The Effect of Active Traffic Management on Travel Time Reliability: A Case Study of I-5 in Seattle

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Introduction

Active traffic management (ATM) strategies involve the implementation of intelligent transportation systems that influence and regulate the flow of vehicles on a freeway. The goal of these strategies is to improve the safety and operation of a road that has exceeded its capacity. They can include:

- Variable Speed Limits (VSL)
- Queue Warning
- Dynamic Lane Control

A roadway’s travel time reliability is an indicator of the level of congestion experienced on it. A measure of travel time reliability attempts to quantify the variability of the travel times users experience along the same route at different times.

- 95th Percentile Travel Time
- Planning Time Index

Measurements of Travel Time Reliability

Travel time reliability is defined as the consistency or dependability of travel times. Measures of travel time reliability can quantify the variability of travel times along a route measured either on a day-to-day basis or across different times of the day.

95th Percentile Travel Time: Also called the planning time. This value indicates the longest travel time users can reasonably expect along a given route.

Planning Time Index: A ratio between the planning time and the free flow time along the route.

Buffer Index (BI): Which relates the buffer time to the mean travel time. Buffer time is defined as the difference between the 95th percentile travel time and the mean travel time.

BI = 95th percentile travel time – mean travel time

Smaller PTI and BI mean higher travel time reliability.

Data Aggregation Method

WSDOT provided volume and occupancy data from each of the loop detectors along the 7 miles of I-5 affected by the ATM system. These loop detectors are the same ones that feed data into the control algorithm. The road’s dynamic rules are not provided by WSDOT included flow and occupancy for 19 loop detector locations along the route. The period before ATM implementation includes data from February 2009 to August 2010. The period after ATM implementation includes data from August 2010 to March 2012. From the loop detector data, travel times were calculated using the Wang and Nihan formula for speed estimation:

\[ f = \frac{v}{s} \]

Where:
- \( f \) is the time interval index
- \( s \) is the free space given in m for each interval
- \( v \) is the vehicle (circuit) per interval
- \( s \) is the free space (m) given in the lane
- \( p \) is the constant

Categorical Analysis on Flow and Travel Time Characteristics

Scenarios: Day of week, weekday or weekend, the time of day, detector locations.

1. Minor flow reduction (less than 10%) can be observed after the ATM implementation throughout the corridor.
2. Both mean and 95th percentile travel times reduce from 4% to 31% except during morning peak.
3. In general, mean travel times reduce more significantly than 95 percentile, thereby reducing the TTR index.
4. The most significant travel time reliability improvement is during off-peak hours such as 10am to 12pm, and during the evening.
5. The evaluations from both indexes confirm the worsened travel time reliability for traffic condition between 6 and 8 am.

Conclusions

1. Travel time reliability analysis indicates that ATM systems on I-5 for Seattle have positive impact on safety and reliability.
2. Travel time reliability changes under scenarios such as day of week, weekday or weekend, time of day, and by detector locations for the morning peak hour. The increase in travel time reliability is statistically significant on the corridor in most scenarios except for the morning peak hours between 6 to 8 am.
3. The reduction of travel time reliability indexes in those scenarios are due to general decreasing trend of mean and percentile travel times before and after the ATM deployment. Significant by the mean travel time changes, traffic condition during the morning peak hours after the ATM deployment are affected by the changes in the travel time reliability indexes.
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