

Sample Calculations: MAP-21 NPRM Subpart E

National Performance Management Measures to Assess Performance of the National Highway System

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Introduction

This document provides step-by-step instructions for calculating MAP-21 performance measures on a small sample data set as a demonstration. Actual implementation of these calculations will use an entire year's worth of data for a far larger number of reporting segments.

The performance measures described in this document pertain to Subpart E: *National Performance Management Measures to Assess Performance of the National Highway System* of the NPRM issued April 22, 2016 by the Federal Highway Administration (FHWA).

This document and associated sample data are available for download at <http://www.cattlab.umd.edu/MAP-21/>. Any future revisions will also be posted at this address.

The sample data consists of two files.

1. **MAP-21_Sample_Data_Set_TMC.csv**: This file contains 6 data records specifying TMC segments, defined by the Traffic Message Channel (TMC) location referencing system. The sample data consists of 3 eastbound and 3 westbound segments of Interstate 66 in northern Virginia.
2. **MAP-21_Sample_Data_Set_TT.csv**: This file contains 34,082 data records, the subset generated from the December 2015 National Performance Management Research Data Set (NPMRDS) and contains data for the same six reporting segments.

Each of these files uses the comma-separated values text file format with an initial header record providing the name of each sequential field contained in the subsequent rows.

Level of Travel Time Reliability (LOTTR)

Data needed

- Geographic range: entire state
- 5-minute interval travel times for the entire year
 - Use "all vehicles" value
 - Fill in missing and "0" values with travel time at posted speed limit
- Time period bins:
 - Weekday 6:00 AM – 10:00 AM
 - Weekday 10:00 AM – 4:00 PM
 - Weekday 4:00 PM – 8:00 PM
 - Weekend 6:00 AM – 8:00 PM

Calculating LOTTR

1. For every reporting segment, find the LOTTR for every time period bin:

- a.
$$LOTTR = \frac{80th\ percentile\ travel\ time}{50th\ percentile\ "normal\ travel\ time"}$$

Sample calculation

1. Prepare data
 - a. Group travel times into time period bins by reporting segment (TMC)
 - i. Throw out travel times with a value of 0, as they will be replaced
 - ii. Using the sample data set, you should end up with 24 groups (6 reporting segments, 4 time period bins each)
 - b. Fill in missing readings with travel time at posted speed limit
 - i. First, find the travel time using the posted speed limit for each reporting segment. All of the segments in the sample data set have a posted speed limit of 55 mph, giving us the following travel times:

Reporting Segment	Segment Length (miles)	Travel Time at 55mph Speed Limit (seconds)
110N04173	0.30804	20
110N04174	1.86218	122
110N04175	2.08511	136
110P04173	1.24972	82
110P04174	0.81046	53
110P04175	1.76393	115

- ii. For each time period bin, calculate the expected number of readings. Using the sample data set's 1-month time range (December 2015), we get the following numbers:
 - Weekday 6:00 AM – 10:00 AM
 - (23 weekdays * 4 hours * 12 readings per hour) = 1104
 - Weekday 10:00 AM – 4:00 PM
 - (23 weekdays * 6 hours * 12 readings per hour) = 1656
 - Weekday 4:00 PM – 8:00 PM
 - (23 weekdays * 4 hours * 12 readings per hour) = 1104
 - Weekend 6:00 AM – 8:00 PM
 - (8 weekend days * 14 hours * 12 readings per hour) = 1344
- iii. Add readings with travel times equal to the values calculated in i to the travel time groupings from a based on the number of missing readings:
 - Using the sample data set, reporting segment 110N04173 has 536 travel time readings for the "Weekday 6:00 AM – 10:00 AM" time period. Since we expect 1104 readings, we will add 568 travel times to this time bin (1104 expected – 536 available = 568) with the calculated speed limit travel time of 20 seconds.

2. Calculate LOTTR for each reporting segment

Reporting Segment	Time period	80 th percentile travel time (seconds)	50 th percentile travel time (seconds)	LOTTR
110N04173	Weekday AM	26	20	1.30
	Weekday Midday	20	20	1.00
	Weekday PM	121	20	6.05
	Weekend	20	20	1.00
110N04174	Weekday AM	130	120	1.08
	Weekday Midday	122	112	1.09
	Weekday PM	193	122	1.58
	Weekend	122	122	1.00
110N04175	Weekday AM	225	164	1.37
	Weekday Midday	174	142	1.23
	Weekday PM	167	141	1.18
	Weekend	170	136	1.25
110P04173	Weekday AM	82	76	1.08
	Weekday Midday	81	76	1.07
	Weekday PM	82	82	1.00
	Weekend	82	78	1.05
110P04174	Weekday AM	53	53	1.00
	Weekday Midday	56	53	1.06
	Weekday PM	54	53	1.02
	Weekend	53	53	1
110P04175	Weekday AM	118	110	1.07
	Weekday Midday	121	111	1.09
	Weekday PM	165	117	1.41
	Weekend	115	109	1.06

Peak Hour Travel Time Ratio (PHTTR)

Data needed

- Geographic range: urbanized area with a population over 1 million
- 5-minute interval travel times for all non-holiday weekdays
 - Remove travel times representing speeds less than 2 mph or greater than 100 mph
- Agency-defined *Desired Peak Period Travel Time*
 - Coordinate between State DOTs, MPOs, and any applicable operating agencies
 - Every reporting segment
 - Separate values for AM and PM periods
- Peak hour time 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

Calculating PHTTR

1. For every reporting segment, calculate the average travel time for every time period bin:

- a.
$$\text{Average Travel Time} = \frac{\sum_1^N \text{Travel Time}}{N}$$

Where:

- N = number of travel times recorded within time period bin

2. For every reporting segment, calculate the *Peak Hour Travel Time*:

- a.
$$\text{Peak Hour Travel Time} = \text{Max}_{j=1}^{j=6} \{ \text{Average Travel Time}_j \}$$

Where:

- j = Peak hour time bin
- $\text{Average Travel Time}_j$ = Average Travel Time for time period j

3. For every reporting segment, calculate the *Peak Hour Travel Time Ratio (PHTTR)*:

- a.
$$\text{PHTTR} = \frac{\text{Peak Hour Travel Time}}{\text{Desired Peak Period Travel Time}}$$

Where:

- *Peak Hour Travel Time* = value calculated in step 2 above
- *Desired Peak Period Travel Time* = desired travel time corresponding to the hour in which the *Peak Hour Travel Time* occurred (see **Data needed** section above)

Sample calculation

1. Prepare data
 - a. Group travel times into six peak hour time period bins by reporting segment (TMC)
 - i. Weekdays only
 - ii. Ignore travel times occurring on a holiday
 - The sample data set includes Christmas Day (December 25, 2015), so any readings from this day will be ignored
 - iii. Ignore travel times representing speeds less than 2 mph or greater than 100 mph.
 - Using the sample data set, we can define the upper and lower bounds for acceptable travel times for each reporting segment. Any travel times outside of this range will be ignored.

Reporting Segment	Segment Length (miles)	Minimum Travel Time (seconds) <i>speed = 100 mph</i>	Maximum Travel Time (seconds) <i>speed = 2 mph</i>
110N04173	0.30804	11	554
110N04174	1.86218	67	3352
110N04175	2.08511	75	3753
110P04173	1.24972	45	2249
110P04174	0.81046	29	1459
110P04175	1.76393	64	3175

- iv. Using the sample data set, you should end up with 36 groups (6 reporting segments, 6 peak hour time bins each)

- b. Define *Desired Peak Period Travel Time* values for each reporting segment. AM and PM periods get their own values
- i. For this sample calculation, we will use a travel time representing speeds equal to 80% of the posted speed limit for the AM period, and 60% of the posted speed limit for the PM period:

Reporting Segment	Segment Length (miles)	Desired Travel Time AM <i>80% of Speed Limit = 44 mph</i>	Desired Travel Time PM <i>60% of Speed Limit = 33 mph</i>
110N04173	0.30804	25	34
110N04174	1.86218	152	203
110N04175	2.08511	171	227
110P04173	1.24972	102	136
110P04174	0.81046	66	88
110P04175	1.76393	144	192

2. Calculate the *Average Travel Time* for each peak hour time bin:

Reporting Segment	Travel Time (seconds)					
	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
110N04173	38	21	27	106	142	131
110N04174	161	120	129	335	411	362
110N04175	191	200	187	146	196	183
110P04173	74	76	83	76	77	87
110P04174	51	51	52	60	58	56
110P04175	111	115	114	209	218	164

3. Find the *Peak Hour Travel Time* for each reporting segment by selecting the maximum *Average Travel Time* value from step 2 above. Use this value to calculate the PHTR for each reporting segment:

Reporting Segment	Peak Hour Travel Time (seconds)	Peak Hour	Desired Travel Time (seconds)	PHTR
110N04173	142	5:00 PM – 6:00 PM	34	4.18
110N04174	411	5:00 PM – 6:00 PM	203	2.02
110N04175	200	7:00 AM – 8:00 AM	171	1.17
110P04173	87	6:00 PM – 7:00 PM	136	0.64
110P04174	60	4:00 PM – 5:00 PM	88	0.68
110P04175	218	5:00 PM – 6:00 PM	192	1.14

System Performance Measures

Data Needed

The system-level performance measures are based on the performance metrics defined above (*Level of Travel Time Reliability* and *Peak Hour Travel Time Ratio*). For each reporting segment, you will need the following:

- Length of the reporting segment
- LOTTR values for all four time period bins
- PHTTR value

Calculating system performance measures

Both LOTTR and PHTTR are reported on a system-wide level using the following formula:

$$Measure = 100 \times \frac{\sum_{i=1}^R SL_i}{\sum_{i=1}^T SL_i}$$

where:

- i = reporting segment
- R = total number of reporting segments operating at a specified performance level, as defined through a threshold proposed for each metric
 - Both LOTTR and PHTTR have a threshold of < 1.50
 - For the LOTTR measure, all four LOTTR values must meet this threshold to be counted here
- T = total number of reporting segments in the system and area applicable to the measure
- SL_i = length of the reporting segment, to the nearest thousandth of a mile
- $Measure$ = the percentage of the system operating at a specified performance level, to the nearest tenth of a percent

Sample calculation

1. Prepare the data. The chart below summarizes the necessary values calculated from the sample data set in previous sections of this document. LOTTR and PHTTR values of 1.50 or above have been highlight for use in later steps:

Reporting Segment	Segment Length (miles)	LOTTR				PHTTR
110N04173	0.308	1.30	1.00	6.05	1.00	4.18
110N04174	1.862	1.08	1.09	1.58	1.00	2.02
110N04175	2.085	1.37	1.23	1.18	1.25	1.17
110P04173	1.249	1.08	1.07	1.00	1.05	0.64
110P04174	0.810	1.00	1.06	1.02	1.00	0.68
110P04175	1.763	1.07	1.09	1.41	1.06	1.14

2. Calculate LOTTR system measure
 - a. Identify reporting segments for which all four LOTTR values less than the 1.50 threshold:
 - i. 110N04175, 110P04173, 110P04174, and 110P04175
 - b. Calculate sum of reporting segment lengths meeting threshold
 - i. $2.085 + 1.249 + 0.810 + 1.763 = 5.907$
 - c. Calculate sum of all reporting segment lengths
 - i. $0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763 = 8.077$
 - d. Calculate LOTTR system measure
 - i. $LOTTR = 100 \times \frac{5.907}{8.077} = 73.1\%$

3. Calculate PHTTR system measure
 - a. Identify reporting segments with a PHTTR value less than the 1.50 threshold:
 - i. 110N04175, 110P04173, 110P04174, and 110P04175
 - b. Calculate sum of reporting segment lengths meeting threshold
 - i. $2.085 + 1.249 + 0.810 + 1.763 = 5.907$
 - c. Calculate sum of all reporting segment lengths
 - i. $0.308 + 1.862 + 2.085 + 1.249 + 0.810 + 1.763 = 8.077$
 - d. Calculate PHTTR system measure
 - i. $PHTTR = 100 \times \frac{5.907}{8.077} = 73.1\%$
but the calculation method is identical.

What is the CATT Lab & Why Are We Doing This?

We specialize in transportation data analytics, TSM&O, performance management, and information visualization. As a non-profit entity, our goal is to solve problems for Federal, State, and Local transportation departments and first responders through technology and data-informed policy guidance. In short, we're offering our support because it fits within our mission, we feel we have knowledge and tools that can make this less painful for everyone, and it's the right thing to do. To learn more about our other capabilities, please contact the CATT Lab Director, Michael Pack at PackML@umd.edu.