MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION

RESEARCH SUMMARY

Integration of Ramp Metering and Off-Ramp Progression

WHAT WAS THE NEED?

Many ramp metering applications in the United States are on a preset time-of-day control at individual ramps and are not coordinated with neighboring ramps or surrounding arterial signals. Advanced strategies/systems reported in the literature for congestion control and traffic management have been mainly at the project demonstration level. Bridging the gaps between state-of-the-art and state-of-the-practice models/algorithms for congestion management remains a challenging and imperative task for the traffic community.

WHAT WAS THE GOAL?

The primary objective of this project is to develop an integrated freeway control system that can effectively guide the timely activation of key operation components either concurrently or sequentially to address daily recurring congestion in real time.

WHAT DID THE RESEARCH TEAM DO?

This project produced four traffic models for highway agencies to overcome various constraints existing in practice. Depending on the congestion patterns and their spatial evolution over the target freeway segment, responsible traffic control centers can apply these models individually or collectively, ranging from local ramp metering to coordinated freeway control or eventual integrated corridor management.

JUNE 2020

REPORT NUMBER:
MD-20-SHA/UM/5-14

START DATE:
January 2019

COMPLETION DATE:
April 2020

PRINCIPAL INVESTIGATOR:
Dr. Gang-Len Chang
University of Maryland
gang@umd.edu

First, this study produced an arterial-friendly local ramp metering model coordinated with neighboring signals to prevent ramp queues from spilling back to local arterials.

To extend the local metering to coordinated ramp control, this study further developed two models to mitigate the impacts of on-ramp weavings and off-ramp queue spillback on the freeway mainline segment, so that two neighboring ramps and their common connected mainline segment can be properly captured to constitute a coordinated control system.

This study also proposed an alternative for operating the corridor-wide control in practice, independently from the arterial progression. The arterial to facilitate the corridor-wide control will be controlled with the advanced multi-path progression system. This system was also developed in this study. It functions to coordinate not only the intersection phase for the arterial-to-ramp flows with the ramp metering signal, but also to provide dual progression bands to both the through traffic flows and the large-volume of turning flows from the off-ramp to the arterial.

WHAT WAS THE OUTCOME?

The most significant outcome is the integrated corridor control capability. It is geared toward a system including a freeway segment and parallel arterials that has an objective of minimizing the total system-wide delay or maximizing the total throughput. Theoretically, all key control modules responsible for regulating either freeway or arterial flows can be constructed and operated on the same control platform with either a time-of-day or real-time control mode.

MDOT SHA'S PERSPECTIVE

Despite being conceptually appealing, the integrated control requires highly accurate and reliable field data to establish the complex temporal and spatial relations between all traffic state variables, especially to yield concurrently optimal states for both the freeway and arterials. It likely demands that system operators perform ad hoc manual-adjustment, especially under highly fluctuating traffic conditions, to prevent any performance conflict (e. g., on- and off-ramp queue spillbacks).

The application(s) chosen will need field data at the required accuracy level(s) to validate and calibrate the models. Some key model parameters include the data interval (e.g., 5 or 15 minutes) for time-of-day off-line control, maximal signal turning ratios for moving-to-ramp flows, the cycle length constraints for arterial and ramp signals, and the threshold for activating and deactivating the local metering control.

A significant deviation from conventional traffic signal phasing principles/practices is that the ramp signal allows multiple vehicles to pass during the green phase, and then directly switches to a red phase without the presence/use of a yellow signal indication.

LEARN MORE

To view the complete report, click here.