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

Arizona Department of Transportation

Implementing a Suite of Travel Time Reliability Tools in Arizona

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 Arizona Department of Transportation (ADOT) 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.

BACKGROUND

Congestion is a serious concern in both the Phoenix and Tucson metropolitan areas. In 2014, congestion in Phoenix caused over 155 million person-hours of delay, and 36 percent of vehicle-miles traveled (VMT) in the metro area were under congested conditions. Similarly, Tucson experienced over 35 million person-hours of delay, with 28 percent of VMT experiencing congested conditions.

ADOT sought to better understand travel time reliability (TTR) and identify mitigation strategies for non-recurring congestion in both metro areas using the L02 and L07 tools developed under the SHRP2 program. In a pilot concluded in 2020, ADOT investigated TTR on three segments of I-10 (figure 1):

- I-10 between US-60 and I-17 in Phoenix
- I-10 between 35th Avenue and Sky Harbor Boulevard in Phoenix
- I-10 between Ina Road and I-19 in Tucson

ADOT also developed a prototype travel time reliability monitoring system (TTRMS) as well as other countermeasures to address congestion. The L02 guide defines the essential components of a TTRMS, including data sources and analysis methods. ADOT used L02 to develop the prototype TTRMS.

The L07 guidebook and analysis tool help agencies estimate the reliability impacts of design alternatives for a specific location. ADOT used the tool to evaluate several countermeasures for the two segments of I-10 in Phoenix with poor TTR.

PRODUCT IMPLEMENTATION

ADOT first developed the prototype TTRMS and evaluated TTR on the three study segments. The research team found that I-10 westbound between 35th Avenue and Sky Harbor Boulevard was the worst performing segment. ADOT evaluated the potential impact of countermeasures on the segments in Phoenix using the L07 guidebook and analysis tool.
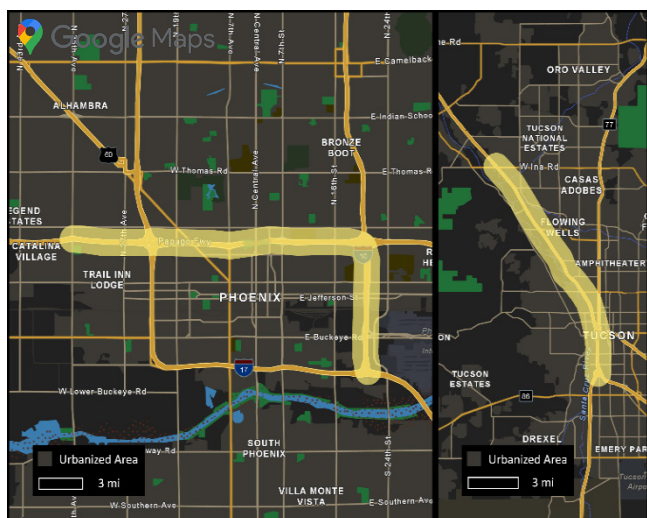
Figure 1. Maps. I-10 segments in Phoenix (left) and Tucson (right). Source: ADOT. Map Data © 2020 Google.

Data

The implementation of L02 and L07 is data intensive. ADOT used a variety of data sources, including the Regional Archived Data System (RADS), National Performance Management Research Data Set (NPMRDS), Highway Condition Reporting System (HCRS), Accident Location Identification Surveillance System (ALISS), and Multimodal Planning Division (MPD) data. At times, there was inadequate data for incidents, work zones, and other unplanned events that cause lane closures. The agency did not record weather or special event data.

ADOT worked with a University of Arizona research team to process and archive their travel time data. The team developed algorithms to clean the data, identify outliers, and conduct data imputation. ADOT found that working with a university partner enhanced their capacity and expertise and allowed them to accomplish more with their SHRP2 pilot project.

L02

L02 helps agencies establish TTRMS programs to monitor and determine TTR. To establish this system, an agency must:

- Collect and manage traffic data.
- Measure travel times.
- Characterize the observed travel times.
- Collect, manage, and impute non-recurring event data.
- Identify sources of non-recurring congestion.
- Understand the impact of the sources of congestion and unreliability before making a decision.

To find the most accurate travel time dataset for the TTRMS, ADOT compared the travel times from NPMRDS to the travel times obtained using loop data from RADS. The agency used both quantitative and qualitative analyses to identify key differences between the datasets. ADOT found that NPMRDS and RADS present distinct strengths and weaknesses. NPMRDS data, for example, tend to predict longer travel times than RADS. While using RADS is computationally expensive and difficult to implement, the system offers transparency and flexibility in data handling. The NPMRDS dataset, in contrast, is neither transparent nor flexible, but is more user-friendly. There is a cost associated with obtaining and cleaning both NPMRDS and RADS data. ADOT also plotted the Cumulative Distribution Functions (CDF) of travel speed for the three study segments at different times of day (figure 2). CDFs are a useful way to visualize and compare TTR on different segments. The agency used three indices to evaluate TTR:

- Misery Index (MI), which compares the worst trips to the expected travel times under free-flow conditions.
- Buffer Index (BI), which represents the additional time most travelers should add to their trip to arrive on time.
- Travel Time Index (TTI), which measures the average trip length and compares it to the expected travel time under free-flow conditions.

Under the framework developed for this project, ADOT will be able to identify locations that would benefit most from interventions to improve reliability. By comparing CDFs, MIs, BIs, and TTIs, ADOT can easily identify sites that suffer from the worst congestion and reliability issues.

L07

ADOT used the L07 method for the two I-10 segments in Phoenix that had already been analyzed with L02. Based on staff experience, ADOT implemented the following countermeasures from the L07 design guidebook:

- Accessible shoulder.
- Alternating shoulder.
- Crash investigation site.
- Emergency pull-off.
- Emergency access.
- Drivable shoulder.
- Incident screen.

Neither segment showed significant improvement in TTR as a result of the treatments. ADOT staff hypothesize this is because

the treatments only have a marginal effect on segments with high travel demand.

ADOT noted that the design guide provided useful information on the countermeasures, even if they would not improve TTR on these specific interstate segments. ADOT praised the L07 tool for the readability of its automatically generated spreadsheet results, both from the input tabs and in report form.
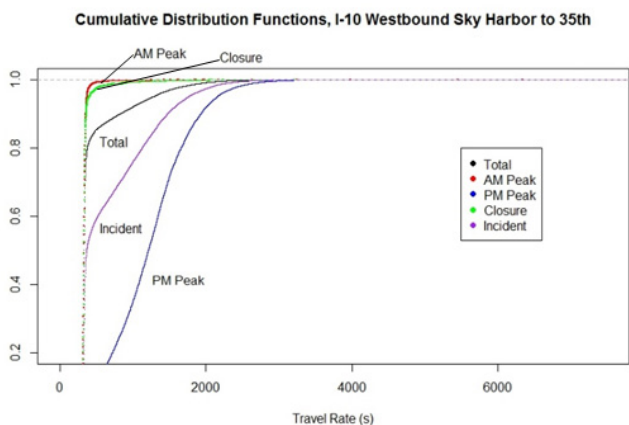

Figure 2. Graph. Example of the Cumulative Distribution Function of travel speed for one of the project segments, showing a high percentage of vehicles travel below free-flow speed conditions during the afternoon peak and roadway incidents. Source: ADOT

Incorporating TTRMS into Performance Measurement

The project enhances the TTRMS prototype by developing a new online, Statewide performance measurement prototype system. The Statewide performance measurement framework (table 1) initially developed for this project demonstrates the feasibility of the integration of TTRMS with other performance measures. This framework contains 27 measures in four categories that can all be obtained from automated databases. The measures use Statewide data collected by ADOT to address issues with freeway management, freight, incident management, and ITS management. ADOT is actively integrating the database into its online system to produce a website that allows users to design their own queries. The database will enable advanced users to quantify measures directly in safety, mobility, freight, and ITS management.

Table 1. ADOT Performance Measurement Framework. Source: Adapted from ADOT figure.

Area	Performance Categories
Freeway Management	Mobility (Congestion, Travel Time Reliability)
	Safety
	Work Zone
Freight	Mobility, Reliability, and Congestion
	Safety
Incident Management	Timely Response (Management Time, Congestion, Safety)
ITS Management	Operationality, efficiency, and coverage of ITS elements

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

The L02 guidelines helped ADOT to create a successful TTRMS prototype that the agency intends to use for Statewide analysis. ADOT found that the L07 design guide contained helpful information on a variety of countermeasures available to mitigate non-recurring congestion. Although ADOT found the L07 spreadsheet tool to be difficult to use, the results allowed users to quickly identify possible alternatives to ameliorate recurring problems. With a more user-friendly interface and improved instructions, the L07 spreadsheet tool could serve as a valuable resource to support the engineering process by identifying possible alternatives for further evaluation.

ADOT used HCRS data inputs for the L02 and L07 projects. A variety of agencies add lane restriction data to the HCRS via computer-aided dispatch; however, input errors are common. An improved dataset could create additional opportunities for ADOT in the L02/L07 projects as well as in other applications.

ADOT found that the L07 user interface was difficult to use in practice. ADOT experienced challenges using the macros in the Excel spreadsheet. Even though most of these challenges could be handled adequately through trial and error, they made the use of the tool tedious and time consuming.

Another issue with the L07 spreadsheet tool was the lack of a user guide. The L07 design guide document provided a comprehensive overview of potential countermeasures but contained little information for users seeking to use the spreadsheet tool. ADOT found the best resources for

implementing the spreadsheet were the L38 Pilot Studies, rather than the L07 study itself.

ADOT makes the following recommendations to improve the tools:

- Redesign the L07 spreadsheet tool to be more user friendly.
- Create a user guide for the L07 design guide.
- Incorporate additional performance measures using the data collected in L02.
- Develop an online tool that allows the user uploads pre-formatted data and that runs calculations to prepare the data for use in the SHRP2 analysis tools.

IMPACTS ON BUSINESS PRACTICES

The TTRMS prototype contributed useful TTR information along the study segments and helped improve the agency's understanding of the underlying causes of traffic congestion. As a result, the agency recommended developing TTRMS for Statewide use. ADOT will also consider establishing a dedicated data server and user-friendly website to facilitate access to the TTRMS for users across the State.

The project prompted the agency to consider several additional actions. ADOT recognizes the need to collect more detailed weather and special events data along the State's major interstates and arterial roads as well as the need for traffic engineers to acquire basic coding skills, particularly in the R programming language.

CONCLUSION

ADOT used L02 and L07 to create a prototype TTRMS and evaluate countermeasures for non-recurring congestion on three

segments of I-10 in Phoenix and Tucson. The TTRMS proved useful in understanding TTR on the study segments. None of the countermeasures evaluated in L07 significantly improved TTR on the study segments, and ADOT found that the tool's user interface could be improved. However, the design guidebook provided detailed information on a range of options for congestion mitigation.

ADOT plans to implement the Statewide TTRMS, collect additional datasets to measure non-recurring congestion, and train agency staff to incorporate reliability metrics into their work.

FOR MORE INFORMATION

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