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Optimization of transit total bus stop time models

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ABSTRACT

Several factors influence bus transit reliability which includes bus stop conditions along the route, traffic conditions, route of travel and time of day. The overall transit bus reliability is generally affected by dwell time (DT), the fare payment method, the bus stop location, and the number of passengers alighting or boarding. A new variable is defined in this study, total bus stop time (TBST), which is the summation of DT and the time it takes a bus to effectively park at a bus stop and the re-entering the traffic stream. It is suggested that the overall bus transit reliability along routes could be improved if the TBST is minimized at bus stops.

In this study, TBST models for bus stops located at mid-blocks and near intersections were developed based on multivariate regression analysis using ordinary least squares method. Data collection was conducted at 60 bus stops, 30 of which were near intersections and 30 at mid-blocks, in Washington DC during morning, mid-day and evening peak hours. The variables observed at each bus stop are as follows: number of passengers alighting or boarding, DT, TBST, bus stop type, bus pad, length number of lanes on approach to the bus stop, and permitted parking. Statistical inferences were based on 5% level of significance. From the results, it was inferred that the new variable, TBST, could potentially be used to improve scheduling and transit bus systems planning in a dense urban area.

1. Introduction

Several factors along the route of travel affect the overall reliability of a transit bus system. These include, but are not limited to, dwell time at bus stops, weather conditions, traffic congestion, scheduled arrivals, and the number of passengers boarding and alighting. The time it takes a transit vehicle to stop for the purpose of serving passengers is defined as the dwell time (DT). It includes the total passenger service time between the opening and closing of the doors (TRB, 2010). A major portion of a route's variability and operating time is represented by DT at bus stops, which is also linked to the reliability of the service being provided. For the purpose of planning and managing bus schedules, there is a need to estimate the total time that buses spend at bus stops, not

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just the DT, which is time used during boarding and alighting of passengers. The additional time used to safely maneuver buses into a bus stop and time involved in re-entering the traffic stream are important elements in urban bus transit's schedule development. The extra time plus the DT is being referred to as the total bus stop time (TBST), which is potentially influenced by traffic conditions at or near the bus stops and by bus-specific activities and systems.

TBST is one of the variables needed to be measured by transit bus authorities, such as the Washington Metropolitan Area Transit Authority (WMATA), since it affects overall transit reliability. In addition to several initiatives aiming at providing timely information regarding travel time and bus arrivals, WMATA has real-time online information regarding the arrival time of buses on various routes. With the increasing availability of software applications for bus location, patrons could use standard computers, their smart phones, and a variation of portable devices to obtain real-time information on the arrival status of buses at bus stops. WMATA has recently incorporated automatic passenger counting (APC) and automatic vehicle location (AVL) systems to improve the bus information system. A bus transit's reliability is often gauged by determining whether the transit system is consistent with its publicized schedules. Since TBST is a factor inherently used in reliability assessments, it is essential to forecast its value along bus transit routes. This study is aimed at developing TBST and DT models based on peak periods, which could be used to improve the overall reliability of bus transit. The research objectives are presented as follows:

(1) Determine variables that could potentially influence TBST.
(2) Develop TBST regression models for bus stops near intersections and at mid-blocks.
(3) Perform the optimization of the TBST models to obtain thresholds for the improvement of bus transit schedule planning and efficiency.

2. Literature review

Due to thriving employment opportunities, population density is increasing in already crowded urban areas. It is recognized that the use of urban transit systems is an efficient mode of travel that generally helps in reducing air pollution and the dependency on petroleum based fuels for transportation. The effectiveness of bus transit service relies heavily on the quality of its route structure, schedules and management. Travel time and a full understanding of how time is utilized and lost during service are a constant concern of bus transit operators, since urban streets pose a number of challenges for bus drivers to maintain schedules. Street traffic, weather, crashes, traffic control, and various curb lane activities are among the conditions that randomly affect the docking and undocking of buses at curb-side bus stops as they enter to discharge and pick up passengers. The docking activities of buses in a large urban transit system are affected by location of bus stops, the mix of street traffic, turns at intersections, traffic control, design of bus stops, and curb-side parking activities, among others. Data on the magnitude of the dwell, access and departure intervals of transit buses are important in schedule design and operation management.

The literature review of this study focused on researches that were aimed at developing a better understanding of the total time involved, as buses arrive, dwell, and leave curb-side bus stops. Studies and literatures on models related to bus dwell time are generally limited, due to the manual data collection time and cost requirements. Consequently, some studies on dwell time were based on small sample sizes and generally route-specific, with the focus on examining the reasons of bus delays (Dueker et al., 2004; Milkovits, 2008). Some dwell time studies were based on ordinary least squares (OLS) method that established relationships between dwell time, passenger alighting and boarding, based on selected operating conditions that were likely to affect dwell time (Dueker et al., 2004). Besides, dwell time models for heavy rail, bus transit and light rail systems were developed by Milkovits (2008).

Kraft and Bergen (1974) determined that traveler administration time prerequisites for morning and evening peaks were comparative, and mid-day requirements were more prominent than those in peak periods. Their examination established that loading up times surpassed alighting times, and that back entryway and front entryway alighting times were similar. From the consequences of their study, it was resolved that the DT was equivalent to 2 s in addition to 4.5 s for every loading up traveler for money and change admission structures, and 1.5 s in addition to 1.9 s for exact fare.

In another study directed by Kraft (1975), 7 noteworthy factors that influence DT were recognized: operating policies and practices, human, modal, climate, mobility, and other system variables. The study implied that particular bus stop qualities could impact the time the bus spends at the bus stop, which includes, right-lane volumes, vehicle classifications, control path utilization, right-lane design, traffic gaps, length of space for bus to maneuver in and out of bus stop, etc. In a study conducted in 1983 on transit travel time performance, the dwell time was determined to be equal to 2.75 s per alighting or boarding passenger plus an additional 5 s (Levinson, 1983). Similarly, another study determined that there was a 10–20 s penalty for each stop plus a 3–5 s penalty for each passenger boarding or alighting (Guenthner and Sinha, 1983). However, both studies based their inferences on small sample sizes (< 30) with low explanatory power, despite the fact that the research controlled variables such as number of doors, fare structure, and lift activity.

A field research on the behavior of buses was conducted by Chen et al. (2013) at bay-side and curb-side bus stops in Beijing, China due to their concerns about the extent of bus delays at bus stops which had an effect on service. The authors hypothesized that as a bus entered a bus stop to service passengers, there was an arrival phase that would include a cautious maneuvering of the bus toward the assigned bus stop position while avoiding pedestrians, stopped vehicles and physical features at the bus stop. This arrival pattern was conceived to be unlike the arrival of