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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

Maryland Department of Transportation State Highway Administration

Implementation of SHRP2 Reliability Tools in Maryland

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. SHRP2 provided funding to help agencies test the tools and incorporate reliability into their business practices. The Maryland Department of Transportation State Highway Administration (MDOT SHA) project included the following tools:

DATA COLLECTION

L02 Guide to Establish Monitoring Programs for Travel-Time Reliability
Guidebook, visualization tools, and methods for integrating data to analyze reliability, including causes and locations of unreliable performance and identification of potential mitigating strategies.

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

The MDOT SHA sought to adopt relevant SHRP2 reliability procedures and products as standard practice. MDOT SHA received technical support and assistance from the University of Maryland Center for Advanced Transportation Technology (UMD CATT) and a transportation consultancy firm. The MDOT SHA pilot, which concluded in 2020, included the following locations:

- I-270, and I-95 between the Capital Beltway and the Baltimore Beltway.
- The American Legion Bridge, located on I-495 (Capital Beltway) between MD 190 and VA 193.
- A longer segment of I-495, including the American Legion Bridge, with an additional general-purpose lane between the west leg of I-270 and the high-occupancy toll (HOT) lanes in Virginia near the Dulles Toll Road.
- I-95, from MD 198 to I-895, which contains the State's third worst bottleneck northbound at MD 175 during the PM peak (figure 1, figure 2).

PRODUCT IMPLEMENTATION

L02

MDOT SHA modified the L02 reliability monitoring system to use existing State archival and other data to meet the agency's traffic modeling needs. Using the system, MDOT SHA conducted case studies on two segments: I-270, and I-95 between the Capital Beltway and the Baltimore Beltway. The agency sought to identify and quantify the factors that impact the

reliability of these freeway systems. This analysis could contribute to selecting interventions that improve travel-time reliability and setting benchmarks against which future improvements could be compared.

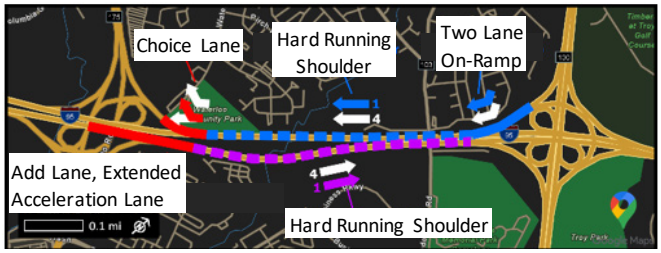

Figure 1. Map. Example of I-95 Improvement Concept 1. Source: MDOT SHA. Map Data © 2020 Google.

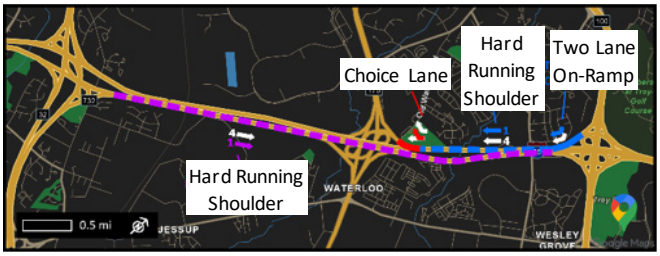

Figure 2. Map. Example of I-95 Improvement Concept 2. Source: MDOT SHA. Map Data © 2020 Google.

The L02 project created a travel time reliability monitoring system (TTRMS) that helps users understand the reliability performance of highway systems and monitor reliability changes over time under different operating conditions. The system:

- Provides the distribution of travel times.
- Demonstrates how congestion, both recurring and nonrecurring, affects the distribution.
- Analyzes the need for capacity investments or other transportation systems management and operations (TSMO) strategies given current travel time distributions.
- Evaluates how operational improvement actions and capacity investments affect travel times and travel time reliability (TTR).

MDOT SHA customized the tool and developed a new set of measures and visualizations to quantify contributing factors to travel time unreliability along important highway network links. MDOT SHA modified the methodology to include several inputs including travel time, speed data, weather data, and incident data. The agency also modified system travel times with archival speed data and generated an event database by joining weather, incident, and speed data.

L07

MDOT SHA conducted a case study to evaluate the effects of the geometric design treatments for the American Legion Bridge in Maryland located on the Interstate I-495 (Capital Beltway) between MD-190 and VA-193. Developers created the SHRP2 L07 tool to help transportation engineers, designers, planners, and decision makers evaluate how different highway geometric design elements can reduce nonrecurring congestion and improve TTR when deployed in new designs or site retrofit projects (figure 3). MDOT SHA found the user interface easy to use. At the same time, its "Site Input" and "Treatment Data and Calculation" modules affected the tool's accuracy and usability. MDOT SHA found limited use for the L07 tool and its implementation opportunities in highway design.

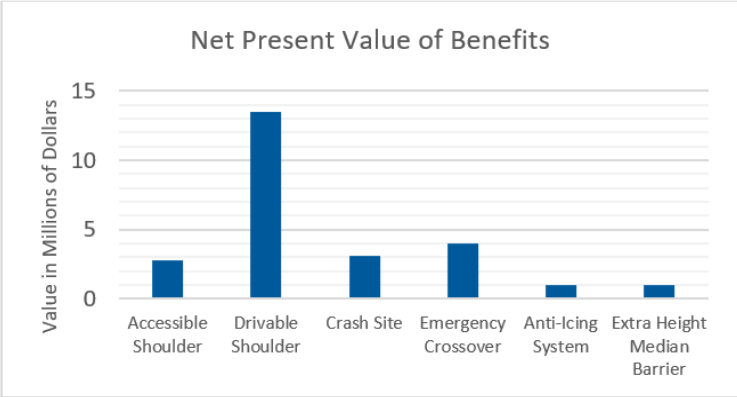

Figure 3. Chart. Net present value of reliability benefits for L07 design treatments of the I-495 American Legion Bridge. Source: MDOT SHA

L08

The L08 procedures extend previous MDOT SHA methods with a scenario generator that develops realistic combinations of the factors causing unreliable travel (e.g., incidents, weather, and demand variability), and a reliability postprocessor. MDOT SHA applied L08 methods to I-95, from MD 198 to I-895 (figure 4), which contains the State's third worst bottleneck northbound at MD 175 during the PM peak. The segment is highly to extremely unreliable. MDOT SHA identified two improvement concepts and analyzed them along with no-build conditions using L08 methods. Prior to the pilot, MDOT SHA used a simple scalar for reliability by adding a premium, based on the reliability ratio, to the travel-time benefits obtained from traditional models. This approach assumes a linear relationship between reliability and average conditions, which is unrealistic.

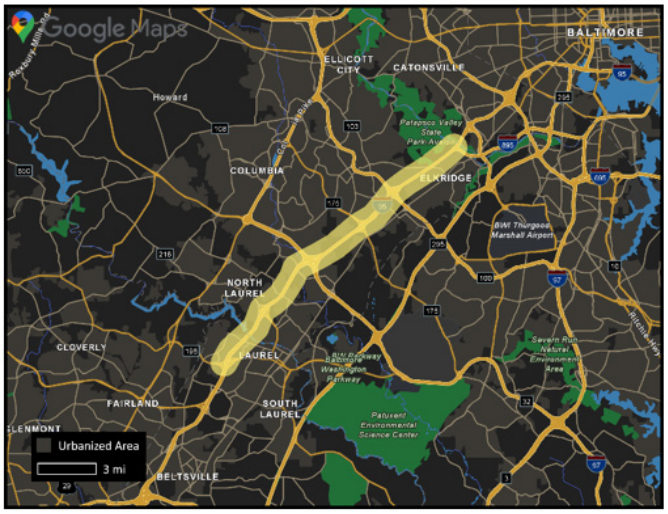

Figure 4. Map. I-95 project segment from MD 198 to I-895. Source: MDOT SHA. Map Data © 2020 Google.

The L08 Highway Capacity Manual (HCM) procedures improved the estimation of reliability benefits in MDOT SHA analyses. The features, including a scenario generator and a reliability postprocessor, enabled a more realistic picture of a facility's congestion than the "single perfect day" condition in traditional HCM procedures.

MDOT SHA tested the new L08 software on two concepts for improvements on I-95. MDOT SHA analyzed these two concepts, along with the no-build conditions, using the HCM calculation (HCM-CALC) software, which follows the reliability analysis methodology in the sixth edition of the HCM. MDOT SHA encountered several challenges and limitations during the reliability analysis of the I-95 segment, including steep data requirements, high level of knowledge and time required to operate the system, demand variation, and occurrence of incidents (including traffic and weather events).

Despite challenges related to model calibration, validation, and data specification, MDOT SHA found value in the L08 methodologies. The outputs provided reliability metrics for the concepts and helped in evaluation. MDOT SHA found that even though both concepts had very similar performance for recurring congestion, one concept offered better reliability performance. In the process of deploying and mainstreaming the L08 tool, MDOT SHA developed an L08 Tool User Guide and offered technical training to staff and consultants.

C11

The C11 Post-Processor produces travel time reliability (TTR) measures and estimates crashes for input to travel demand model long-range forecasts. MDOT SHA tested the updated C11 Post-Processor with data from a planning study of a project to widen the I-495 American Legion Bridge with an additional general purpose lane between the west leg of I-270 and the high-occupancy toll (HOT) lanes in Virginia near the Dulles Toll Road. MDOT SHA conducted base year and 2040 forecasts using the Maryland Statewide Transportation Model (MSTM).

The C11 Post-Processor produces TTR measures and estimates of crashes and allows users to estimate improvement in reliability due to the deployment of a range of strategies. As part of this project, MDOT SHA made several technical enhancements to the C11 Post-Processor, including:

- Updating impact factors and deployment costs for operations and intelligent transportation strategies.
- Developing state-specific temporal traffic distributions.
- Analyzing automatic traffic recorder data to develop State variability factors for average annual daily traffic.
- Developing Maryland-specific relationships for predicting reliability as a function of the mean travel-time index for a segment.

After calibrating the updated C11 Post-Processor to base travel times, MDOT SHA applied it to the I-495 no-build and alternative MSTM forecasts. MDOT SHA found a positive effect of the capacity increase from the extra lane, and that the facility would still operate under severe congestion during peak hours in 2040. One reason for the forecasted congestion was that the percent increase in capacity was not significant given that the cross-section was already four to five lanes in each direction.

The C11 Post-Processor provides additional reliability performance metrics to help inform decision making. To mainstream the C11 Post-Processor, MDOT SHA developed a web-based version of the tool with user-friendly interfaces. Since the early testing, MDOT SHA has used the tool to evaluate long-range planning alternatives on other major highways.

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

The MDOT SHA pilots highlighted the benefits and a few challenges and recommendations for the SHRP2 reliability products going forward. Overall, existing output mechanisms present challenges. They often require additional data sources than those automatically identified and require additional levels of analysis to be usable in the desired context. Adding more datasets would provide further detail for these tools.

L02

A benefit of the updated L02 TTRMS is that MDOT SHA can conduct a more in-depth analysis of travel-time reliability for any combination of weather-, incident-, and congestion-induced conditions. In addition, for any segment of interest, the agency can use the modified TTRMS implementation to identify the most effective mitigating actions with a focus on the top three disruptors of travel time reliability. In addition, MDOT SHA developed a new report generation method to assist decision makers and operators in understanding the outputs and to facilitate communication of results within and outside MDOT SHA.

Additional features would enhance the utility of L02 methods, including:

- Evaluation and estimation of reliability given two or more concurrent events (e.g., a weather event and a traffic incident at the same time).
- Additional visualization capacity beyond probability distribution functions and cumulative distribution functions.
- A quantitative measure of the effects of different events on system reliability.

L07

A potential benefit is for MDOT SHA to apply the L07 methods and output to promote early consideration of reliability for projects in the earliest design stages. MDOT SHA suggested the following improvements, especially with regard to the L07 tool:

- Include simpler user interfaces.
- Reduce use of commands outside the written program.
- Account for demand growth over time.
- Increase capability for multiple simultaneous treatment alternatives.

L08

MDOT SHA viewed the L08 methodologies as more implementation-ready than simulation model-based techniques that are highly resource-intensive. As L08 methods have been incorporated into the HCM, MDOT SHA is optimistic about their long-term sustainability. The methods provide a good first step to include reliability metrics for alternative concept evaluations.

The test process found that implementing the L08-based HCM methodology using the HCM-CALC software is problematic. Severe restrictions must be observed on how queuing data are input for the HCM methodology to operate as designed.

C11

MDOT SHA adjusted the existing C11 tool to specifically suit in-state conditions, which made the tool accurate and helpful. The tool helped MDOT SHA incorporate reliability metrics for all planned investments, including long-range projects and TSMO strategy implementation.

MDOT SHA found that the C11 Post-Processor strongly under-predicted congestion as the volume/capacity ratios coming out of the MSTM were unusually low, indicating that link capacities were not adequately capturing bottleneck locations on the facility. Applying a capacity calibration of 0.8 produced model results that corresponded with observed travel times. As next steps, the agency is planning to test TSMO strategies to support the TSMO Program.

IMPACTS ON BUSINESS PRACTICES

At a strategic level, MDOT SHA is committed to the broader success of a TSMO Program. The agency has made tremendous progress in last few years in mainstreaming TSMO in the organization, including the adoption of the recent MDOT SHA TSMO Strategic Plan. Data, Analysis, and Performance has been identified as one of four goals in the TSMO Plan. MDOT SHA found that it was a challenge to engage the highway designers to include reliability strategies in the projects where design was already underway. The reliability suite of tools should support transportation decision making at strategic, tactical, and operational levels, including in the following ways:

- The L02 methods offer opportunities to understand the sources of unreliability so that necessary mitigation strategies can be employed. MDOT SHA is mainstreaming these processes by expanding the

methodology to other segments and developing applications for easy access and user experience.

- The L07 methods can help in integrating operational decisions in early design activities so that the project offers more reliability benefits. The L07 tool could provide high-level evaluation of TSMO strategies. There appears to be some synergies between the C11 and L07 methods. MDOT SHA will explore opportunities to incorporate the L07 methods in the C11 web tool for consistency and end-user experience.
- The L08 tools offer analytical capabilities to analyze concepts, alternatives, and operational scenario analysis at a project level. The L08 methods provide a good first step to include reliability metrics for alternatives or concept evaluations.
- The C11 method offers capabilities in long-range planning activities including regional assessments of policy, supply and demand scenarios, alternatives screening, and evaluation.

CONCLUSION

The SHRP2 reliability tools implementation opportunity provided a great starting point to incorporate reliability analysis into the MDOT SHA transportation decision-making process.

At a strategic level, MDOT SHA sees value in improving its methods and tools to mainstream reliability analysis and reliability performance measures for transportation decision making in the planning, operations, and TSMO realms.

As the transportation industry prepares for future advances in technology, automation, increased socio-economic activity, and diverse transportation demands, understanding the factors that impact reliability will be vital. At the same time, mainstreaming methods and applications that enable practitioners and decision makers to understand the impact of reliability and TSMO strategies will be equally significant.

FOR MORE INFORMATION

Maryland State Highway Administration Mobility and Reliability Website
https://www.roads.maryland.gov/mdotsha/pages/index.aspx?PageId=711
SHRP 2 Solutions
https://www.fhwa.dot.gov/goshrp2

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