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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

Washington State Department of Transportation

Implementation of L02 and L08 in Seattle

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 Washington State Department of Transportation (WSDOT) 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

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 in a corridor.

BACKGROUND

WSDOT, in collaboration with the University of Washington (UW), used the SHRP2 L02 and L08 products to improve its capability to monitor and analyze travel time reliability (TTR) in both urban and rural areas of Washington State. Through the project concluded in 2020, WSDOT sought to improve its decision-making and operational practices in addressing traffic congestion by adding multiple sources of travel time data to its Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net) system. Developed and maintained by UW's Smart Transportation Applications and Research Laboratory (STAR Lab), DRIVE Net is an online system for sharing, integrating, visualizing, and analyzing transportation data that creates key inputs for WSDOT's planning, project selection, and programming processes and tools.

The WSDOT study team tested the reliability methods with data from highway segments of the two principal north-south corridors through the Seattle metropolitan area and hopes to apply the study results to the entire State freeway network. Test locations included:

- 12-mile segment of I-5 from the Seattle-Tacoma Airport (Sea-Tac) to downtown Seattle (figure 1). This segment experiences significant congestion northbound into downtown Seattle during the morning peak.
- 16-mile segment of I-405 from Bellevue to Lynnwood (figure 2). This segment suffers from congestion out of downtown Bellevue during the evening peak.

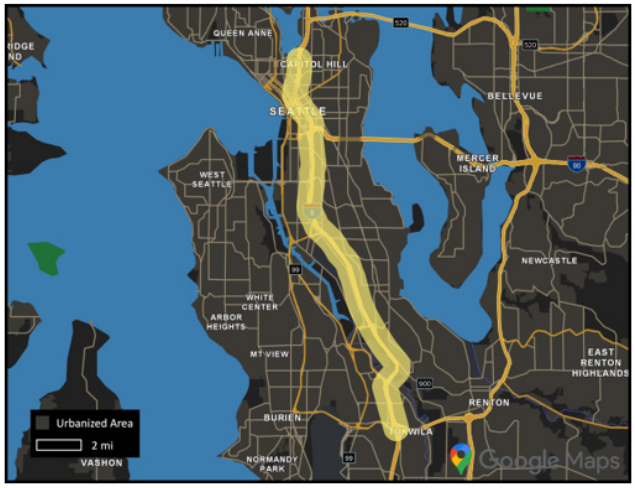

Figure 1. Map. I-5 project segment from the Seattle-Tacoma Airport to downtown Seattle, WA. Source: FHWA. Map Data © 2020 Google.

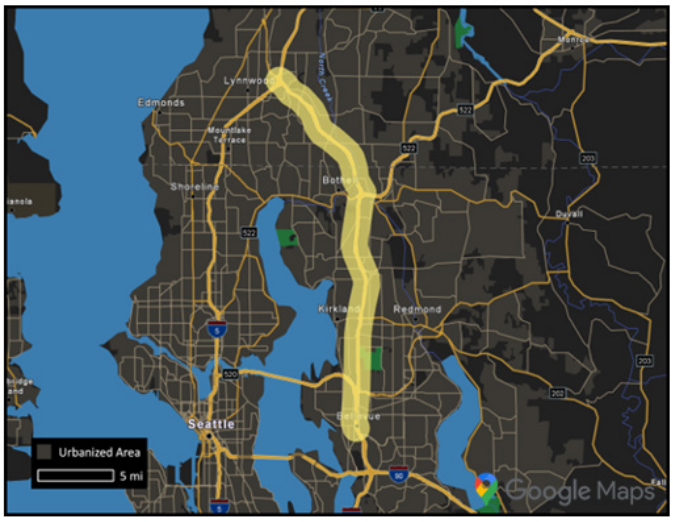

Figure 2. Map. I-405 project segment from Bellevue, WA to Lynnwood, WA. Source: FHWA. Map Data © 2020 Google.

PRODUCT IMPLEMENTATION

Data

The study team conducted the research needed to integrate the following data sources into DRIVE Net:

- WSDOT freeway loop detector data (location-based speed data).
- National Performance Management Research Data Set (NPMRDS/HERE® Technologies) (segment-based speed data).
- INRIX® probe vehicle data.
- Washington Incident Tracking System (WITS).

Each dataset covers different areas and routes within the State. WSDOT loop data cover 84 commute routes in major urban areas, reporting volume and lane occupancy measurements, while INRIX data cover significantly more routes statewide, reporting average speed data at locations defined by Traffic Message Channel (TMC). The coverage range of the NPMRDS/HERE data falls between the WSDOT loop detectors and the INRIX datasets. As a result of the research, the study team found the INRIX data unsuitable for the study.

WSDOT performed the following activities to incorporate the loop detector and NPMRDS data sets using principles from the SHRP2 reliability products:

- Integrate multiple online data sources for use in the implementation of the methodology.
- Control data quality and handle missing data through imputation models based on spatial and temporal relationships present in the loop detector dataset.
- Merge data from multiple sources by implementing functions that generate improved TTR measures for different roadway facilities and time periods.
- Use other data sources, such as weather data and incident data, to enable analysis of travel time under nonrecurrent congestion conditions.

L02

WSDOT used L02 methods to design and build an integrated database from multiple sources. With the integration, DRIVE Net supported enhanced TTR measures for various roadway facilities across time periods. The agency used contextual data, such as weather and incident data, to analyze travel time under non-recurrent congestion conditions. Guided by the L02 tool the study team successfully joined the geospatial and temporal referencing systems of the constituent datasets.

As a result of this study, WSDOT enhanced DRIVE Net's capabilities for reliability analysis by improving the interfaces between DRIVE Net and other modeling tools used by WSDOT and State metropolitan planning organizations (MPOs). The new DRIVE Net features are as follows:

- **Custom reports.** WSDOT built flexibility into the user's ability to specify the content of DRIVE Net output, which improved data quality analysis and customized reporting to create inputs for other WSDOT software tools.
- **Geospatial database management system.** Geospatial databases, such as PostgreSQL® with extenders PostGIS and pgRouting, bridged the spatial processing gaps introduced by the multiple data sources in DRIVE Net.
- **Mapping software.** Additional mapping visualization software, OpenStreetMap® and OpenLayers, increased DRIVE Net's flexibility and accuracy.
- **Route selection parameters.** A new DRIVE Net feature allowed users to select both pre-defined and user-defined highway segments for analysis.

L08

The study team modified DRIVE Net to implement reliability performance measures as defined in the L08 product. The DRIVE Net implementation estimated travel time and reliability

measures for pre-defined Puget Sound commuter routes. The DRIVE Net software required the user to select which data set was to be analyzed. When using the loop detector data, for example, the user could analyze travel times separately for general purpose and high-occupancy vehicle lanes. Table 1 summarizes the travel time metrics created using the travel time analysis function of the DRIVE Net system.

Table 1. DRIVE Net Travel Time Metrics

TRAVEL TIME METRIC	DESCRIPTION
Travel Time Index (TTI)	A ratio of a specific travel time divided by the free-flow travel time
Reliability Rating	Percentage of trips serviced at or below a threshold travel time index, 1.5, which is consistent as the MAP-21 PM3 threshold.
Planning Time Index (PTI)	95th percentile TTI (95th percentile travel time divided by the free-flow travel time)
80th Percentile TTI	80th percentile travel time divided by the free-flow travel time
Average Travel Time	Average of all the recorded travel times.
Standard Deviation	Standard deviation of the all the travel time values
50th Percentile Travel Time	Median of all the recorded travel times.
80th Percentile Travel Time	80 percent of all the recorded travel times are shorter than this duration.
DRIVE NET TRAVEL TIME METRIC TABLE CONTINUED	
90th Percentile Travel Time	90 percent of all the recorded travel times are shorter than this duration.
95th Percentile Travel Time	95 percent of all the recorded travel times are shorter than this duration.

The study team tested DRIVE Net by running analyses on the effects of incidents and lane type on TTR using historical data for the I-405 segment in 2015. The results were consistent where more severe incidents (as measured by the number of lanes closed) resulted in degraded TTR. The study notes that as part of its business processes, WSDOT uses the 95th percentile travel time as its key reliability metric.

ASSESSMENT OF THE TOOLS: BENEFITS, CHALLENGES, AND RECOMMENDATIONS

WSDOT cited several benefits associated with the changes to DRIVE Net that were guided by the SHRP2 products, including:

- **Increased data coverage.** WSDOT benefited from integrating data from different sources for their analyses, including incident, weather, and construction data. The agency's existing tool had used loop detector data but lacked statewide breadth.
- **Time savings.** The new tool offered automated analysis, allowing WSDOT to analyze data and produce a congestion report in only a few hours. Previously, staff required 3 to 4 months to manually produce this type of report.
- **Consistency of results.** Tool results were consistent across users, who could track and check the analytic process afterwards. When relying on manual analyses, results were previously difficult to replicate across users.
- **Crash analysis.** Data in DRIVE Net can support staff in determining causes for crashes.

The guidance from the SHRP2 L02 and L08 products made these benefits possible. At the same time, WSDOT faced several challenges during the study that affect the conditions needed to continue to use the enhanced DRIVE Net. These challenges concerned the institutional context of WSDOT's analysis infrastructure, rather than the methodologies and processes in the L02 and L08 products. The challenges included:

- **Data cost.** The agency must purchase the necessary data on an ongoing basis. At the time of the study. WSDOT obtained data from 2015; in the longer term, the agency would require designated funding to purchase the data annually.
- **Process validation.** WSDOT compared the results of the new automated process with the results of previous similar runs using a predecessor traffic data analysis system with manual data inputs. WSDOT has not reconciled the small difference between the results.
- **Competing system requirements.** The agency found, for example, that data maintained as static variables in a UW research data system should be dynamic variables in the business intelligence system that WSDOT required.

- **Partner business practices.** WSDOT is dependent on UW staff availability to update and maintain DRIVE Net data. The data transfer systems would need to be built into each participating agency's business processes.

The DRIVE Net functionality is limited to the agency's partnership with UW. Although the tool automates analysis, it still requires manual data entry, which is unsustainable in the long-term. WSDOT indicated that automated data entry would have increased the utility of the tool.

IMPACTS ON BUSINESS PRACTICES

The development of DRIVE Net motivated WSDOT to explore how to move beyond planning for reliability and towards development of a transportation systems management and operations (TSMO) program. The agency realized that it needed to focus on staff education and awareness about TSMO. To that end, the agency developed a website, tsmowa.org, to educate and raise awareness of TSMO among internal and external practitioners, especially those who do not use TSMO day-to-day.

WSDOT has fully embedded reliability performance reporting in its work. Understanding that flexible data systems to support these processes are key to their success, the agency has actively developed improved project identification, selection, and prioritization processes to support corridor reliability.

WSDOT also used the performance measuring results to provide guidance that helps constituent units and MPOs with planning and programming tasks.

CONCLUSION

WSDOT used integrated multi-source data and implemented functions on DRIVE Net to provide comprehensive TTR measures for the statewide traffic network in urban and rural areas. The results provided guidance that can help other states and MPOs with planning and programming tasks.

WSDOT sees value in additional internal training for using DRIVE Net in reliablity analyses, as well as additional testing and validation for DRIVE Net. The agency is considering several enhancements to the system, including the incorporation of data from new technologies, enhanced multi-dimensional data integration, and enriched travel time analysis functions. Lastly, WSDOT will continue integrating TSMO into its business practices.

FOR MORE INFORMATION

WsDOT Transportation Systems Management and Operations
https://tsmowa.org/
WsDOT DRIVE Net
http://www.uwdrive.net/
SHRP 2 Solutions
https://www.fhwa.dot.gov/goshrp2

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