segment
- Use appropriate *Desired Travel Time* based on *Peak Hour*

\[
\text{Peak Hour Travel Time Ratio} = \frac{\text{Peak Hour Travel Time}}{\text{Desired Peak Period Travel Time}}
\]

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Peak Hour Travel Time</th>
<th>Peak Hour</th>
<th>Desired Travel Time</th>
<th>PHTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>142</td>
<td>5:00 PM – 6:00 PM</td>
<td>34</td>
<td>4.18</td>
</tr>
<tr>
<td>110N04174</td>
<td>411</td>
<td>5:00 PM – 6:00 PM</td>
<td>203</td>
<td>2.02</td>
</tr>
<tr>
<td>110N04175</td>
<td>200</td>
<td>7:00 AM – 8:00 AM</td>
<td>171</td>
<td>1.17</td>
</tr>
<tr>
<td>110P04173</td>
<td>87</td>
<td>6:00 PM – 7:00 PM</td>
<td>136</td>
<td>0.64</td>
</tr>
<tr>
<td>110P04174</td>
<td>60</td>
<td>4:00 PM – 5:00 PM</td>
<td>88</td>
<td>0.68</td>
</tr>
<tr>
<td>110P04175</td>
<td>218</td>
<td>5:00 PM – 6:00 PM</td>
<td>192</td>
<td>1.14</td>
</tr>
</tbody>
</table>
Subpart E – PHTTR sample calculation

Step 5. Calculate
Percent of the System where Peak Hour Travel Times Meet Expectations

\[
\text{Percent of the System where Peak Hour Travel Times Meet Expectations} = 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}
\]

• Summary of PHTTR values previously calculated, with values ≥ 1.50 highlighted

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>PHTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.308</td>
<td>4.18</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.862</td>
<td>2.02</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.085</td>
<td>1.17</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.249</td>
<td>0.64</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.810</td>
<td>0.68</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.763</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Percent of the System where Peak Hour Travel Times Meet Expectations

\[
= 100 \times \frac{2.085 + 1.249 + 0.810 + 1.763}{0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763} = \frac{5.907}{8.077} = 73.1\%
\]
Subpart F consists of two performance measures:
1. Percent of the Interstate System Mileage providing for Reliable Truck Travel Times
   • Based on the Truck Travel Time Reliability (TTTR) metric
2. Percent of the Interstate System Mileage Uncongested
   • Based on the Average Truck Speed metric
Subpart F – TTTR data requirements

Data requirements

- **Geographic range**: all mainline highways on the Interstate System for an entire state
- **5-minute average travel times for entire reporting period**
  - Use “trucks only” value from the NPMRDS when available
  - Fill in missing “trucks only” travel times and “0” or null travel time values with the greater of the following two:
    - The “all vehicles” travel time corresponding to the missing reading
    - The travel time that would occur while traveling at the posted speed limit
Calculating TTTR

For every reporting segment, TTTR is calculated using the following formula:

\[ \text{Truck Travel Time Reliability} = \frac{95\text{th percentile truck travel time}}{50\text{th percentile truck travel time ("normal truck travel time")}} \]
Calculating TTTR (continued…)

• Calculate the system-level performance measure, 

\[
\text{Percent of the Interstate System Mileage Providing for Reliable Truck Travel Times}
\]

\[
= 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}
\]

where

- \(i\) = a reporting segment
- \(R\) = total number of reporting segments where \(TTTR < 1.50\)
- \(T\) = total number of reporting segments
- \(SL_i\) = length of reporting segment \(i\)

The summation of \textit{acceptable} reporting segment lengths divided by the summation of \textit{all} reporting segment lengths
Step 1. Prepare data
- Group travel time readings for each reporting segment
  - Replace any missing truck travel times or truck travel times of “0” or null with the “all vehicles” travel time corresponding to the missing reading, if available and as long as it is greater than the travel time that would occur while traveling at the posted speed limit

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Travel Time, in seconds, at Speed Limit (55 mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.30804</td>
<td>20</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.86218</td>
<td>122</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.08511</td>
<td>136</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.24972</td>
<td>82</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.81046</td>
<td>53</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.76393</td>
<td>115</td>
</tr>
</tbody>
</table>

Using the sample data set, we will end up with 6 travel time sets (6 reporting segments)
Step 1. Prepare data (continued…)

- Fill in missing readings with the travel time at the posted speed limit
- Calculate expected number of readings for each reporting segment
  - \[(31 \text{ days} \times 24 \text{ hours} \times 12 \text{ readings per hour}) = 8928\]
- Add appropriate number of readings with travel times at the posted speed limit
  - **Example:** The sample data set contains 5569 valid truck travel time readings for reporting segment 110N04175, and an additional 1174 “all vehicles” travel time readings with values greater than 136 (the travel time at the posted speed limit), giving us a total of 6743 readings. There are an expected 8928 readings, so an additional 2185 travel times will be added with a value of 136 seconds.

\[
8928 \text{ expected} - 5569 \text{ valid truck readings} - 1174 \text{ valid all vehicles readings} = 2185 \text{ missing}
\]
Step 2. Calculate TTTR values
• Calculate the TTTR for each reporting segment

\[
\text{Truck Travel Time Reliability} = \frac{95\text{th percentile truck travel time}}{50\text{th percentile truck travel time}}
\]

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>95th percentile travel time</th>
<th>50th percentile travel time</th>
<th>TTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>112</td>
<td>20</td>
<td>5.60</td>
</tr>
<tr>
<td>110N04174</td>
<td>196</td>
<td>122</td>
<td>1.61</td>
</tr>
<tr>
<td>110N04175</td>
<td>270</td>
<td>141</td>
<td>1.91</td>
</tr>
<tr>
<td>110P04173</td>
<td>86</td>
<td>82</td>
<td>1.05</td>
</tr>
<tr>
<td>110P04174</td>
<td>62</td>
<td>53</td>
<td>1.17</td>
</tr>
<tr>
<td>110P04175</td>
<td>174</td>
<td>115</td>
<td>1.51</td>
</tr>
</tbody>
</table>
Subpart F – TTTR sample calculation

Step 3. Calculate Percent of the Interstate System Mileage providing for Reliable Truck Travel Times

Percent of the Interstate System Mileage providing for Reliable Truck Travel Times = \(100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}\)

- Summary of TTTR values previously calculated, with values ≥ 1.50 highlighted

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>TTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.308</td>
<td>5.60</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.862</td>
<td>1.61</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.085</td>
<td>1.91</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.249</td>
<td>1.05</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.810</td>
<td>1.17</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.763</td>
<td>1.51</td>
</tr>
</tbody>
</table>

Percent of the Interstate System Mileage providing for Reliable Truck Travel Times

\[
= 100 \times \frac{1.249 + 0.810}{0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763} = 100 \times \frac{2.059}{8.077} = 25.5\%
\]
Data requirements

• **Geographic range**: all mainline highways on the Interstate System for an entire state

• **5-minute average travel times for entire reporting period**
  • Use “trucks only” value from the NPMRDS when available
  • Fill in missing “trucks only” travel times and “0” or null travel time values with the greater of the following two:
    • The “all vehicles” travel time corresponding to the missing reading
    • The travel time that would occur while traveling at the posted speed limit
Calculating Average Truck Speed

• For every reporting segment, Average Truck Speed is calculated using the following formula:

\[
Average\ Truck\ Speed = \frac{\sum_{b=1}^{T} \frac{Segment\ Length}{Truck\ Travel\ Time_b}}{T} \times 60 \times 60
\]

where

- \(b\) = a 5-minute time interval
- \(T\) = total number of time intervals in reporting period
- \(Truck\ Travel\ Time_b\) = travel time for trucks at time period \(b\)
Calculating Average Truck Speed (continued…)

• Calculate the system-level performance measure, *Percent of the Interstate System Mileage Uncongested*

\[
\text{Percent of the Interstate System Mileage Uncongested} = 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i}
\]

where
- \(i\) = a reporting segment
- \(R\) = total number of reporting segments where *Average Truck Speed* > 50 mph
- \(T\) = total number of reporting segments
- \(SL_i\) = length of reporting segment \(i\)

The summation of *acceptable* reporting segment lengths divided by the summation of *all* reporting segment lengths
Step 1. Prepare data

- Group travel time readings for each reporting segment
- Replace any missing truck travel times or truck travel times of “0” or null with the “all vehicles” travel time corresponding to the missing reading, if available and as long as it is greater than the travel time that would occur while traveling at the posted speed limit

### Subpart F – Average Truck Speed sample calculation

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Travel Time, in seconds, at Speed Limit (55 mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.30804</td>
<td>20</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.86218</td>
<td>122</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.08511</td>
<td>136</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.24972</td>
<td>82</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.81046</td>
<td>53</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.76393</td>
<td>115</td>
</tr>
</tbody>
</table>

Using the sample data set, we will end up with 6 travel time sets (6 reporting segments)
Subpart F – Average Truck Speed sample calculation

Step 1. Prepare data (continued…)
• Fill in missing readings with the travel time at the posted speed limit
  • Calculate expected number of readings for each reporting segment
    • \((31 \text{ days} \times 24 \text{ hours} \times 12 \text{ readings per hour}) = 8928\)
  
  • Add appropriate number of readings with travel times at the posted speed limit
    • **Example:** The sample data set contains 5569 valid truck travel time readings for reporting segment 110N04175, and an additional 1174 “all vehicles” travel time readings with values greater than 136 (the travel time at the posted speed limit), giving us a total of 6743 readings. There are an expected 8928 readings, so an additional 2185 travel times will be added with a value of 136 seconds.

\[
8928 \text{ expected } - 5569 \text{ valid truck readings } - 1174 \text{ valid all vehicles readings } = 2185 \text{ missing}
\]
Step 2. Calculate Average Truck Speed values

- Calculate the Average Truck Speed for each reporting segment

\[
\text{Average Truck Speed} = \frac{\sum_{b=1}^{T} \frac{\text{Segment Length}}{\text{Truck Travel Time}_b}}{T} \times 60 \times 60
\]

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Average Truck Speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>50.65</td>
</tr>
<tr>
<td>110N04174</td>
<td>52.39</td>
</tr>
<tr>
<td>110N04175</td>
<td>49.28</td>
</tr>
<tr>
<td>110P04173</td>
<td>54.40</td>
</tr>
<tr>
<td>110P04174</td>
<td>53.87</td>
</tr>
<tr>
<td>110P04175</td>
<td>52.54</td>
</tr>
</tbody>
</table>
Subpart F – Average Truck Speed sample calculation

Step 3. Calculate Percent of the Interstate System Mileage Uncongested

Percent of the Interstate System Mileage Uncongested = \( 100 \times \frac{\sum_{i=1}^{R} SL_i}{\sum_{i=1}^{T} SL_i} \)

• Summary of Average Truck Speed values previously calculated, with speeds ≤ 50 mph highlighted

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Average Truck Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.308</td>
<td>50.65</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.862</td>
<td>52.39</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.085</td>
<td>49.28</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.249</td>
<td>54.40</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.810</td>
<td>53.87</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.763</td>
<td>52.54</td>
</tr>
</tbody>
</table>

Percent of the Interstate System Mileage Uncongested

\[
= 100 \times \frac{0.308 + 1.862 + 1.249 + 0.810 + 1.763}{0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763} = 100 \times \frac{5.992}{8.077} = 74.2\%
\]
Subpart G consists of one performance measure:
1. Annual Hours of Excessive Delay Per Capita
   • Based on the Total Excessive Delay metric
Subpart G – Total Excessive Delay data requirements

Data requirements

• **Geographic range**: all of the NHS in urbanized areas with a population over one million that are designated as nonattainment or maintenance areas for ozone, carbon monoxide, or particulate matter National Ambient Air Quality Standards

• **5-minute average travel times for entire reporting period**
  • Use “all vehicles” value from the NPMRDS
  • NO GAP FILL

• **Hourly volume estimation for every reporting segment**

• **Estimated population for the urbanized area**
Calculating Total Excessive Delay

- For every reporting segment, calculate the *Excessive Delay Threshold Travel Time*:

\[ \text{Excessive Delay Threshold Travel Time} = \left( \frac{\text{Segment Length}}{\text{Threshold Speed}} \right) \times 3600 \]

where  *Threshold Speed* = the speed at which any slower measured speeds would result in excessive delay

- 35 mph for Interstates, freeways, and expressways
- 15 mph for all other roads
Calculating Total Excessive Delay (continued…)

For every travel time reading, calculate the Reporting Segment Delay (RSD)

\[
RSD = \min(\text{Travel Time} - \text{Excessive Delay Threshold Travel Time}, 300 \text{ seconds})
\]

For every travel time reading, calculate the Excessive Delay

- If \( RSD \) is greater than or equal to 0, then \( \text{Excessive Delay} = \frac{RSD}{3600} \)
- If \( RSD \) is less than 0, then \( \text{Excessive Delay} = 0 \)
Calculating Total Excessive Delay (continued…)

- For every reporting segment, calculate the Total Excessive Delay

\[
\text{Total Excessive Delay} = \sum_{d=1}^{TD} \sum_{h=1}^{TH} \sum_{b=1}^{TB} \text{Excessive Delay}_{b,h,d} \times \left( \frac{\text{hourly volume}}{12} \right)_{h,d}
\]

Summation of all Excessive Delay values weighted by the estimated volume

- Calculate the system-level performance measure, Excessive Delay per Capita

\[
\text{Annual Hours of Excessive Delay per Capita} = \frac{\sum_{s=1}^{T} \text{Total Excessive Delays}_s}{\text{Total Population}}
\]

where:
- \( S \) = a reporting segment
- \( T \) = total number of reporting segments
Subpart G – Total Excessive Delay sample calculation

Step 1. Prepare data
- Group travel time readings for each reporting segment (6 travel time sets)
- Identify hourly volume estimation for each reporting segment

<table>
<thead>
<tr>
<th>Hour of Day</th>
<th>110N04173</th>
<th>110N04174</th>
<th>110N04175</th>
<th>110P04173</th>
<th>110P04174</th>
<th>110P04175</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 AM</td>
<td>400</td>
<td>300</td>
<td>800</td>
<td>700</td>
<td>400</td>
<td>900</td>
</tr>
<tr>
<td>1 AM</td>
<td>200</td>
<td>200</td>
<td>500</td>
<td>400</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>2 AM</td>
<td>200</td>
<td>100</td>
<td>400</td>
<td>300</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>3 AM</td>
<td>100</td>
<td>100</td>
<td>400</td>
<td>300</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>4 AM</td>
<td>200</td>
<td>200</td>
<td>800</td>
<td>500</td>
<td>200</td>
<td>600</td>
</tr>
<tr>
<td>5 AM</td>
<td>700</td>
<td>700</td>
<td>2300</td>
<td>1100</td>
<td>600</td>
<td>1600</td>
</tr>
<tr>
<td>6 AM</td>
<td>1600</td>
<td>1500</td>
<td>4900</td>
<td>2400</td>
<td>1400</td>
<td>3600</td>
</tr>
<tr>
<td>7 AM</td>
<td>2000</td>
<td>1900</td>
<td>5900</td>
<td>3100</td>
<td>1800</td>
<td>4500</td>
</tr>
<tr>
<td>8 AM</td>
<td>1900</td>
<td>1800</td>
<td>4900</td>
<td>3000</td>
<td>1700</td>
<td>4300</td>
</tr>
<tr>
<td>9 AM</td>
<td>1800</td>
<td>1700</td>
<td>4200</td>
<td>3000</td>
<td>1600</td>
<td>4100</td>
</tr>
<tr>
<td>10 AM</td>
<td>1900</td>
<td>1800</td>
<td>4300</td>
<td>3200</td>
<td>1800</td>
<td>4300</td>
</tr>
<tr>
<td>11 AM</td>
<td>2100</td>
<td>2000</td>
<td>4500</td>
<td>3500</td>
<td>2000</td>
<td>4700</td>
</tr>
<tr>
<td>12 PM</td>
<td>2100</td>
<td>2100</td>
<td>4700</td>
<td>3700</td>
<td>2000</td>
<td>4800</td>
</tr>
<tr>
<td>1 PM</td>
<td>2200</td>
<td>2100</td>
<td>4800</td>
<td>3900</td>
<td>2100</td>
<td>5000</td>
</tr>
<tr>
<td>2 PM</td>
<td>2400</td>
<td>2300</td>
<td>5100</td>
<td>4400</td>
<td>2400</td>
<td>5500</td>
</tr>
<tr>
<td>3 PM</td>
<td>2600</td>
<td>2500</td>
<td>5400</td>
<td>5300</td>
<td>2800</td>
<td>5900</td>
</tr>
<tr>
<td>4 PM</td>
<td>2700</td>
<td>2600</td>
<td>5500</td>
<td>5800</td>
<td>2900</td>
<td>6100</td>
</tr>
<tr>
<td>5 PM</td>
<td>2500</td>
<td>2400</td>
<td>5100</td>
<td>5100</td>
<td>2600</td>
<td>5700</td>
</tr>
<tr>
<td>6 PM</td>
<td>2100</td>
<td>2000</td>
<td>4100</td>
<td>3600</td>
<td>2000</td>
<td>4700</td>
</tr>
<tr>
<td>7 PM</td>
<td>1600</td>
<td>1500</td>
<td>3100</td>
<td>2700</td>
<td>1500</td>
<td>3600</td>
</tr>
<tr>
<td>8 PM</td>
<td>1300</td>
<td>1300</td>
<td>2600</td>
<td>2300</td>
<td>1200</td>
<td>3000</td>
</tr>
<tr>
<td>9 PM</td>
<td>1200</td>
<td>1100</td>
<td>2300</td>
<td>2000</td>
<td>1100</td>
<td>2700</td>
</tr>
<tr>
<td>10 PM</td>
<td>900</td>
<td>900</td>
<td>1800</td>
<td>1600</td>
<td>900</td>
<td>2200</td>
</tr>
<tr>
<td>11 PM</td>
<td>600</td>
<td>600</td>
<td>1200</td>
<td>1100</td>
<td>600</td>
<td>1500</td>
</tr>
</tbody>
</table>
Step 1. Prepare data (continued…)

- Identify population information for the reporting urban area
  - Based on the most recent U.S. Decennial Census available
  - For this example, we will use 1,000,000
Subpart G – Total Excessive Delay sample calculation

Step 2. Calculate *Excessive Delay Threshold Travel Time*

\[
\text{Excessive Delay Threshold Travel Time} = \left( \frac{\text{Segment Length}}{\text{Threshold Speed}} \right) \times 3600
\]

- All six reporting segments in the sample data set are on an interstate, so a *Threshold Speed* of 35 mph will be used

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Segment Length in miles</th>
<th>Excessive Delay Threshold Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>0.308</td>
<td>32</td>
</tr>
<tr>
<td>110N04174</td>
<td>1.862</td>
<td>192</td>
</tr>
<tr>
<td>110N04175</td>
<td>2.085</td>
<td>214</td>
</tr>
<tr>
<td>110P04173</td>
<td>1.249</td>
<td>128</td>
</tr>
<tr>
<td>110P04174</td>
<td>0.810</td>
<td>83</td>
</tr>
<tr>
<td>110P04175</td>
<td>1.763</td>
<td>181</td>
</tr>
</tbody>
</table>
Step 3. Calculate *Excessive Delay* for each travel time reading

- Use the following formulas for each reading

\[
\text{Reporting Segment Delay} = \min(\text{Travel Time} - \text{Excessive Delay Threshold Travel Time}, 300 \text{ seconds})
\]

\[
\text{Excessive Delay} = \begin{cases} 
RSD \geq 0, & \frac{RSD}{3600} \\
RSD < 0, & 0
\end{cases}
\]

- Example: Assume a travel time reading of 240 seconds for segment 110N04174. This segment has an *Excessive Delay Threshold Travel Time* of 192 seconds, so…

\[
RSD = \min(240 - 192, \quad 300 \text{ seconds}) = 48 \text{ seconds}
\]

48 seconds is greater than 0, so…

\[
\text{Excessive Delay} = \frac{48}{3600} = 0.013 \text{ hours}
\]
Step 4. Calculate Total Excessive Delay

Calculate Total Excessive Delay for every reporting segment

\[
Total \ Excessive \ Delay = \sum_{d=1}^{TD} \sum_{h=1}^{TH} \sum_{b=1}^{TB} \left( \frac{Excessive \ Delay_{b,h,d}}{12} \right)
\]

- Make sure the appropriate hourly volume is applied to each reading

<table>
<thead>
<tr>
<th>Reporting Segment</th>
<th>Total Excessive Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>110N04173</td>
<td>4276.331</td>
</tr>
<tr>
<td>110N04174</td>
<td>4175.025</td>
</tr>
<tr>
<td>110N04175</td>
<td>5645.796</td>
</tr>
<tr>
<td>110P04173</td>
<td>241.903</td>
</tr>
<tr>
<td>110P04174</td>
<td>162.132</td>
</tr>
<tr>
<td>110P04175</td>
<td>6412.252</td>
</tr>
</tbody>
</table>
Step 5. Calculate Annual Hours of Excessive Delay per Capita
• Calculate the system-level performance measure

\[ \text{Annual Hours of Excessive Delay per Capita} = \frac{\sum_{s=1}^{T} \text{Total Excessive Delays}_s}{\text{Total Population}} \]

Annual Hours of Excessive Delay per Capita

\[ = \frac{(4276.331 + 4175.025 + 5645.796 + 241.903 + 162.132 + 6412.252)}{1,000,000} = \frac{20,913.439}{1,000,000} \]

\[ = 0.02 \text{ hours} \]

Note that this number is relatively low due to limited date range and low number of reporting segments.
Thank You!

Drew Lund
alund1@umd.edu

© UMD CATT
We’re Here to Help: cattlab.umd.edu/MAP-21

Working with AASHTO, I-95 Corridor Coalition, and others to evaluate MAP-21 measures and test hypothesis/alternatives

Helping State DOTs and MPOs:
• Exploring the NPMRDS
• Working with other data sources
• Providing guidance and feedback
• A forum for discussion
• A place to ask question
• How to provide us your volume and speed limit data
• What else can we do for you?
We’re Here to Help: cattlab.umd.edu/MAP-21

The CATT Lab Can Help You!

This page includes a number of resources to:

- Help you understand the proposed rule
- Use free tools to see how your State, MPO, and/or Urban Area are performing
- Use free tools to experiment with variations to the proposed rule such as:
  - Impedance methods other than using speed limits
  - Arithmetic mean vs. harmonic mean
  - NPARDS vs. other 3rd Party Data Sources (HERE, INRIX, and TomTom)
  - Experiment with target setting
- Send us your own suggestion
  - Provide us your travel time and/or speed limit data for use in our free tools
- Learn to compute the measures yourself using sample data sets
- Link to FHWA webinars and other resources
- Discuss the rule, ask questions, request support, and collaborate in an open forum
- Learn about us

Our goal is to enable MPOs and DOTs to evaluate the proposed measures, assess their impact, experiment with alternatives, and respond to the docket. Comments on the latest Systems Performance NPRM are currently due by August 20.

Understanding the Notice of Proposed Rule Making (coming soon)

FHWA’s MAP-21 NPRM Website has a lot of good information about the rule, but here is our quick and dirty interpretation of what is being asked, how it will affect you, and how complicated it’s going to be. (Coming soon)

Free MAP-21 Performance Calculation Tools

The CATT Lab has developed some free tools that are available to states, MPOs, and consultants working on behalf of an agency to better explore the National Performance Management Research Data Set (NPARDS) data (one of the datasets that FHWA suggests using for computing performance). Within this suite of tools is a MAP-21 widget that allows you to quickly and easily calculate your region’s performance as described in the NPRM subsections F.1.3. and 14.

The tool outputs the systems performance measures as charts, maps, and data files that can be used to report up to FHWA or to simply understand your agency’s performance.

The tool can be found at npards.fhwa.dot.gov.

Detailed tutorials will be added soon, so please check back often.

How do I see these tools?

- If you already use RTIS tools, your existing login is all you need to access the NPARDS analytics tools.
- If you do not have a RTIS account, click here to request a login. Most accounts will be ready within 1 business day.

Any users experiencing issues with access or login should email support@fhwa.dot.gov.

Our databases already include everything needed to calculate Level of Travel-Time Reliability (LOTT) across all states and MPOs nationwide. However, we do not have all data needed to calculate all measures for all areas. We can work with you to load your data for immediate analysis of additional parameters such as speed limits and traffic volume.

Experimenting with the Rule (coming soon)

Many who read the NPRM may question the algorithm, methods, data, etc. Our goal is to modify our free tools described above to allow your agency to experiment with variations to the proposed rule to see how these variations might impact both your performance and the intent of the rule. We encourage you to email us (or post to the forum) your questions and/or requests for what you’d like us to experiment with. Time permitting, we will attempt to add options to the tools to allow you to test each possibility (or combination of possibilities). Examples could include things like:

- Testing of Impedance methods other than using speed limits
- Arithmetic mean vs. harmonic mean
- NPARDS vs. other 3rd Party Data Sources (HERE, INRIX, and TomTom)
Getting Access

If you have an existing RITIS account, you can access the tool at: npmrds.ritis.org

If you do not have a RITIS account, you can request one at: ritis.org/register

For more information visit: cattlab.umd.edu/MAP-21