

## Accessibility of Multimodal Transport Systems: Development of Indicators for Accessibility Analyses from a Holistic Approach

In recent years, the performance of cities and networks to ease the reach to valued locations has been evaluated through accessibility measures. These measures consider impeding trip factors such as time, physical effort, or monetary cost. In common practice, travel time is used in accessibility measurements as it is experienced relatively equally by different demographics. However, the perception of time varies due to individual's preferences and experiences. For example, the waiting time at a traffic light can be perceived as shorter or longer for everybody.

Some studies that explore the differences between self-reported and calculated accessibility measurements have found mismatches caused by the individual's perception of accessibility and the omission of meaningful indicators (Carrion & Levinson, 2019; Lättman et al., 2018; Pot et al., 2023). Pot et al. (2021) hypothesise that the source of these mismatches may arise due to inaccuracies in awareness, excluding components of accessibility (i.e. times of the day or transport modes), and deficient evaluations of accessibility components regarding individual preferences and capabilities. Therefore, including individuals' perceptions and contemplating a more extensive range of accessibility components may reduce the gap between perceived and calculated accessibility measures and produce a more accurate representation of reality.

To contemplate a more extensive range of accessibility components, the concept of the full cost of accessibility has been introduced in accessibility studies (Cui & Levinson, 2019; Willberg et al., 2023). From a social welfare perspective, travel times and monetary costs are only part of the total cost of making a trip. Cui and Levinson (2018) present a conceptual model, Full Cost Accessibility (FCA), to account for both internal and external travel costs in accessibility analyses. This model considers four major cost components: time, safety (crashes), emissions, and money; each containing internal and external factors. Thus, the FCA model pretends to provide a more accurate calculation of accessibility.

To test the performance of the FCA model, Cui and Levinson (2019) compared the results of the FCA against a time-based accessibility measure for a single transport mode (in this case, a car). From the results, the two measurements showed low correlation values and significant variation in accessibility within the same threshold. In the study, the time-based measure exceeded the FCA when calculating accessibility which, in this case, is considered an overestimation of the actual level of accessibility. This overestimation arises from excluding impeding factors such as emissions ( $CO^2$ ) or the monetary cost of travelling by car (i.e. gas price, ownership, parking fees, etc.). Therefore, the implementation of a full-cost accessibility approach to measure the performance of a multimodal transport network may present an advantage over traditional accessibility analyses.

Accessibility measurements also provide insights into how transport systems contribute to an equitable society (in this case, access to opportunities). Two of the most dominant perspectives on the transportation equity debate are egalitarianism and sufficientarianism. From an egalitarian perspective, accessibility can be defined as a primary social good, where opportunities should be equally distributed to equalise the relative level of accessibility between different social groups (van Wee & Geurs, 2011). This means that egalitarian theories focus on differences between people. In contrast, a sufficientarian perspective assumes that everybody should be satisfied up to a certain minimum threshold to fulfil their basic needs (Lucas, 2012).

Despite the perspective, indicators and metrics are needed to assess the equity of a certain transport network. For this, identifying the dimensions of transport that relate to equity is necessary. For example, Martens et al. (2019) identify mobility and accessibility, traffic-related pollution, traffic safety,

and health as the main dimensions to focus in a transport-related equity assessment allowing to reveal disparities within the society. Therefore, revealing current disparities across these dimensions would enable the development of future interventions that address such disparities.

This research aims to *provide theoretical and empirical insights into accessibility analyses about conventional and emerging transportation modes*. To fill the research gaps in accessibility measurements and to reflect on the impact of multimodal transport networks on equity, four sub-objectives are considered:

1. To explore the dissonances and correlations between calculated and perceived accessibility measures of transportation modes across different socio-demographic groups and geographical areas.
2. To develop an integrated accessibility measure, that bridges the disparities between calculated and perceived accessibility, facilitating discussions on the contributions of multiple transportation modes towards overall accessibility.
3. To reflect on the results from the developed accessibility measure regarding transportation equity based on transportation justice theories.
4. To use the developed accessibility measure for scenario analyses aiming to evaluate the impact on accessibility and equity resulting from targeted interventions (i.e. the adoption of different mobility services or activity hubs).

## References

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