Transportation Research Procedia

Volume 15, 2016, Pages 438–446

ISEHP 2016. International Symposium on Enhancing Highway Performance

Development of a Mobility-Based Service Measure for Freeway Facilities

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Abstract
The Highway Capacity Manual (HCM) currently uses a bipolar approach to defining level of service (LOS) for freeway facilities: either (1) weighted density or (2) assigning LOS F if one or more segments experience LOS F. The major shortcoming of this approach is that density is a poor indicator of travelers' experiences under congested conditions; speeds or travel times are more relevant to travelers and are consistent with how agencies measure and report congestion using field data.
This paper deals with this issue by defining a travel time-based service measure for freeway facilities. The main purpose is to bring the HCM in line with empirically-based performance measures used in performance management. Two HCM applications are explored: (1) traditional (static) freeway analysis and (2) the new travel time reliability (TTR) analysis procedure. Several performance measures are explored for the service measures by analyzing field data from seven U.S. urban areas.
A shift away from the current density-based LOS structure is recommended. The new structure uses ranges of the selected travel time measures that indicate different levels of the user experience. This approach is similar to what is done in the HCM for urban streets. Reconciling LOS concepts between freeways and urban streets will make the HCM more usable for the emerging field of performance management. Also, by allowing for multiple levels of flow breakdown (i.e., severity of congestion), the proposed method is sensitive to transportation improvements and demand reduction strategies that are not as expansive as physical capacity additions, especially transportation system management and operations (TSM&O) strategies.

Keywords: Highway capacity, level of service, congestion performance measurement, travel time reliability

1 Introduction

The HCM currently uses density to define LOS for all freeway features. For freeway facilities, the HCM defines LOS thusly:[1]

 Selection and peer-review under responsibility of the Scientific Programme Committee of ISEHP 2016

doi:10.1016/j.trpro.2016.06.037

> Because LOS for basic, weaving, merge, and diverge segments on a freeway is defined in terms of density, LOS for a freeway facility is also defined on the basis of density. A facility analysis will result in a density determination and LOS for each component segment. The facility LOS will be based on the weighted average density for all segments within the defined facility.

The definition also allows for oversaturation as defined by a value of 1.0 or higher for the demand volume-to-capacity ratio (v_d/c) on **any** component segment on the facility.

The major shortcoming of this approach is that density is a poor indicator of travelers' experiences under congested conditions; speeds or travel times are more relevant to travelers and are consistent with how agencies measure and report congestion using field data. Further, five of the six LOS ranges exist where speeds are relatively high (above approximately 50 mph) and only one LOS range is used to define the congested regime, which is of the highest interest in large urbanized areas. Especially with regard to operations improvements, many congestion management techniques will improve congestion (e.g., delay) but the facility will still be classified as LOS F under the current definition.

A second shortcoming is the reliance on the LOS for each segment to determine the facility LOS. Having this detail is important for identifying physical bottlenecks and other deficiencies, but the user experience in terms of travel time occurs over the entire facility. Therefore, the authors believe that a LOS scheme based on travel time should be for performance of the **facility as a whole**, not a summation of the LOS of segments that comprise the facility.

Finally, the measurement of congestion with empirical data has improved immensely over the past decade. Agencies and researchers involved in monitoring mobility performance use measures that are based on travel times, not density, at least in urban situations. It is critical that the HCM's view of performance mesh with that of the wider profession in order for it to provide relevant analyses. Even if a travel time-based service measure is not adopted, defining ranges for reporting purposes that cover both monitoring (measurement with empirical data) and forecasting would provide consistency. This consistency would allow direct comparisons across studies and enables a systematic assembly of evaluation studies. This new perspective is especially critical as the profession adopts a performance management philosophy, as advanced by the MAP-21 legislation.[2]

2 Requirements for a Freeway Facility Service Measure

If travel time is to be the basis for LOS on freeway facilities, what aspect of travel time performance should be used? The traditional HCM LOS methodology considers only a single demand and that no disruptions exist, a relatively ideal condition that travelers can expect to experience only a few times per year ("static" approach). The update to the HCM will include a more sophisticated accounting of the sources of congestion, based on the research conducted in Strategic Highway Research Program 2 (SHRP 2) Project L08.[3] This project was designed to incorporate reliability into the HCM. It considers all the potential sources of recurring and nonrecurring congestion, including variations in demand, incident, weather, and work zone conditions ("stochastic" approach). The result is a distribution of travel times which more realistically reflects how a facility will perform over the course of time (for example, a year). Measures that capture the nature of the travel time distribution are referred to as "reliability measures". The SHRP 2 L08 Project recommended several measures for this purpose (Table 1). The SHRP 2 L08 research led directly to the reliability method for freeway facilities that is being included in the next update of the HCM, including the specification of performance measures. It is likely that both freeway facility methods (static and stochastic) will remain in the HCM for the foreseeable future.