Open data for accessibility and travel time analyses: Helsinki Region Travel Time and CO_2 Matrix

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Abstract

Comparable data on travel times and distances by different travel modes are frequently called for in land use and urban planning. Here, we present the creation process of a newly published dataset called the Helsinki Region Travel Time Matrix 2015. The Matrix is a dataset that contains travel time and distance information of the routes that have been calculated from all 250 m x 250 m grid cell centroids (n = 13231) in the Capital Region of Helsinki by walking, public transportation (PT) and private car. The grid cells are compatible with the statistical grid cells of the country. The routings behind this data is based primarily on open data sources and our own research. Walking is calculated based on Open Street map, PT schedules are derived from Journey Planner and private car routings from the national road database Digiroad. All routings follow the door-to-door principle, meaning that PT and private car trips include the walking, and on private car trips an estimate of parking time/distance is taken into account. A separate CO_2 Matrix contains the CO_2 burden for each trip between all the grid centroids of the region. The matric creates a snapshot of the accessibility conditions within the city, allowing comparisons of the changes in travel times and accessibility in the region. The data is available freely and openly and has been used e.g. for land use planning.

Keywords: Travel time, routing, open data, public transportation, private car, walking

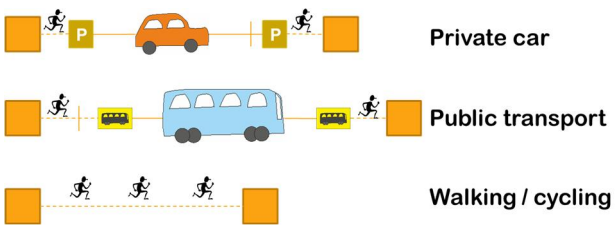
1 Background

Understanding spatial patterns of accessibility is a key to understand the functionality of urban regions. Accessibility is a useful concept both for urban geographical analyses as well as practical urban planning, as it brings together the characteristics of transportation network and land use [1, 2]. Travel times between origins and destinations form the backbone of most geographically orientated accessibility analyses.

When modelling travel times in an urban environment for accessibility analyses, it is important to take into account the diversity of transport modes. Furthermore, attention is needed to make the travel times for different modes of transportation comparable. Easy to use, comparable spatial data on travel times and distances by different travel modes are frequently called for in land use and urban planning [3]. Furthermore, environmentally orientated urban planning would benefit also from information on the CO_2 emissions of urban mobility.

Here, we describe the creation of a large open data set for urban accessibility analyses. To create the data product called Helsinki Region Travel Time and CO_2 Matrix 2015, we developed methods to estimate the door-to-door travel times [4], distances and CO_2 emissions for public transportation, walking and private car. The models were developed to reflect the realities of the Helsinki region, but the tools could be fitted also to other regions. We then applied these tools to calculate travel times, distances and CO2 emissions between all 13000 statistical grid squares (250 m by 250 m) in the Helsinki region. The dataset is downloadable from http://www.helsinki.fi/science/accessibility/data and usable for everyone under CC-BY 4.0 license.

Figure 1: Door to door approach means that all parts of the travel chain (like finding a parking spot or waiting for a bus) are included in the total travel time. This makes the travel modes comparable in terms of the real time required to travel with this mode.



2 Data and methods

We estimated the door-to-door travel times, distances and CO_2 for different modes of transportation between the national standard 250 meter statistical grid squares provided by the Statistics Finland. The travel times were calculated separately for each mode of transportation for a normal week day, Monday 28th September 2015. Calculations were done separately for two different times of the day using rush hour (08:00-09:00) and midday (12:00-13:00) schedules/traffic conditions. The methods are described below and the actual processing codes and the tools are available at GitHub (https://github.com/AccessibilityRG/) and more documentation is found from our project pages (www.helsinki.fi/science/accessibility).

2.1 Public transportation (PT)

The routes by public transportation are based on the Journey Planner schedule data provided by the Helsinki Region Traffic. The routes and door-to-door travel chains have been calculated using the MetropAccess-Reititin tool [5]. The tool takes into account the whole travel chains ("door-to-door approach") from the origin to the destination:

- possible waiting at home before leaving
- walking from home to the transit stop
- waiting at the transit stop
- travel time to next transit stop
- transport mode change
- travel time to next transit stop
- walking to the destination

Travel times by public transportation have been optimized using 10 different departure times within the calculation hour using so called Golomb ruler that can be used to gain maximal representation of departure times within one hour. The fastest route from these calculations is selected for the final travel time matrix.

2.2 Walking

The routes by walking were also calculated using the MetropAccess-Reititin by disabling all motorized transport modes in the calculation. Thus, all routes are based on the Open Street Map geometry. The walking speed has been adjusted to 70 meters per minute, which is the default speed in the HRT Journey Planner (also in the calculations by public transportation).

2.3 Private car

The private car travel time estimates are based on floating car data analysis from the Helsinki region [6]. The routes by car have been calculated in ArcGIS 10.2 software by using MetropAccess-Digiroad tool which transforms the national road database Digiroad to a network data set that can be used in more realistic routing for urban regions, Helsinki in particular. The more realistic routing times are achieved by slowing the speed limit based drive-through times for the segments by adding an extra cost for passing a crossing. Crossings of different road types have different impedances, that have been defined with a floating car data from the region (for more, see [6]). Additionally, there is a time cost for searching for a parking space, which varies for different parts of the region. This cost has been defined based on earlier studies.

The tool for building the network data set is composed of several sub-processes. First, the tool is used for modifying the Digiroad data and adding the crossing impediments to create a network data set. Once this is done, the tool can be used to calculate travel times and distances between a set of points, or calculating service areas for selected points.

For the travel time matrix, the calculations were repeated for two times of the day using 1) the "midday impedance" (i.e. travel times outside rush hour) and 2) the "rush hour impedance" as impedance in the calculations.

The door-to-door approach for car routes includes:

- walking time from the real origin to the nearest network location (based on Euclidean distance)
- average walking time from the origin to the parking lot
- travel time from parking lot to destination
- average time for searching a parking lot
- walking time from parking lot to nearest network location of the destination
- walking time from network location to the real destination (based on Euclidean distance)

The midday values are comparable to the previous version of the matrix from year 2013 [7].

2.4 CO_2 calculations for PT

The CO_2 emissions are calculated based on the distance that is travelled on an individual route between origins and destinations. The emission values (CO_2 in grams per passenger kilometre, g/pkm) are based on the LIPASTO calculation system of the Technical Research Centre of Finland (VTT). Helsinki Region Transport (HRT) uses the same estimate values in their Journey Planner service.

Public transportation emissions are based on bus, tram, metro, ferry and train. CO_2 emissions for each trip leg and for each transport mode are calculated separately and then summed together. As Helsinki Region Public Transport is mainly CO_2 free, the only transport modes that actually causes CO_2 emissions are bus (73 g/pkm) and ferry (389 g/pkm). The number of passengers on buses is estimated to be on average 13 passengers per bus.

2.5 CO_2 and fuel consumption calculations for private car

Travel distances by private car take into account the actual driving distance between origin and destination location and the distance that it approximately takes to find a parking place at the destination. Carbon emission factor for private car is 171 g/pkm. Again, the estimate is based on the LIPASTO calculation system of the Technical Research Centre of Finland (VTT).

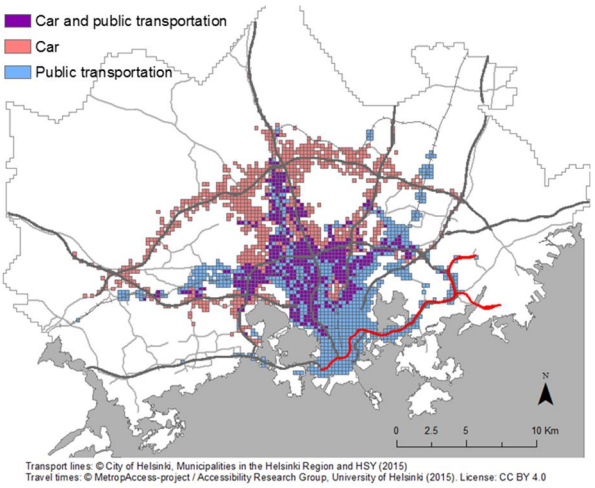
Fuel consumption calculations (for private car) are also based on driving distance between origin and destination locations plus additional distance that it takes to find a parking place (i.e. a single route). Average fuel consumption of a car is depending on various factors such as age and size of the car, fuel that is used (petrol vs diesel), weather conditions (summer vs winter) and traffic conditions (city center vs rural highway). Thus, it is rather impossible to calculate "accurate" and static fuel consumption for an average car, let alone for all cars in Helsinki Region. Hence, the average fuel consumption used in the matrix is a compromise and a heavily simplified measure of 7.3 liters per 100 kilometers that is the average fuel consumption of all different sizes of cars (small, midsize, large), and all different ages of cars (0-5 years, 6-10 years, 10+ years), and all cars using either petrol or diesel as fuel.

3 Accessibility patterns of Helsinki region

The dataset presented here allows various analyses of the accessibility patterns of the Helsinki region. Additionally, the methodological approaches and particularly the codes for the tools might be useful for researchers and practitioners working in other urban regions having access to similar data sources.

For the Helsinki region, the data set reveals for example the discrepancy between the hotspots of accessibility depending on the transportation mode (Figure 2). The areas that are most accessible in the regional scale for public transportation are found from the densely inhabited city center and its outer areas. For private car, the most accessible areas are located along the ring roads. For e.g. city planners and traffic planners this is an important finding when thinking about the equity of service access or focus areas for public transportation development.

Figure 2: Travel time hotspots (the most accessible 10 % of the statistical grid squares) in the Helsinki region by different transportation modes.



The matrix has been calculated with approximately the same settings twice, for the year 2013 and now for 2015. The new data set allows analysis of the temporal changes in the accessibility patterns of the region.

Between the two years, a new railroad connection has been opened to the airport of Helsinki-Vantaa and several bus routes have been changed. While the travel times to the central Helsinki have remained roughly the same, most dramatic changes have been happening around the airport in public transportation connections (Figure 3). In 2013, less than 70 000 inhabitants could reach the biggest airport in Finland from their homes in 30 minutes by public transportation. In 2015, the airport is reachable by 190 000 people in the same 30 minutes by public transportation, door-to-door (Figure 4).

Figure 3. The travel times to Helsinki airport by public transportation after the opening of the new rail road connection in 2015.

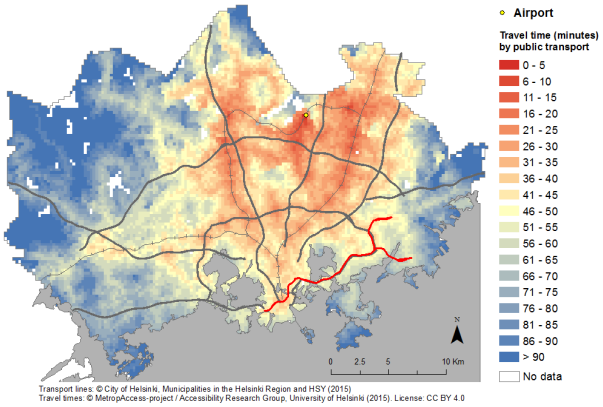
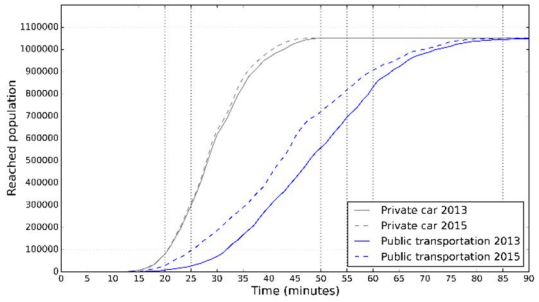


Figure 4. Accessibility of Helsinki-Vantaa airport by PT and private car according to 2013 and 2015 matrices. The cumulative curve demonstrates how many people (y-axis) can reach the airport in a certain time (x-axis).



The matrix allows also different analyses of accessibility for the region. The 2013 version has already been used for analysing the accessibility of recreational areas [8], libraries [9], sports facilities [10], grocery stores [11], or novel transportation options [12].

While this short paper describes the creation of one data set, it more broadly links to the movements for the openness of research data, open democracy and more transparent planning that highlight the responsibility of researchers to share their data [13]. We hope that our data would inspire researchers and practitioners to carry out multimodal accessibility analyses and also share their data for wider use.

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