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A multi-modal transportation score to evaluate infrastructure supply-demand for commuters

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Abstract

This research presents a novel multi-modal transportation score for commuters bicycling or walking to transit stops. The score requires basic data necessary for its calculation, namely - travel time information, population, employment and the transportation network for the considered modes within the multi-modal context. The proposed score is validated with observations from data obtained for El Paso, Texas. A sensitivity analysis was carried out on transportation supply and demand assessment of multi-modal transportation system for El Paso and its surrounding rural cities of Socorro, San Elizario, Horizon City, Vinton and Anthony. Results showed that the supply (multi-modal transportation facility) for commuters do not meet the needs of the latent demand (population or employment) for most areas in El Paso and for all the five rural cities studied. The disparity between supply-demand is mainly attributed to the poor last mile transport connectivity available to bicyclists and pedestrians around transit stops.

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1. Introduction and Background

Multi-modal transportation involves interconnectivity of several modes, consisting primarily of walking, cycling,

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and transit. The fundamental goals of a multi-modal transportation system are to achieve support for multiple modes and users, reduce vehicle ownership and usage, and promote mixed-use development. Planning for multi-modal transportation requires consideration for transport demand, mobility, transportation options, user information, integration, affordability, mobility substitutes, land use factors, transport network connectivity, roadway design and management, prioritization and inaccessibility [1]. All of these factors are basic ingredients for accessibility provisions made in transportation planning. In order to make a multi-modal transportation system popular, reasonable access to transit stops should be provided. This is often achieved by making provisions for first and last mile through walking or biking to stops [2]. Studies have also shown that the availability, accessibility and convenience of public transport are critical for sustaining multi-modal commuter trips in a city [3].

Most cities and metropolitan planning organizations (MPOs) across the United States are making investments in developing multi-modal transportation facilities by providing last mile connectivity to transit stations through improvements of bike and sidewalk network. The basic starting point for these improvements lie in conducting a preliminary survey and gathering information regarding “existing physical conditions of the transportation system and concerns of the residents” [4] – this, however, is often quite an expensive process due to the extensive data collection efforts. There is only limited help available from existing literatures and guides in conducting a low cost data collection of physical conditions of infrastructure related to bike and sidewalk networks. Thus, given the present situation cities and MPOs are crippled with available procedures of identifying critical areas of a region needing improvements for the last mile connectivity.

There are currently three most popular scores for measuring performance of infrastructure of a given location. The Walk Score (measures its walkability), the Bike Score (measures the suitability of the location for bicycling) and the Transit Score (measures access to public transit) [5]. However, these scores are disaggregated measure for only specific mode of transportation and hence, have limited utility in multi-modal transportation evaluations. ActiveTrans Priority Tool (APT) addresses this shortcoming partially with a systematic methodology for prioritizing pedestrian and bicycle improvements along existing roads [6]. However, APT is designed to address walking and bicycling separately with no proper guidance for integrating the two modes together with public transit. Similarly, the Bicycle Compatibility Index (BCI) [7] and Bicycle Environmental Quality Index (BEQI) [8] are two common methods, which evaluate the capability of a variety of roadways to accommodate bicyclists. However, other important multi-modal modes needs for walking and public transit access are left out in the assessments using the two indices. Moreover, while BEQI requires quantitative observational survey of more than a dozen factors to decide on infrastructure improvements needed for bicycling, BCI needs geometric and operational characteristics such as lane widths, speed, and existing volume data for any evaluation.

The authors in this research aim to fulfill this need of cities and MPOs by proposing a new but effective scoring methodology for evaluation of multi-modal transportation system by treating transit stops as nodal points of transfers for bicyclists and pedestrians. The score uses commonly available data from cities and MPOs for population, employment and network information for bike and sidewalks of a given area for its computation.

2. Framework

The multi-modal score developed in this paper captures the entire trip experience involving multiple modes. This is important since independent evaluations of modes neglect operational elements of travel such as waiting times, transfer inconveniences, total travel impedance etc. For commuter trips using modes such as bicycling, walking and public transit, a trip-based score should consider the following events in sequence: walking/biking from trip origin to a transit stop → waiting at the stop → riding the transit → (transfer with walking/biking, if any) → walking/riding to the final trip destination.

In developing the multi-modal score, accessibility is being considered as the driving force for assessing performance measure of a multi-modal transportation system [2]. The transit stops serve as the focal point of waiting, boarding and transfer activities by multi-modal users. Thus, the score, which is the ratio of the actual multi-modal component to the ideal multi-modal component and varies from 0 to 100, is presented in Eqs. (1) - (3). Note that higher the spatial resolution of data availability, better the scores are. In Eqs. (1) and (2), it is assumed that the lowest resolution at which data are available is for the traffic analysis zone (TAZ). A score of ‘0’ means poor multi-modal transport facility and a score of ‘100’ means high or perfect multi-modal facility around the concerned transit stop. In the formulation presented below, the inconvenience caused due to transfers and waiting times can be adjusted within the impedance values used. Alternatively, adjustments in the weights for walking or bicycling can be made to reflect