Research Note

Quantifying Incident-Induced Travel Delays on Freeways Using Traffic Sensor Data: Phase II

From the WSDOT Research Office
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Traffic incidents affect safety, travel time, and fuel cost

Traffic incidents cause not only adverse safety impacts on roadway travel, but also approximately 50 percent of freeway congestion in metropolitan areas, resulting in extra travel time and fuel cost. Managing traffic incidents efficiently and effectively is crucial for congestion mitigation. The Washington State Department of Transportation (WSDOT) established its Incident Response Program (IRP) in collaboration with the Washington State Patrol, the Washington State Association of Fire Chiefs, and the Washington Traffic Incident Management Coalition (WaTIMCo).

Washington State Department of Transportation

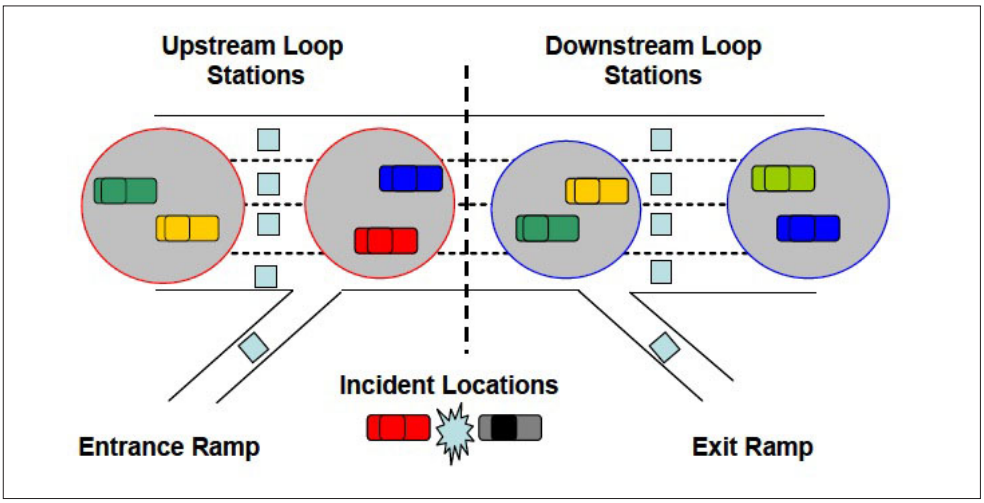
WSDOT needed a practical way to quantify freeway delay due to incidents

To improve understanding of incidents and manage them more effectively, WSDOT launched this research project to develop a practical method for quantifying freeway Incident-Induced Delay (IID) using traffic sensor data. IID refers to the extra travel time, in addition to the travel time of an incident-free scenario, which all incident-impacted drivers take to complete a certain length of trip. Quantifying IID for an incident requires knowing both the total delay under the incident scenario and the recurrent delay under the incident-free scenario. The difference between total delay and recurrent delay is the delay induced by the incident.

A method that can accurately quantify IID is highly desirable for the following reasons:

- IID estimates are crucial for assessing the effectiveness of operational strategies of roadway network;
- IID estimates provide important information for traffic engineers to understand the impacts of various types of incidents under different traffic and roadway conditions;
- IID estimates are essential for optimizing the incident response program so that limited monetary and labor resources can be allocated to maximize its benefit/cost ratio; and
- IID is a key component of incident cost calculations and hence is essential for the development of active traffic management and integrated corridor management strategies.

As an extension of the Phase I study, this research project aimed to improve IID estimates by developing a new algorithm that only uses traffic volumes as input. Such an algorithm is more suitable for WSDOT because single loop detectors are the most common type of traffic sensors in Washington and only traffic volume and lane occupancy can be directly measured by single loops.



Loop stations upstream and downstream of an incident.

The researchers investigated a better approach to measure freeway delays caused by incidents

To overcome the difficulties in IID estimation using the Phase I approach, a modified approach was developed. This new approach applies techniques to predict the unobservable downstream volumes under the incident-free scenario to eliminate the need of estimating the recurrent delay at the incident location (Figure 1). This new approach enables IID estimation at locations with only volume measurements.

Two techniques were investigated in this study for downstream volume prediction. Their prediction accuracies were evaluated and compared to help determine the best prediction approach. To predict the downstream curve accurately, a number of models were calibrated for applications under different scenarios featured by time of day, number of lanes, route, and direction.

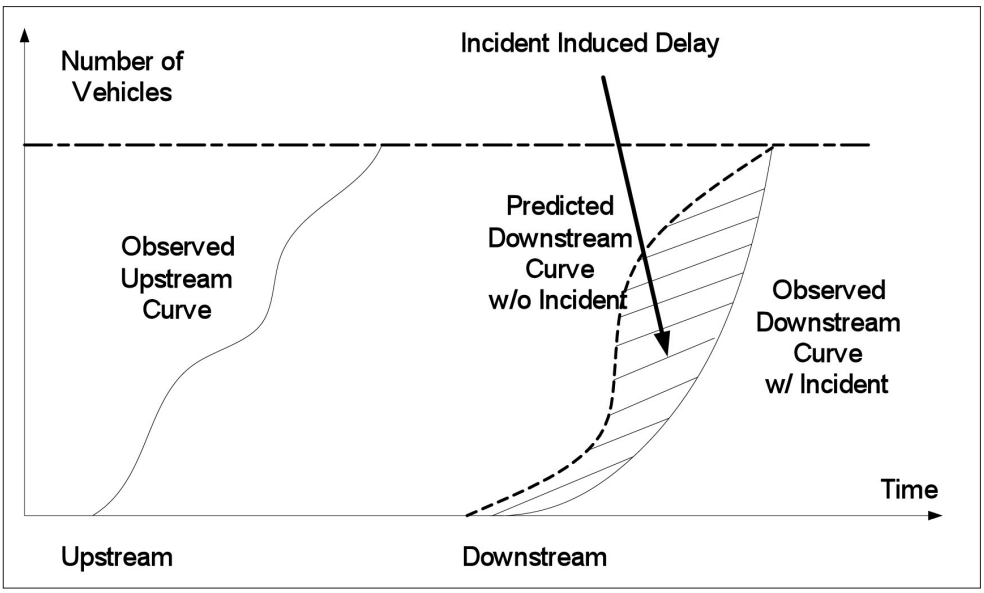


Figure 1. Illustration of the modified queuing diagram.

To verify the accuracy of the new IID estimation algorithm, IIDs estimated by the proposed approach were compared with the ground-truth data. The ground-truth IIDs were extracted from video images captured by the WSDOT surveillance video cameras at two study sites, one on I-5 and the other on SR 520. The relative errors associated with the proposed approach were 1.4 percent and -5.6 percent for the I-5 and SR 520 cases, respectively, indicating that the new approach is able to produce fairly accurate IID estimates.

Researchers investigated the statistical patterns of incident occurrence frequency and incident duration based on the 2009 incident data archived in the Washington Incident Tracking System. A statistical analysis was conducted on the estimated IID and obtained valuable findings. The analysis results not only help people understand incident impacts on roadway travel, but also provide crucial information for WSDOT to develop countermeasures against traffic incidents and incident-induced congestion.

A prototype online system was developed to implement the proposed algorithm. It was integrated into the Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net). DRIVE Net is a regional map-based online platform for data sharing, visualization, modeling, and analysis developed by the Smart Transportation Applications and Research Laboratory (STAR Lab) of the University of Washington. Through the regional map-based user interface and the query tools provided by the online application, users can easily configure queries on the incident database of DRIVE Net. For example, a user can specify the time period and routes to define the incidents to display. All incidents that fit the query criteria will be marked on the regional map by balloon symbols. If a user is interested to know details of an incident, he or she can click the corresponding balloon and see the fundamental data of the incident in a callout textbox. To view the incident-induced delay, users can click the "Calculate Delay" button at the bottom of the callout (Figure 2) and IID of the incident will be presented in the callout.

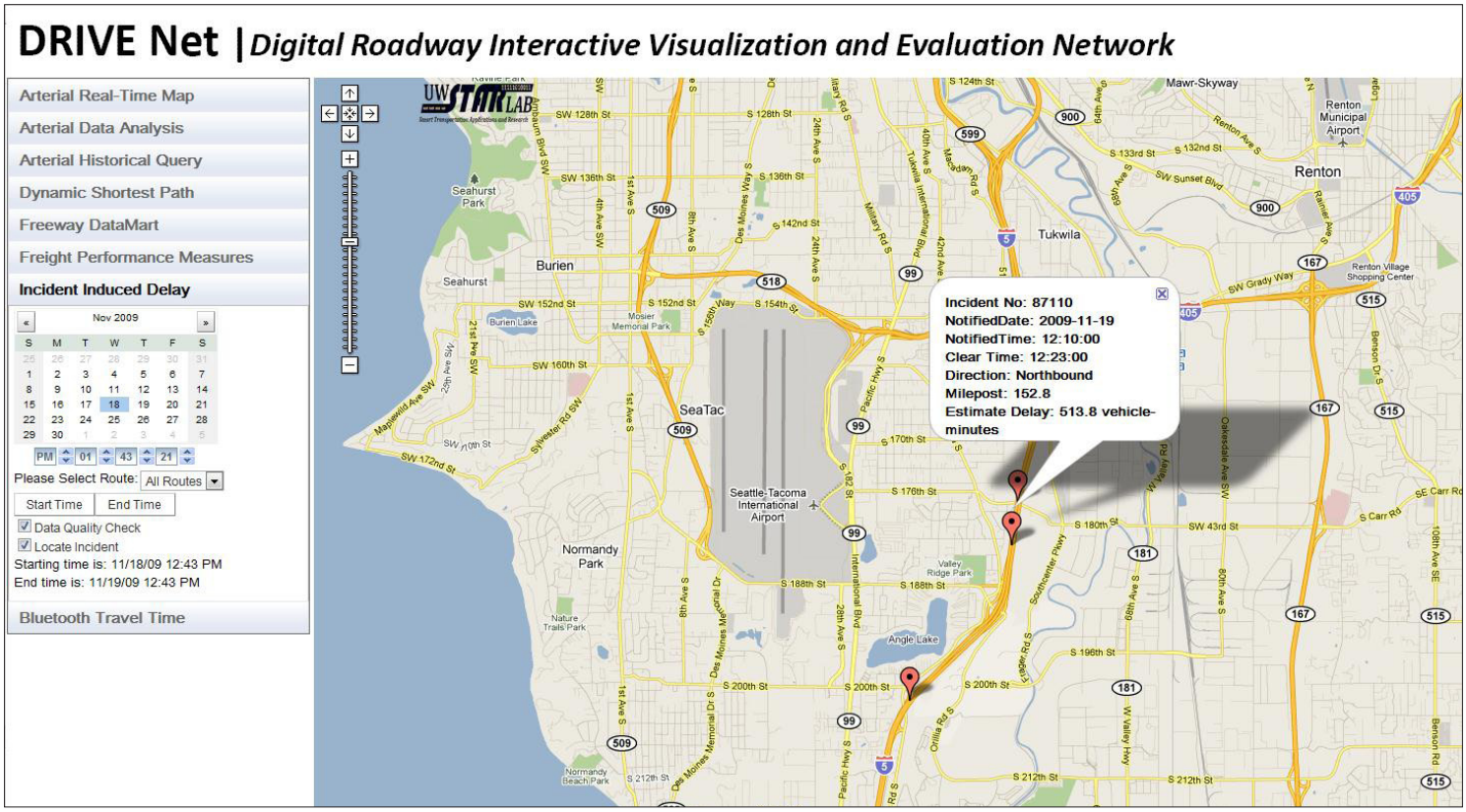


Figure 2. Snapshot of the online system.

The researchers found weekend incidents and traffic accidents cause longer delays

By using the method developed in this study, users can automatically calculate IID with a good accuracy for a large-scale freeway network equipped with traffic counters.

Incident response on weekends should be strengthened. A case study on I-5 incidents revealed that weekend incidents have longer average IIDs than weekday incidents of the same type. This implies that more IRP resources may be needed for busy corridors during weekend days.

Traffic accidents were found to be associated with significantly longer IIDs than other types of incidents. More effective response to traffic accidents, particularly casualty accidents, would definitely be helpful in decreasing average IIDs.

Researchers recommend need for better location-specific models

With IID estimated by the proposed algorithm, IID cost can be derived with value of time information. This enables the opportunity for optimizing the configurations of the IRP crew teams, including their scheduling, personnel allocation, and spatial deployment.

IIDs for a significant amount of incidents cannot be estimated because of missing or incorrect data. Improvement of data quality in both the incident database and the loop database are needed to further enhance IID estimation. Since ramp milepost information is currently missing in the loop detector database, the research team was not able to consider ramp volumes in the calculations. In the future, the milepost locations for on- and off-ramps should be added to the online system database so that the proposed algorithm can incorporate ramp volumes.

Accurately predicting the downstream volume under the incident-free scenario is critical for quantifying IID in this new approach. Since geometric factors, in addition to volume levels, are highly relevant to traffic movements, prediction models that take location-specific variables into account are likely to yield better results and should be investigated in future research. Further study should address this and develop more location-specific models for improved IID estimation accuracy.

WSDOT plans to use the results in freeway operations and infrastructure investments

Implement the algorithm

The approach presented in the study does not require inputs other than traffic volumes, so it can be easily applied statewide. WSDOT will implement this algorithm for IID estimation.

Improve the online platform for information query and analysis

The prototype online system developed in this study provides a great platform for WSDOT staff to query the incident database, visualize incident distributions, analyze incident characteristics, and quantify incident impacts. At the current stage, the system only has the 2009 incident data uploaded and limited analytical functions. With further improvements of the online system, important statistics of incidents can be more accurately and automatically calculated for various purposes. These statistics are greatly helpful for WSDOT to make optimal decisions on freeway operations and infrastructure investments.

Use IID results to optimize the Incident Response Program

With IID estimates and the value of time for a particular area, the congestion-related cost of an incident can be calculated. This will not only help understand total cost of an incident, but also improve analysis of options for location of IRP personnel and equipment to identify optimal placement.

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WA-RD # 758.1
http://www.wsdot.wa.gov/research/reports/fullreports/758.1.pdf

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