Joint Transportation Research Program

Principal Investigator: Yaobin Chen, Purdue University, ychen@iupui.edu, 317.274.4032

Program Office: jtrp@purdue.edu, 765.494.6508, www.purdue.edu/jtrp

Sponsor: Indiana Department of Transportation, 765.463.1521

SPR-4306 2019

Back of Queue Warning and Critical Information Delivery to Motorists

Introduction

Recent INDOT JTRP studies have found that back-of-queue or end-of-queue crashes are one of the main sources for fatal accidents on the highway. A variety of factors, including low visibility, slippery road surface, and driver distraction/drowsiness during highway cruising, contribute to this type of fatal crash.

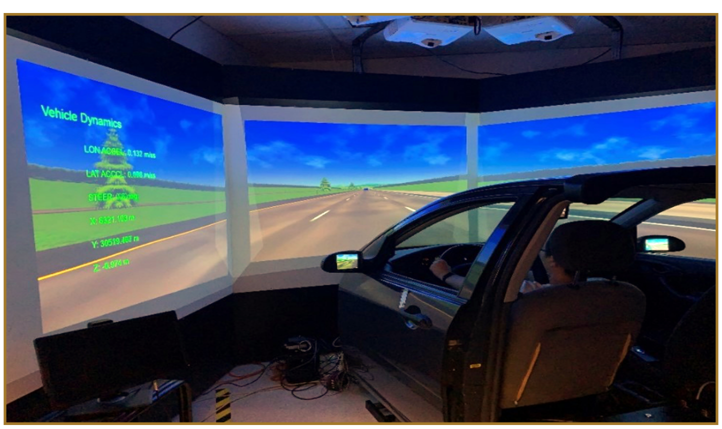
Based on probe vehicle data acquired through freight, smartphones, and in-vehicle GPS units, INDOT is able to monitor highway congestion, queue-starting locations, and queue lengths covering all interstate highways in Indiana. Although this information is available to the traffic managers, there are no methods that are currently available to effectively distribute information about potentially hazardous conditions to drivers on the road.

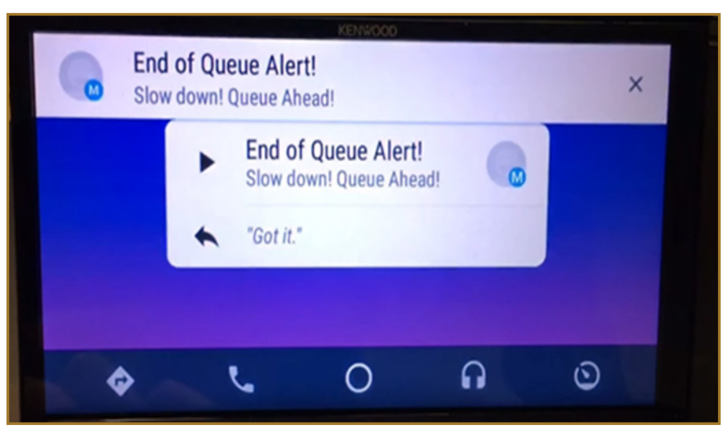
Based on the existing INDOT real-time queue-monitoring system, this project focused on developing a prototype end-of-queue alerting system for drivers approaching traffic queues on Indiana highways. More specifically, this research aimed to do the following:

- Investigate feasible solutions to implement end-of-queue alarms, considering both in-car and roadside options, and tune the alarm parameters through driver simulator-based studies.
- Determine the best practice for end-of-queue alarms by examining the technical requirements and limitations of different feasible solutions, with a focus on queue data acquisition, vehicle localization, communications, and adaptive in-vehicle alarms.
- Develop a prototype end-of-queue alerting system based on probe vehicle data and evaluate the benefits via a driving simulator–based study and a limited number of on-road driving tests.

Findings

- The establishment of INDOT's web service was very important for the IUPUI team, allowing them to fetch traffic data in real-time and develop algorithms for issuing the end-of-queue alerts to drivers on the road.
- To find efficient and effective ways to distribute hazardous road information to on-road drivers, multiple potential solutions were investigated, such as portable roadside message boards, in-vehicle smartphone apps, and vehicle-to-vehicle communications based on in-vehicle devices. After a thorough literature review and an evaluation of existing data sources, the chosen end-of-queue alerting mechanism was in-vehicle smartphone app-based alerts.





The alert messages will be sent through Android-based smartphone apps via the 4G network and the Android Auto device.

- The driving simulator is a very useful tool for evaluating the benefits of the developed prototype end-of-queue alerting system. Subjects were recruited to be tested in traffic scenarios with and without alerts and with different driving statuses (normal, distracted, and drowsy). Driver and driving data were collected and analyzed.
- Initial investigation proves that this alerting system can reduce intensive driving behavior overall and has the potential to increase driving safety.

Implementation

To implement the end-of-queue alerting system on the Android-based smartphone, a Java-based application was developed. Google map API was used to show the map information on the smartphone. To monitor the delta-speed changes, web service from INDOT was used. An algorithm was developed to find the speed events based on the current GPS coordinates of the smartphone. To debug the application, a separate mechanism was developed to simulate the real-time data in computer programs. This application was also tested on different highways and associated log files were created for debugging purposes. The notification classes were used to show the alerts on the smartphone, including sound, text, and vibration features.

The Android devices were purchased and their functions were evaluated. The Android Auto device we used was the Kenwood DDX9704S display and the Android phone was the Samsung S7; both were powerful enough for our research needs. Based on the evaluation, two different methods for sending out notifications were tested. The first one was to send notification as a text message. Taking advantage of the powerful Android Auto app and Google Assistant, the notification can be clearly displayed and interactive. The second method was to mirror the screen of the phone to the Android Auto display. In this way, more intuitive information can be shown. Both methods have pros and cons and are suitable for different needs. The smartphone app and Android Auto device were road tested. Both devices functioned well on the highway during the test runs.

The driving simulator in the TASI laboratory at IUPUI was set up for the testing of the prototype system. A platform was designed to utilize the driving simulator system (HyperDrive) and provide the mobile application with a simulated real-world view of Indiana highway traffic. Five subjects were asked to participate in tests designed to evaluate the effects of having an end-of-queue alerting system in the driving simulator. Each subject was asked to perform six driving tests in total. Subjects drove in the driving simulator under normal, distracted, and drowsy conditions with and without alerts. The driving simulator was able to collect braking and crashing data when the subject approached the queue. The performance of the prototype system was evaluated through the comparison of the data from the two test categories.

Recommended Citation for Report

Li, L., Chen, Y., Tian, R., & Li, F. (2019). *Back of queue warning and critical information delivery to motorists* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2019/24). West Lafayette, IN: Purdue University. https://doi.org/10.5703/1288284317102

View the full text of this technical report here: https://doi.org/10.5703/1288284317102

Published reports of the Joint Transportation Research Program are available at http://docs.lib.purdue.edu/jtrp/.