

Sample Calculations: MAP-21 NPRM Subpart F

National Performance Management Measures to Assess Freight Movement on the Interstate System

Document Version 1.1: May 5, 2016

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 F: *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.

Truck Travel Time Reliability (TTTR)

Data needed

- Geographic range: Interstate system within a state
- 5-minute interval travel times for entire year
 - Use "trucks only" travel times when available
 - Fill in missing and "0" values with the greater of the following two values:
 - The "all vehicles" travel time reported for the missing reading
 - The travel time that would have occurred while traveling at the posted speed limit

Calculating Truck Travel Time Reliability

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

$$TTTR = \frac{95th\ percentile\ truck\ travel\ time}{50th\ percentile\ "normal\ truck\ travel\ time"}$$

Sample calculation

1. Prepare data
 - a. Group truck travel times by reporting segment (TMC)
 - i. Replace truck travel times with a value of 0 with the greater of the “all vehicles” travel time or the travel time at the posted speed limit
 - ii. Using the sample data set, you should end up with 6 groups (one for each reporting segment)
 - b. Fill in missing readings with the 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. Calculate the expected number of readings for each reporting segment. Using the sample data set’s 1-month time range (December 2015), we should expect 8928 readings (31 days * 24 hours * 12 readings per hour).
- iii. Add readings with travel times equal to the values calculated in **1.b.i** just above to the travel time groupings from **1.a** above, based on the number of missing readings:
 - Using the sample data set, reporting segment 110N04175 has 5569 truck travel time readings, and an additional 2740 “all vehicle” travel time readings. Since we expect 8928 readings, we will add 619 travel times to this time bin (8928 expected – 5569 truck travel times – 2740 all vehicle travel times = 619 missing travel times) with the calculated speed limit travel time of 136 seconds.

- Calculate TTTR for each reporting segment

Reporting Segment	95 th percentile travel time (seconds)	50 th percentile travel time (seconds)	TTTR
110N04173	112	20	5.60
110N04174	196	122	1.61
110N04175	270	141	1.91
110P04173	86	82	1.05
110P04174	62	53	1.17
110P04175	174	115	1.51

Average Truck Speed

Data needed

- Geographic range: Interstate system within a state
- 5-minute interval travel times for entire year
 - Use “trucks only” travel times when available
 - Fill in missing and “0” values with the greater of the following two values:
 - The “all vehicles” travel time reported for the missing reading
 - The travel time that would have occurred while traveling at the posted speed limit

Calculating Average Truck Speed

For every reporting segment, calculate the *Average Truck Speed*:

$$Average\ Truck\ Speed_s = \frac{\sum_{b=1}^T \frac{Segment\ Length_s}{Truck\ Travel\ Time_b}}{T} \times 60 \times 60$$

where:

- b = a 5-minute time interval for a travel time reporting segment s
- s = a travel time reporting segment
- T = total number of time intervals in reporting period
- $Segment\ Length_s$ = length of reporting segment s , to the nearest thousandth of a mile
- $Truck\ Travel\ Time_b$ = travel time for trucks at time interval b
- $Average\ Truck\ Speed_s$ = average speed of trucks traveling through reporting segment b , to the nearest hundredth miles per hour

Sample calculation

- Prepare data
 - Group truck travel times by reporting segment
 - Replace truck travel times with a value of 0 with the greater of the “all vehicles” travel time or the travel time at the posted speed limit
 - Using the sample data set, you should end up with 6 groups (one for each reporting segment)
 - Fill in missing readings with the 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. Calculate the expected number of readings for each reporting segment. Using the sample data set's 1-month time range (December 2015), we should expect 8928 readings (31 days * 24 hours * 12 readings per hour).
- iii. Add readings with travel times equal to the values calculated in **1.b.i** just above to the travel time groupings from **1.a** based on the number of missing readings:
- Using the sample data set, reporting segment 110N04175 has 5569 truck travel time readings, and an additional 2740 "all vehicle" travel time readings. Since we expect 8928 readings, we will add 619 travel times to this time bin (8928 expected – 5569 truck travel times – 2740 all vehicle travel times = 619 missing travel times) with the calculated speed limit travel time of 136 seconds.

2. Calculate Average Truck Speed for each reporting segment

Reporting Segment	Average Truck Speed (mph)
110N04173	50.65
110N04174	52.39
110N04175	49.28
110P04173	54.40
110P04174	53.87
110P04175	52.54

System Freight Movement Measures

Data Needed

The system-level freight movement measures are based on the freight measures defined above (*Truck Travel Time Reliability* and *Average Truck Speed*). For each reporting segment, you will need the following:

- Length of the reporting segment
- TTTR value
- Average Truck Speed value

Calculating system performance measures

TTTR is reported on a system-wide level using the following formula:

$$\begin{aligned} & \text{Percent of the Interstate System Mileage providing for Reliable Truck Travel Times} \\ & = 100 \times \frac{\sum_{a=1}^R SL_a}{\sum_{i=1}^T SL_i} \end{aligned}$$

where:

- a = reporting segment exhibiting Reliable Truck Travel Times (TTTR < 1.50)
- R = total number of reporting segments exhibiting Reliable Truck Travel Times
- SL_a = Segment length, to the nearest thousandth of a mile, for reporting segment a
- i = a reporting segment
- T = total number of reporting segments
- SL_i = Segment length, to the nearest thousandth of a mile, for reporting segment i

Average Truck Speed is reported on a system-wide level using the following formula:

$$\text{Percent of the Interstate System Mileage Uncongested} = 100 \times \frac{\sum_{g=1}^U SL_g}{\sum_{i=1}^T SL_i}$$

where:

- g = An uncongested reporting segment (Average Truck Speed > 50 mph)
- U = total number of uncongested reporting segments
- SL_g = Segment length, to the nearest thousandth of a mile, for reporting segment g
- i = a reporting segment
- T = total number of reporting segments
- SL_i = Segment length, to the nearest thousandth of a mile, for reporting segment i

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. TTTR values of 1.50 or above and Average Truck Speeds below 50 mph have been highlighted for use in later steps:

Reporting Segment	Segment Length in miles	TTTR	Average Truck Speed
110N04173	0.308	5.60	50.65
110N04174	1.862	1.61	52.39
110N04175	2.085	1.91	49.28
110P04173	1.249	1.05	54.40
110P04174	0.810	1.17	53.87
110P04175	1.763	1.51	52.54

2. Calculate TTTR system measure
 - a. Identify reporting segments with a TTTR value less than the 1.50 threshold:
 - i. 110P04173 and 110P04174
 - b. Calculate sum of reporting segment lengths meeting threshold
 - i. $1.249 + 0.810 = 2.059$
 - 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 TTTR system measure
 - i. *Percent of the Interstate System Mileage providing for Reliable Truck Travel Times =*
 $100 \times \frac{2.059}{8.077} = 25.5\%$
3. Calculate Average Truck Speed system measure (Percent of the Interstate System Mileage Uncongested)
 - a. Identify reporting segments with an Average Truck Speed greater than 50 mph:
 - i. 110N04173, 110N04174, 110P04173, 110P04174, and 110P04175
 - b. Calculate sum of reporting segment lengths meeting threshold
 - i. $0.308 + 1.862 + 1.249 + 0.810 + 1.763 = 5.992$
 - 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 Average Truck Speed system measure
 - i. *Percent of the Interstate System Mileage Uncongested =* $100 \times \frac{5.992}{8.077} = 74.2\%$

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.