U.S. Department of Transportation
Federal Highway Administration

OFFICE OF OPERATIONS
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FHWA-HOP-21-078

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

Arkansas Department of Transportation

Implementing a Suite of Travel Time Reliability Tools on I-540

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 Arkansas Department of Transportation (ARDOT) 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 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.

BACKGROUND

Through a project concluded in 2020, the Arkansas Department of Transportation (ARDOT) studied travel-time reliability on I-540 between I-40 and State Highway 22 to improve congestion along I-540's crossing of the Arkansas River. This four-lane bridge is one of only three crossings connecting Crawford and Sebastian Counties. The bridge experiences non-recurring congestion due to inclement weather and incidents.

ARDOT has evaluated constructing a new river crossing and adding a new segment of I-49 between AR-255 and I-40 (figure 1). However, that would be expensive and would take years to complete. ARDOT is looking for a more immediate and cost-effective solution to address congestion on I-540. The goal of this project was to use two SHRP2 tools (the L08 and L07 Analysis Tools) to study how non-recurring events impact travel-time reliability on the segment and to identify design interventions to ease non-recurring congestion, apart from bridge widening or replacement.

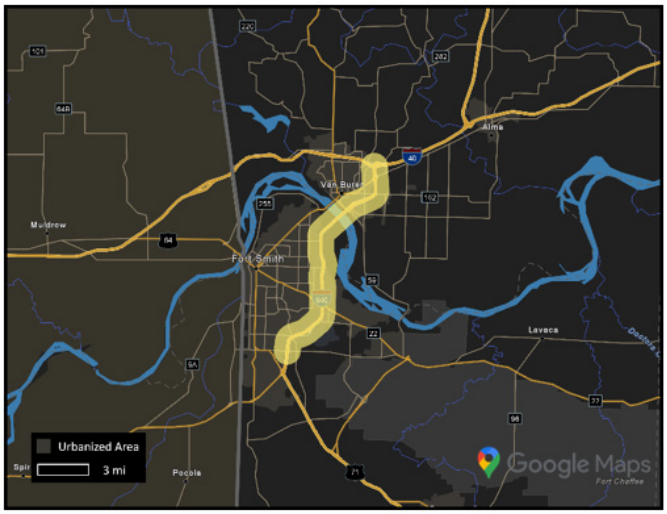

Figure 1. Map. Example of I-540 crossing over the Arkansas River near Fort Smith. Source: FHWA. Map Data © 2020 Google.

PRODUCT IMPLEMENTATION

ARDOT used L08 to perform an analysis of current and future travel-time reliability on the I-540 segment. Then, ARDOT chose several potential design alternatives from the L07 design guidebook and used the L07 spreadsheet tool to estimate how effectively they would reduce non-recurring congestion.

Data

The L08 and L07 tools require calibration data to produce more accurate predictions. To calibrate L07 and L8, ARDOT collected and used data from multiple sources, including: the National Performance Management Research Data Set (NPMRDS), ARDOT 2017 traffic counts, ARDOT traffic demand models, Google Earth aerial imagery, and crash records from 2012-2016. Anecdotal data from ARDOT staff supplemented the formal data sources. ARDOT was unable to obtain some of the necessary inputs; in these cases (described below in more detail), the tool's default values were used.

L08

ARDOT used L08 to evaluate the north and southbound directions on I-540 for the morning and afternoon peak periods. Each peak period was divided into four 15-minute analysis periods.

ARDOT obtained free-flow speed data for the segment from NPMRDS. ARDOT used internal traffic volume data from 2017, and they obtained vehicle demand data by analyzing the volume data in an Excel[1] demand generator model. They estimated values for truck and bus percentages, truck passenger-car equivalents, and the driver population capacity adjustment factor based on staff members' experience. ARDOT used default values for jam density, capacity drop due to breakdown, and general-purpose lane vehicle occupancy as local data was not available. Additionally, they selected weather data for Little Rock as data for Fort Smith was not available in the model. See table 1 for a summary of data sources used in the analysis.

The results matched current observations of occasional non-recurring congestion. They also suggest that by 2040, I-540 southbound will operate at slow speeds and reduced reliability during the AM peak. ARDOT found that auxiliary lanes downstream of the Arkansas River Bridge can address current and future congestion conditions.

Table 1. Data sources used in L08 analysis tool.

DATA TYPE	DATA SOURCE
Free-flow speed data	NPMRDS
Traffic volume and demand	2017 ARDOT traffic count
Truck percentage	ARDOT staff experience
Bus percentage	ARDOT staff experience
Truck passenger-car equivalent	ARDOT staff experience
Driver population capacity adjustment	ARDOT staff experience
Jam density	L08 default value
Capacity drop due to breakdown	L08 default value
General-purpose lane vehicle occupancy	L08 default value
Weather data	L08 default values for Little Rock

L07

After reviewing the L07 design guidebook, ARDOT staff used the L07 Analysis Tool to evaluate two alternative roadway design elements: extra-height median barriers and crash investigation sites. Extra-height median barriers can prevent crashes and reduce congestion by minimizing rubbernecking at accident scenes, reducing headlight glare at night, and preventing cross-median collisions for taller vehicles. Crash investigation sites are paved areas near highways that allow the relocation of crash-involved vehicles to provide a safe location for crash investigations. They can reduce non-recurring congestion by minimizing the time that vehicles remain in the roadway after an incident. ARDOT chose these alternatives because they do not require additional roadway space on the bridge. ARDOT performed two analyses for I-540 northbound and southbound. Each analysis consisted of a 24-hour study period broken into 1-hour analysis periods. Each of the two treatments was used on segments that experience a high planning time index (1.95 or higher). ARDOT used default input values for each treatment.

Table 2 presents the data sources used in the L07 analysis. ARDOT staff estimated non-crash incident frequency based on the calculated crash frequency and the ratio of the default values for crash and non-crash incidents. Default values were used for average crash durations, and special events were not incorporated into the analysis.

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

Table 2. Data sources used in L07 analysis tool.

DATA TYPE	DATA SOURCE
Free-flow speed data	NPMRDS
Traffic volume and demand	2017 ARDOT traffic count
Segment locations	Google Earth aerial imagery
Lane geometry	Google Earth aerial imagery
Speed	Google Earth aerial imagery
Crash frequency	ARDOT 2012-2016 crash counts
Non-crash incident frequency	See text
Average crash durations	L07 default value
Special events	Not incorporated in analysis

The results showed that the two design treatments, an extra-height barrier and a crash investigation site, did not significantly improve mobility.

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

Overall, ARDOT found L08 to be useful in measuring the problem of non-recurrent congestion and evaluating congestion management strategies on I-540, given the constraints of the current Arkansas River Bridge. The tool also pushed ARDOT to consider new variables when weighing congestion mitigation strategies, including:

- Weather conditions.
- Incident response times. Metrics focused on reliability rather than free-flow speed.

ARDOT staff found L08's interface similar to other FHWA highway capacity management (HCM) tools and easy to incorporate into their existing workflows. Implementing L08 also proved easier than microsimulations, which are a standard method of evaluating different build scenarios on a freeway. The tool's value would be further enhanced if more consultants were familiar with it, as ARDOT often contracts with other firms to conduct more complex congestion studies.

ARDOT's application of L07 was contrary to its design. Because of this misapplication, ARDOT did not find results from L07 to be as helpful as L08. Agency staff found many of the design alternatives available in the guidebook unsuited to the project's context. For example, movable traffic barriers and medians, shoulder upgrades, vehicle turnouts, and arterials and ramp upgrades would not be realistic options given the geometric constraints of the four-lane bridge. The tool could be improved if it were applicable to a wider variety of projects with a greater variety of design alternatives.

Agency staff discussed opportunities to improve the L07 interface. Unlike L08, L07 does not mimic other FHWA HCM tools. Redesigning the interface to more closely resemble other tools would make the tool more useful and easier to integrate into existing workflows. Additionally, ARDOT suggests combining L07 and L08 inputs into a single interface, since they require much of the same input data. This would eliminate duplicate efforts by agency staff. The Additional Technical Comments table summarizes and compares the strengths and weaknesses of the L08 and L07 tools based on ARDOT's experience.

IMPACTS ON BUSINESS PRACTICES

The L08 Tool provides a user-friendly way to assess highway alternatives and will help ARDOT make more data-driven decisions around highway planning, particularly for considering reliability metrics and for modeling smaller interventions. ARDOT has already started applying the tool to other freeway segments. Furthermore, the two tools also pushed ARDOT to consider new variables when weighing congestion mitigation strategies, and, as a result, the agency plans to collect additional data on local conditions, including weather conditions and incident response times.

CONCLUSION

ARDOT used L08 and L07 to estimate travel-time reliability on I-540 and evaluate alternatives to bridge widening that relieve non-recurrent congestion. The tools encouraged ARDOT to consider reliability metrics to evaluate current and future conditions and potential mitigation strategies. The tools helped ARDOT to consider more variables in their congestion modeling and revealed data gaps that ARDOT will fill going forward as the agency plans to use L08 for long-term planning in other freeway segments.

FOR MORE INFORMATION

Arkansas Department of Transportation
https://www.ardot.gov/
SHRP 2 Solutions
https://www.fhwa.dot.gov/goshrp2

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ADDITIONAL TECHNICAL COMMENTS	
STRENGTHS	
L07 & L08	See Assessment of the Tools.
GAPS	
L07	The design treatments available in the guidebook are not appropriate for many project types, especially where road space is constrained. The user interface differs from L08 and other HCM tools, making it difficult to integrate into existing workflows. Some output graphics are difficult to read. On many output graphs, the axis scale is not appropriate for the data.
SUGGESTED ENHANCEMENTS	
L07	A greater variety of design treatments in the guidebook would make the tool useful for evaluating a wider range of projects. Redesigning the tool to use a similar interface to other HCM tools, or even combining L07 and L08 into one interface, would allow agencies to more easily integrate L07 into their workflows.

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