Addendum to Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools

Reliability Analysis Guidance Addendum

July 2023

U.S. Department of Transportation
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16. Abstract

This report reflects up-to-date guidance on incorporating travel time reliability (TTR) in the *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools* (FHWA-HRT-04-039) which itself provides an overview of the role of traffic analysis tools in the transportation analysis process and provides a detailed decision support methodology for selecting the appropriate type of analysis tool for the job at hand.

An introduction to the role of traffic analysis tools and tool categories is provided. A set of criteria for selecting the appropriate type of traffic analysis tool is described in detail, and each tool category is scored as to its relevance to the criteria. The criteria include the analysis context, study area, facility type, travel mode, management strategy, traveler response, performance measures, and cost-effectiveness. A process and worksheets for an analyst to rate a tool category for a particular transportation analysis task are presented based on the criteria and the analyst's weighting of the criteria. Some challenges and limitations of the use of traffic analysis tools are provided.

The appendices include: a) a summary of current limitations to the *Highway Capacity Manual* (HCM) methodologies, b) tool category selection worksheets, c) worksheets for selecting an individual tool within a category, d) a list of recommended further reading, and e) a list of traffic analysis tools by category.

This is the second volume in a series of volumes in the Traffic Analysis Toolbox. The other volumes currently in the Traffic Analysis Toolbox are: *Volume I: Traffic Analysis Tools Primer* (FHWA-HRT-04-038), *Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (FHWA-HRT-04-040)

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1,000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1. PURPOSE

This document is an addendum to the *Traffic Analysis Toolbox Volume II: Decision Support Methodology for Selecting Traffic Analysis Tools* (Federal Highway Administration Report No. FHWA-HRT-04-039) and reflects up-to-date guidance on incorporating travel time reliability (TTR) in the Traffic Analysis Toolbox (TAT). This addendum consists of:

- Updates to the existing Toolbox volume text
- Additional content to be appended to the Toolbox volume

CHAPTER 2. UPDATES TO EXISTING TOOLBOX VOLUME TEXT

BACKGROUND AND OBJECTIVES

Page 2:

- With reference to Appendix C, Tool Selection Worksheet in Volume II:
  - Since the original TAT Volume II publication, a number of valuable tools have been developed with explicit capability of TTR analysis. Some examples of these reliability analysis tools (and the categories of such tools) are listed in the addendum to this volume.

- With reference to Appendix D, Recommended Reading:
  - The addendum to this volume provides recommended literature for TTR analysis.

Page 11:

- With reference to section 1.4.4, Traffic Performance Measures: Differences Between HCM and Simulation in Volume II:

  - A few years after FHWA originally published TAT Volume II, the Transportation Research Board (TRB) incorporated multiple period analysis procedures and TTR analysis procedures into the *Highway Capacity Manual* (HCM). Today's HCM procedures can support single-day analyses that span several hours or reliability analyses that span several months.

CRITERIA FOR SELECTING THE APPROPRIATE TYPE OF TRAFFIC ANALYSIS TOOL

Page 14

- With reference to a listing of available tools in Volume II:
  - Since the original TAT Volume II publication, a number of valuable tools have been developed with explicit capability of TTR analysis. This addendum lists some examples of these reliability analysis tools (and the categories of such tools).

Page 15

- With reference to figure 5 in Volume II:
  - Not all tools are capable of explicitly analyzing TTR. The ability to analyze TTR should be a criterion considered during the tool selection process.

Page 28

- With reference to TTR in table 7 in Volume II:
  - Many performance measures are associated with TTR. These measures are described in the TTR addendum to TAT Volume VI: Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness. The TTR addendum to this Volume II provides an overview of the analytical tools capable of performing TTR analysis. The TTR addendum to

TAT Volume III discusses the Scenario Generator and Trajectory Processor, plus other alternative approaches to performing TTR analysis via microsimulation.

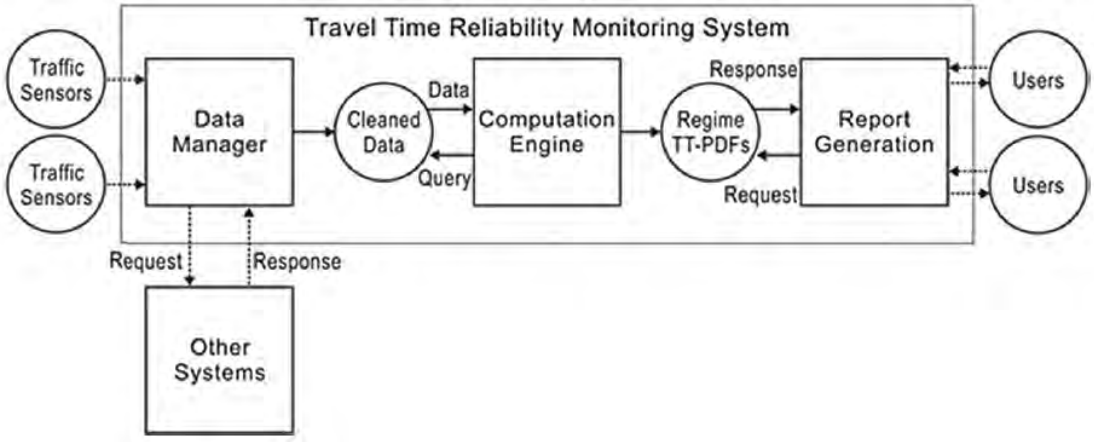
APPENDIX C

On Page 75: With reference to Appendix C, Tool Selection Worksheet in Volume II, since the original TAT Volume II publication, a number of valuable tools have been developed with explicit capability of TTR analysis. This addendum lists some examples of these reliability analysis tools (and the categories of such tools).

CHAPTER 3. ADDITIONAL CONTENT TO BE APPENDED TO THE TOOLBOX VOLUME

VOLUME II. ADDENDUM

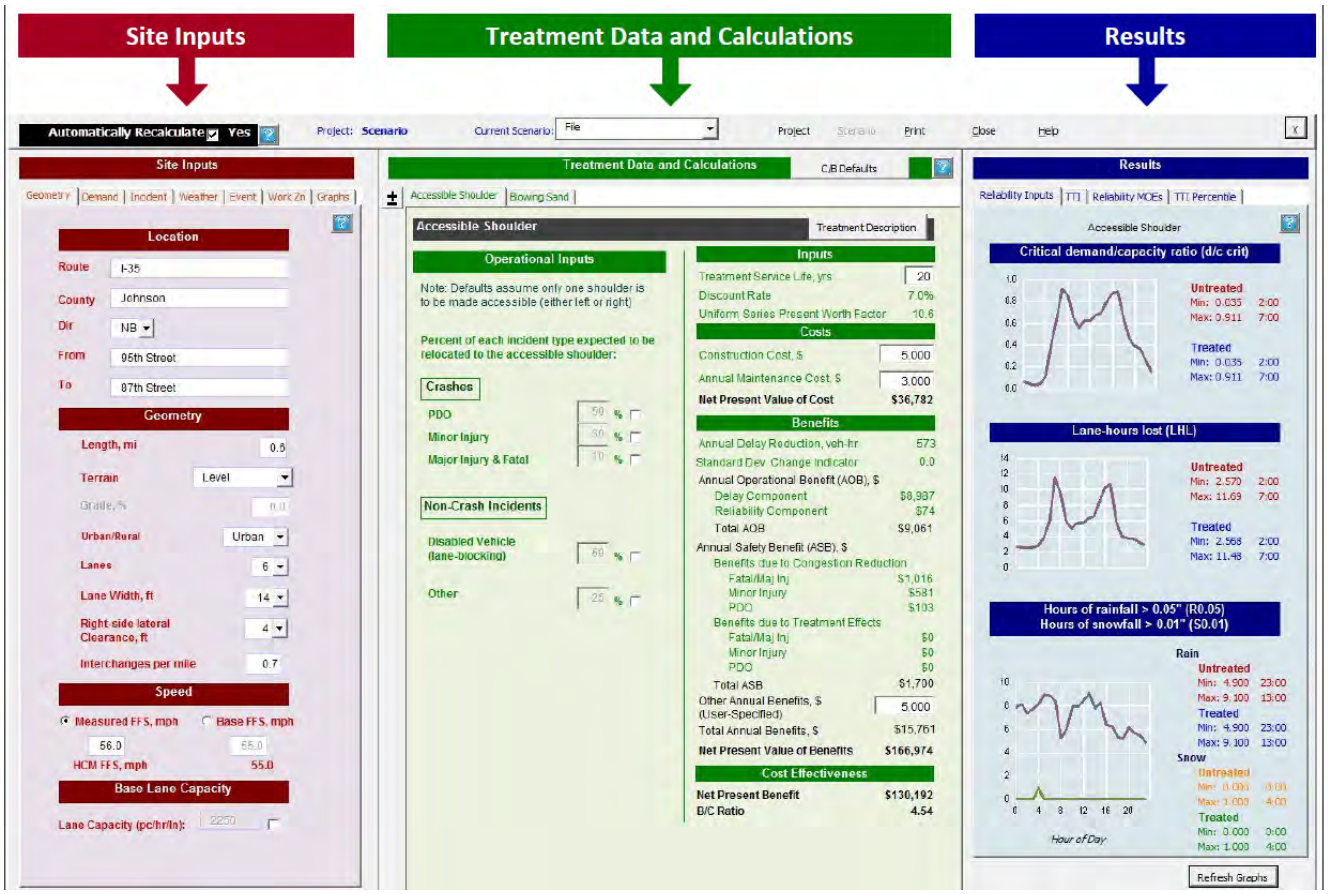
Some of today's sketch planning, the HCM, traffic simulation, and field data analytics tools provide explicit reliability output data, while others may facilitate derivation of reliability outputs. The travel time reliability monitoring systems (TTRMS) described in the Second Strategic Highway Research Program (SHRP 2) report S2-L02-RR-2, *Guide to Establishing Monitoring Programs for Travel Time Reliability* (SHRP 2 L02), are examples of field data analytics tools that can provide explicit reliability output data (List et al. 2014). Some TTRMS make their analyses available through websites. Note that TTRMS are not TAT that can predict future conditions or evaluate alternatives, but they can be a vital part of TAT validation and application processes. Figure 1 depicts a flow chart for travel time reliability monitoring.



Source: List et al. 2014

Figure 1. Flowchart. Travel time reliability monitoring system.

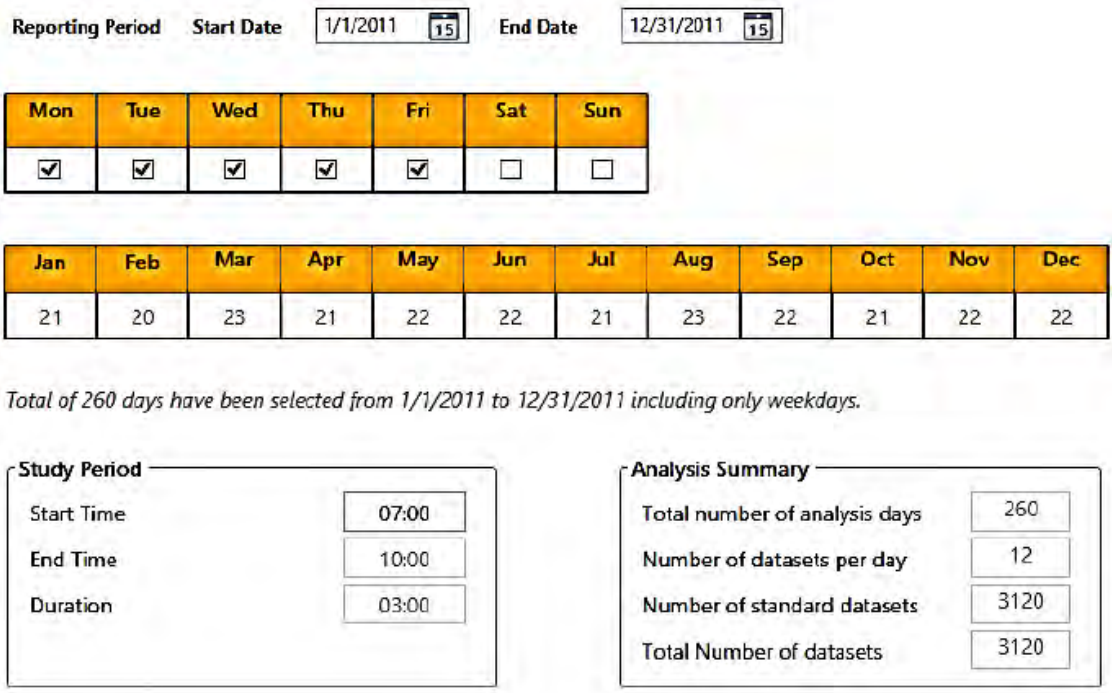
TRB's second SHRP 2 report, S2-L07-RR-1, *Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion* (SHRP 2 L07), produced a sketch-planning TAT to analyze the effects of highway geometric design treatments on nonrecurrent congestion using a reliability framework (Potts 2014). The tool, which includes a limited number of HCM-compliant calculations and benefit-cost ratio calculations, is designed to analyze a generally homogenous segment of a freeway (typically between successive interchanges). It allows users to input data regarding site geometry, traffic demand, incident history, weather, special events, and work zones. Based on these data, the tool calculates base reliability conditions. Users can then analyze the effectiveness of a variety of treatments by providing fairly simple input data regarding treatment effects and cost parameters. Regarding outputs, the tool predicts cumulative travel time index (TTI) curves for each hour of the day, from which other reliability variables are computed and displayed. The tool also calculates cost effectiveness by assigning monetary values to delay and reliability improvements and comparing these benefits with expected cost over the life of each treatment. Figure 2 is a screenshot of the SHRP 2 Project L07 tool.



Source: Potts et al. 2014.

Figure 2. Screenshot. Project L07 spreadsheet analysis tool user interface.

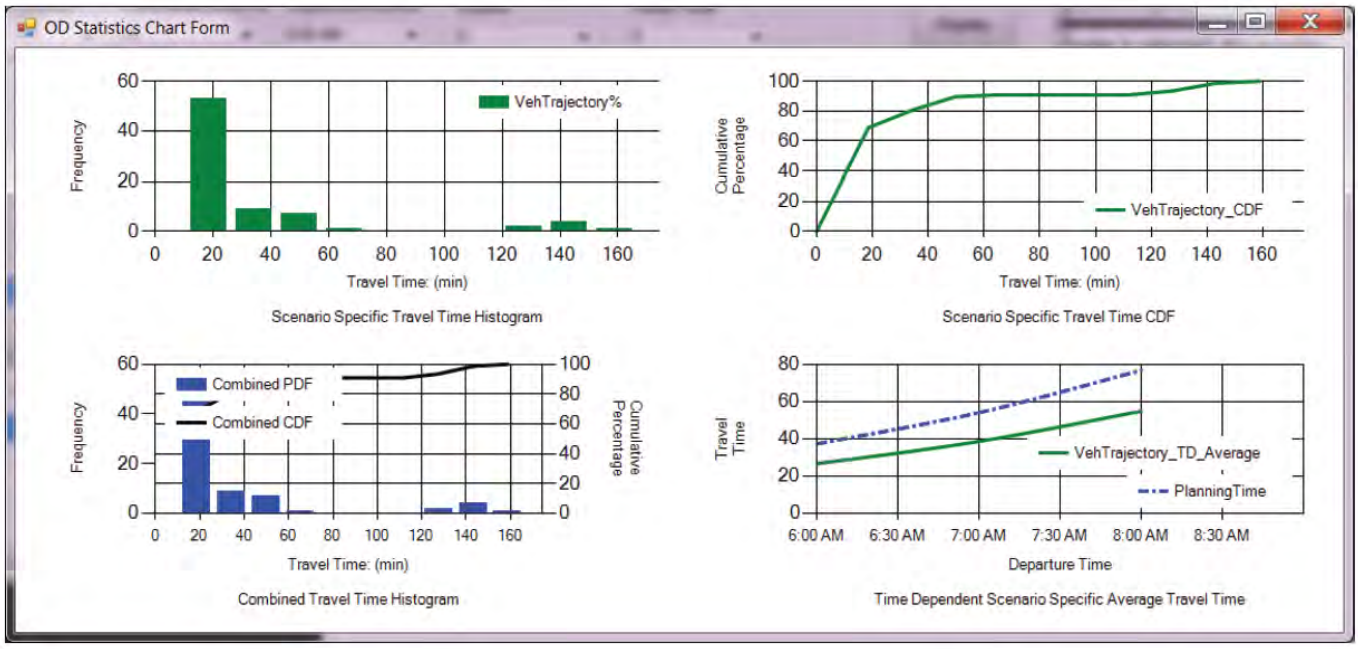
TRB's second Strategic Highway Research Program SHRP 2 Report, S2-L08-RW-1, *Incorporation of Travel Time Reliability into the Highway Capacity Manual* (SHRP 2 L08), incorporated TTR analysis into the HCM (Zegeer et al. 2014). SHRP 2 L08 describes a scenario-based procedure in which hundreds of scenario datasets contain variants of the original base dataset. Examples of scenario-specific adjustments include time-of-day demand adjustments, day-of-week demand adjustments, seasonal demand adjustments, free-flow speed adjustments caused by poor weather, and number-of-lane reductions caused by incidents or work zones. Examples of HCM reliability analysis tools include FREEVAL, STREETVAL, HCM-CALC, and Highway Capacity Software™ (HCS) and the University of Florida's 2021 data input tool, a screenshot of which is shown in figure 3.



Source: University of Florida

Figure 3. Screenshot. Input data to describe the reliability reporting period and analysis scenarios.

The SHRP 2 report S2-L04-RR-1, *Incorporating Reliability Performance Measures into Operations and Planning Modeling Tools* (SHRP 2 L04), described the Scenario Generator and Trajectory Processor tools for traffic simulation (Mahmassani 2014). The Scenario Generator produces scenario datasets similar to the HCM-based tools inspired by the SHRP 2 L08 report. However, because traffic simulations are more computationally intensive than HCM methods, the number of generated scenarios is typically smaller (e.g., dozens instead of hundreds). The Trajectory Processor automatically reads the outputs of all simulation scenarios. It then generates TTR reliability performance measures and visualizations, an example of which is shown in figure 4.



Source: Mahmassani et al. 2015.

Figure 4. Screenshot. Strategic Highway Research Program 2 L04 Trajectory Processor.

When the above reliability tools are not available or practical, traditional HCM-based and/or traffic simulation analyses may facilitate derivation of reliability outputs. Analysts may decide to create a variety of scenario datasets reflecting variability in demand, weather, incidents, work zones, and special events. They can then obtain a more comprehensive set of outputs by manually executing each scenario. They can then apply heavier weighting factors (or consideration) to the outputs from scenarios that occur more frequently.

Often, the desired spatial scope of the analysis (e.g., intersection, segment, facility, corridor, and region) dictates the choice of TAT. Smaller facilities are usually analyzed via microsimulation tools or HCM tools, as opposed to macroscopic or mesoscopic simulation tools because the fine-grained, lane-level input and output data associated with the microsimulation or HCM tools are more practical for smaller areas.

OTHER PUBLICATIONS

In addition to the SHRP 2 reliability reports, other publications that provide helpful information on travel time reliability analysis include:

- *Scoping and Conducting Data-Driven 21st Century Transportation System Analyses* (FHWA-HOP-16-072):[1]
    - This report describes a spreadsheet tool developed under the project, used to estimate the number of labor hours needed to conduct various analyses of surface transportation systems

[1]Wunderlich, K., V. Alexiadis, and P. Wang. 2017. *Scoping and Conducting Data-Driven 21st Century Transportation System Analyses*. Report No. FHWA-HOP-16-072. Washington, DC: Federal Highway Administration. https://ops.fhwa.dot.gov/publications/fhwahop16072/fhwahop16072.pdf.

(e.g., simulation, HCM analysis, and other off-line analyses). This document could help estimate labor hours associated with many of the data-centric tasks essential for preparing data for inputs in a reliability analysis.

- *Integrating Business Processes to Improve Travel Time Reliability. (SHRP2 Report S2-L01-RR-1)*[2]

  - This report details how to properly gather, store, and analyze large volumes of diverse data to extract trends and other valuable information. While TTR may not be a focus of this document, the information and concepts may still be helpful when conducting a reliability analysis.

- *Does Travel Time Reliability Matter? (FHWA-HOP-19-062) October 2019*[3]
  - This guidebook helps practitioners properly and comfortably analyze TTR from multidimensional and probabilistic perspectives to enable further analysis using real-world data (e.g., data that contain noise and other issues). Practitioners will be able to better understand statistical issues associated with reliability analyses that will give them further context in the usage of reliability data.

- *Travel Time Reliability: Making It There On Time, All The Time. (FHWA-HOP-06-070)*[4]
  - This document is an introduction to explaining that a key step to understanding reliability is to be able to measure it. Travelers want to get where they are intending on time.

[2] Kimley-Horn and Associates, in cooperation with PB Consultants. Transportation Research Board, 2011. *Integrating Business Processes to Improve Travel Time Reliability*. SHRP2 Report S2-L01-RR-1. https://nap.nationalacademies.org/read/14510/chapter/1

[3] Battelle Institute, MacroSys LLC, and FHWA. *Does Travel Time Reliability Matter?* FHWA-HOP-19-062. https://ops.fhwa.dot.gov/publications/fhwahop19062/fhwahop19062.pdf

[4] *Travel Time Reliability: Making It There On Time, All The Time.* FHWA-HOP-06-070. https://ops.fhwa.dot.gov/publications/tt_reliability/brochure/index.htm

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