Travel time reliability and road network accessibility: two sides of one coin

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Accessibility is a key dimension of network performance, which reflects the ability of the population to reach valued opportunities using the transportation system. Gravity-based measures of accessibility, which are commonly used in transport planning studies, use travel times as inputs to compute travel deterrence. Travel times will vary within and between days as a result of the normal rhythms of urban life. These variations can be reflected in a fairly coarse way in accessibility studies using representative values of travel time for, say, the morning peak, inter-peak and evening peak periods. However, this approach does not fully reflect the extent of travel time variation and the consequent variation in accessibility experienced by the population. In addition to expected day-to-day variations in travel time caused by small perturbations in demand and/or capacity, travel times will also be increased by less expected disruptive incidents such as road traffic accidents and road closures, which reduce the capacity of the network. Any such increases in travel times will reduce accessibility below expected levels; and the distribution of these accessibility losses over time will reflect the reliability of the network.

Clearly, accessibility and network reliability are closely connected concepts. The probability of reaching a destination within a given travel time will directly affect the level of accessibility experienced by the population. Empirical analysis of the impact of network reliability on accessibility requires travel time data with a high temporal resolution, which has recently become more available due to data derived from tracking smart phones and GPS-equipped vehicles. The statistical analysis of travel time data for periods across the day is now possible and measures based on more robust statistics than the travel time mean can be used to describe the expected. Therefore, we propose a new travel time reliability metric that is based on percentiles, which is easy to understand and interpret (by travellers and traffic managers) and can be used for comparing the travel time reliability of different routes or links. Furthermore, we demonstrate the way to fully implement the travel time reliability metric into an accessibility indicator to make it capable to reflect the network reliability.

This paper explores the temporal and socio-spatial variation in accessibility and presents a new method to integrate travel time reliability into accessibility analysis. A case study of accessibility to the Queen Elizabeth University Hospital (QEUH) in Glasgow is presented to demonstrate the applicability and the utility value of the method. The case study uses real-time travel time data collected from November 2016 until April 2017 every 15 minutes using Google Maps Distance Matrix API, which is a web-based interface that provides shortest path travel times between specified locations, while taking into account the traffic conditions. The catchment area of the QEUH was divided into 89 zones that coincide with postcode sectors and their typical centroids were defined. Then, we related the travel time of the zones to socio-spatial data from census 2011 and data from the National Health System concerning patients' admissions in the Accident and Emergency (A&E) unit. The results show that the proposed accessibility measure, accounting for travel time reliability, bridges the gap between the static interpretation of accessibility and that experienced by travellers within the day. Findings also reveal a high correlation between A&E admissions and travel time (and travel time reliability). The linear regression modelling indicates a good fit between travel time variation and demand.

Keywords: Network performance; accessibility; transport planning; travel times

Accepted manuscript of the following research output: Bimpou, K., & Ferguson, N. (2018). *Travel time reliability and road network accessibility: two sides of one coin*. Abstract from NECTAR Cluster 6 workshop, Lyon, France.