Iowa DOT System Performance and Freight Measures – Mid Performance Period Progress Review Update

September 2020

Performance measures

Through the Moving Ahead for Progress in the 21st Century (MAP-21) Act, Congress required the establishment of measures to assess performance in several areas, including performance of the Interstate and non-Interstate National Highway System (NHS), now codified in 23 CFR 490.507, and freight movement on the Interstate System, now codified in 23 CFR 490.607. The State Departments of Transportation (DOTs), as well as metropolitan planning organizations (MPOs) with applicable roadways within their metropolitan planning areas, were required to set targets for the following performance measures, known as "PM3"[1].

1. Percent of the person-miles traveled on the Interstate that are reliable (referred to as the Interstate Travel Time Reliability measure)
2. Percent of person-miles traveled on the non-Interstate NHS that are reliable (referred to as the Non-Interstate Travel Time Reliability measure).
3. Freight movement on the Interstate System - the Truck Travel Time Reliability (TTTR) Index (referred to as the Freight Reliability measure)

States were required to set 2- and 4-year targets for these measures by May 20, 2018, and reported them to FHWA as part of the submittal of State baseline performance period reports on October 1, 2018. States are required to submit a mid-performance period progress report by October 1, 2020. This update corresponds to the middle of the first 4-year performance reporting period, at a time designated by regulation to allow for states to review their 4-year targets and potentially make adjustments.

Data and methodology

Data for these measures is provided by FHWA through the National Performance Management Research Data Set (NPMRDS). This is a national data set of average travel times on the NHS. Since February 2017, speed and travel time data from INRIX has been used for the NPMRDS, which is hosted by the University of Maryland Center for Advanced Transportation Technology Laboratory (CATT Lab). States and MPOs can access the raw data at no cost. CATT Lab has also developed a MAP-21 tool to assist States and MPOs in calculating PM3 measures. This tool is available through a pooled fund effort led by the American Association of State Highway and Transportation Officials (AASHTO). Iowa DOT has joined the pooled fund for a five-year period, which provides access to the MAP-21 tool and output for the State and Iowa MPOs.

In addition to joining the pooled fund, in 2018 Iowa DOT downloaded the NPMRDS data and processed it internally to calculate the PM3 measures in parallel with the CATT Lab's efforts.

[1] This target-setting process and memo focuses only on PM3 measures applicable to Iowa. The final rule for PM3 also contains measures related to air quality, which are not required for Iowa or its MPOs as there are no non-attainment areas in the State.

Long-term, Iowa DOT anticipates continuing to conduct this analysis in-house to improve its understanding of the measures and the raw data. The internal analysis and CATT Lab output have both evolved since early 2018, as clarifications have been provided from FHWA on the measure calculations. Additionally, January 2017 NPMRDS data was reformatted to match the February-December 2017 NPMRDS data, to allow for a full year of consistent data for 2017.

The CATT Lab annual and monthly output for Iowa's PM3 measures in 2017, 2018, and 2019 was downloaded on March 17, 2020 and is being used to review progress towards 2-year targets and consider adjustments to 4-year targets.

NPMRDS data was collected for several years prior to 2017, but due to a change in vendor, only three complete years of data is available from NPMRDS that is formatted in the manner data is currently being collected. This creates challenges in setting targets because there is not enough information to create trends or obtain a good understanding of the natural variability in the annual measure. As a proxy for annual variation, the monthly variance of each measure for the three available years (36 months) is used. The data were analyzed to seek a "best fit" theoretical distribution for each measure, and parameters of those distributions were estimated. The cumulative distribution properties of each distribution were used to derive probabilistic (risk-based) targets. This is described for each target below.

Measure 1: Interstate travel time reliability measure

State DOTs were required to establish 2- and 4-year targets for percent of reliable person-miles on the Interstate system. This measure is calculated in the same manner as non-Interstate NHS reliability (measure 2).

The level of travel time reliability (LOTTR) is the metric for determining the performance measure. The LOTTR is calculated for four time periods:

1. Weekdays from 6:00 a.m. – 10:00 a.m.
2. Weekdays from 10:00 a.m. – 4:00 p.m.
3. Weekdays from 4:00 p.m. – 8:00 p.m.
4. Weekends from 6:00 a.m. – 8:00 p.m.

For each time period across an entire year, the LOTTR is defined as the ratio of the longer travel times (80th percentile) to a "normal" travel time (50th percentile) for all vehicles. Data are analyzed based on 15-minute groupings of speeds and travel times for traffic message channels (TMCs), which are highways segments that NPMRDS data is grouped into. FHWA defines a segment as reliable if its LOTTR is less than 1.5 during all four time periods. If the highest LOTTR is 1.5 or above, the segment is unreliable. To translate the LOTTR to the performance measure, the length of each segment is multiplied by its annual average daily traffic (AADT) and average occupancy factor for all vehicles (FHWA's default is 1.7), which results in person-miles. This calculation is done for reliable segments and for all segments. Dividing reliable segment person-miles by all person-miles provides the measure of percent of travel time reliability.

To develop targets, the percentage of reliable Interstate person-miles was calculated for each of the 36 months in calendar years 2017 – 2019, and the annual figures were also calculated. Using Palisade @RISK software, the 36 monthly observations were analyzed and various theoretical distributions were fit and compared. The monthly data are heavily skewed, and naturally cannot exceed 100%. Therefore, a truncated distribution such as a "triangular" distribution seems logical, and in fact is suggested as a best-fit option. As shown in Figure 1,

the software fits the distribution and generates the parameters. We can then use this theoretical distribution to obtain target values corresponding to various levels of confidence. For example, to be at least 75 percent confident in achieving the target, we would look for the point in the theoretical curve where the cumulative probability (area under the curve) is 0.75. There is a function in the @RISK package that allows us to calculate such values, and it returns 98.89%. Therefore, if we want to be at least 75 percent confident in achieving our target, we should set it to 98.89%.

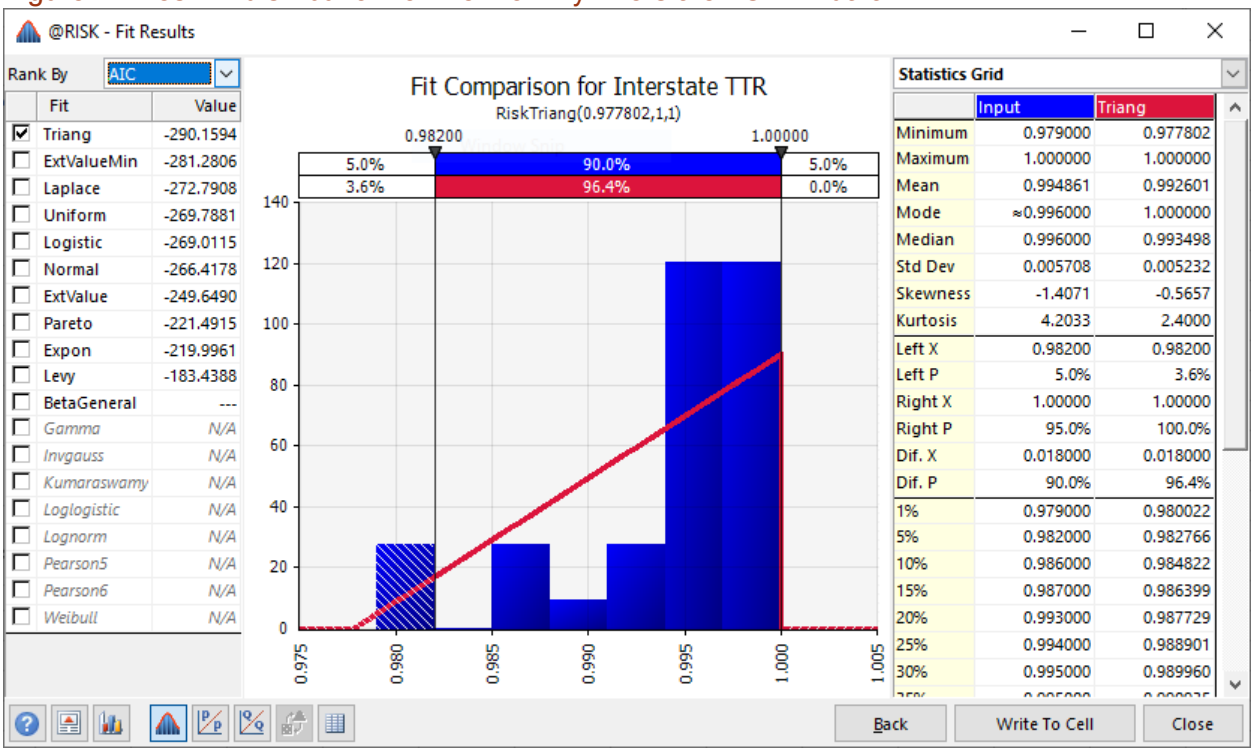
This assumes that the monthly values and the annual values follow the same distribution, however we know that the relationship between monthly and annual data is not straightforward, as the LOTTR is recalculated based on the 80th and 50th percentile travel times for the specific timeframe being evaluated. This can result in annual values that are higher than any single monthly value or the average of monthly values. Because of this issue, we analyzed the annual values to see how "likely" they would be to come from the distribution of the monthly values. We observed that these values were typical of the theoretical distribution, so we therefore did not find evidence to suggest significant problems with the assumption. This assumption should be more rigorously explored as additional annual figures become available.

Table 1: Level of travel time reliability for the Interstate system
4-year targets at various confidence levels

Confidence Level	Target
70 percent	99.00%
75 percent	**98.89%**
80 percent	98.77%
85 percent	98.64%
90 percent	98.48%
95 percent	98.28%

The target value is rounded down to the nearest half percent. Using a 75 percent confidence level results in a revised 4-year target of 98.5 percent for person-miles traveled on the Interstate that are reliable.

Figure 1: “Best fit” distribution for the monthly Interstate LOTTR data



Measure 2: Non-Interstate NHS travel time reliability measure

State DOTs were also required to establish 2- and 4-year targets for the percent of reliable person-miles on the non-Interstate NHS. The metrics and measure are calculated in the same manner as measure 1, and the same methodology was used to derive targets.

To develop targets, the percentage of reliable non-Interstate person-miles was calculated for each of the 36 months in calendar years 2017 – 2019, and the annual figures were also calculated. Using Palisade @RISK software, the 36 monthly observations were analyzed and various theoretical distributions were fit and compared. Although it is not an ideal fit for the data, the software recommends using a "normal" distribution, and this makes sense given what we know about the process that generates the data values. As shown in Figure 2 the software fits the distribution and generates the parameters. We can then use this theoretical distribution to obtain target values corresponding to various levels of confidence. For example, to be at least 75 percent confident in achieving the target, we would look for the point in the theoretical curve where the cumulative probability (area under the curve) is 0.75. There is a function in the @RISK package that allows us to calculate such values, and it returns 95.39%. Therefore, if we want to be at least 75 percent confident in achieving our target, we should set it to 95.39%.

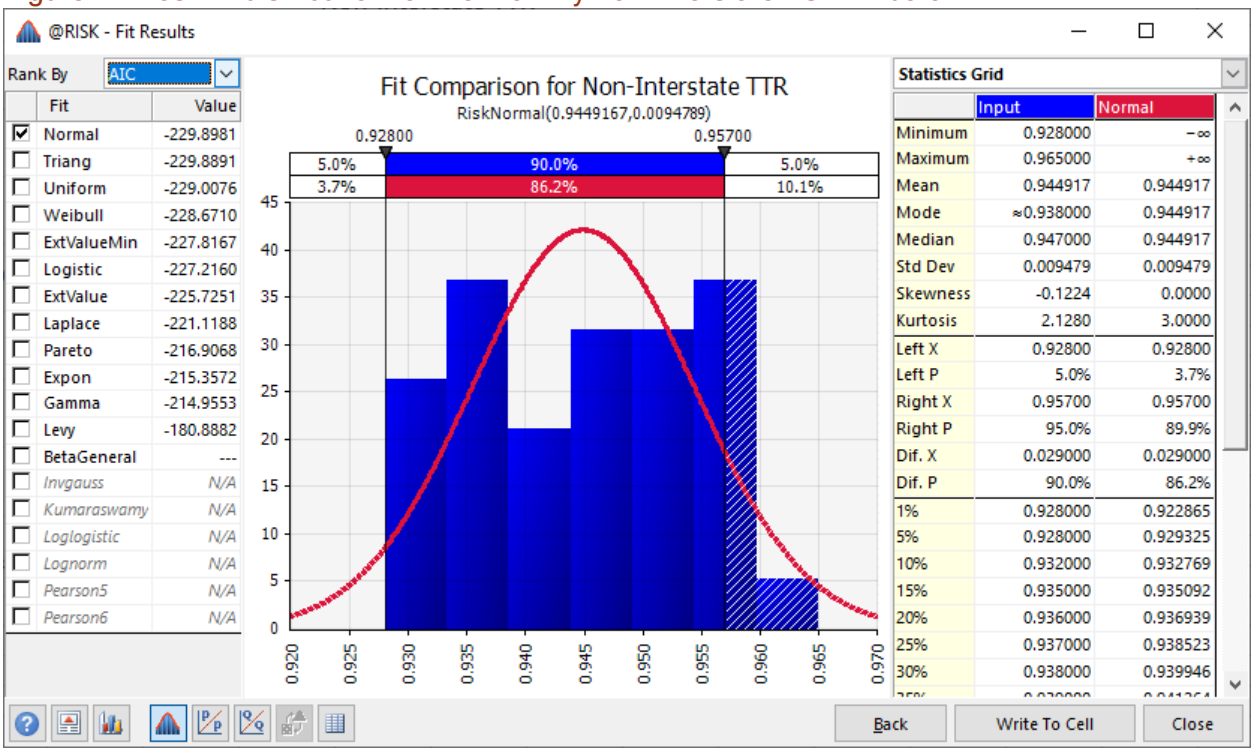
This assumes that the monthly values and the annual values follow the same distribution, however we know that the relationship between monthly and annual data is not straightforward, as the LOTTR is recalculated based on the 80th and 50th percentile travel times for the specific timeframe being evaluated. This can result in annual values that are higher than any single monthly value or the average of monthly values. Because of this issue, we analyzed the annual values to see how "likely" they would be to come from the distribution of the monthly values. We observed that these values were atypical of the theoretical distribution, so we therefore used the same spread (standard deviation) as the monthly data, but we substituted the mean of the three annual observations, resulting in a "shifted" distribution. Instead of the monthly mean value of 94.49%, the annual mean value of 96.03% was used to center the distribution.

Table 2: Level of travel time reliability for the non-Interstate NHS
4-year targets at various confidence levels

Confidence Level	Target
70 percent	95.54%
75 percent	**95.39%**
80 percent	95.24%
85 percent	95.05%
90 percent	94.82%
95 percent	94.47%

The target value is rounded down to the nearest half percent. Using a 75 percent confidence level results in a target of 95.0% for person-miles traveled on the non-Interstate NHS that are reliable. The 4-year target for this measure was originally set at 95.0%, therefore there is no change to the target for non-Interstate NHS reliability.

Figure 2: “Best fit” distribution for the monthly non-Interstate LOTTR data



Measure 3: Truck travel time reliability

State DOTs were required to establish 2- and 4-year targets for truck travel time reliability (TTTR) on the Interstate System. This measure is calculated similarly to measures 1 and 2, but the metric's parameters are different and it is not translated into a percentage of reliable miles. This measure also uses a subset of the NPMRDS data that contains only truck data, rather than the all-vehicle data used for measures 1 and 2.

The TTTR index is the metric for determining the performance measure. The TTTR is calculated for five time periods:

1. Weekdays from 6:00 a.m. – 10:00 a.m.
2. Weekdays from 10:00 a.m. – 4:00 p.m.
3. Weekdays from 4:00 p.m. – 8:00 p.m.
4. Overnight (all days) from 8:00 p.m. – 6:00 a.m.
5. Weekends from 6:00 a.m. – 8:00 p.m.

For each time period across an entire year, the TTTR is defined as the ratio of the longer truck travel times (95th percentile) to a "normal" truck travel time (50th percentile). Data are analyzed based on 15-minute groupings of speeds and travel times for traffic message channels (TMCs), which are highways segments that NPMRDS data is grouped into. For each TMC, the highest TTTR value is carried forward into the measure calculation. To translate the individual TMC values into the overall TTTR index, the length of each segment is multiplied by its maximum TTTR of the five time periods. These length weighted TTTRs are then divided by the sum of all segment lengths to result in the TTTR index for the performance measure.

To develop targets, the TTTR was calculated for each of the 36 months in calendar years 2017 – 2019, and the annual figures were also calculated. Using Palisade @RISK software, the 36 monthly observations were analyzed and various theoretical distributions were fit and compared. The software recommends using a Pareto distribution, however the Lognormal distribution also performs well and has the advantage of making more sense given the nature of the TTTR measure. As shown in Figure 3, the software fits the distribution and generates the parameters. We can then use this theoretical distribution to obtain target values corresponding to various levels of confidence. For example, to be at least 75 percent confident in achieving the target, we would look for the point in the theoretical curve where the cumulative probability (area under the curve) is 0.75. There is a function in the @RISK package that allows us to calculate such values, and it returns 1.20. Therefore, if we want to be at least 75 percent confident in achieving our target, we should set it to 1.20.

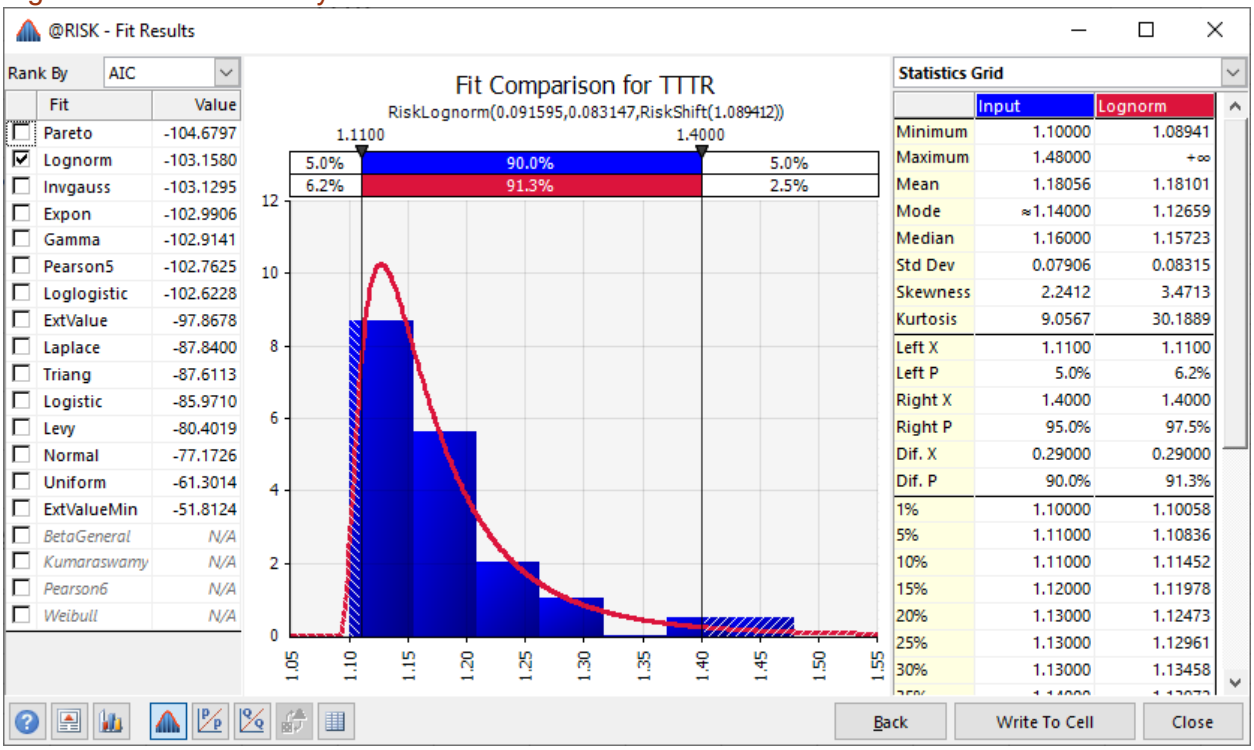
This analysis assumes that the monthly values and the annual values follow the same distribution, however we know that the relationship between monthly and annual data is not straightforward, as the TTTR is recalculated based on the 95^{th} and 50^{th} percentile travel times for the specific timeframe being evaluated. This can result in annual values that are lower than any single monthly value or the average of monthly values. Because of this issue, we analyzed the annual values to see how "likely" they would be to come from the distribution of the monthly values. We observed that these values were typical of the theoretical distribution, so we therefore did not find evidence to suggest significant problems with the assumption. This assumption should be more rigorously explored as additional annual figures become available.

Table 3: Truck travel time reliability for the Interstate System
4-year targets at various confidence levels

Confidence Level	Target
70 percent	1.191
75 percent	**1.204**
80 percent	1.220
85 percent	1.241
90 percent	1.273
95 percent	1.332

The target is rounded up to the nearest hundredth. Using a 75 percent confidence level results in a revised 4-year target of 1.21 for truck travel time reliability on the Interstate system.

Figure 3: Statistical analysis for the Interstate TTTR measure



Iowa DOT FHWA performance targets for system reliability and freight

Through revisiting the original analysis and targets at the mid-point of the performance period with more data available, it is clear that we have had and continue to have an incomplete understanding of the natural variability in these mobility measures. Therefore, it is not surprising that we should take this opportunity to employ some of our learning and revise the targets. Our analysis suggests revising two of the three targets (Interstate TTR and Truck TTR), while making no change to the non-Interstate NHS TTR target.

Iowa DOT's suggested 4-year targets are shown in Table 4. The targets are being set at the 75 percent confidence level. This still means that, assuming the processes generating these measures follow these distributions, we have about a one in four chance of not meeting these targets.

Table 4: Iowa DOT 4-year targets for system reliability and freight performance measures

	Interstate level of travel time reliability 2022 target	Non-interstate NHS level of travel time reliability 2022 target	Truck travel time reliability index 2022 target
Original	99.5%	95.0%	1.14
Revised	**98.5%**	**95.0%**	**1.21**