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SHRP2 SOLUTIONS
TOOLS FOR THE ROAD AHEAD

RELIABILITY DATA AND ANALYSIS TOOLS (L02/L05/L07/L08/C11)

A tool suite to help transportation planners and engineers improve data monitoring and analysis to achieve more consistent, predictable highway travel.

CASE STUDY

Minnesota Department of Transportation

Measuring Reliability in Minnesota

ABOUT THIS CASE STUDY

The second Strategic Highway Research Program (SHRP2) developed data and analysis tools to improve the measurement and management of travel time reliability by transportation practitioners. The SHRP2 Program provided funding to help agencies test the tools and incorporate reliability into their business practices. The Minnesota Department of Transportation (MnDOT) project included the following tools:

ANALYSIS	
L07	**Reliability by Design** Spreadsheet-based treatment analysis tool to assess how different design improvements affect reliability, delay, safety, and benefit versus cost over the lifecycle.
L08	**Incorporating Travel-Time Reliability into the Highway Capacity Manual** Highway Capacity Manual (HCM) update to estimate travel-time reliability performance measures on major freeways and urban arterials.
C11	**Tools for Assessing Wider Economic Benefits of Transportation** Spreadsheet-based tools that expand economic benefits analysis of highway projects to contain network-oriented concepts, including reliability.

BACKGROUND

Through a pilot concluded in 2020, MnDOT sought to collect travel time data and evaluate SHRP2 reliability tools to determine whether the tools were applicable within the agency's existing business model. The research team included the Metropolitan Council (the metropolitan planning organization—MPO—for the Twin Cities), the University of Minnesota, and a contractor. MnDOT proposed to refine and/or develop the tools to inform decision making for several transportation programs and projects.

PRODUCT IMPLEMENTATION

L07

The L07 tool estimates the most cost-effective spot-geometric improvements that will reduce nonrecurring congestion. Using the L07 analysis tool, MnDOT sought to assess the economic effectiveness of two contexts:

- The Freeway Incident Response Safety Team (FIRST), which targets incident locations and mitigates the resulting congestion by reducing incident duration.
- I-94 Emergency Pull-Offs in the Minneapolis-St. Paul Metropolitan Area (figure 1).

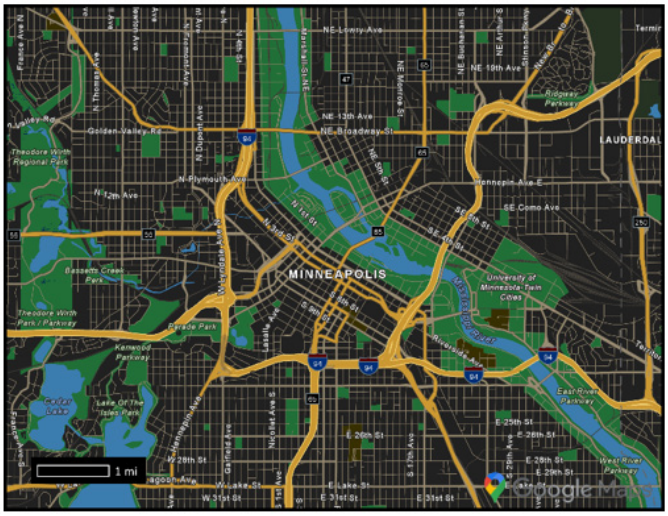


Figure 1. Map. I-94 in downtown Minneapolis, where emergency pull-offs were installed. Source: MnDOT. Map Data © 2020 Google.

MnDOT performed a comparative analysis of the results from the FIRST Program pilot to the findings published in the Minnesota Department of Transportation FIRST Program Evaluation to determine the reliability and effectiveness of the L07 tool. MnDOT noted the following benefits of implementing the tool:

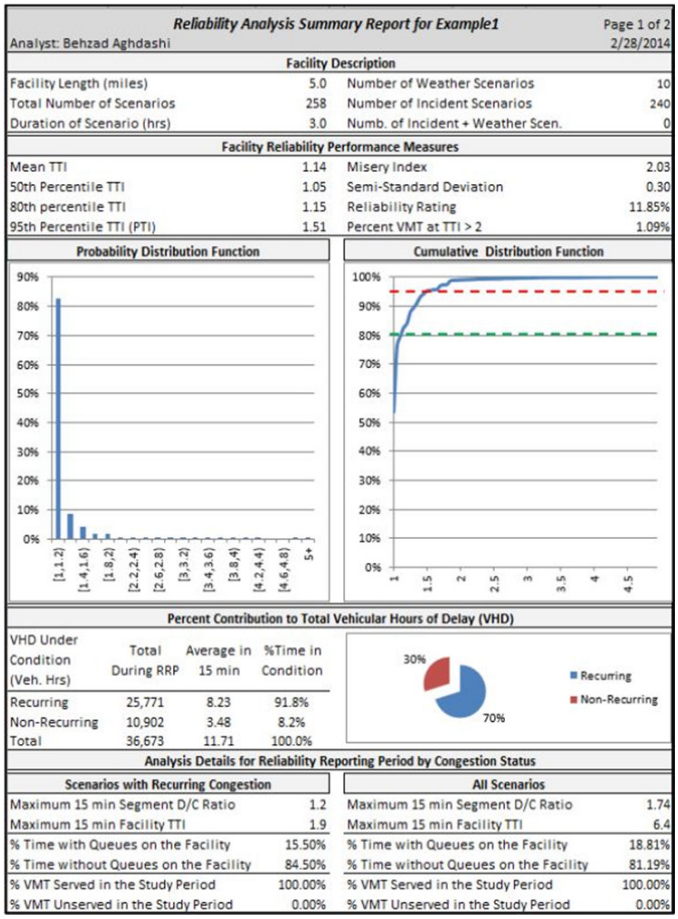
- Treatment effectiveness can be easily compared by adding those treatments to existing scenarios.
- Built-in custom treatments give the user flexibility to replicate projects that adjust demand, capacity, incident frequency and duration reduction, lane-hours lost, amount of rain and snow endured, and maximum demand to capacity ratios.

L08

The L08 products updated two Highway Capacity Manual (HCM) analytic tools to incorporate the expanded data required to measure travel time reliability (TTR). Those HCM tools are (1) FREEVAL, for use in freeway corridor analysis; and (2) STREETVAL, for urban signalized corridors. FREEVAL runs on a spreadsheet platform and includes an alternative Java® application version with a user interface. FREEVAL-RL refers to the version of FREEVAL that incorporates reliability measures, while HCM-CALC is the version in Java (Figure 2).

MnDOT applied both the spreadsheet and Java versions of FREEVAL in the early stages of pilot testing to gauge differences in usability. MnDOT computed performance measures to determine the impacts of adding reliability to project planning and evaluation for three test cases:

- Westbound I-494 relative to the expanded capacity resulting from the Auxiliary Lane from I-35W to France Avenue (Figure 3). FREEVAL-RL's performance measures weight each time period by the respective vehicle-miles traveled.
- Trunk Highway 65 (TH-65) Conversion to Superstreet, where a principal arterial located in the Twin Cities' North Metro Area experiences substantial peak-period delay at several signalized intersections. Using STREETVAL, MnDOT first calculated performance measure values for individual time periods, then calculated arithmetic averages across all time periods.
- Trunk Highway 252 (TH-252) Conversion to Freeway to determine the conversion's impacts on recurring and nonrecurring congestion. MnDOT used L08 to assess freeway conversion impacts on both recurring congestion and travel times under nonrecurring events.



Reliability Analysis Summary Report for Example1 — Page 1 of 2

Analyst: Behzad Aghdashi — 2/28/2014

Facility Description

Facility Length (miles)	5.0	Number of Weather Scenarios	10
Total Number of Scenarios	258	Number of Incident Scenarios	240
Duration of Scenario (hrs)	3.0	Numb. of Incident + Weather Scen.	0

Facility Reliability Performance Measures

Mean TTI	1.14	Misery Index	2.03
50th Percentile TTI	1.05	Semi-Standard Deviation	0.30
80th percentile TTI	1.15	Reliability Rating	11.85%
95th Percentile TTI (PTI)	1.51	Percent VMT at TTI > 2	1.09%

Probability Distribution Function

Cumulative Distribution Function

Percent Contribution to Total Vehicular Hours of Delay (VHD)

VHD Under Condition (Veh. Hrs)	Total During RRP	Average in 15 min	%Time in Condition
Recurring	25,771	8.23	91.8%
Non-Recurring	10,902	3.48	8.2%
Total	36,673	11.71	100.0%

Analysis Details for Reliability Reporting Period by Congestion Status

Scenarios with Recurring Congestion		All Scenarios	
Maximum 15 min Segment D/C Ratio	1.2	Maximum 15 min Segment D/C Ratio	1.74
Maximum 15 min Facility TTI	1.9	Maximum 15 min Facility TTI	6.4
% Time with Queues on the Facility	15.50%	% Time with Queues on the Facility	18.81%
% Time without Queues on the Facility	84.50%	% Time without Queues on the Facility	81.19%
% VMT Served in the Study Period	100.00%	% VMT Served in the Study Period	100.00%
% VMT Unserved in the Study Period	0.00%	% VMT Unserved in the Study Period	0.00%

Figure 2. Example of FREEVAL-RL: Evaluation of freeway facilities. Source: MnDOT

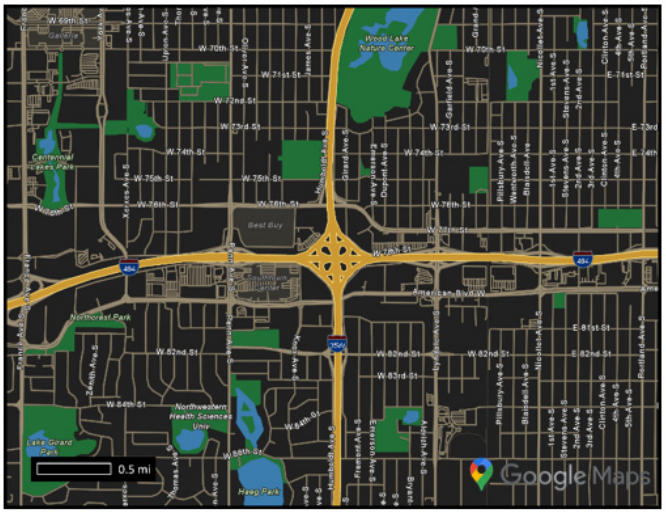


Figure 3. Map. Westbound I-494 relative to the expanded capacity resulting from the Auxiliary Lane from I-35W. Source: MnDOT. Map Data © 2020 Google.

C11

The C11 reliability tool can quickly estimate TTR benefits for planning-level analysis. The tool applies HCM methodology and demand-capacity relationships (developed under the SHRP2 L03 process) to generate recurring and nonrecurring delay information. The tool also monetizes the values to produce a high-level approximation of user costs for each alternative. Prior to comparison, the tool analyzes base and improved scenarios separately to generate project benefits. Using the C11 tool, MnDOT sought to determine the reliability benefits of two different projects:

- Reopening a second eastbound lane during the reconstruction of the Kellogg Boulevard Bridge, an integral connector of downtown St. Paul to neighborhoods and suburbs to the northeast. MnDOT sought to determine the reliability benefits of reopening the second eastbound lane.
- I-494/Trunk Highway 62 (TH-62) Congestion Relief Study to determine impacts on network-wide travel time performance. I-494 and TH-62 are parallel corridors in the southwestern Minneapolis-St. Paul Metropolitan Area. MnDOT sought to evaluate how alleviating congestion and inducing more demand along each of these routes impacts network-wide travel time performance (Figure 4).

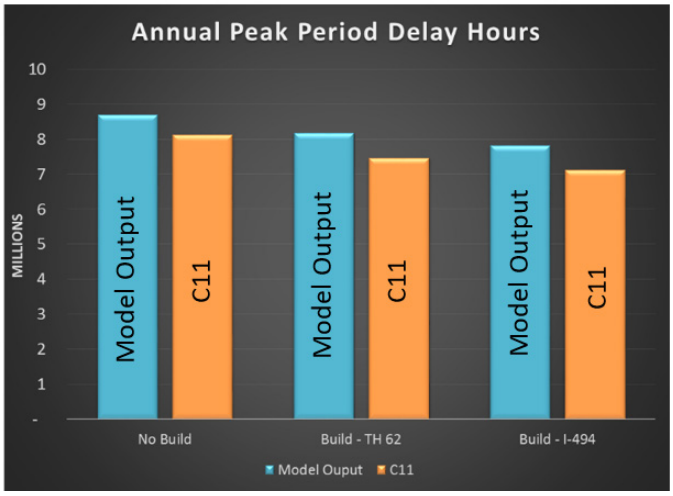


Figure 4. Chart. C11 versus Travel Demand Model Output. Source: MnDOT

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

L07

MnDOT found the L07 tool to be simple, easy to use, and flexible, given its comparative features. MnDOT also found that:

- The order of magnitude for reliability benefits compared to delay savings seemed low in the two pilot tests. This was likely a function of the number of incidents failing to generate enough variability in overall travel times, which was a primary factor in developing the reliability component of benefits.
- The accuracy of the L07 analysis process may need further validation before being incorporated into real-life decision-making. It may be wise to consider where the study segment is located relative to congestion in developing more realistic reliability results.

L08

As a first step, MnDOT compared the spreadsheet and Java versions of the L08 tool for freeway corridor analysis. The comparison found that the spreadsheet version may be more reflective of drivers' experience because it more accurately replicates the travel time distribution experienced for all users, rather than just one user in each time period. FREEVAL-RL, the spreadsheet format, expedited running multiple alternatives using text files. This facilitated multiple iterations of additional, more detailed analyses of results, especially given that the tool's output presented an extensive level of detail. In addition, the ability to modify analysis information within text files accelerated evaluation of multiple alternatives. HCM-CALC, the Java application, has a user-friendly interface but produces less refined results and requires more time-consuming data input.

MnDOT piloted both FREEVAL and STREETVAL and determined the following:

- FREEVAL-RL can be more widely used as it has multiple features for adjustment.
- FREEVAL-RL and STREETVAL provide detailed output for each scenario, which allows the user to identify operational impacts under various corridor conditions.
- FREEVAL-RL and STREETVAL offer more flexibility with demand, weather, and incident development if empirical data are more/less available.

- STREETVAL can evaluate work zones and special events.

The following suggested improvements can be addressed in future releases of the software:

- FREEVAL-RL should include nonrecurring events like work zones and special events.
- STREETVAL should streamline the process for developing work zones and special events. The tool requires the user to create a new computational engine with updated intersection demand volumes and segment/intersection geometry to account for any demand or capacity adjustment.
- STREETVAL should offer more options for restrictions at signalized intersections (e.g., no phase overlap, no U-turns, right turn on red).

C11

Given its short computational time and minimal input needs, C11 is a viable option for a planning-level comparison of multiple project alternatives. MnDOT hopes to further validate delay computations before implementing these procedures in its business model. However, the lack of detail available for inputs diminishes the tool's success for analyzing smaller projects.

IMPACTS ON BUSINESS PRACTICES

The SHRP2 efforts generated a variety of reliability data and analysis tools for multiple MnDOT projects. MnDOT now considers TTR analysis a standard practice in developing plans and evaluating highway improvements. Using the knowledge obtained from the SHRP2 bundle of products, MnDOT developed and refined other decision-making support tools.

CONCLUSION

A common theme in the feedback from the technical committee, including reviewers from the University of Minnesota, was that the tools provided innovative and time-efficient opportunities to evaluate TTR in situations where it was previously difficult or required an extensive amount of time to prepare and run the data. The committee also indicated that it would like to further enhance or test the tools to validate the procedures and methodologies in two potential applications:

- Extend analysis of freeway operations using the L08 FREEVAL-RL module.
- Incorporate the C11 reliability methodology into a regional travel demand model to estimate network-wide impacts of large-scale projects in a time effective way.

FOR MORE INFORMATION

Contact Jim Henricksen (see contacts) to request a report.
Minnesota Department of Transportation
https://www.dot.state.mn.us/
SHRP 2 Solutions
https://www.fhwa.dot.gov/goshrp2

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