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Measuring access to public transport in European cities

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Regional and Urban Policy

> Executive Summary

Within Europe there have been multiple attempts to collect data on the supply and access to public transport in cities. So far none of these attempts have produced comparable results because they were (1) not based on comparable geographies, (2) did not take into account the spatial distribution of the population and (3) did not take account of the frequency of public transport. As a result, the number of vehicles, trips or length of the routes could not be interpreted in a meaningful way.

This paper describes a new methodology that solves both of these two obstacles using a new EU-OECD city definition, high-resolution data on population distribution and 'big data' on public transport stops and trips. Because of these three new ingredients, it produces comparable indicators of the access to and supply of public transport in cities. These indicators allow for the first time a comparison of the offer of public transport that is easily accessible to the urban population. This allows cities to benchmark themselves against other cities of a similar size. This is particularly relevant given that Cohesion Policy allocated EUR 6 billion during the 2007-2013 period to clean urban transport; an amount which we expect to increase significantly during the 2014-2020 period.

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1   INTRODUCTION

Monitoring of passenger mobility patterns and trends in urban areas is an important element in assessing issues of sustainable development of cities and their surroundings. A recent European Environment Agency (EEA) report (EEA, 2013) provides a comprehensive overview of available indicators on urban passenger transport in Europe. Focusing on topics of modal split, commuting time and transport costs, these indicators are typically collected from surveys in a limited number of cities. These surveys are expensive to conduct and typically follow administrative borders, which hinder comparisons between cities.

This paper describes the results of a new methodology that creates comparable indicators on the level of services provided by public transport without the need for a survey. The impacts of increasing frequencies or adding new lines and stops can easily be measured. The methodology also allows for benchmarking between cities in Europe.

2   THREE BIG OBSTACLES OVERCOME

The new methodology solves three distinct problems: (1) the lack of a harmonised geographic definition, (2) the lack of information about the population distribution and (3) no information about the frequency of public transport.

Why are these three issues crucial to meaningful comparisons?

2.1   A harmonised definition of a city

The administrative boundary of a city can encompass the central business district or include a much wider area, including rural areas outside the commuter belt. For example, the city of Paris only captures two million inhabitants of the densely populated urban centre of seven million inhabitants. The city of Zaragoza encompasses an area of 974 km^2 even though its urban centre is only 41 km^2. Any indicator will differ substantially when measured only for the most central part of the city, as compared to the city plus vast tracts of rural areas. For example, the length of the routes will be really short in the city centre, but frequencies, modal share of urban transport and ridership will be extremely high. In a city like Zaragoza, the length of the routes will be much longer, but frequencies, modal share and ridership are likely to be much lower than in its centre.

Maps 1.1-3 show the urban centres of Brussels, Dublin and Malmö. In Brussels, the urban centre is only a little bit larger than the city boundary (Brussels Capital Region). In Dublin, the urban centre extends well beyond the city limits. In Malmö, the city limits are further removed from the urban centre. As a result, the data for Brussels will capture the offer of public transport in the urban centre relatively well. In Dublin, it will only capture the offer in the most central part of the urban centre, while in Malmö it will capture the situation in the urban centre and its wider surroundings.

To compare the offer of public transport, it makes more sense to compare the offer in the urban centre than in the city, as the latter may include the suburbs or only the most central part of the urban centre.

2.2   The distribution of population within a city

Two cities with a same population, area and number of transport stops can still have a radically different access to public transport. If development has been oriented towards public transport stops, by encouraging higher densities and more development close to public transport and limiting development further away from stops, it will have a high level of accessibility. If on the contrary, the population distribution is fairly uniformly distributed without concentrations around transport stops, access will be much lower. For example, Map 2.1 and 2.2 show population distribution in Dublin. Map 2.1 shows the actual situation with a significant clustering

Map 1.1-3: Urban centres and city boundaries

Brussels   Dublin   Malmö

City   Urban centre (high-density cluster)   LAU2 / LAU1 units
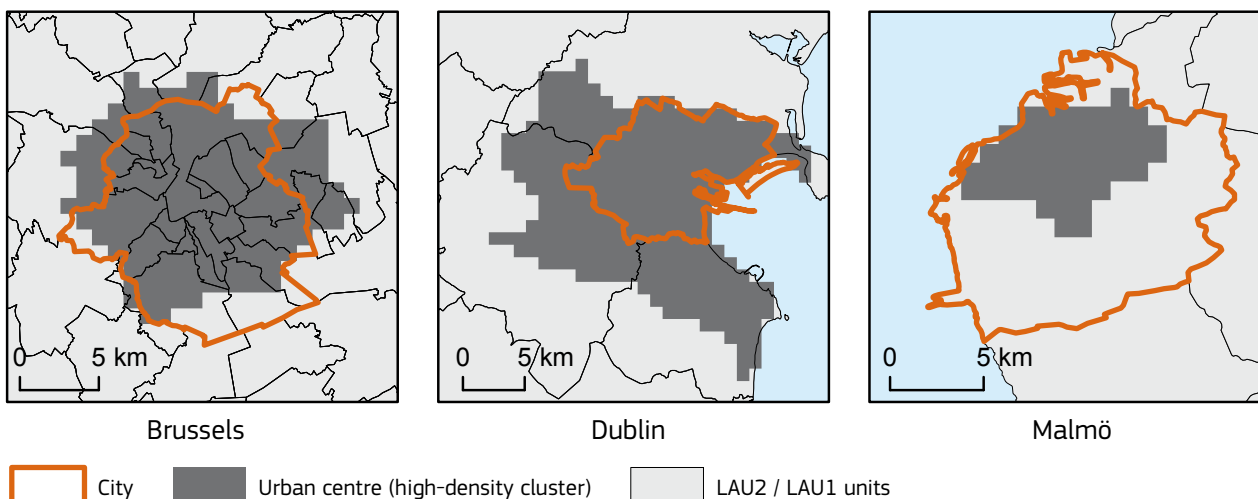
Map 2.1–2: Dublin actual and uniform population distribution
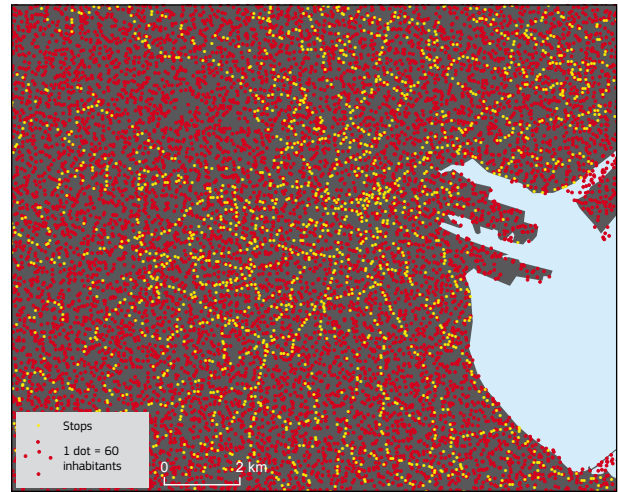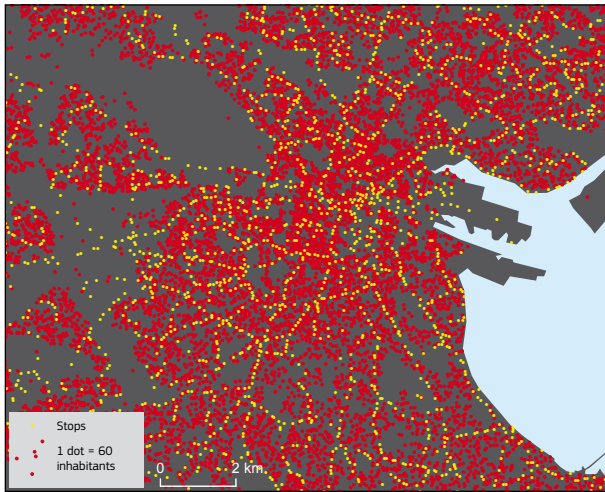
of population along some transport lines. Map 2.2 shows what the situation would look like if the population was uniformly distributed.

This map illustrates why comparisons of access to public transport should take into account population distribution. In a city with a concentrated population, only a few stops are needed to provide a high level of access, while in cities with a more dispersed population, far more stops will be needed to offer a merely adequate level of access.

2.3 Frequency of departures

Anyone who has waited a long time for a bus will understand that the frequency of departures makes a big difference. If departures are every five minutes, most people will not aim to catch a specific departure but just catch the next bus or metro.

Also when comparing cities, the frequencies of departures and how these are distributed across the lines and stops have to be taken into account. With the same number of departures, a city could provide most of its population with a medium frequency or could provide half with a high frequency and the remaining with a low frequency. Given that some stops have only one departure an hour while others have one or more departures a minute, merely measuring the proximity to a public transport stop would hide these differences.

The benefit of this methodology is that it is based on micro data, in other words the data is not pre-aggregated. This paper shows how the full range of frequencies can be analysed without any need for additional data.

3 HOW DID WE MEASURE THE ACCESS TO PUBLIC TRANSPORT?

First we calculated how many people could easily walk to a public transport stop. For bus and trams, we assumed that people would be willing to walk five minutes (417 metres) to a bus or a tram stop. For a train or a metro, we assumed people would be willing to walk 10 minutes (833 metres) as they generally offer a higher speed. The walking distance was calculated using a street network. This means that it takes into account the density of the street network and obstacles such as rivers, steep slopes, highways or railroads, which cannot easily be crossed on foot.

We took into account the number of departures on a normal weekday between 6:00 and 20:00. We calculated the average per hour to create frequency classes. We grouped stops that were less than 50 metres apart, which means that in most cases departures in both directions on the same route were taken into account. So for example, a bus stop with only one route with six departures an hour would have three departures in one direction and three in the other.

We created five groups based on access and departure frequency:

1. No access: people cannot easily walk to a public transport stop, in other words it takes more than 5 minutes to reach a bus or tram stop and more than 10 minutes to reach a metro or train station.

2. Low access: people can easily walk to a public transport stop with less than four departures an hour.

3. Medium access: people can easily walk to a public transport stop with between 4 and ten departures an hour.

4. High access: people can easily walk to a bus or tram stop with more than 10 departures an hour OR people can easily walk to a metro or train station with more than 10 departures an hour (but not both).

5. Very high access: people can easily walk to a bus or tram stop with more than 10 departures an hour AND a metro or train station with more than 10 departures an hour.

Very high access is only possible in cities with a metro and/or a train network and depends heavily on the extent of this network.

4 WHAT CITIES OFFER THE BEST ACCESS TO PUBLIC TRANSPORT?

Here we will focus on the results per urban centre, because as shown above this is the most comparable geographical definition [1]. In the attached tables, the indicators are included for all available urban centres, cities, greater cities, functional urban areas and NUTS3 regions.

Graphs 1 and 2 show the results for a selection of larger- and medium-sized urban centres. On average, access levels in larger cities are higher than in medium-sized cities, but there is substantial diversity within each group. The share of population with (very) high access in this selection of larger urban centres varies from 38% in Dublin to 84% in Brussels, while this level varies from 12% in Eindhoven to 77% in Malmö in the selected medium-sized urban centres. Very high access tends to be quite rare in medium-sized cities, because most of them do not have a metro system and the rail network consists usually of only one or two stations in the urban centre.

On the other extreme, the share of population without any easy access to public transport does not follow a particularly strong pattern throughout the selected cities. Within this selection of urban centres, the share of population without access is slightly lower in the large centres than in the medium-size centres. Centres with a large population share with (very) high access tend to have a low share with no access, but this depends on the share of population with low or medium access, which varies substantially from less than 10% in Marseille to over 40% in Dublin among the larger centres.
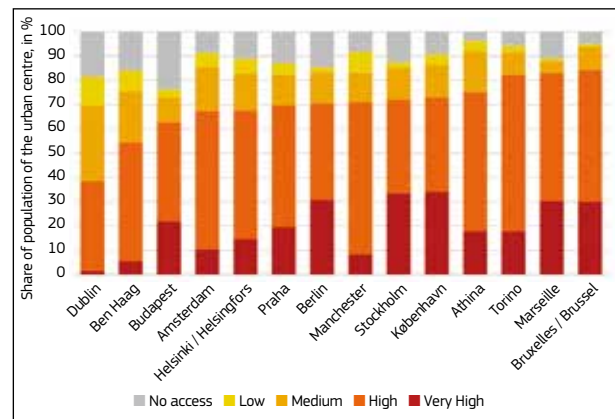
The share of population without access depends on three main components: (1) the number of stops, (2) the clustering of population close to stops and (3) the density of the street network. Increasing the number of public transport stops will

increase the share of population with access. However, adding more stops tends to have a decreasing impact. Existing public transport stops tend be concentrated in areas with high population density. New stops will be added in areas with increasingly lower densities and thus provide access to fewer and fewer people.

Clustering of population along transport stops is easier to achieve when a neighbourhood is being designed, as replacing existing houses with a taller development is often faced with local opposition. This is why new development should take into account the location of current and future public transport stops.

Low street density can limit the share of people that have access to a particular stop. Again getting this right from the start is easier than having to retrofit connections once a neighbourhood has been constructed. The overall impact of this, however, is limited. Once the network density is high, the access cannot be further improved by increasing density.

Graph 1: Typology of service frequencies in large urban centres / Access to public transport in large European cities

In the Dutch cities, the share of population with (very) high access tends to be lower than in cities of the same size in other countries. This is likely due to the high share of trips by bicycle in Dutch cities, which reduced demand for public transport, which in turn will reduce frequencies and the number of stops.
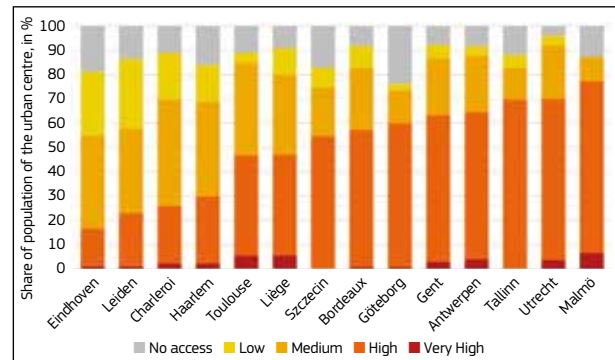
Graph 2: Typology of service frequencies in medium-sized urban centres / Access to public transport in mid-sized European cities

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1   Urban centres as defined in Dijkstra and Poelman (2012). The extent of the urban centres only depends on population density and population size measured at grid cell level, and does not suffer from distortions due to the variety in administrative definitions of cities.

Maps 3 and 4 present the same typology of frequencies for all cities in the Netherlands, Belgium, Estonia, Finland, Sweden and Denmark. The size of the pie charts reflects the population size of the urban centres. It shows that in each country the capital and the other large cities have the highest access to public transport.

The relationship between the distribution of the frequency of services and the residential population can be explored on graphs 3 and 4. The lines can be read as 'Y% of the total population of the urban centre has easy access to more than X departures an hour': a steep slope shows a relatively low and/or unequal availability of departures. The gap on the vertical axis between the starting point of the lines and 100% indicates the share of total population not having any easy access to public transport. The same starting point can be read as 'Y% of population has access to at least one departure an hour'. The graphs also help to compare the median number of hourly departures between cities: the number of departures to which 50% of the urban population has easy access. Amongst the selected larger cities, this population-weighted median number of departures an hour varies between 7.4 in Dublin and 28.3 in Brussels. In the example of the Netherlands, the pattern of the major cities is relatively similar, although the median frequency is still higher in the biggest city of the three (Amsterdam, with a median value of 17.2).

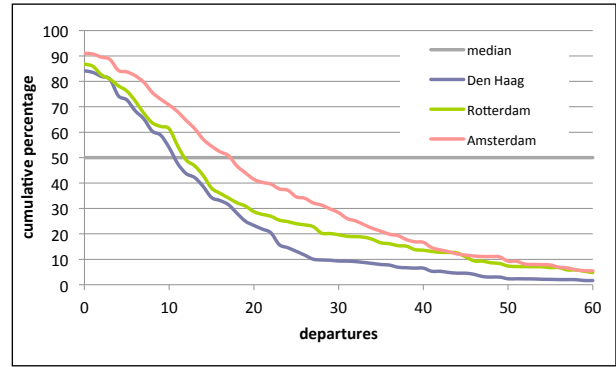Map 3: Access to public transport in urban centres in Denmark, Sweden, Finland and Estonia
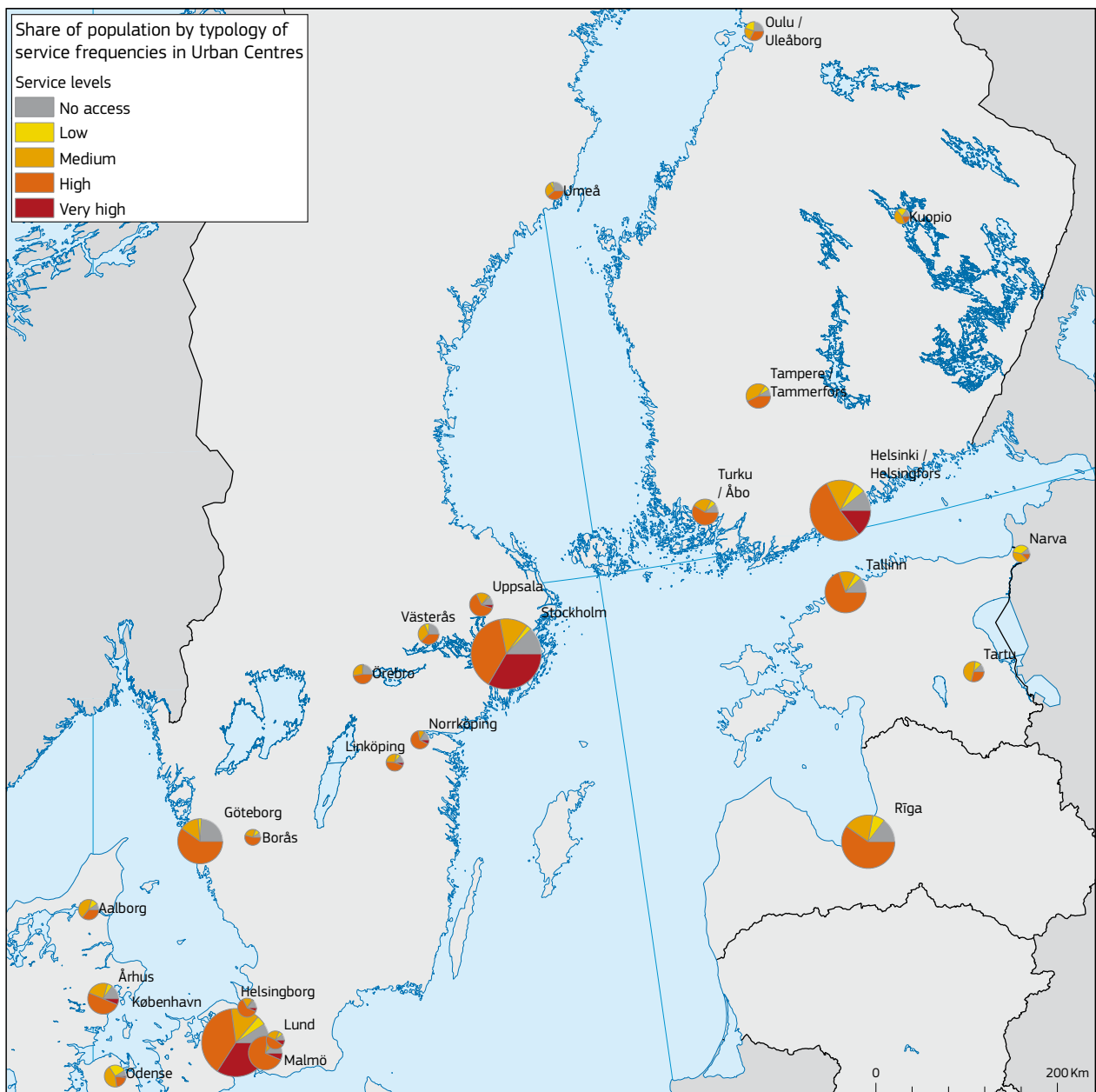
Graph 3: Frequency of departures and cumulative population distribution in major urban centres (Dublin, Helsinki, Brussels)
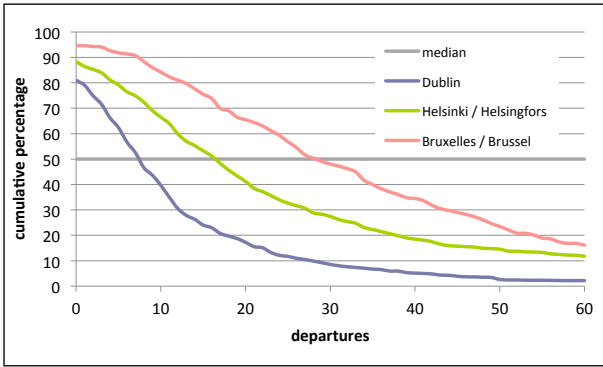
Graph 4: Frequency of departures and cumulative population distribution in major urban centres (Den Haag, Rotterdam, Amsterdam)

Map 4: Access to public transport in urban centres in Belgium and the Netherlands
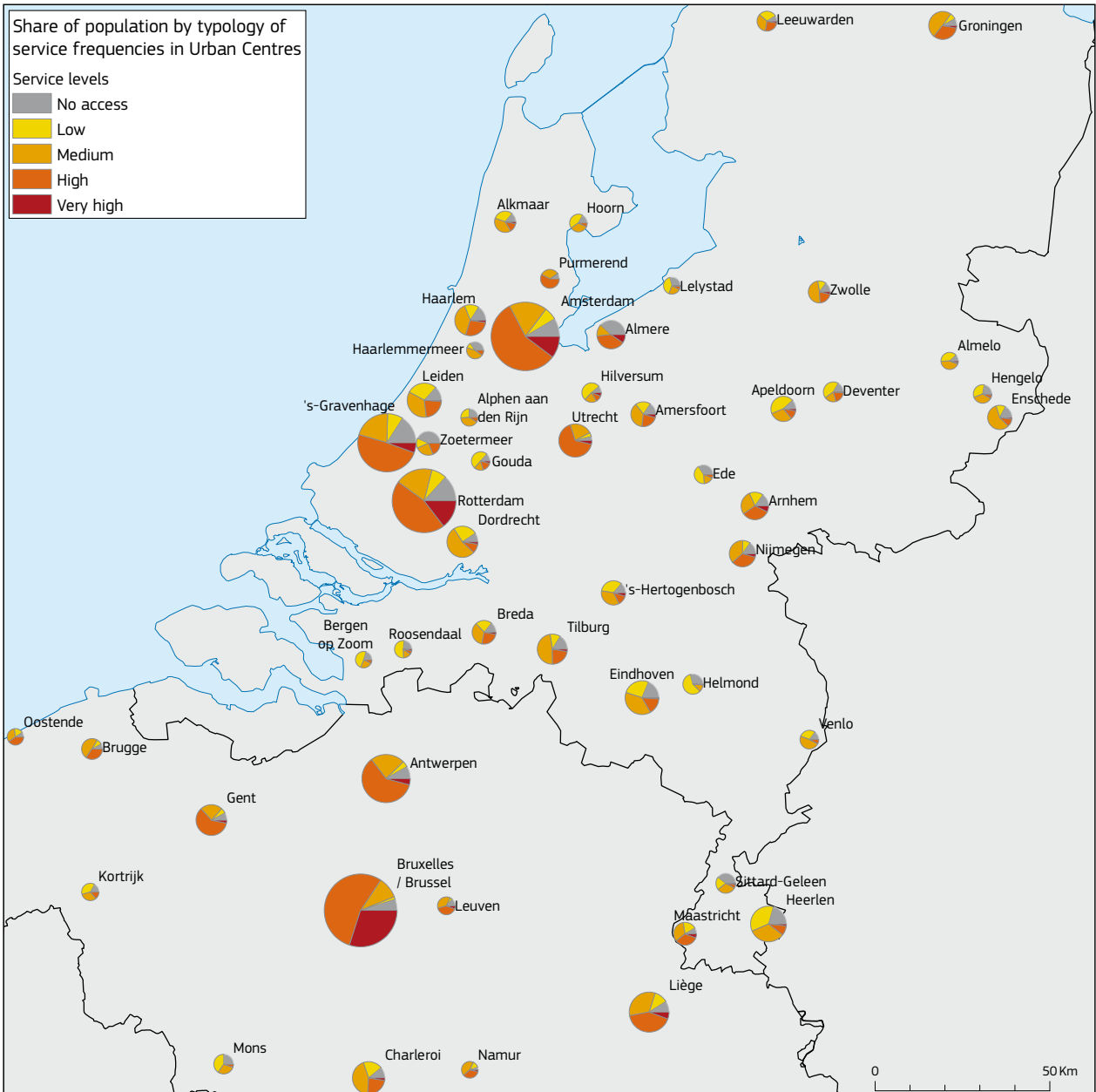
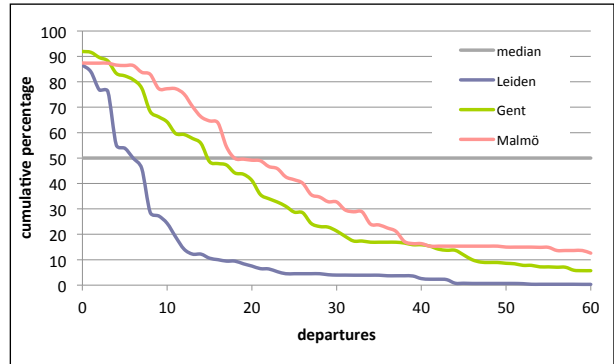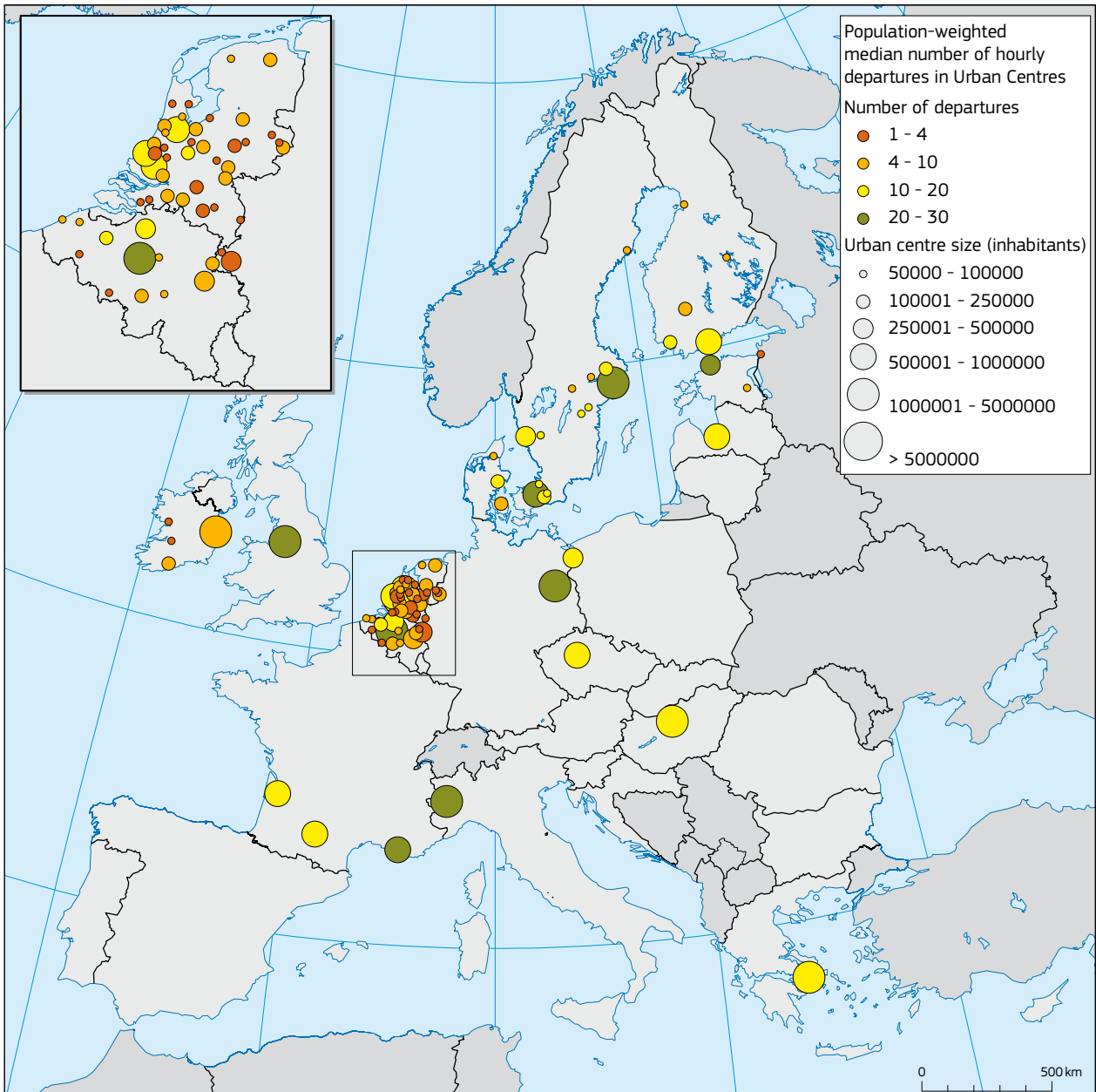Graph 5: Frequency of departures and cumulative population distribution in medium-sized urban centres (Göteborg, Bordeaux, Tallinn)
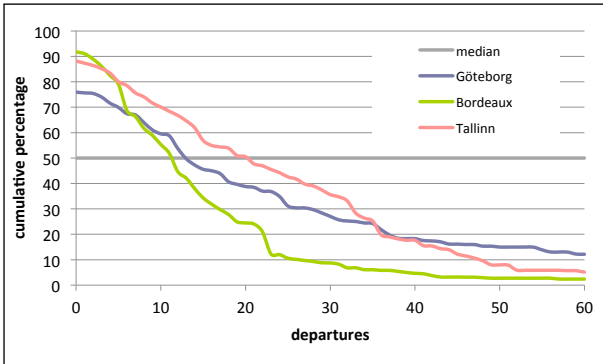
Graph 6: Frequency of departures and cumulative population distribution in medium-sized urban centres (Leiden, Gent, Malmo)

Map 5: Population-weighted median number of departures an hour in urban centres

Some examples of medium-sized cities again show substantial differences in distribution. Median values in cities with a population between approx. 350 000 and 500 000 vary from 11.3 in Bordeaux to 20.2 in Tallinn. In cities with a population around 250 000, we see values between 6.0 in Leiden and 18.0 in Malmö. The graphs also show that some medium-sized cities actually perform better than some of the bigger ones in terms of the distribution of frequencies.

Map 5 shows the relationship between urban centre size, expressed in population, and the median hourly frequency for all cities under review. When considering all urban centres of more than 100 000 inhabitants, population size clearly helps to predict the median hourly frequency (R^2 = 0.39). Amongst the capital cities in this group, Athens and Dublin are negative outliers, while Brussels, Copenhagen and Tallinn score substantially better than predicted.

So far, our analysis has focused on the availability of services to residential population. Ideally, the assessment should also consider the relationship between public transport services and daytime population. Unfortunately, spatially detailed data on the distribution of urban daytime population are still very scarce. Nevertheless, for a limited set of cities we were able to use data on workplace-based employment [2]. Here, we explored the relationship between the spatial distribution of the frequency of services and workplace-based employment. Graphs 7-9 compare the results for employment with those for population. In the three selected urban centres, easy access to public transport is substantially better for jobs than for residential population. Values of median hourly departures (weighted by the spatial distribution of jobs) vary between 17.4 in Dublin, 29.8 in Helsinki and 41.2 in Stockholm [3].

A three-dimensional representation of the spatial distribution of employment or population (Maps 6-11), combined with the typology of public transport frequencies confirms the finding that access to public transport tends to be better for jobs than for residential population. The 3-D maps are coloured according to the typology of frequencies, developed in section 3. Population and jobs are shown at a spatial resolution of 250 m x 250 m grid cells, where the height of the bars is proportional to population density or jobs density. Good public transport access is easier to implement for jobs than for residential population, because of the higher spatial concentration of jobs. The relatively low and dispersed population densities observed in many areas of Dublin, as compared to the pattern in Stockholm or Helsinki, also help to explain the relatively low values of access to transport, found in Dublin.

Graphs 7-9: Frequency of departures and cumulative distribution of residential population and workplace-based employment in urban centres

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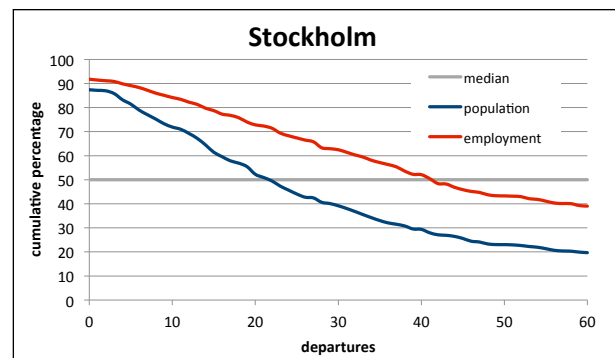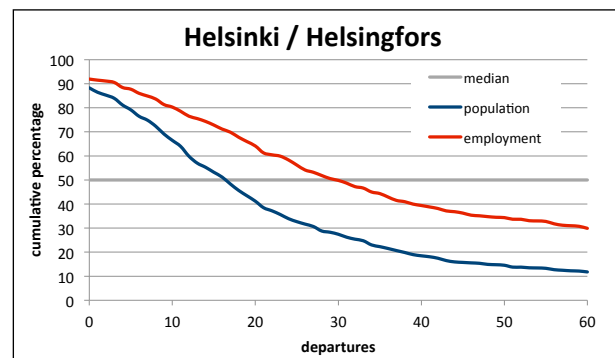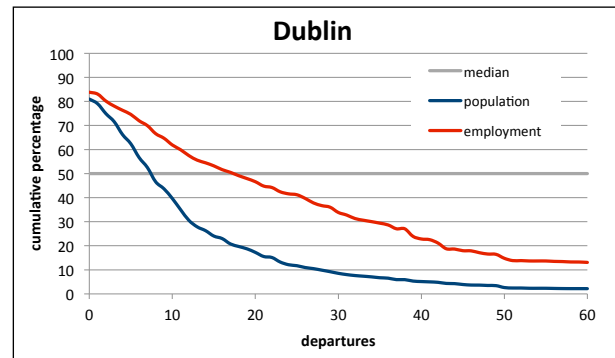
2 Data at grid cell level (250 x 250 m cell size): register-based employment for Finland (2006) and for urban areas in Sweden (2006); census-based employment for Ireland (2011).

3 The employment level in the urban centres of Dublin and Helsinki is quite similar (448 000 in Dublin, 482 000 in Helsinki). In Stockholm it amounts to 711 000 jobs.
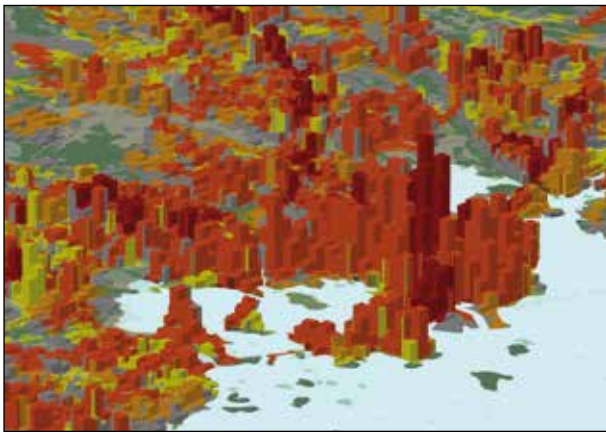
Maps 6–11: Population density, job density and typology of frequencies in Dublin, Helsinki and Stockholm
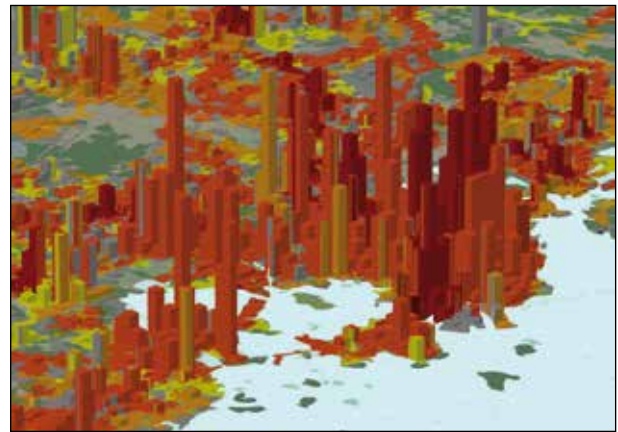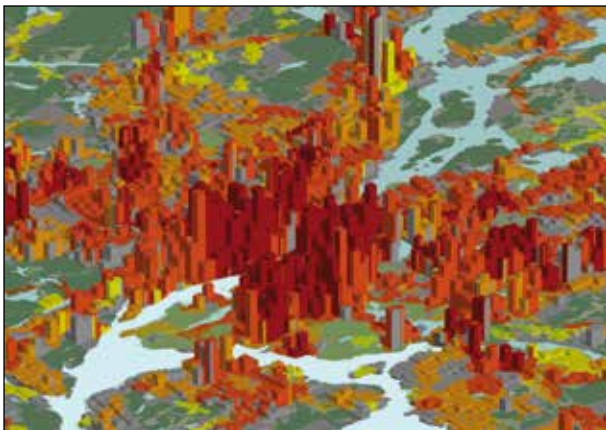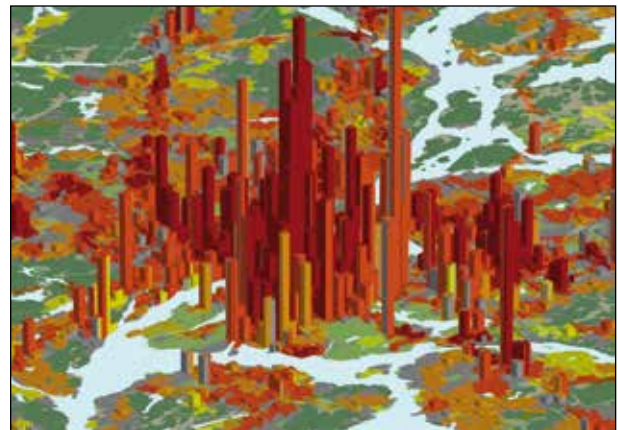

Dublin: population

Dublin: jobs

Helsinki: population

Helsinki: jobs

Stockholm: population

Stockholm: jobs

5 CONCLUSION

Cohesion Policy is a substantial source of investments in clean urban transport. Between 2007 and 2020 a significant share of EU funding has been, and will be, allocated to this priority. A better understanding of public transport in European cities can help target these investments in the cities and neighbourhoods where it adds the most value.

This new method of analysing access to public transport is an important step forward because it overcomes several obstacles which hindered meaningful comparisons in the past. It allows us to analyse cities in an identical manner taking into account the extent of the urban centre, the distribution of population and the exact location of public transport stops, and the frequency of departures. This type of analysis can also help cities to benchmark themselves with other cities of a similar size. The impacts of higher frequencies, extension of lines and new lines can also be easily simulated with this new approach.

Our analysis has highlighted the substantial variation between cities of the same size. For example, Brussels is currently considering a new metro line. This analysis shows that Brussels already has the highest share of population with a (very) high access to public transport. This suggests that it may be more efficient for Brussels to find ways of increasing the speed of the existing public transport offer, instead of spending large amounts on constructing a new metro line. This method can also be used to compare the impact of different strategies to improve public transport in a transparent and quantitative manner, which can support the decision making process.

The only major constraint facing this new method is data availability. High resolution data on population distribution is in most cases available. Open access to data on public transport in the right format however is still insufficient. For example, several public transport operators provide Google with the timetable data, but do not provide open access to this data. The street network is sufficiently developed in most European cities, but for some the data still needs to be further improved. Fortunately, more and more data has become available over the past five years and we expect this to continue. We encourage all interested parties to share data on public transport with us so that we can extend this analysis to more cities in Europe.

Last but not least, high-resolution data on the locations of jobs at the workplace is still quite rare. More high-resolution data on employment locations could enhance this analysis and would be critical to support decisions on further investment in public transport.

> METHODOLOGICAL ANNEX

1 INPUT DATA

1.1 Public transport data

In the context of this analysis, we define public transport as the collection of regular and scheduled services operated by bus, tram, metro, suburban rail or mainline rail, especially in an urban environment, but potentially also in non-urban areas.

The analysis requires data on two aspects of public transport: the location of stops and stations, and the frequency of departures at these stops. For each stop we register the precise geographic coordinates and the available transport mode(s). In addition, we need data on the frequency of departures during a typical weekday. Frequency data can be derived from individual departure records when available, or from departure counts aggregated per hour or per day.

Map 1: Study area of the analysis of public transport services

© EuroGeographics Association for the administrative boundaries

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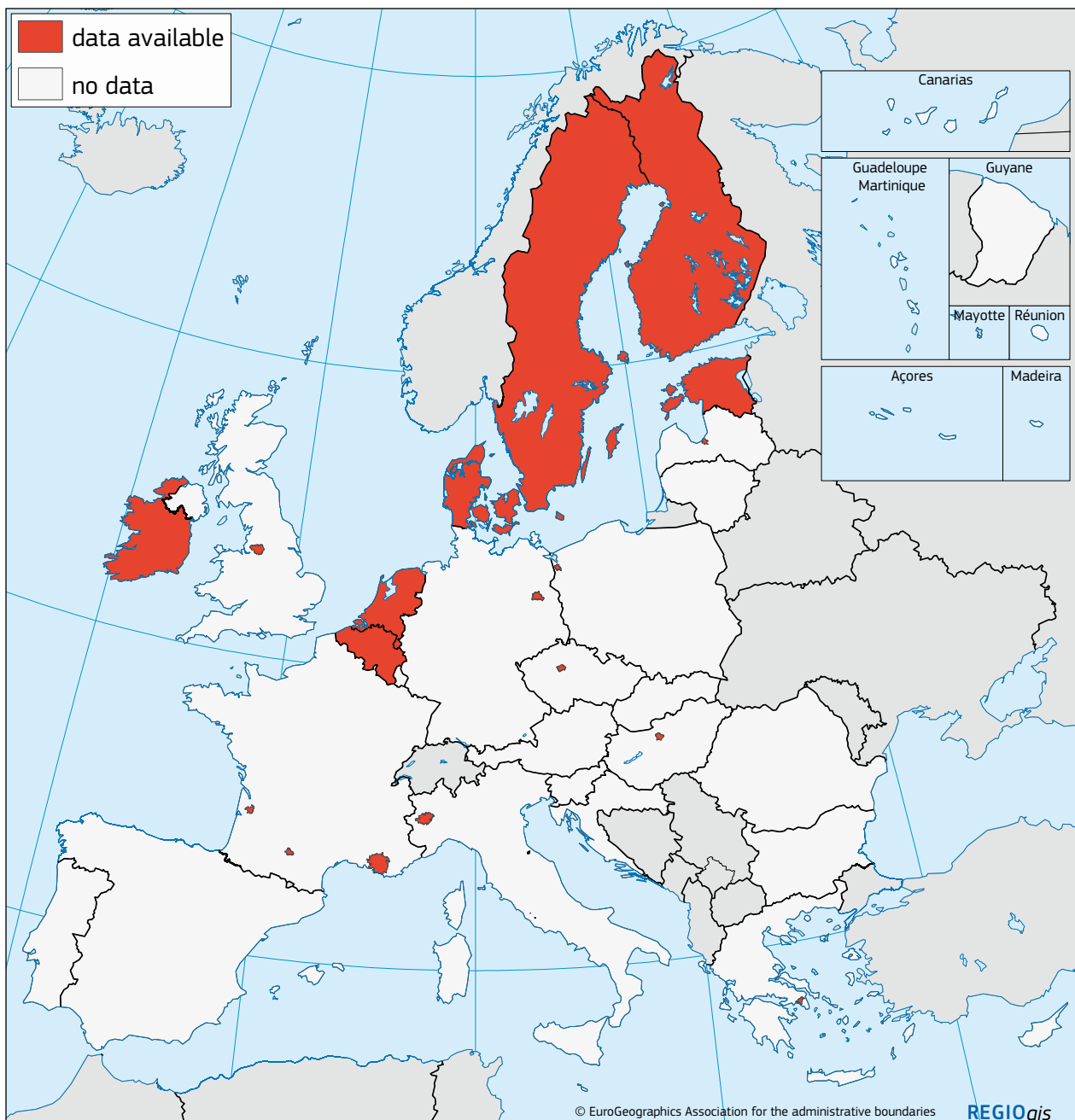
Triggered by open data initiatives (e.g. European Commission (2011)), various public transport operators and organisations integrating operators' information by region or country have started to disseminate data on stops location and services offered. While a variety of dissemination formats persists, many of these datasets have become available according to the General Transit Feed Specification (GTFS) [4]. This specification provides a relatively simple model of public transport schedules and related geographic information.

Amongst other items, the specification contains a table of stops including their location [5]. Other tables from the model need to be related to the stops in order to retrieve the departure times per stop, to select the relevant days of operation, and to select the transport mode available at each stop.

By combining data from more than 20 sources, provided in at least seven different formats, we were able to derive indicators for all major cities in Belgium, Denmark, Estonia, Ireland, the Netherlands, Finland and Sweden, and for selected cities in Czech Republic, Germany, Greece, France, Italy, Hungary, Poland and the UK [6]. Data availability has been assessed in 2013-2014. More data may have been available, especially in national formats, involving additional conversion work falling beyond the scope of this project.

1.2   Street network

To be able to assess the ease of access to the stops, a comprehensive road network is needed. The road segments should include attributes allowing for a selection of streets accessible by pedestrians. The coverage and content of the TomTom MultiNet data was considered to be appropriate for the analysis in the selected cities and regions. For each of the areas under review we have built a geographical information system (GIS) road network dedicated for use by pedestrians.

1.3   Population distribution

In order to evaluate the relevance of the public transport offer for the urban population, we need to include data on a spatially detailed distribution of residential population inside the cities or regions. The spatial resolution of the population distribution should be high enough to allow for a meaningful combination with relatively small service areas that will be created around public transport stops.

Depending on the areas under review, possible population distribution data are available at the level of grid cells with a cell size of 250 x 250 m or 100 x 100 m, preferably based on registered and georeferenced population counts, or by census tract, enumeration district, neighbourhood, or local administrative unit. Nevertheless, because of its good connectivity with the street network, our preferred unit of analysis in the context of this project is the building block, defined as a polygon containing built-up areas, and delimited by streets or other features. In urban centres, these building blocks correspond to the polygons of the Copernicus Urban Atlas land use layer, based on satellite imagery with main reference year 2006 [7]. A combination of the aforementioned detailed population distribution input data and Urban Atlas polygon characteristics resulted in population estimates for each of the Urban Atlas polygons (Batista e Silva e.a., 2013). In areas where Urban Atlas data were not available, we used an estimation of population by 100 x 100 metre grid cell, by combining the EU-wide 2006 population grid at 1 km² resolution [8] with a 100 * 100 metre downscaled grid [9].

As some calculations in subsequent steps of the workflow will assume area-weighted distributions inside polygons, it is preferable that all layers used in this project are stored in an equal-area projection [10].

2   METHOD

2.1   Combining frequency data with stops locations

From the data on the frequency of services, we select the departures between 6:00 and 20:00 during a typical working day. The actual day depends on the availability of the schedules in the input datasets. We took care to avoid public holidays and periods of national/regional school holidays. For further analysis, we distinguished two groups of transport modes: 1) bus and tram [11], and 2) metro, suburban train and mainline train. We created this distinction to take into account the differences in operational speed of the vehicles. We decided to combine tram services with bus services, despite the fact that some new or modernised tramlines can perform better than bus lines. We assume that tram services are often subject to similar congestion issues as buses, especially in city centres.

For each stop location and for each of the two groups of transport modes, we calculate the average number of departures per hour [12]. But depending on the input datasets, the definition of the location of the stops can vary. For instance, if a bus stop is located at both sides of a street (i.e. a stop for

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4   For a detailed description of the specification, see: https://developers.google.com/transit/gtfs/. Some countries use national standards (often more elaborate than the GTFS specification): e.g. UK TransXChange, Finland kalkati.net.

5   XY coordinates according to the WGS84 coordinate reference system.

6   Reference years of the public transport data depend on the data sources, and varied between 2011 and 2014.

7   For more information, see: http://www.eea.europa.eu/data-and-maps/data/urban-atlas/mapping-guide

8   GEOSTAT 2006 grid, see: http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/publications/geostat_population_grid_report

9   Grid produced by DG JRC (Institute for Environment and Sustainability) for internal analytical purposes.

10   Lambert Azimuthal Equal Area projection (GCS ETRS 1989), EPSG:3035.

11   When input data also contained schedules of ferry services, these were included in the bus and tram group.

12   An additional indicator could reflect peak hour frequencies, by calculating the maximum value of the number of departures an hour (between 6:00 and 20:00), without pre-selecting when the peak hours occur during the day. As this indicator could not be calculated from all datasets available, we decided not to pursue its calculation at this stage.

each direction), some datasets will consider this to be one single stop, while others will provide separate data for the actual location of each of the stops. The same diversity can happen when representing bus stations or platforms of railway or metro stations. In order to create more homogeneity in the data and to enhance the comparability of the results, we identified all stops located within 50 metres distance from another stop. These stops will be considered as one single cluster of stops. A single point located at the centre of the clustered stops represents each cluster. For each of the clusters, we calculate the sum of the hourly average numbers of departures. All further steps of the method will use the clustered stops. Hence, in the further description we will simply call them stops.

2.2 Creating service areas around stops

In this step we create accessibility areas ('service areas') around each of the stops. These zones are considered to provide easy walking access to the stops. We define them as a five-minute walk (at 5 km/h) to bus and tram stops, and as a ten-minute walk to stops of high-speed modes (metro and train). The service areas are created using all streets of the road network accessible to pedestrians. While many of the resulting service areas will roughly look like a circular neighbourhood, using the street network instead of creating areas by Euclidian distance takes into account the existence of barriers (e.g. motorways, railways, water bodies) better and also helps to better represent the influence of the density of the urban street network.

Map 2: Hourly average number of departures by clustered stop in Stockholm
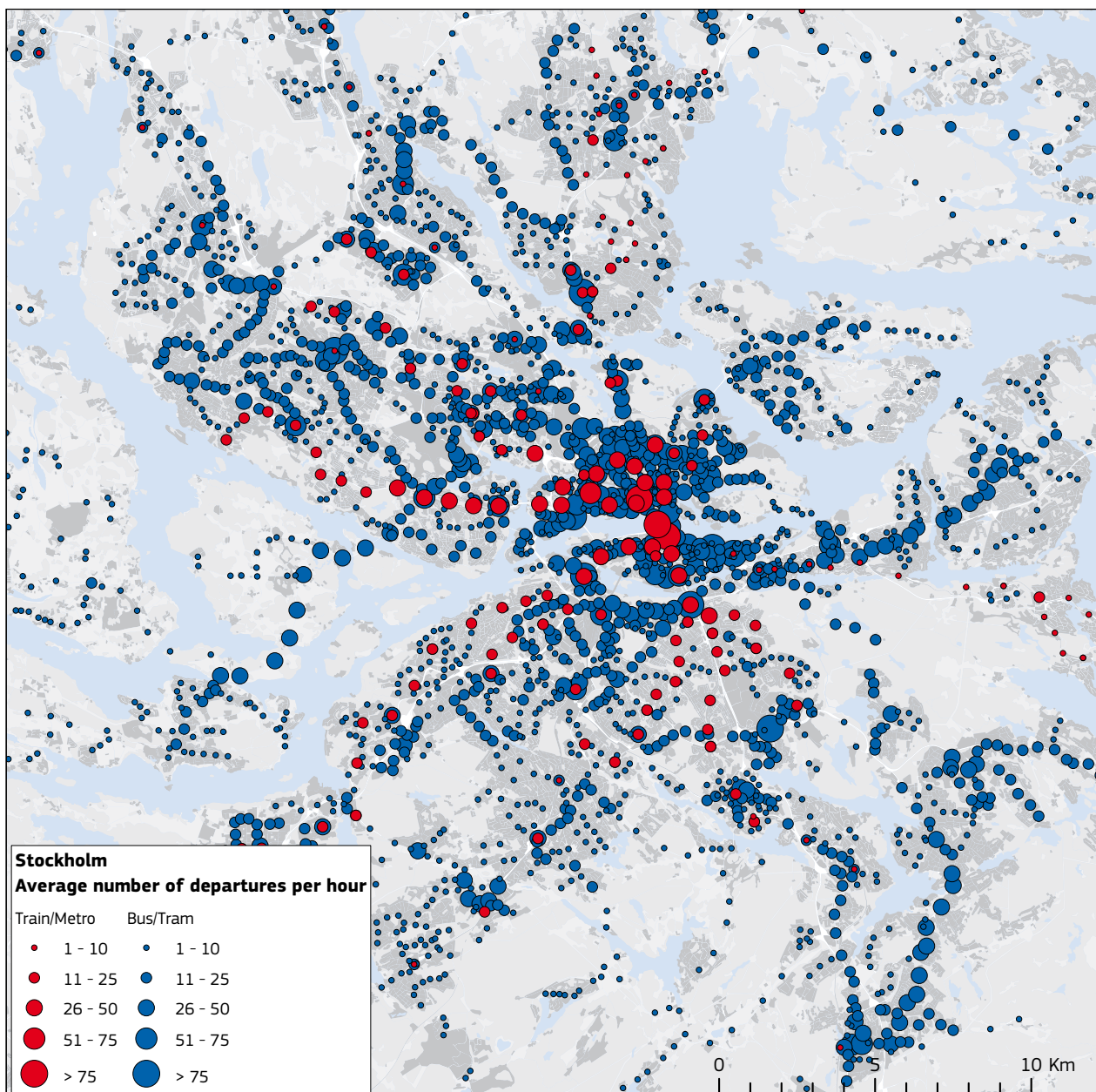
Each of the service area polygons is characterised by the sum of the hourly average number of departures available at the stop around which it is created. The service areas tend to partly overlap each other, especially in an urban environment. In these overlapping areas, people have the choice between two or more stops nearby, where the departure frequency can be different. If this situation occurs, we assume that the stop with the most frequent departures is the most probable choice. For this reason, we intersect the service areas within each of the groups of transport modes, and to each of the overlapping areas we attribute the maximum value of the hourly average number of departures. Mapping this result shows the best available level of service (within each of the groups of transport modes) at any area within the city.

2.3 Creating a typology of service frequencies

In order to obtain meaningful indicators, aggregated at the level of cities, we will combine the information about the frequency of departures with the distribution of population inside the city. First, we will develop a simplified typology of service frequencies by group of transport mode. Within each group (bus and tram / metro and train) we reclassify the frequencies into four categories of service levels.

Table 1: Frequency classes by group of transport modes

	Rail and metro/Bus and tram
No services	Outside service areas
Low frequency	Less than 4 departures an hour
Medium frequency	>= 4 and < 10 departures an hour
High frequency	More than 10 departures an hour

By intersection of the reclassified service areas of both groups of transport modes, we obtain a set of areas containing the combination of the frequency classes, i.e. a matrix of 16 possible classes. Some of these 16 classes are grouped to obtain a final typology with 5 categories of frequencies:

- Very high: access to more than 10 departures an hour for both groups of modes;
- High: access to more than ten departures for one group of modes, but not for both;
- Medium: access to between 4 and 10 departures an hour for at least one group of modes, but no access to more than 10 departures an hour;

- Low: less than 4 departures an hour for at least 1 group of modes, but no access to more than 4 departures an hour;
- No access: no easily accessible departures (by none of the modes).

The areas corresponding to this typology are now intersected with the areas containing the population counts. The population by intersected polygon is estimated by simple areal weighting. From the intersected areas we can easily obtain a distribution of population by category of service frequency, aggregated by area of interest (e.g. city, urban centre, commuting zone).

2.4 Creating a distribution of frequencies of all services

In addition to the creation of a typology of frequencies, we will summarise the frequencies of all accessible services, again aiming to combine it with the distribution of population. Starting from the two sets of service areas created in step 2.2, we create a single set of service areas by intersecting the service areas of bus and tram with those of train and metro. The resulting polygons contain information about the maximum number of departures by bus and tram and about the maximum number of departures by metro and train. For each of these polygons we calculate the total number of easily accessible departures, regardless of the transport mode used, as being the sum of both maxima. By intersecting this result [13] with the areas containing the population figures, we obtain the geographical distribution of population according to the overall average level of services available at walking distance. This information can be easily summarised in a frequency table by city, urban centre, or any other area of interest. As we can expect that the frequency distribution will be rather skewed and contain a-typical outliers, we will also derive the population-weighted median number of departures an hour from this table.

Table 2: Typology of service frequencies

		Metro and train			
		High frequency	Medium frequency	Low frequency	No services
Bus and tram	High frequency	VERY HIGH	HIGH	HIGH	HIGH
	Medium frequency	HIGH	MEDIUM	MEDIUM	MEDIUM
	Low frequency	HIGH	MEDIUM	LOW	LOW
	No services	HIGH	MEDIUM	LOW	NO ACCESS

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13 Frequencies are converted to integer values before intersecting, in order to obtain a manageable number of output polygons.

3   CONCLUSIONS

The described methodology has allowed exploring and synthesising the relationship between the offer of (urban) public transport and the distribution of population and jobs, using a maximum of standardised and harmonised input data. We described the offer in terms of service frequency, but the timetable data also offer opportunities to assess the efficiency of the network by studying the speed of the available services. We plan to investigate this particular topic further.

While data availability on the offer and location of public transport, both in terms of geographical coverage and timeliness, has been boosted by open data initiatives, the degree of openness still varies enormously within Europe. It is currently not possible to extend this analysis to many more cities or regions. Where detailed public transport data are effectively available, they challenge the quality and availability of spatially (very) detailed data on population and employment distribution. Under the current circumstances, discrepancies in terms of reference dates are inevitable: data on public transport offer tend to be more recent (and often updated more frequently) than population distribution data. Forthcoming results of the Copernicus Urban Atlas 2012, geo-referenced population data from the census 2011, including grid-based data, and high-resolution spatial modelling of building footprints are each very promising sources for further analysis in the context of urban public transport. In parallel, openness of public transport related data is well worth being further promoted, in order to enable a more balanced analysis of urban areas throughout the European territory.

Map 3: Typology of service frequencies in Stockholm

Stockholm
Typology of service frequencies

- No access
- Low
- Medium
- High
- Very high

0   5   10 Km
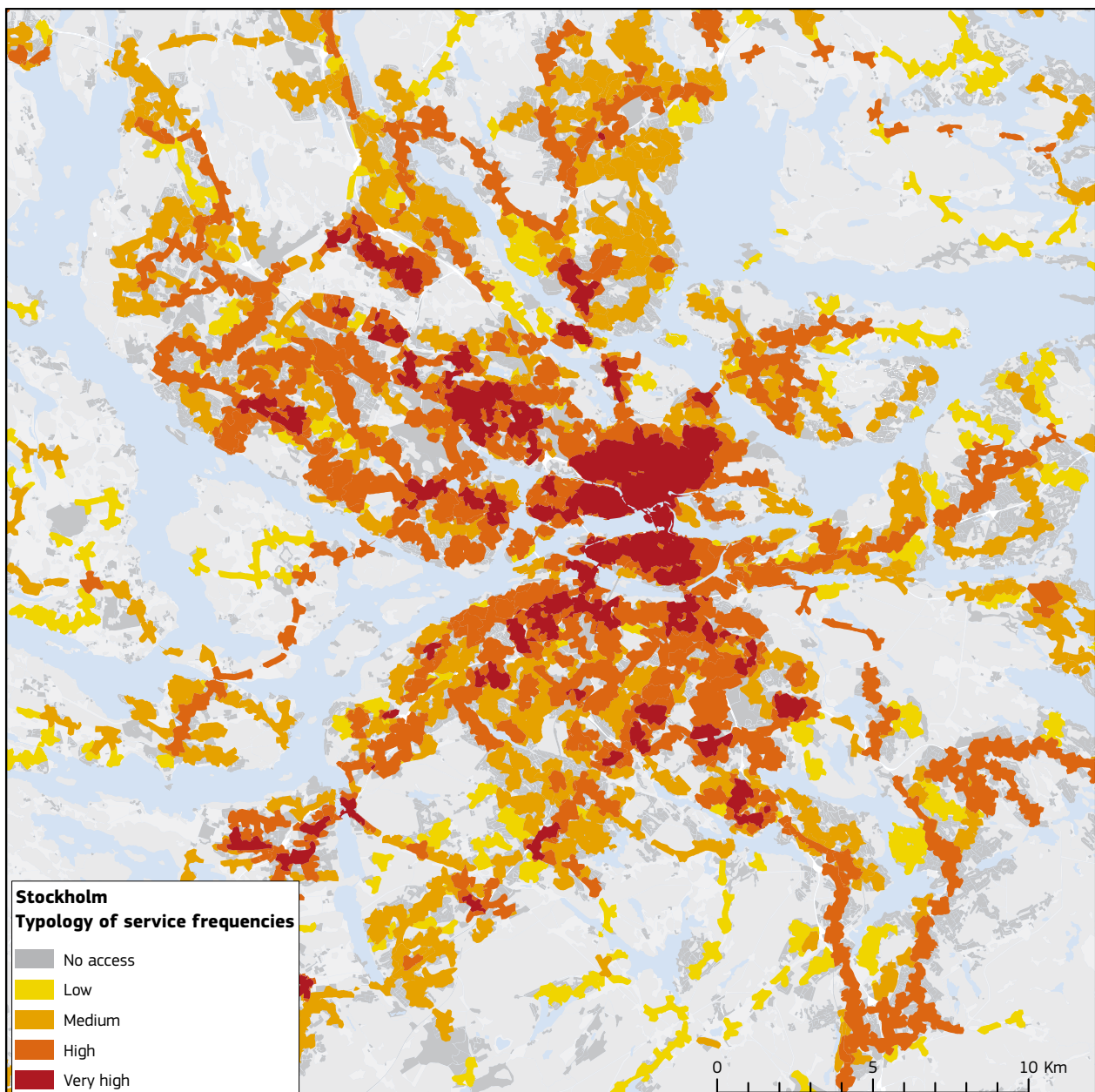
> REFERENCES

Batista e Silva, F., Poelman, H., Martens, V. and Lavalle, C., *Population estimation for the Urban Atlas polygons*, JRC Technical Report EUR 26437 EN, European Commission Joint Research Centre, Ispra, 2013. (http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/30408/1/qms_h08_intesa_deliverable_2_2_eur_26437.pdf)

Dijkstra, L. and Poelman, H., *Cities in Europe, the new OECD-EC definition*, European Commission, Brussels, 2012. (http://ec.europa.eu/regional_policy/sources/docgener/focus/2012_01_city.pdf)

European Commission, *Open data. An engine for innovation, growth and transparent governance*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, COM(2011)882 final, Brussels, 2011. (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0882:FIN:EN:PDF)

European Environment Agency (EEA), 'A closer look at urban transport. TERM 2013: transport indicators tracking progress towards environmental targets in Europe', *EEA Report* n° 11/2013, 2013. (http://www.eea.europa.eu/publications/term-2013/at_download/file)

European Forum for GeoStatistics (EFGS), 'GEOSTAT 1A – Representing census data in a European population grid', Final report of the ESSnet project, 2012. (http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/documents/ESSnet%20project%20GEOSTAT1A%20final%20report_0.pdf)

> PUBLIC TRANSPORT DATA SOURCES

Belgium: bus and tram Vlaams Gewest: VVM – De Lijn: data provided under licence, January 2013; bus and tram Région Wallonne: SRWT-TEC: data provided September 2013; urban transport in Brussels: STIB/MIVB: data provided September 2013; rail timetable data: Infrabel, from www.railtime.be, retrieved 2012-2013.

Czech Republic (Praha): urban transport: http://www.infoprovsechny.cz, retrieved March 2014.

Denmark: stops location and departure data, http://www.rejseplanen.dk, retrieved 2010.

Germany (Berlin): integrated urban transport data: http://www.gtfs-data-exchange.com/agencies, retrieved February 2013.

Estonia: integrated data: http://www.peatus.ee/gtfs/, retrieved February 2013.

Ireland: integrated data by operator: National Transport Authority, http://dublinked.ie/datastore/by-agency/NTA.php, retrieved October 2013.

Greece (Athens): urban transport: http://www.gtfs-data-exchange.com/agencies, retrieved February 2013; rail timetable data: www.trainose.gr, retrieved January 2013.

France: rail timetable data: SNCF: http://ressources.data.sncf.com/explore/, retrieved July 2013; urban transport Bordeaux: http://data.lacub.fr/data.php?themes=10, retrieved September 2013; urban transport Toulouse: http://data.toulouse-metropole.fr/, retrieved September 2013; urban transport Marseille: Agence d'Urbanisme de l'Agglomération Marseillaise, data provided October 2013.

Italy (Torino): urban transport data: http://opendata.5t.torino.it/gtfs/, retrieved January 2013.

Hungary (Budapest): urban transport: http://www.gtfs-data-exchange.com/agencies, retrieved February 2013.

Netherlands: integrated data: OV-9292 data 2013, http://9292opendata.org/, retrieved May 2013.

Poland (Szczecin): urban transport: http://www.zditm.szczecin.pl, retrieved March 2014; rail: http://rozklad-pkp.pl/, retrieved March 2014.

Finland: integrated data: http://developer.reittiopas.fi/pages/en/kalkati.net-xml-database-dump.php, retrieved December 2012.

Sweden: integrated data: http://www.trafiklab.se/api/gtfs-sverige, retrieved December 2012.

United Kingdom: location of stops and stations: National Public Transport Access Node (NaPTAN), 2011, http://data.gov.uk/dataset/nptdr, retrieved January 2013; timetable data: National Public Transport Data Repository (NPTDR) TransXchange data 2011, http://data.gov.uk/dataset/nptdr, retrieved January 2013.

Additional data: rail station locations: EuroRegionalMap, EuroGeographics Association; rail timetable data: http://reiseausfunkt.bahn.de/.

> ACKNOWLEDGMENTS

> ANNEXES

Indicators on access to public transport in European cities(http://ec.europa.eu/regional_policy/sources/docgener/work/access_public_transport_city_indicators.xls)