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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

Iowa Department of Transportation

Travel Time Reliability Pilot for TSMO Program Plan in Iowa

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 Iowa Department of Transportation (Iowa DOT) project included the following tools:

DATA COLLECTION AND INTEGRATION

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 vs. 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

Iowa DOT, in partnership with Iowa State University, led a pilot project ending in 2020 that tested four of the SHRP2 Reliability Data and Analysis Tools (L02, L07, L08, and C11) to assess the products' strengths and suitability. Travel time reliability (TTR) is an important metric of transportation system performance and service quality, quantifying the predictability of travel for road users. Iowa DOT uses TTR to quantify the benefits of transportation systems management and operations (TSMO) strategies that reduce the impacts of non-recurring congestion. Iowa experiences a substantial amount of non-recurring congestion due to unplanned causes: around 72 percent of congestion in Iowa is a result of non-recurring sources, compared to 45 percent of congestion Nationwide.

Iowa DOT tested the products on the I-80 segment in the western portion of the State (figure 1). The chosen site helped the project team explore the data requirements of the different products that would most benefit the agency. One challenge for the pilot location, and other rural locations in Iowa, is the lack of sensors to measure hourly volume data. To address this challenge, the pilot location was selected to be adjacent to the urban area of Council Bluffs, where traffic sensor data is readily available.

PRODUCT IMPLEMENTATION

Data

The pilot project supported further integration of Iowa DOT's traffic operations data systems. Iowa DOT currently partners with Iowa State University to operate the Real-Time Analytics of Transportation Data (REACTOR) Lab.

REACTOR is a high-performance computing cluster that rapidly integrates and processes transportation data. REACTOR has the potential to play the crucial role of data manager for the travel time reliability monitoring system (TTRMS) developed under the pilot program.

Figure 1. Map. The I-80 project segment in western Iowa. Source: Iowa DOT. Map Data © 2020 Google.

L02

The SHRP2 L02 project introduced the concept of a TTRMS, which can generate information on travel times and reliability for highway operations personnel.

The TTRMS combines computational processes and roadside data collection equipment to generate reliability information for internal performance review, or to communicate with drivers on roadway conditions through Intelligent Transportation Systems devices installed on the transportation network. The L02 guide enables the agency to use travel time and congestion data to measure reliability and identify potential sources of congestion.

Iowa DOT developed a pilot implementation of a TTRMS based on INRIX® probe data rather than point sensor data. This travel time data can be characterized by weather condition or to isolate the impacts of collisions. For example, over 20 percent of annual delay in the Council Bluffs area is due to adverse weather conditions.

L07

The L07 tool analyzes the TTR of a roadway segment or series of segments using a statistical approach based on data from SHRP2 testbeds. The results are cumulative travel time index (TTI) plots. The research team can compare the TTI plots of a before-and-after scenario where a reliability treatment has been incorporated to assess improvements. The Iowa pilot used the L07 model to estimate TTI curves for multiple scenarios representing different demand levels and levels of automated vehicle market penetration.

L08

The FREEVAL-RL Model created under the L08 project is a computational engine that uses inputs to develop and run scenarios to create a holistic picture of TTR for a given period of analysis. This analysis requires segment data that captures characteristics for demand, geometry, and driver behavior.

Prior to running the scenarios through FREEVAL, the project team smoothed and balanced traffic volume data from sensor locations using Microsoft Excel.[1] The research team constructed a demand multiplier table for study locations without traffic sensing equipment. Iowa's permanent automatic traffic recorder (ATR) stations are a strong data source for constructing demand multiplier data. However, these data do not necessarily represent driver behaviors in all locations and require an alternative method of identifying demand variation. Iowa DOT's advanced traffic management system (ATMS) also provided both work zone and incident data with good spatial accuracy and thus appears to be an appropriate tool for meeting FREEVAL data needs on future projects.

C11

The C11 Reliability Tool calculates a monetary value for non-recurring congestion and monetizes changes in TTR with respect to congestion countermeasures.

Iowa applied the C11 monetization feature during the pilot test to the outputs from the L07 and L08 models. The C11 tool generates a dollar value of the change in reliability between a baseline scenario and an alternate scenario. The agency evaluated the tool in two parts: using the key performance measures external to the

[1] Microsoft and Excel are trademarks of the Microsoft group of companies.

model itself and using the mathematical equations provided in both the L07 and C11 documentation.

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

L02

The SHRP2 L02 TTRMS framework provides Iowa DOT with a potential future development plan to streamline their traffic operations data into a seamless monitoring and analysis tool. The Iowa State University Center for Transportation Research and Education (CTRE) already assists the Iowa DOT in developing an annual mobility report that includes reliability measures. The State's data sources offer opportunities for increased integration with a more sophisticated data management component. L02 visualizations for reliability could improve future versions of the annual mobility report and help agency staff better understand how reliably the routes they manage are operating.

L07

The L07 model captures both incidents and weather events; however, crash data and incident data differ. As a solution, the program provides default values and estimation procedures to fill any data gaps. For reliability analysis, the Iowa DOT team recommends using the L07 quick method for estimating non-crash incidents, since available non-crash data are inconsistent. As data reporting improves, future studies may use reported non-crash incident data from the State's advanced transportation management system (ATMS). Prior to modeling, the L07 tool requires tedious preparation of demand data. Streamlining the data development would improve the L07 modeling process and allow an agency to treat demand data uniformly. The L07 model intentionally uses a "one stop" data entry setup to create a clean, user-friendly interface. However, this setup requires the analyst to populate each data cell, which can be labor intensive and can lead to errors. To lower the input demand burden, the L07 tool was developed alongside a supplemental spreadsheet tool called DemandGen, which provides a fixed format to input traffic demand volumes, truck percentages, and recreational vehicle (RV) percentages.

The L07 spreadsheet also automatically links the segment input data into interim models. The analyst can review the interim values in the results tab, but the values cannot be modified. From the interim calculations, the regression models can develop segment Cumulative Density Functions (CDF), but like the interim calculations, the analyst cannot directly review the calculations. These hidden features limit the analyst's ability to modify the tool to replicate local conditions. The L07 tool models each directional segment of freeway, requiring several unique segments to complete a full corridor. The program models the segments independently, meaning that congestion in one segment may not influence segments upstream. Thus, the research team adjusts the individual segment models to capture off-segment, related congestion (e.g., bottlenecks).

L08

Unlike L07, the L08 tool provides the analyst flexibility in adjusting the range of the plot to look at different parts of the CDF. The reliability summary screen provides performance measures like TTI. From this screen, the analyst has many options for summarizing a route's reliability. If the analyst needs even greater flexibility, the L08 tool provides an export button to extract raw results. However, IowaDOT noted the L08 FREEVAL model interface is not particularly user friendly. In addition, FREEVAL requires a significant quantity of data that may not be realistic for all implementations. In the future, commercial software catering to transportation engineers and planners may include FREEVAL functionality.

C11

Iowa DOT encountered several issues when attempting to monetize the reliability benefits generated by the C11 tools. The shape of the reliability curves influences the monetization approach calculations at the tail ends of the distribution. For example, on the piloted locations, most of the reliability changes occurred between the 95th and 99th percentiles of the distribution. Because the C11 methodology examines only the 50th and 80th percentiles of TTI, it showed no difference in reliability between the base and the treatment. The approach does not cover anything above an 80th percentile and thus misses the unreliability at higher percentiles. This is a particular issue on roadways with stable reliability, such as rural roadways, where all the variation occurs in the tails.

As a result of the testing, the study team determined that the best procedure to monetize the results is to take the outputs from the L07 or L08 tool and apply the mean variance/standard deviation approach utilized by the L07 tool. This method produces more practical results for treatments that impact non-recurring congestion in comparison to the results from the C11 monetization.

IMPACTS ON BUSINESS PRACTICES

The SHRP2 products enhanced Iowa DOT's ability to measure reliability and identify sources of nonrecurring congestion on its transportation networks. The four piloted tools impacted the agency's business practices in the following ways:

- **Added to Iowa's existing efforts to improve traffic operations monitoring**. The TTRMS framework under the L02 project provides Iowa with a potential development plan to streamline traffic operations data into a seamless monitoring and analysis tool. Potential enhancements to the data visualizations could help agency staff better understand reliability for the roadways they manage.
- **Confirmed the merits of adding TTR analysis to the capabilities of Iowa agencies**. The methods within the L07 tools were found to be simple enough to apply at the planning/environmental study level to advance Iowa agencies' abilities to reach performance targets over their planning horizon. L08 tools provided the flexibility necessary to analyze reliability on the transportation network. The research team ran ten models to compare FREEVAL results to existing field data and found that the L08 tool's output travel times compared favorably with field collected travel times.
- **Monetized the benefits related to TTR.** A next step for Iowa agencies would be to further explore incorporating TTR monetization into their existing practices using C11 or other methodologies.

CONCLUSION

The SHRP2 Pilot provided Iowa DOT an opportunity to apply tools for collecting data and assessing the benefits of improved reliability. Iowa's current capabilities include their partnership with CTRE at Iowa State University to operate the REACTOR high-performance computing cluster to rapidly ingest big transportation data sources and turn that measured data into structured information. The partnership between Iowa DOT and Iowa State University was essential to the Implementation Assistance Program project.

Through this Iowa Travel Time Reliability Pilot project, the project team was able to further make the case for improvements in integration of Iowa DOT's data systems with the potential for REACTOR to play the crucial role of data manager in the TTRMS. REACTOR can separate out traffic flow states to better understand how root causes of congestion impact travel times. Through better understanding of the sources of congestion, targeted TSMO strategies can be applied to reduce congestion and advance reliable travel times.

FOR MORE INFORMATION

Iowa DOT Transportation Systems Management and Operations (TSMO) Home Page:
https://iowadot.gov/tsmo/
FHWA SHRP2 Home Page:
https://www.fhwa.dot.gov/goshrp2

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