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The Influence of General Purpose Lane Traffic on Managed Lane Speeds: An Operational Study in Houston, Texas

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Abstract

Freeway networks are a critical component of the transportation systems at large metropolitan areas. The use of managed lanes (MLs) is a very important tool in accommodating directional demand, often heavily asymmetrical at peak hours. Current literature establishes that operational performance of MLs may impact, and be impacted by, operations of adjacent general purpose lanes (GPs), despite some degree of physical separation. Such operational co-dependence may especially exist between the GP lane adjacent to the separation buffer and the ML lane. This paper examines how the operations of these lanes relate to each other. Operational data were collected from 2 freeway sites in Houston TX (U.S.A.) for analysis. Both sites feature a buffer separating a single ML from the GP lanes at each site. One of those sites features vertical pylons in its buffer while the other site does not. This dataset spans several months of year 2014, from January to December. Results highlight the influence of the left-most GP lane on the ML operational speed, as well as the apparent degree of mitigation to that influence that the presence of pylons provides.

Keywords: Managed Lanes, Freeway Operations

1 Introduction

Freeway networks are a critical component of the transportation system for large metropolitan areas. Within a freeway, some of the lanes can be actively managed to improve service. These managed lanes (MLs) can provide faster travel speeds and better reliability than what could be observed on adjacent general-purpose (GP) lanes that are not subject to the same level of management. Most managed lanes serve long-distance mobility needs and are typically the left-most lane(s) next to the median barrier. Several separation techniques between the ML and the GP lanes are used, ranging from typical broken single white lane line markings to a concrete barrier including having a flush buffer marked with white and/or yellow solid lane line markings. Adding a vertical pylon in the flush buffer is becoming more common, with the purpose to prevent lane changing.

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Notably, there is reason to believe that ML operations differ from GP lane operations, as previous research has found differences in performance measures. Furthermore, previous work has found that operations at ML and GP lanes are not independent. The primary objective of this paper is to conduct an investigation of freeway operations at buffer-separated managed lanes along with its neighboring GP lane to quantify the potential effect of pylons in the interaction between the ML and the adjacent GP lane.

1.1 Literature Review

Previous work by Carson suggests that the single fact that operations on managed lanes are monitored and controlled is enough reason to expect differences with respect to GP lanes (Carson, 2005). Various studies have investigated traffic flow characteristics in managed lanes. Researchers in Washington observed that MLs move slower when the GP lanes are congested (Nee, Ishimaru, & Hallenbeck, 1999). The study attributed this behavior to lack of comfort when traveling at higher speeds than the GP traffic and to merging traffic from the GP lanes to the ML travelway. Additional evidence was found by Martin et al. (Martin, Perrin, Wu, & Lambert, 2004). They used data from three highways with managed lanes in Utah to analyze travel time, volume counts, and speed for five morning peak hours and five afternoon peak hours at each site. The study observed that when the GP lanes adjacent to the HOV lanes were congested, the HOV lane operated at a speed well below the speed associated with the flow level that is significantly under the capacity.

Kwon and Varaiya (Kwon & Varaiya, 2008) further added to the notion that MLs have features that distinguish them from GP lanes. The study looked at speed and volume data obtained from 700 loop detectors in California. The data covered various months of the year, and the detector stations were located along 1171 miles of a ML on a California highway. The study found that MLs had a maximum flow of 1600 vehicles per hour per lane (vphpl) at 45 miles per hour (mi/h) where GP lanes experience a maximum flow of 2000 vphpl at 60 mi/h. This 20 percent decrease in capacity was attributed to a “snail” effect where the speed on the HOV lane was governed by the slowest moving vehicle.

The National Cooperative Highway Research Program (NCHRP) funded a study to analyze managed lanes on freeway facilities (Wang, Liu, Rouphail, Schroeder, Yin, & Bloomberg, 2012). The study developed different modules to determine speed-flow relationships in ML facilities that were based on sensor and simulation data. The framework of these modules considered different segment types along a ML facility, and types of separation. The study used a total of 63,656 fifteen-minute data points that were extracted from 10 freeway facilities with MLs in order to develop a speed-flow relationship. The study found that the separation type and number of lanes seem to impact the traffic flow behavior of ML facilities.

Liu et al. termed the phenomenon of speeds in the ML being influenced by operations in the GP lane as a “frictional effect”, finding reduced HOV speeds due to adjacent GP lane congestion. The researchers compiled and analyzed data grouped by 5-minute intervals from four study sites (two in Minnesota and two in California), covering partial days within a month in 2009. The study investigated whether the frictional effect between GP lanes and MLs was present across different separation types. The study concluded that the frictional effect was greater at buffer-separated one-lane facilities, followed by facilities with soft separation, such as plastic pylons. Concrete barrier separations had the lowest frictional effect. The frictional effect was also less when the managed lane had two rather than one lane due to the opportunity of passing a slow moving managed lane vehicle.

1.2 Motivation

The work described in this paper is motivated by an interest to quantify how the neighboring GP lane affects the operations of a ML and to measure the size of the co-dependency between the GP lane