TRACC
Transport Accessibility at Regional/Local Scale and Patterns in Europe

Applied Research 2013/1/10

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Volume 4

TRACC Accessibility Indicator Factsheets

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This report presents the final results of an Applied Research Project conducted within the framework of the ESPON 2013 Programme, partly financed by the European Regional Development Fund.

The partnership behind the ESPON Programme consists of the EU Commission and the Member States of the EU27, plus Iceland, Liechtenstein, Norway and Switzerland. Each partner is represented in the ESPON Monitoring Committee.

This report does not necessarily reflect the opinion of the members of the Monitoring Committee.

Information on the ESPON Programme and projects can be found on www.espon.eu

The web site provides the possibility to download and examine the most recent documents produced by finalised and ongoing ESPON projects.

This basic report exists only in an electronic version.

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Introduction

The ESPON project TRACC (**TR**ansport **ACC**essibility at regional/local scale and patterns in Europe) aimed at taking up and updating the results of previous studies on accessibility at the European scale, to extend the range of accessibility indicators by further indicators responding to new policy questions, to extend the spatial resolution of accessibility indicators and to explore the likely impacts of policies at the European and national scale to improve global, European and regional accessibility in the light of new challenges, such as globalisation, energy scarcity and climate change.

The Transnational Project Group (TPG) for the ESPON project TRACC consisted of the following seven Project Partners:

- Spiekermann & Wegener, Urban and Regional Research (S&W), Dortmund, Germany (Lead Partner)
- Charles University of Prague, Faculty of Science, Department of Social Geography and Regional Development (PrF UK), Prague, Czech Republic
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This report is part of the TRACC Final Report. The TRACC Final Report is composed of four volumes.

- Volume 1 contains the Executive Summary and a short version of the Final Report
- Volume 2 contains the TRACC Scientific Report, i.e. a comprehensive overview on state of the art, methodology and concept, and in particular results on the global, Europe-wide and regional accessibility analyses and subsequent conclusions of the TRACC project.
- Volume 3 contains the TRACC Regional Case Study Book. Here, each of the seven case studies conducted within the project is reported in full length.
- Volume 4 contains the TRACC Accessibility Indicator Factsheets, i.e. detailed descriptions of all accessibility indicators used in the project.

1 TRACC accessibility indicator system

The review of accessibility studies done in TRACC (see Volume 2) has shown that there is no single standard accessibility indicator serving all purposes. The conclusion for TRACC was therefore to develop a systematic and consistent set of accessibility indicators which is derived from the conceptual framework as laid down in Chapter 3 of Volume 2 and which matches the following requirements:

- As different types of accessibility indicators provide answers to different questions, the three generic types of accessibility indicators, i.e. travel cost, cumulated opportunities (daily accessibility) and potential accessibility should be used at all levels considered.
- The TRACC project is expected to analyse accessibility at very different spatial levels ranging from the global through the European to the regional level.
- The spatial coverage should be at least the ESPON space. Candidate countries and other countries of the Western Balkan should be included if possible. Regional case studies should cover different types of the regional typologies developed by ESPON.
- The spatial resolution should be appropriate. This is NUTS-3 for the Europe-wide indicators and LAU-2 for the regional case studies. In addition, raster representations of space should be explored to analyse to what extent a finer spatial resolution influences results.
- All relevant transport modes should be addressed, i.e. road, rail and public transport, air and water as well as combinations of modes as multimodal aggregation and intermodal trip chains.
- Traditional accessibility indicators should be amended by newer forms of accessibility. The traditional indicators should guarantee continuity with previous ESPON studies; in particular the potential accessibility indicator should be updated to a recent year.
- There should be accessibility indicators dealing with passenger travel and indicators dealing with freight transport.

Table 1.1 presents the resulting TRACC set of accessibility indicators. The indicator set is differentiated by the three main spatial contexts to be taken into account (global, European, regional), and at each level further differentiated by travel and freight. For the European level, accessibility indicators for travel are further divided into traditional and newer ones. For the regional level, the indicators are differentiated into those regional indicators for both travel and freight that can be calculated for the whole of Europe and those that will be calculated in the regional case studies. For the latter, a distinction is made between traditional indicators and indicators looking at the accessibility to selected services of general interest to reflect current policy debates on the subject of services of general interest. For all levels, each generic indicator type is represented by one indicator.

Table 1.1. TRACC set of accessibility indicators

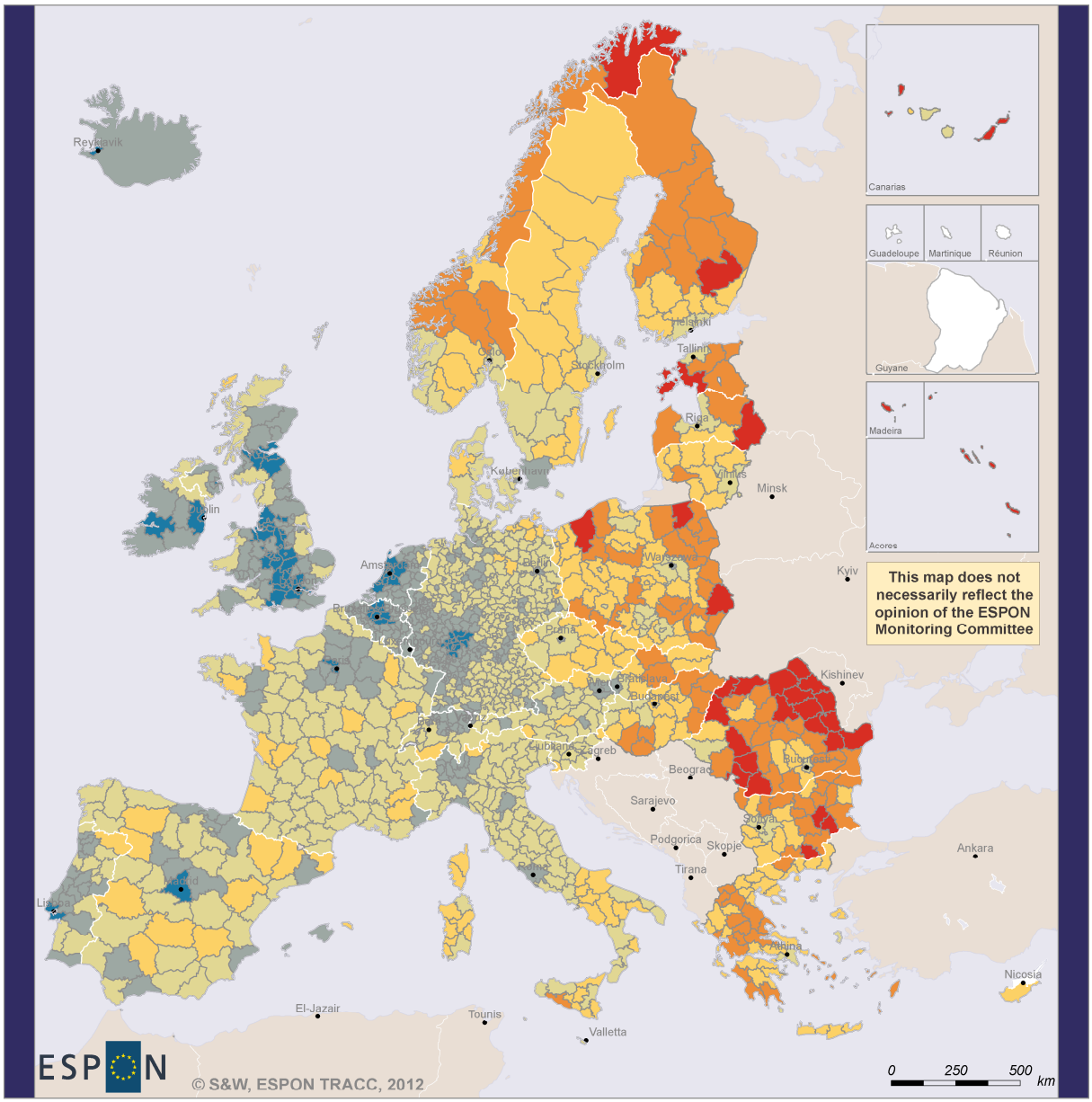
Spatial context	***Basic characteristics***	***Generic type of accessibility indicator***		
		Travel cost	***Cumulated opportunities***	***Potential***
Global	***Travel***	***Access to global cities*** Travel time (intermodal) to global city (New York)	***Global travel connectivity*** Number of flights from European airports to intercontinental destinations reachable within three hours	***Global potential accessibility travel*** Intermodal accessibility to intercontinental flights of European airports weighted by seat capacity as mass
	Freight	***Access to global freight hubs*** Travel time/cost (intermodal) to major intercontinental terminals (New York, Shanghai)	***Global freight connectivity*** Intercontinental container throughput of European sea ports reachable within maximum travel time	***Global potential accessibility freight*** By road and rail to container throughput of European sea ports
Europe	***Travel (traditional)***	***Access to top ten MEGAs*** Average fastest travel time to top group of MEGAs	***European daily accessibility travel*** Daily accessibility to population by road, rail, fastest mode	***European potential accessibility travel*** To population by road, rail, air, multimodal
	Travel (new)	***Travel speed*** Average travel speed by road and rail	***Urban connectivity*** Urban connectivity by road, rail, air, intermodal	***European potential acc. intermodal travel*** To population intermodal
	Freight	***Access to nearest maritime ports*** Generalised cost to nearest maritime port	***European daily accessibility freight*** GDP accessible within allowed lorry driving time	***European potential accessibility freight*** Accessibility potential to GDP by different modes
Regional	***Travel (Europe-wide)***	***Access to high-level transport infrastructure*** Weighted access time to motorway exits, rail stations, airports	***Availability of urban functions*** Cities > 50.000 within 60 minutes by road and rail	***National potential accessibility travel*** To national population by road and rail
	Freight (Europe-wide)	***Access to freight terminals*** Weighted access time to freight terminals	***Availability of freight terminals*** Freight terminals within 2 h by lorry	***National potential accessibility freight*** To national GDP by lorry
	Travel (case studies, traditional)	***Access to regional centres*** Travel time to nearest regional centre by road and public transport/rail	***Daily accessibility of jobs*** Jobs accessible within 60 minutes by road and public transport/rail	***Regional potential accessibility*** To population by road and public transport/rail
	Travel (case studies, to services of general interest)	***Access to health care facilities*** Travel time to nearest hospital	***Availability of secondary schools*** Number of secondary schools within 30 minutes travel time	***Potential accessibility to basic health care*** Potential accessibility to general practice surgeries

2 Global accessibility indicators

2.1 Access to global cities, travel

<table>
<tr><td colspan="3">Indicator name
Access to global cities, travel</td></tr>
<tr><td>Spatial context
Global</td><td>Basic characteristics
Travel</td><td>Generic type
Travel cost</td></tr>
<tr><td>Spatial level
NUTS-3 regions</td><td>Origins
NUTS-3 regions</td><td>Destinations
New York (US)</td></tr>
<tr><td>Modes
Intermodal</td><td colspan="2"></td></tr>
<tr><td colspan="3">Description and rationale
The indicator is defined as the total travel time to reach a selected global city from a European region. New York serves as examples for a non-European global city here.
The indicator reflects one aspect of the integration of regions into the global economy, namely the travel time to one of the top global financial centre outside Europe.</td></tr>
<tr><td colspan="3">Equation
$A_i = c_{igm}$

Where:
A_i is the accessibility indicator value for region i, i.e. the travel time to the global city
c_{igm} is the shortest travel time between region i and the global city g by intermodal trip chain m</td></tr>
<tr><td colspan="3">Details on the indicator calculation
For each NUTS-3 region the shortest total travel time to New York City is calculated. This includes the travel time from the region by road and maybe air to airports with intercontinental flights to New York plus the flight time between that airport and one of the New York airports. Transfer times at the airports and travel time from the New York airports to downtown Manhattan are included as well. .</td></tr>
<tr><td colspan="3">Database
Road network: RRG GIS database
Flight network: S&W flight network</td></tr>
<tr><td colspan="3">Spatial pattern and main observations
The travel times to New York differ very much across European regions (Figure 2.1). There are regions in Europe from which the total travel time is clearly below 15 hours. Not surprisingly, these regions are located in western parts of Europe with close access to airports with intercontinental flights. Countries in which most of the regions belong to this favourable group are the UK, Ireland, Iceland, Portugal and the Benelux. In addition, there are larger areas around Paris, Frankfurt, Madrid; Milano and Zürich and some smaller areas in Spain or France benefitting from relatively low travel times which can also be experienced when travelling from Copenhagen, Vienna or Rome. However, travel times clearly increase up to 18 hours in other regions of western Europe that have a longer access to intercontinental flight services; similar travel times have to be expected when travelling from capital city regions in eastern or northern Europe. Longest travel times exist from non-metropolitan regions in northern and eastern Europe; for few regions it might take almost a full day to travel to New York.</td></tr>
</table>



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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Travel Time to New York, intermodal (minutes)

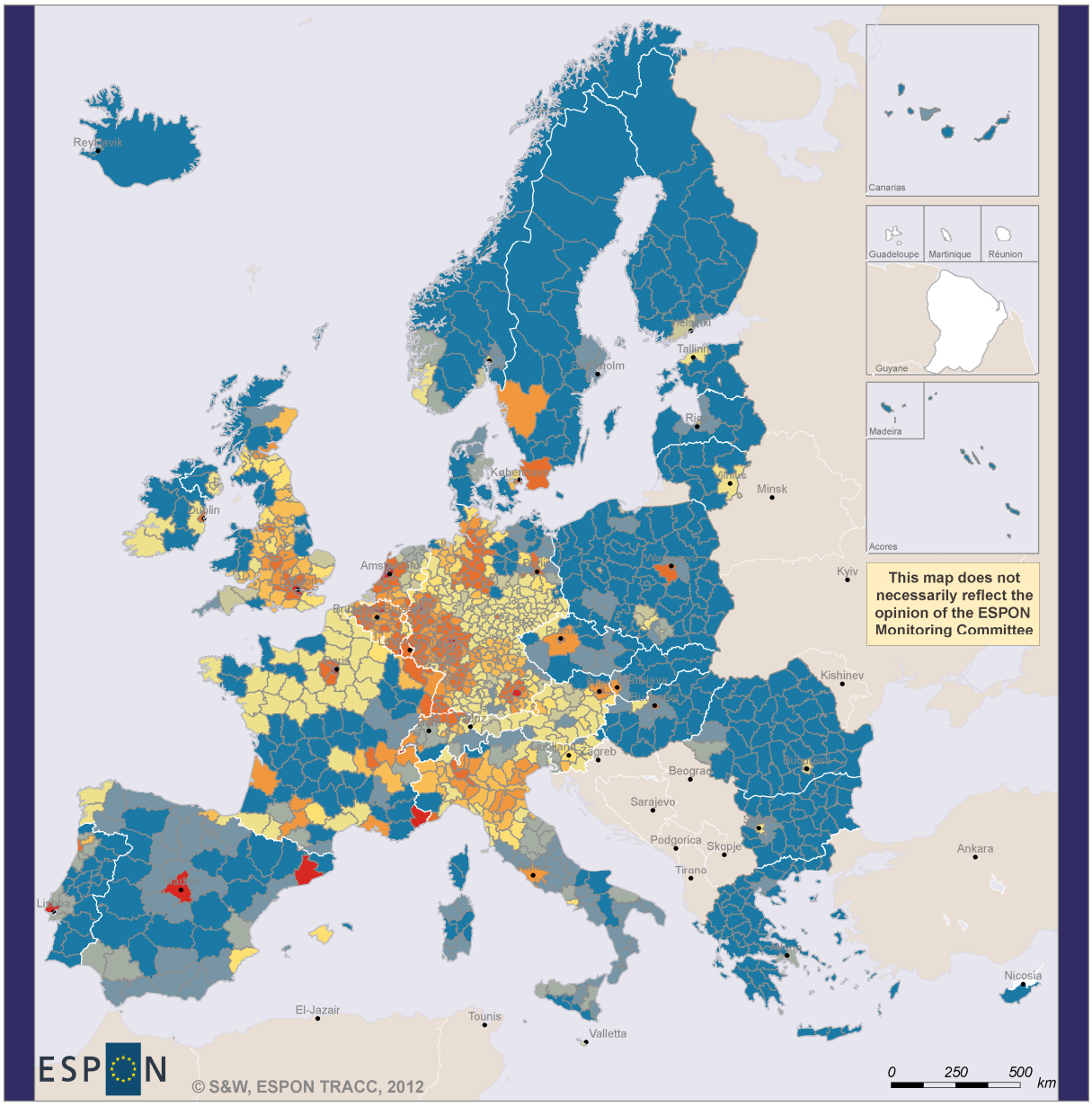
- 702 - 800
- 801 - 900
- 901 - 1000
- 1001 - 1100
- 1101 - 1200
- 1201 - 3256
- no data

Figure 2.1. Access to global cities, travel

2.2 Global travel connectivity

<table>
<tr><td colspan="3">Indicator name
Global travel connectivity</td></tr>
<tr><td>Spatial context
Global</td><td>Basic characteristics
Travel</td><td>Generic type
Cumulated opportunities</td></tr>
<tr><td>Spatial level
NUTS-3 regions</td><td>Origins
NUTS-3 regions</td><td>Destinations
Flights from European airports to intercontinental destinations</td></tr>
<tr><td>Modes
Intermodal</td><td colspan="2"></td></tr>
<tr><td colspan="3">Description and rationale
Being of the accessibility indicator type of cumulative opportunities, the indicator sums up the number of global destinations to which a departure flight can be reached within a maximum travel time of five hours. So, if an airport is reachable from a region within the maximum travel time, the intercontinental destinations served from that airport will be added to the regional global connectivity value.
The interest with this indicator is not related to a single destination such as an individual global city, but to all global destinations The indicator reflects one other transport related aspect of the integration of regions into the global economy, namely the air connectivity of regions to global destinations in all parts of the world outside Europe.</td></tr>
<tr><td colspan="3">Equation
$A_i = \sum_a D_a\, c \qquad c = 1 \quad if \;\; c_{iam} \leq c_{max}$
$c = 0 \quad if \;\; c_{iam} > c_{max}$

Where:
A_i is the accessibility indicator value for region i, i.e. the global travel connectivity value
D_a is the number of intercontinental destinations served from airport a
c_{iam} is the shortest travel time between region i and the airport a by intermodal trip chain m
c_{max} is the threshold value for the maximum travel time from region i to an airport</td></tr>
<tr><td colspan="3">Details on the indicator calculation
For each NUTS-3 region the shortest total intermodal travel times by road and air to airports with intercontinental flight services is calculated. If an airport is within a maximum travel time of five hours, the intercontinental destinations served from that airport are added to the regional global connectivity value. Double counting of destinations for one region is excluded.</td></tr>
<tr><td colspan="3">Database
Road network: RRG GIS database
Flight network: S&W flight network</td></tr>
<tr><td colspan="3">Spatial pattern and main observations
Figure 2.2 shows a very strict differentiation of European regions with areas of high global connectivity in the UK, the Benelux, parts of Germany, France and Northern Italy. However, highest global connectivity can be found in south-western Europe, namely in Barcelona, Madrid and Lisbon. Those regions benefit on the one hand from serving several global destinations on their own and from having good access times to other European intercontinental hubs. In northern and eastern Europe only the capital regions have higher global connectivity all other regions are clearly much behind.</td></tr>
</table>



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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Number of intercontinental destinations to which flight departures are reachable within 5 hours travel time.

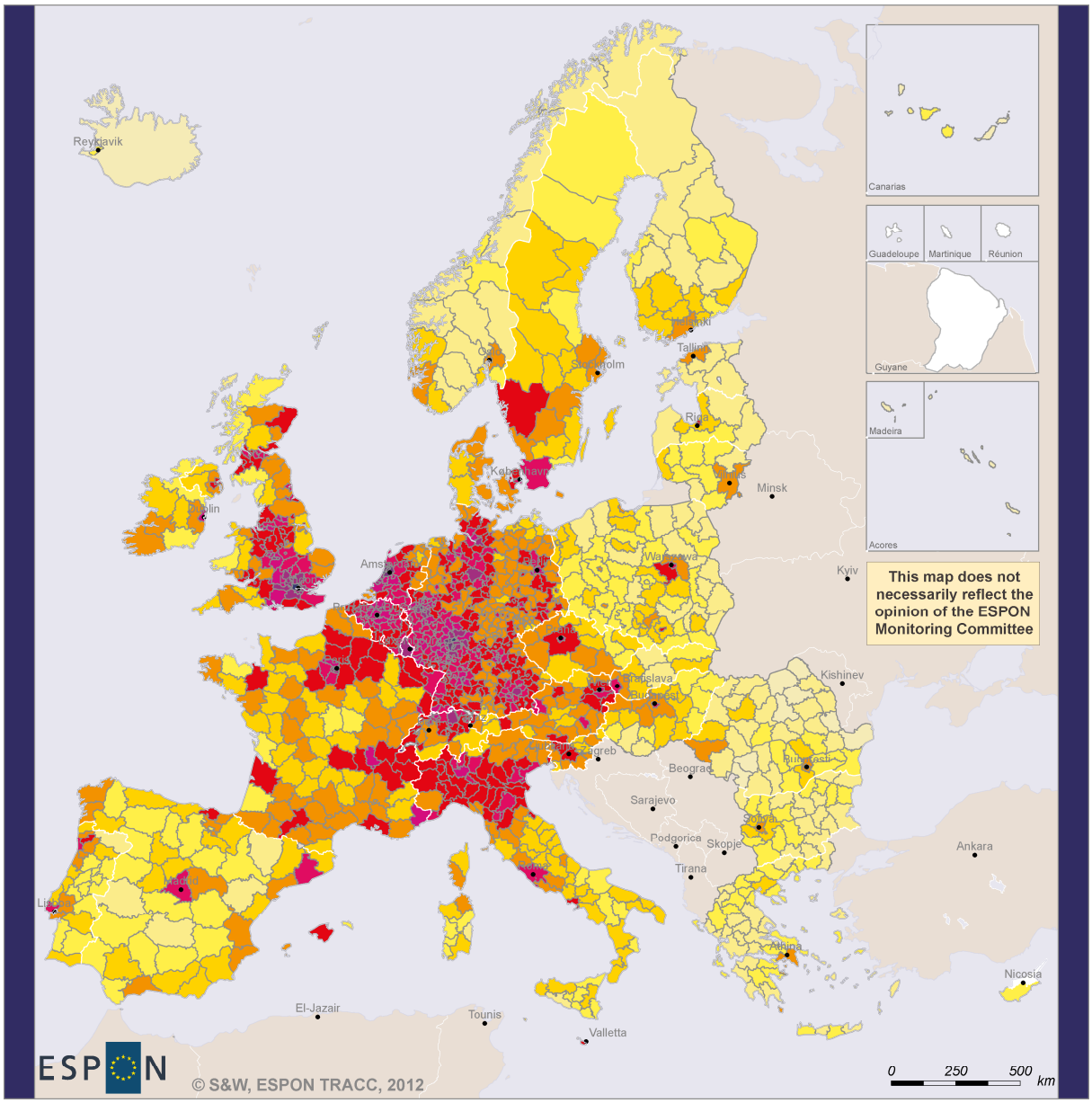
- 0 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 180
- 181 - 200
- no data

Figure 2.2. Global travel connectivity

2.3 Global potential accessibility travel

<table>
<tr><td colspan="3">Indicator name
Global potential accessibility travel</td></tr>
<tr><td>Spatial context
Global</td><td>Basic characteristics
Travel</td><td>Generic type
Potential</td></tr>
<tr><td>Spatial level
NUTS-3 regions</td><td>Origins
NUTS-3 regions</td><td>Destinations
European airports with flights to intercontinental destinations</td></tr>
<tr><td>Modes
Intermodal</td><td colspan="2"></td></tr>
<tr><td colspan="3">Description and rationale
As a proxy for global potential accessibility, the indicator sums up for each region the annual intercontinental seat capacity of airports in Europe weighted by an intermodal travel time to reach that airport.
The interest with this indicator is not related to a single destination such as an individual global city, but to all global destinations The indicator reflects another transport related aspect of the integration of regions into the global economy, namely the easiness in terms of travel time to reach intercontinental flights expressed as annual intercontinental seat capacity.</td></tr>
<tr><td colspan="3">Equation
$\boldsymbol{A_i = \sum_a S_a \, exp(-\beta \, c_{iam})}$

Where:
A_i is the accessibility indicator value for region i, i.e. the global accessibility potential travel
S_a is the annual intercontinental seat capacity of airport a
c_{iam} is the shortest travel time between region i and the airport a by intermodal trip chain m</td></tr>
<tr><td colspan="3">Details on the indicator calculation
For each NUTS-3 region the shortest total intermodal travel times by road and air to airports with intercontinental flight services is calculated. The intercontinental annual seat capacity of the airports is used as attraction, i.e. the mass term in the calculation of the potential accessibility. For the global accessibility potential travel, for each region these European airport attraction terms weighted by the travel time to reach them are summed up.</td></tr>
<tr><td colspan="3">Database
Road network: RRG GIS database
Flight network: S&W flight network</td></tr>
<tr><td colspan="3">Spatial pattern and main observations
Figure 2.3 shows huge disparities in Europe with areas of very high global accessibility potential around intercontinental airport in the UK, the Benelux, western parts of Germany, Denmark, France Spain and Northern Italy. Global accessibility potential very quickly goes down below European average apart from those airports. Most regions in northern and eastern Europe, in southern Italy and in Spain and Portugal are very clear below European average.</td></tr>
</table>



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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Global potential accessiblity (ESPON=100)

0 - 20	121 - 140
21 - 40	141 - 160
41 - 60	161 - 180
61 - 80	181 - 200
81 - 100	201 - 220
101 - 120	no data

Figure 2.3. Global potential accessibility travel

2.4 Access to global freight hubs

Indicator name		
Access to global freight hubs		
Spatial context Global	**Basic characteristics** Freight	**Generic type** Travel cost
Spatial level NUTS3 regions	**Origins** NUTS3 regions	**Destinations:** Shanghai (PRC) or New York (USA)
Modes Maritime - Air		

Description and rationale

This indicator is defined as generalised travel cost by maritime transport (plus land feeder modes required to reach a European port or airport from zones which do not have one) the major intercontinental terminals of Shanghai (PRC) or New York (USA).

This indicator shows how long is to reach overseas gateway to two major extra-European markets. Despite transport cost is just one factor among others, more accessible zones have a comparative advantage to export goods overseas. Therefore zones with a higher accessibility to global freight hubs are in better position, *coeteris paribus*, as trade partners of North American and Chinese markets.

Equation

$IND_{im} = GTC_{ijm}$

Where:

IND_{im} = Indicator value for zone *i* and mode *m*

GTC_{ijm} = Generalised travel cost by mode *m* between zone *i* and destination *j* (New York terminal or Shanghai terminal)

Details on the indicator calculation

Generalised cost from origin zone and the overseas destination is made of monetary cost plus the money equivalent of travel time. Both travel cost and travel time are computed by means of modelling assignment. Two main components can be identified for both cost and time:

- The part of route from the origin zone to an European terminal connected to overseas destinations
- The part of route from the European terminal to the final overseas destination

As far as the first component is concerned, the modelling assignment concern the maritime or the air modes. Since only a subgroup of 25 European ports and 11 European airports are modelled as intercontinental ports/airports, from zones where a non-intercontinental port (airport) exists, the path by coastal sea shipping (air freight) to the most convenient intercontinental port (airport) is estimated. For zones without a port or airport, the model searches for a path towards the most convenient port (airport) by means of a feeder inland mode (road, rail, etc.). If this port (airport) is not an intercontinental one, coastal sea shipping (air freight) is used to reach the intercontinental terminal.

The second component is easier as a fixed travel time and a fixed travel cost is modelled for each intercontinental port (airport) towards New York and towards Shanghai.

The reference for maritime travel time and cost is to containerships as they are the most representative of modern overseas deep sea shipping transport.

Database

NUTS-3 region boundaries come from (ESPON database). Transport networks come from the TRANS-TOOLS model (road, rail), the RRG GIS Database (inland navigation, air freight) and the TRUST model (maritime). Data about intercontinental container throughput of European ports is from EUROSTAT. Data about the freight traffic of airports and the number of extra-European locations connected to each airport are taken from ETISplus database working data.

Spatial pattern and main observations

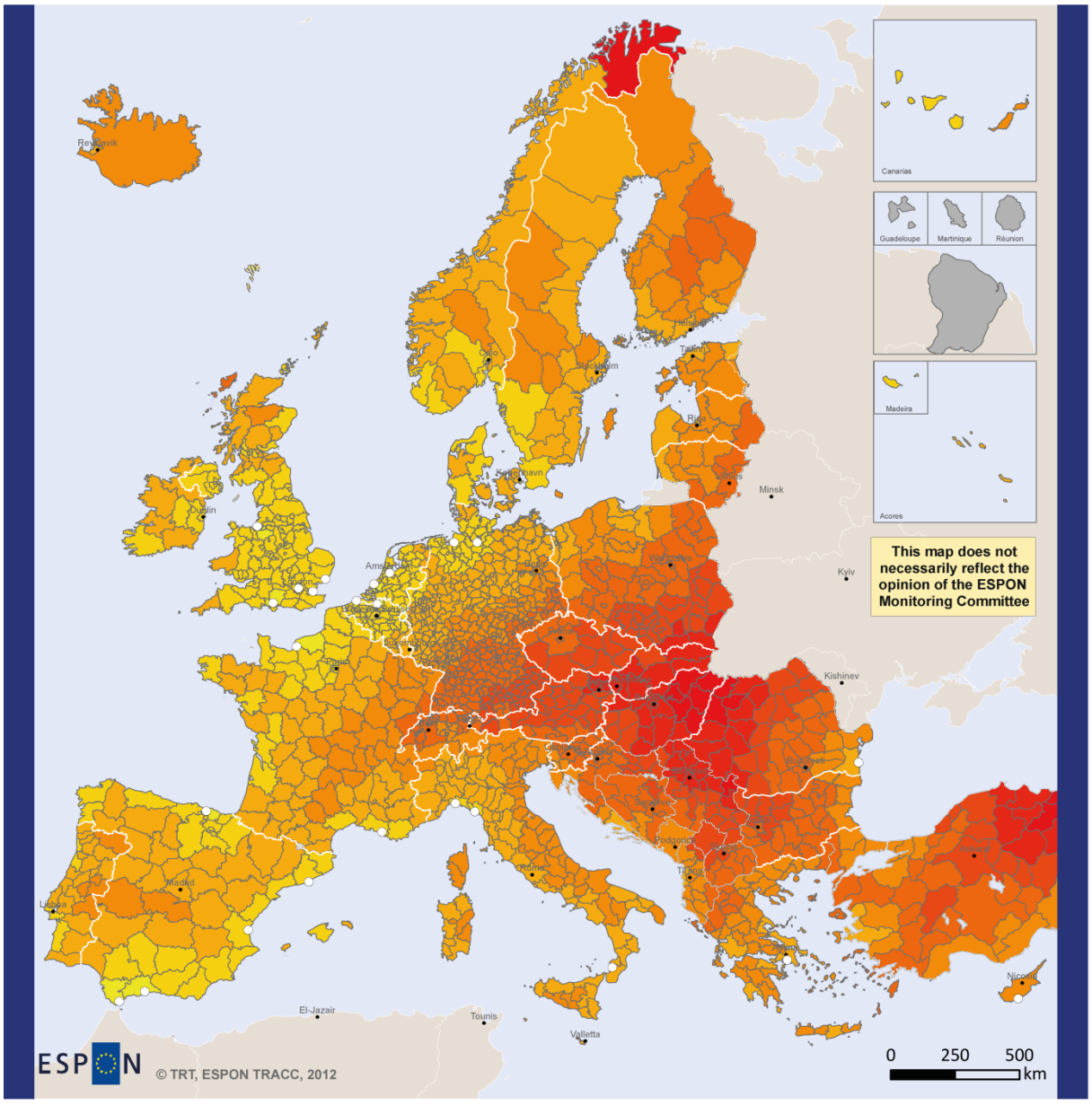
The maps show that maritime accessibility to global hubs is significantly affected by the geographical position of regions. In general, Western European zones are more accessible to the New York hub, while the South-eastern European zones are more accessible to the Shanghai hub. This happens because the travel time from the European intercontinental terminal (port or airport) until the overseas hubs is the most significant component of the indicator.

However, the indicator takes into account that accessibility to European intercontinental ports is more critical than the connection from the European port to the overseas port. The navigation time for deep sea shipping is usually far less important than the time and cost of the European leg of the shipment. That's why the accessibility to maritime global hubs of inner regions basically depends on their accessibility to the most convenient European intercontinental port and convenience is defined by the generalised cost needed to reach such European ports from the region and not by the distance of these ports from the intercontinental hub. For instance, despite reaching Shanghai is faster from Genoa than from Le Havre, for the Paris region the latter is a much more convenient port than the former. Therefore the maritime accessibility to Shanghai from Paris is based on the navigation time from Le Havre and not from Genoa because the generalised cost, corrected to take into account that the inland leg is more important, is minimised for the route passing through Le Havre.

The geographical position is therefore very important, but it is not the only element. Zones with a lower connectivity to intercontinental terminals have a lower maritime accessibility to global hubs even if in a better geographical position. For instance, Northern Poland has lower values of maritime accessibility to Shanghai than Southern UK or Portugal is less accessible by sea from New York than central Spain.

The travel time difference for air transport is of course much smaller than for maritime transport. Also, the air time to New York or Shanghai is not so much different leaving from one or another European hub airport. Therefore the regions location in pure geographical terms is not very relevant for air freight accessibility to global hubs, instead the accessibility is almost entirely explained by the closeness to an intercontinental airport. So the regions surrounding the main European airports show better level of air accessibility to global hubs in term of generalised cost. Thus, zones in the northern periphery of Europe have a significantly lower air accessibility to global hubs because they are far away to major airports and need either long feederage services by truck or to change flight.

Since the key aspect for global air accessibility is the access to intercontinental European airports, rather than the distance to overseas destination, there is basically no difference between the accessibility to Shanghai and the accessibility to New York.



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW network: RRG GIS Database, Intercontinental container throughput of ports (Eurostat data 2007-2009)
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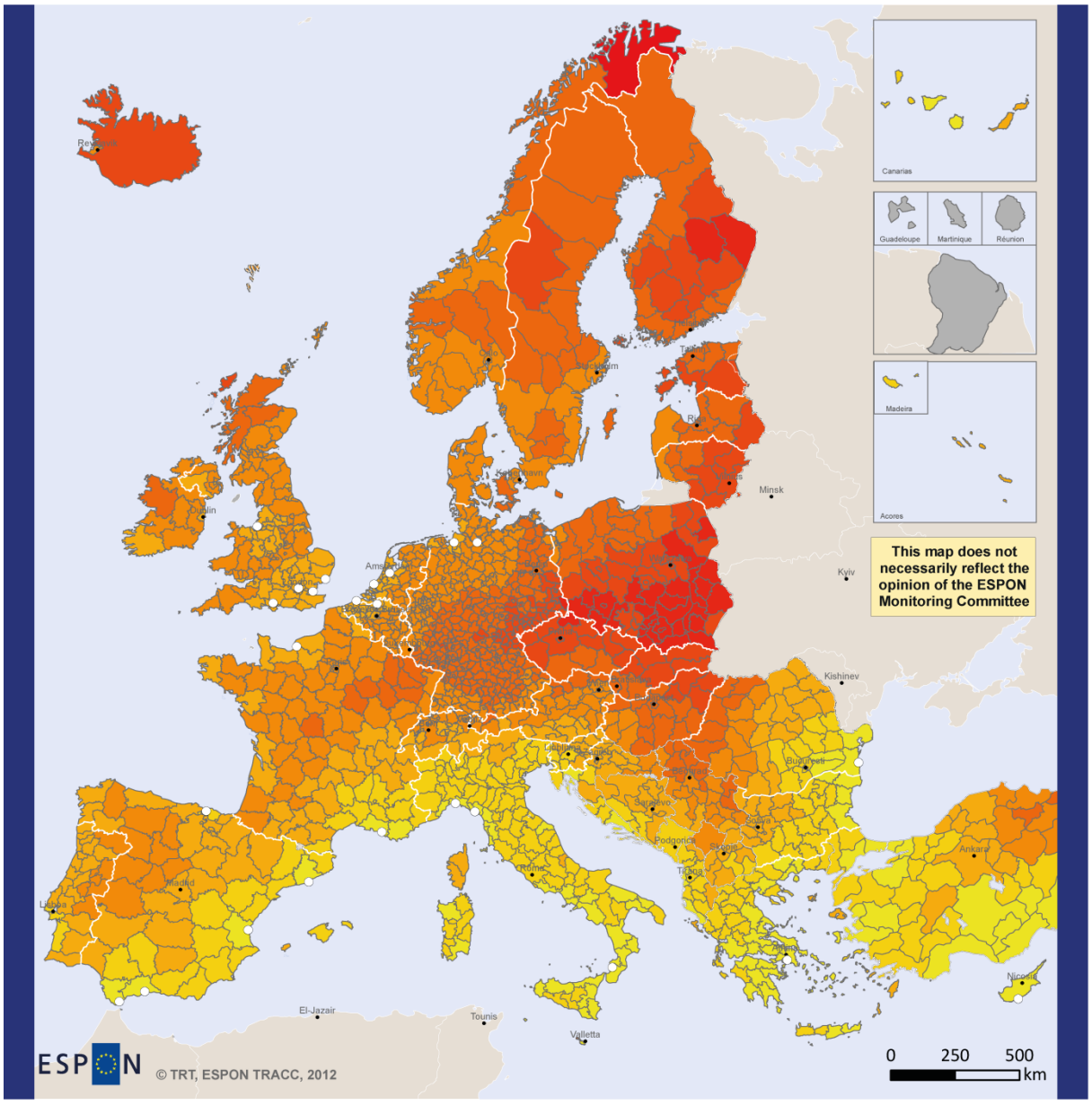
Access to global freight hubs (2011):
Sea Maritime generalized cost (€/ton) to major intercontinental terminals (New York)

- 1 - 300
- 301 - 350
- 351 - 400
- 401 - 450
- 451 - 500
- 501 - 550
- 551 - 600
- 601 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.4. Maritime access to global freight hubs (New York)



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW network: RRG GIS Database, Intercontinental container throughput of ports (Eurostat data 2007-2009)
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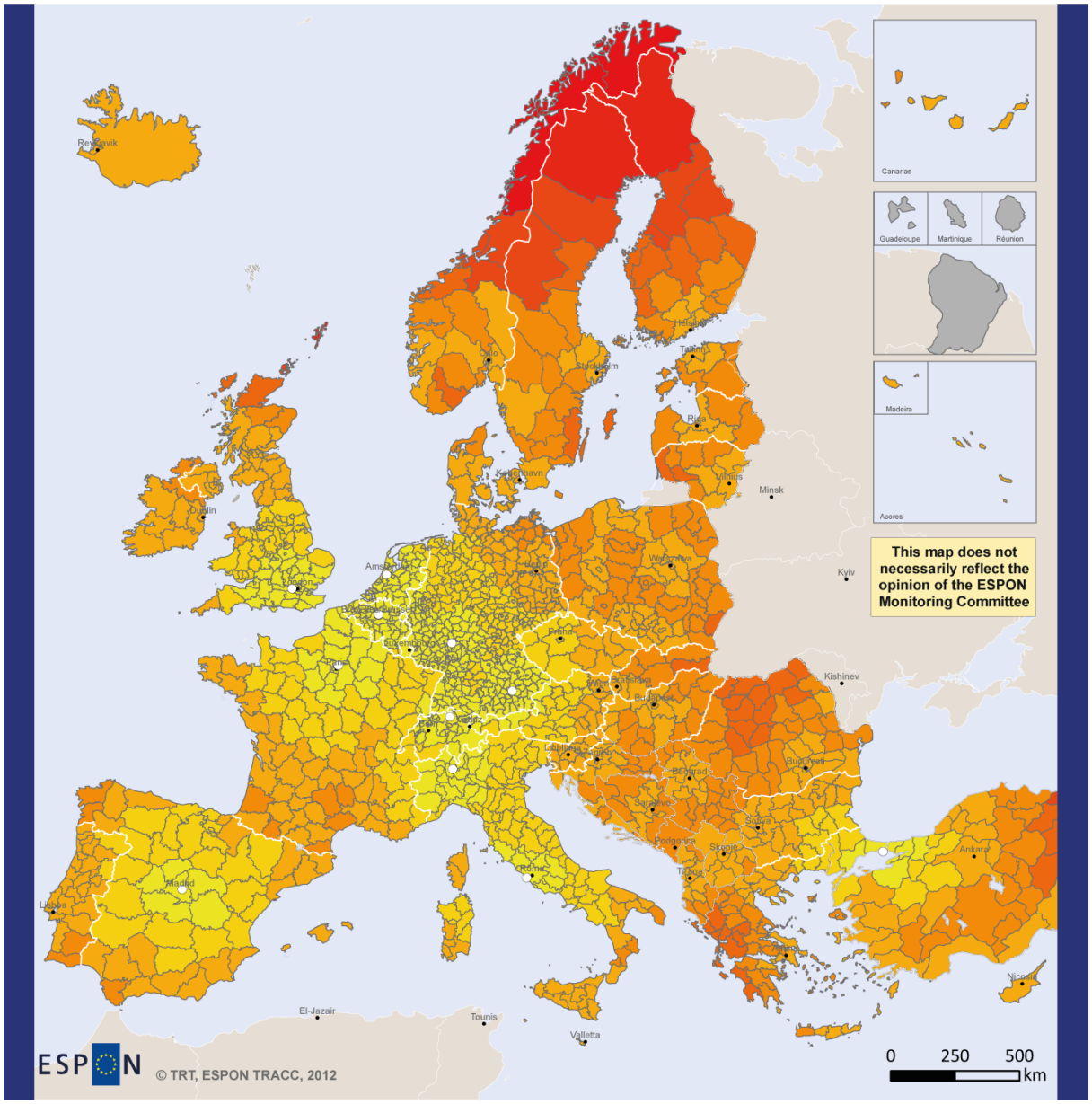
Access to global freight hubs (2011):
Sea Maritime generalized cost (€/ton) to major intercontinental terminals (Shanghai)

- 1 - 600
- 601 - 650
- 651 - 700
- 701 - 750
- 751 - 800
- 801 - 850
- 851 - 900
- 901 < ...
- n.a.

- • *Capital cities*
- ○ *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.5. Maritime access to global freight hubs (Shanghai)



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Source: TRUST Accessibility Model (TRT 2012), Air Network: RRG GIS Database (2011), Road Network: TransTools (2005), Intercontinental freight airports and destinations (ETISplus database working data)
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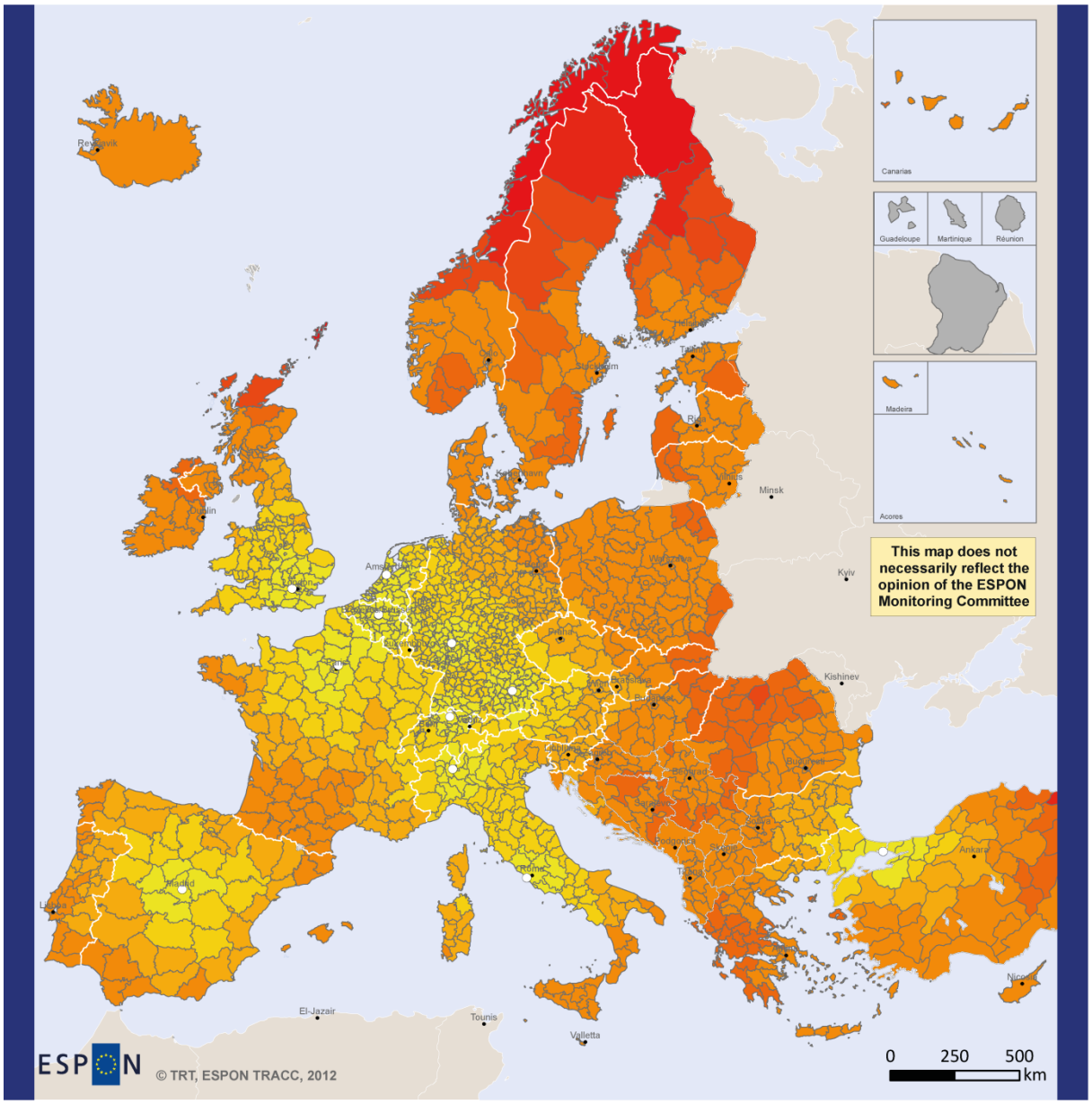
Access to global freight hubs (2011):
Air Freight generalized cost (€/ton) to major intercontinental terminals (New York)

- 1 - 4 000
- 4 001 - 5 000
- 5 001 - 6 000
- 6 001 - 7 000
- 7 001 - 8 000
- 8 001 - 9 000
- 9 001 - 10 000
- 10 001 < ...
- n.a.

- *Capital cities*
- *Intercontinental Freight Airports (>70 intercontinental destinations)*

Figure 2.6. Air access to global hubs freight (New York)



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Source: TRUST Accessibility Model (TRT 2012), Air Network: RRG GIS Database (2011), Road Network: TransTools (2005), Intercontinental freight airports and destinations (ETISplus database working data)
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Access to global freight hubs (2011):
Air Freight generalized cost (€/ton) to major intercontinental terminals (Shanghai)

- 1 - 4 000
- 4 001 - 5 000
- 5 001 - 6 000
- 6 001 - 7 000
- 7 001 - 8 000
- 8 001 - 9 000
- 9 001 - 10 000
- 10 001 < ...
- n.a.

- *Capital cities*
- *Intercontinental Freight Airports (>70 intercontinental destinations)*

Figure 2.7. Air access to global hubs freight (Shanghai)

2.5 Global freight connectivity

Indicator name Global freight connectivity		
Spatial context Global	**Basic characteristics** Freight	**Generic type** Cumulated opportunities
Spatial level: NUTS3 regions	**Origins** NUTS3 regions	**Destinations** Intercontinental European container ports
Modes Road – Rail – Water (coastal sea shipping and inland navigation)		

Description and rationale

This indicator is defined as the intercontinental container throughput of European ports that can be reached within a maximum freight transport time of 36 hours (road) or 48 hours (rail) or 72 hours (water).

The more intercontinental throughput can be reached the more trade opportunities are easily accessible for one region. This indicator is focused on the European leg of global accessibility and it is therefore somewhat complementary to the indicator "accessibility to global hubs". The time threshold considered by the indicator is different by mode to take into account different fixed times (e.g. load/unload).

Equation

$IND_{im} = \Sigma_{h \in Hm} W_h$

Where:

IND_{im} = Indicator value for zone *i* and mode *m*

H_m = set of European container ports connected to overseas destinations that can be reached within 36 (48, 72) hours with mode *m* (road, rail, water) from zone *i*.

W_h = Intercontinental container throughput of port *h*

Details on the indicator calculation

The travel time from each zone to the intercontinental ports is computed by means of modelling assignment. For each mode an independent assignment is performed. For mode "water" ports can be accessed either by inland navigation or by coastal sea shipping. Zones without a maritime or inland port can reach the most convenient one by road or rail used as feeder modes. Travel time includes any fixed time, e.g. loading, transhipment during intermodal chains. Also resting time for truck drivers is considered in the calculation, that's why the threshold is set to 36 hours which corresponds nearly to 24 driving hours.

Database

NUTS-3 region boundaries come from (ESPON database). Transport networks come from the TRANS-TOOLS model (road, rail), the RRG GIS Database (inland navigation) and the TRUST model (maritime). Data about intercontinental container throughput of European ports is from EUROSTAT.

Spatial pattern and main observations

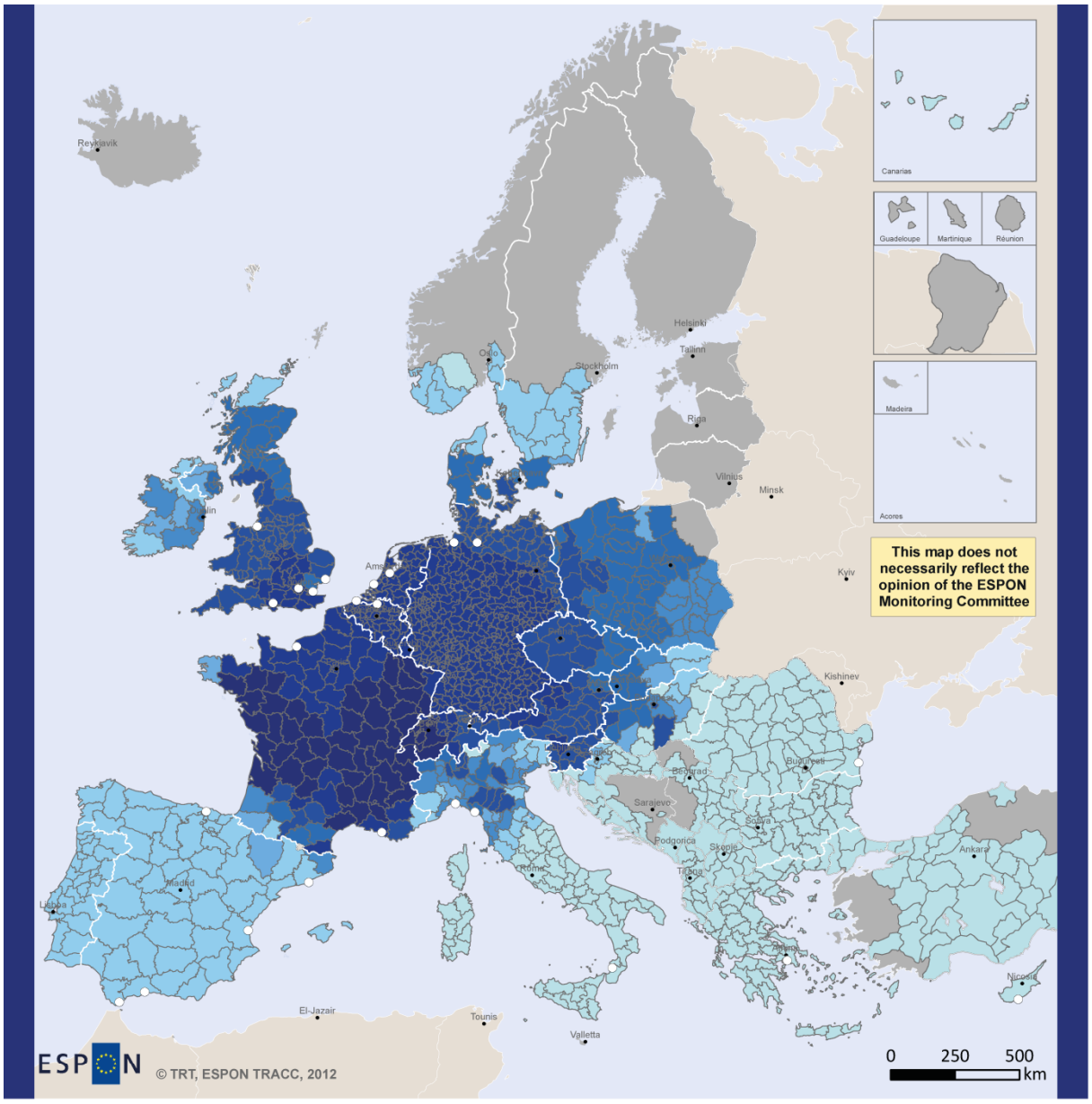
As far as road is concerned, a clear separation is visible between central Europe and periph-

eral Europe in terms of global freight connectivity. Peripheral regions are connected to a much lower amount of intercontinental container throughput and several regions in the north are even unable to reach an intercontinental container port within 36 hours by road. Within the periphery, the western regions are better than the south-eastern ones. This is due to the geographical position of the more important intercontinental ports (most are in the North Sea) but also to the poorer road infrastructure in the Balkan area (some zones in the former Yugoslavia region show a very poor global freight connectivity).

The same pattern can be observed also for rail even if the larger time threshold together with the high density of intermodal centres allows more zones to be included among those with a high global freight connectivity.

When the water connectivity is considered, the map shows that even taking a period of three days (72 hours) the accessibility indicator is non-zero only for a few coastal zones. For all other zones, either loading time or navigation time or both makes all intercontinental container ports unreachable within the fixed time threshold. This applies also to regions located along some important inland waterways such as the Rhine river since barges are very slow and transhipment at ports is also time consuming (and furthermore barges can stop in intermediate ports to drop part of their load) such as only zones within a range of 200-250 km from ports can be reached (on average) within 72 hours.

The level of connectivity is therefore much different if land or water modes are considered, nevertheless the North Sea area is the one with the highest global freight connectivity. The ports in this area are the main gates towards overseas regions and the surrounding regions can enjoy a clear advantage in terms of accessibility.



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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), Intercontinental container throughput of ports (Eurostat data 2007-2009)
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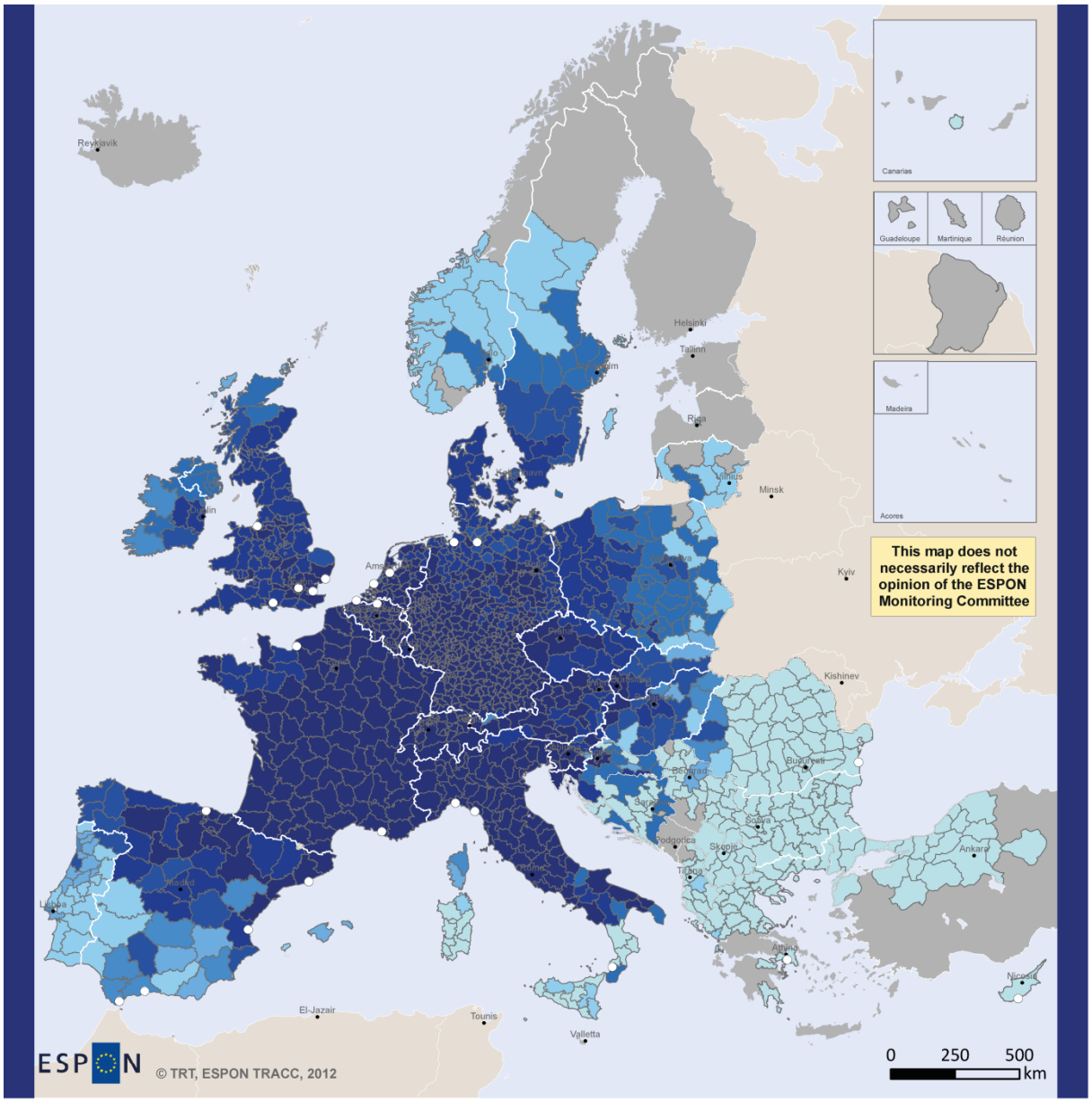
Global freight connectivity (2011):
Intercontinental container throughput (Ths. TEU) of European sea ports reachable within 36h road travel time (including resting times)

- 0 - 4 000
- 4 001 - 10 000
- 10 001 - 15 000
- 15 001 - 20 000
- 20 001 - 25 000
- 25 001 - 30 000
- 30 001 - 35 000
- 35 001 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.8. Global freight connectivity



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Source: TRUST Accessibility Model (TRT 2012), Road/Rail Network: TransTools (2005), Intercontinental container throughput of ports (Eurostat data 2007-2009)
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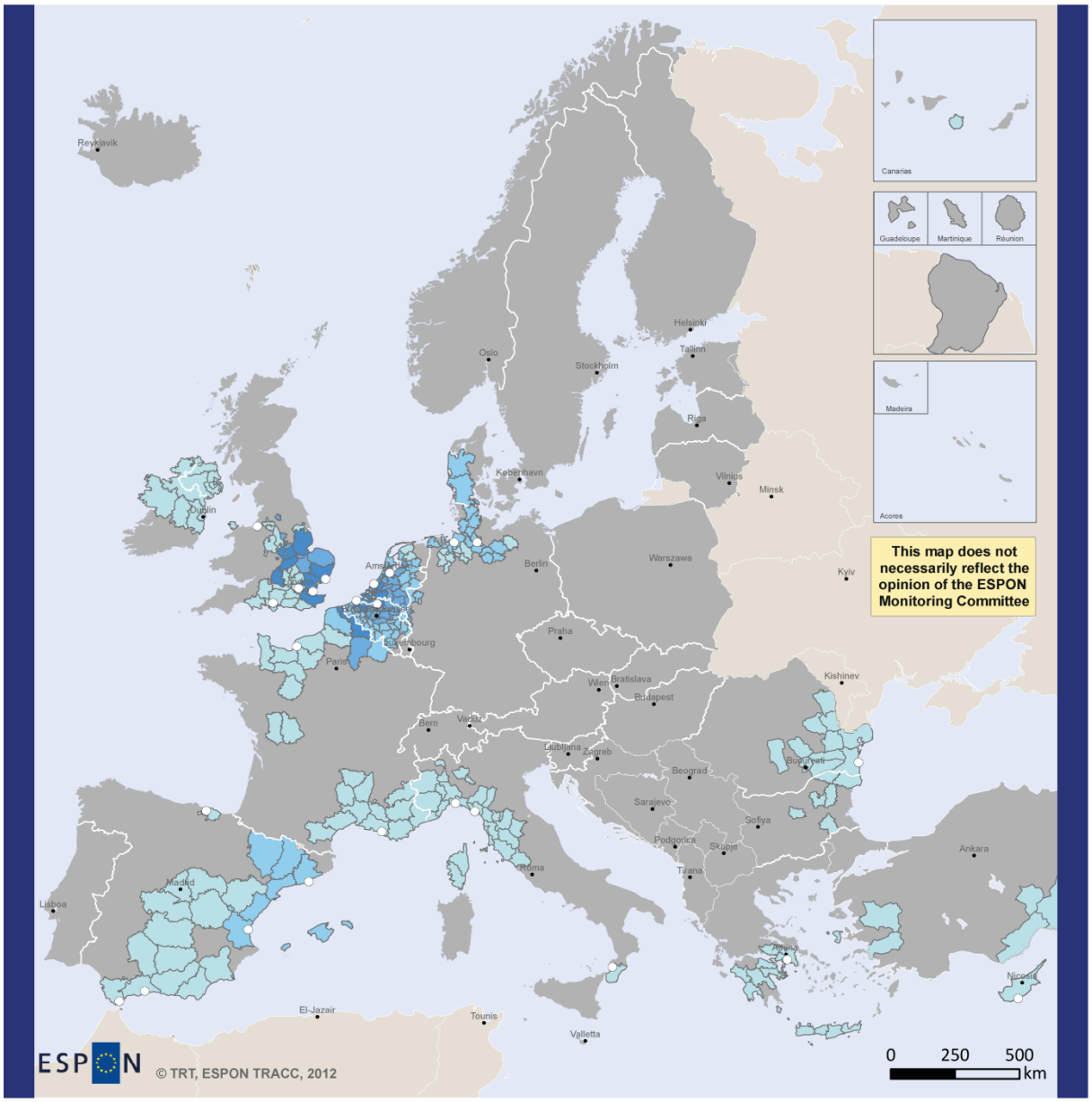
Global freight connectivity (2011):
Intercontinental container throughput (Ths. TEU) of European sea ports reachable within 48h rail travel time (2 days)

- 0 - 4 000
- 4 001 - 10 000
- 10 001 - 15 000
- 15 001 - 20 000
- 20 001 - 25 000
- 25 001 - 30 000
- 30 001 - 35 000
- 35 001 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.9. Global freight connectivity



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW Network: RRG GIS Database, Intercontinental container throughput of ports (Eurostat data 2007-2009)
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Global freight connectivity (2011):
Intercontinental container throughput (Ths. TEU) of European sea ports reachable within 72h Sea Shipping/Inland Waterway travel time (3 days)

- 0 - 4 000
- 4 001 - 10 000
- 10 001 - 15 000
- 15 001 - 20 000
- 20 001 - 25 000
- 25 001 - 30 000
- 30 001 - 35 000
- 35 001 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.10. Global freight connectivity

2.6 Global potential accessibility freight

Indicator name Global potential accessibility freight		
Spatial context Global	**Basic characteristics** Freight	**Generic type** Potential accessibility
Spatial level NUTS3 regions	**Origins** NUTS3 regions	**Destinations** Intercontinental European container ports
Modes Road – Rail – Water (coastal sea shipping and inland navigation) – multimodal		

Description and rationale

The indicator is a construct of two functions:

- attractiveness of the intercontinental ports measured by their intercontinental container throughput
- generalised cost needed to reach the intercontinental ports from the regions using a given mode

This indicator allows to identify a ranking of the regions according to their proximity to the main gates for the global trade. The accessibility to all intercontinental ports matters so being very close to just one big port is not enough to get a high rank according to this indicator.

Equation

$IND_{im} = \Sigma_{h \in H} W_h^{\alpha} GTC_{ihm}^{-\beta}$

Where:

H = set of European container ports connected to overseas destinations.

GTC_{ihm} = Generalised cost (in €/ton) to reach port h from zone i using mode m

W_h = Intercontinental container throughput of port h

α,β = Calibration parameters

Details on the indicator calculation

The generalised travel cost from each zone to the intercontinental ports is computed by means of modelling assignment. For each mode an independent assignment is performed. For mode "water" ports can be accessed either by inland navigation or by coastal sea shipping. Zones without a maritime or inland port can reach the most convenient one by road or rail used as feeder modes. Travel time includes any fixed time, e.g. loading, transhipment during intermodal chains. Also resting time for truck drivers is considered in the calculation.

Multimodal indicator is computed using the logsum of the generalised cost of single modes:

$GTC_{ih} = -1/\lambda * ln\Sigma_m \, exp(-\lambda * GTC_{ihm})$

The λ parameter has been set to 0.5

The value of the indicator depends on the calibration parameters α,β. As usual the α parameter is set to 1 (i.e. the attractiveness of the ports is measured by the pure value of their intercontinental throughput). The β is set to 0.5 as this value has proved to provide the most convincing distribution of values across zones.

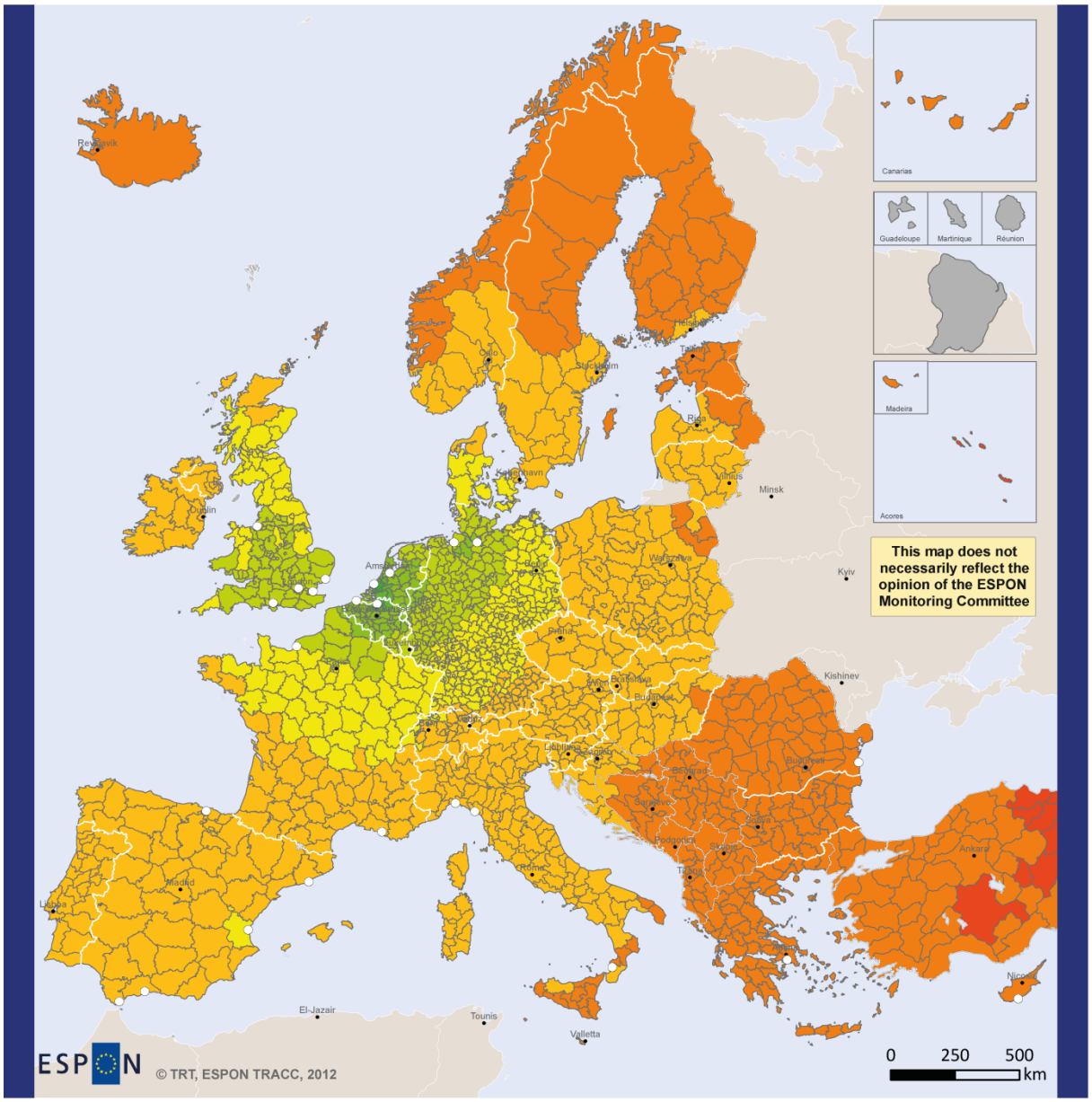
The mapped values are ratios with respect to the average (for each mode the own average has been considered).

Database

NUTS-3 region boundaries come from (ESPON database). Transport networks come from the TRANS-TOOLS model (road, rail), the RRG GIS Database (inland navigation) and the TRUST model (maritime). Data about intercontinental container throughput of European ports is from EUROSTAT.

Spatial pattern and main observations

For all modes, global potential accessibility shows a clear centre-to-periphery pattern with Benelux, north-west of Germany, north of France and South England ranked well above the average. This pattern is explained since North Sea ports are the most attractive destinations and are generally quite conveniently accessible given their central position (of course that the biggest ports are also central is probably not a mere combination). The pattern is particularly clear for road accessibility as road infrastructures are more evenly distributed than terminals, intermodal centres, etc. Rail accessibility, for instance, shows some discontinuity because of the location of intermodal centres. Two zones close to each other, one with an intermodal centre and the other without such facility can have more different accessibility than just their relative position might suggest. This is even clearer for water accessibility, for which coastal zones are generally ranked higher than inner zones, with the exception of the regions where inland waterways are well developed. Since such zones are close to the North Sea ports, the spatial pattern is strengthen. The multimodal indicator confirms the better accessibility of the zones around the North Sea although some coastal zones in the periphery are close or above to the average.



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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), Intercontinental container throughput of ports (Eurostat data 2007-2009)
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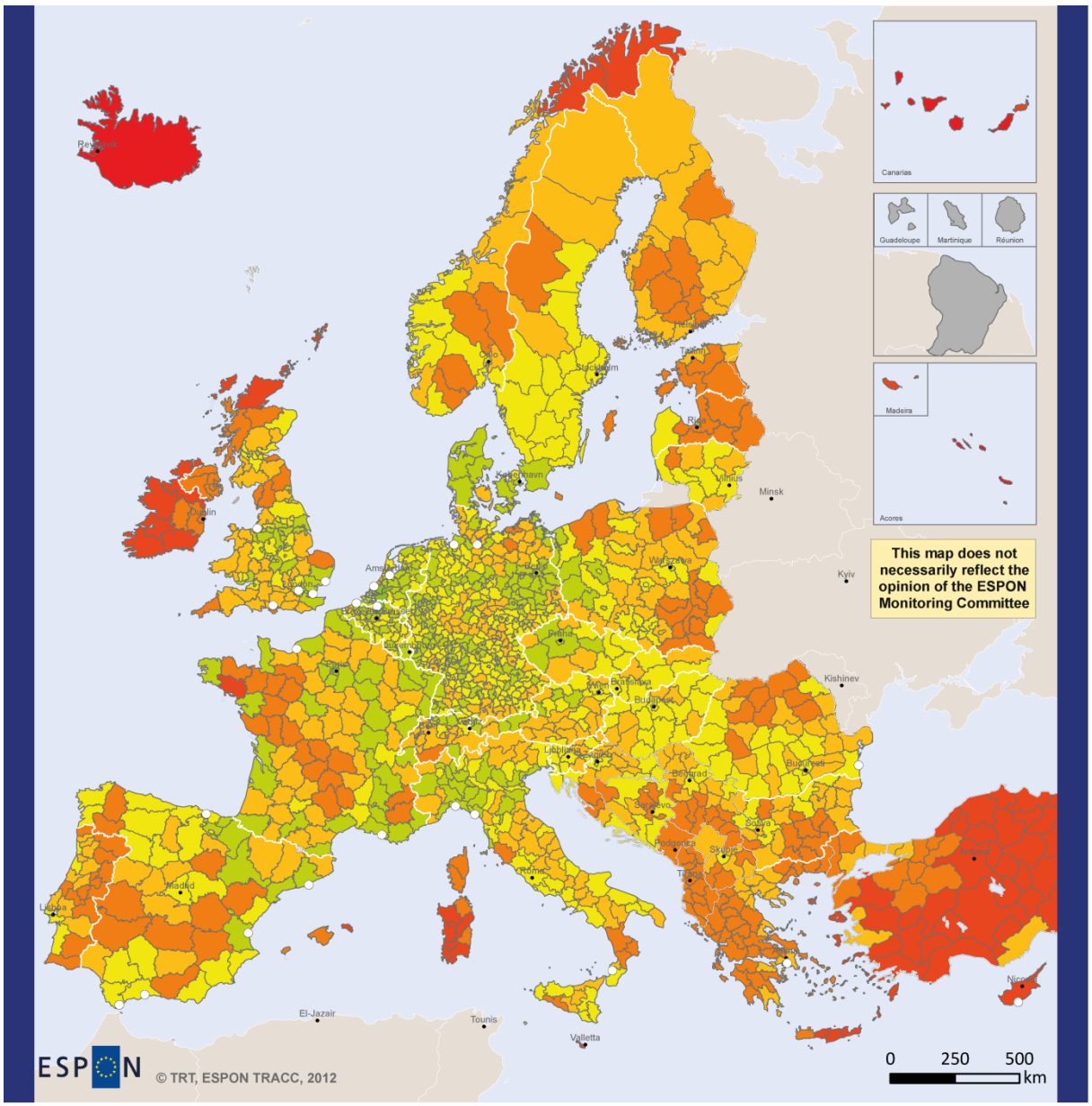
Global potential accessibility freight (2011):
by road to intercontinental container throughput of European sea ports
(percentage of average accessibility by road of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.11. Global potential accessibility freight by road



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Source: TRUST Accessibility Model (TRT 2012), Road/Rail Network: TransTools (2005), Intercontinental container throughput of ports (Eurostat data 2007-2009)
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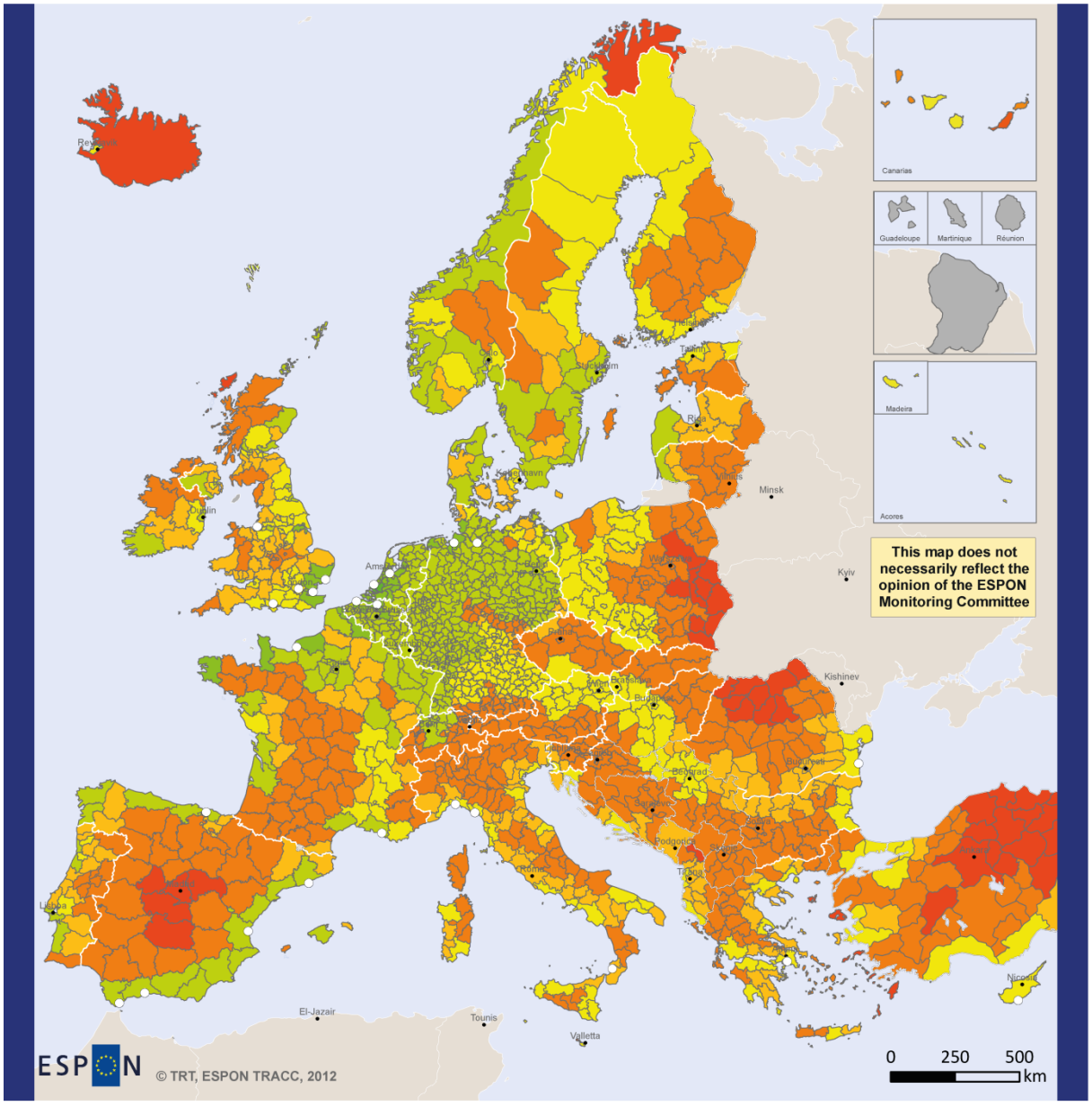
Global potential accessibility freight (2011):
by rail to intercontinental container throughput of European sea ports
(percentage of average accessibility by rail of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.12. Global potential accessibility freight by rail



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW Network: RRG GIS Database, Intercontinental container throughput of ports (Eurostat data 2007-2009)
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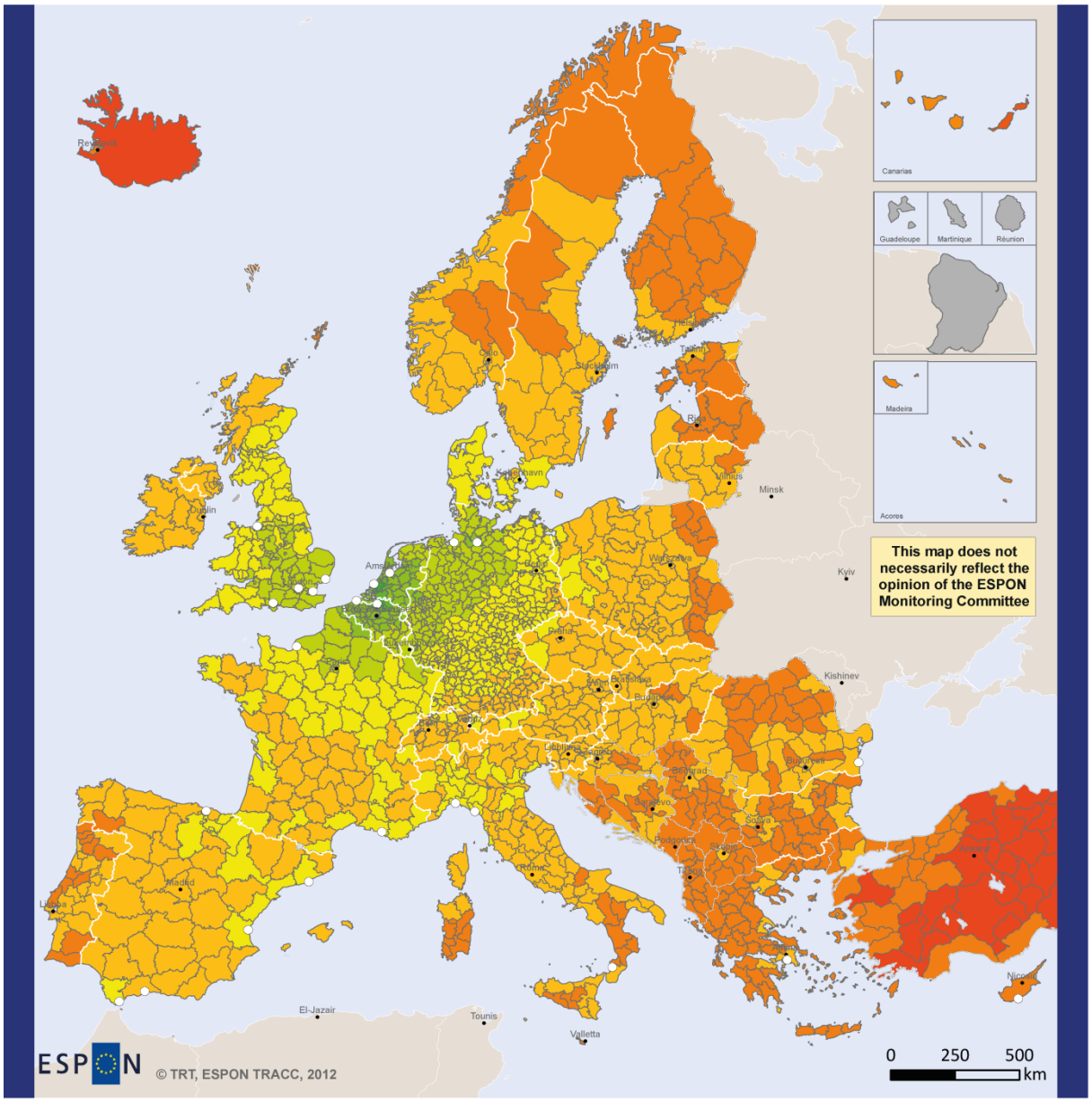
Global potential accessibility freight (2011):
by Water mode (unitised) to intercontinental container throughput of European sea ports (percentage of average accessibility by Water of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.13. Global potential accessibility freight by water



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW/Air Freight Network: RRG GIS Database, Intercontinental container throughput of ports (Eurostat data 2007-2009)
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Multimodal Global potential accessibility freight (unitised) (2011): to intercontinental container throughput of European sea ports (percentage of average accessibility of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

- *Capital cities*
- *Intercontinental Container Seaport (>250000 TEU/year)*

Figure 2.14. Multimodal global potential accessibility freight

3 European accessibility indicators

3.1 Access to top group of MEGAs

Indicator name Access to top group of MEGAs		
Spatial context European	**Basic characteristics** Travel	**Generic type** Travel cost
Spatial level NUTS-3 regions	**Origins** NUTS-3 regions	**Destinations** Top group of MEGAs
Modes Fastest (of road, rail, air)		

Description and rationale

The travel time to the top level of urban agglomerations in Europe is an indication of the regional linkages to the urban system in Europe. The indicator gives the average travel time from the regions to the upper level subset of the European MEGAs? For each NUTS-3 region the fastest travel time of road, rail and air transport to reach each core of the top group of MEGAs is calculated. The indicator expresses the average travel time. .

Equation

$$A_i = \frac{\sum_j c_{ijf}}{n}$$

Where:

A_i is the accessibility indicator value for region i, i.e. the average fastest travel time to the top group of MEGAs

c_{ijf} is the shortest travel time between region i and the MEGA j by fastest mode f

n is the number of MEGAs belonging to the top group of MEGAs

Details on the indicator calculation

For each NUTS-3 region the fastest travel time of road, rail and air to reach the top level of MEGAs has been calculated. The top level of MEGAs consist of 27 MEGAs as identified by the ESPON project 1.1.1 of the ESPON Programme 2006, namely Madrid, Barcelona, Paris, Geneva, Zürich, Torino, Milano, Roma, Wien, Athens, München, Stuttgart, Frankfurt, Köln, Düsseldorf, Hamburg, Berlin, Brüssel, Amsterdam, London, Manchester, Dublin, Kopenhagen, Oslo, Göteborg, Stockholm and Helsinki. The indicator value is expressed for each region as the average fastest travel time to these 27 destinations.

Database

Road and rail networks: RRG GIS database

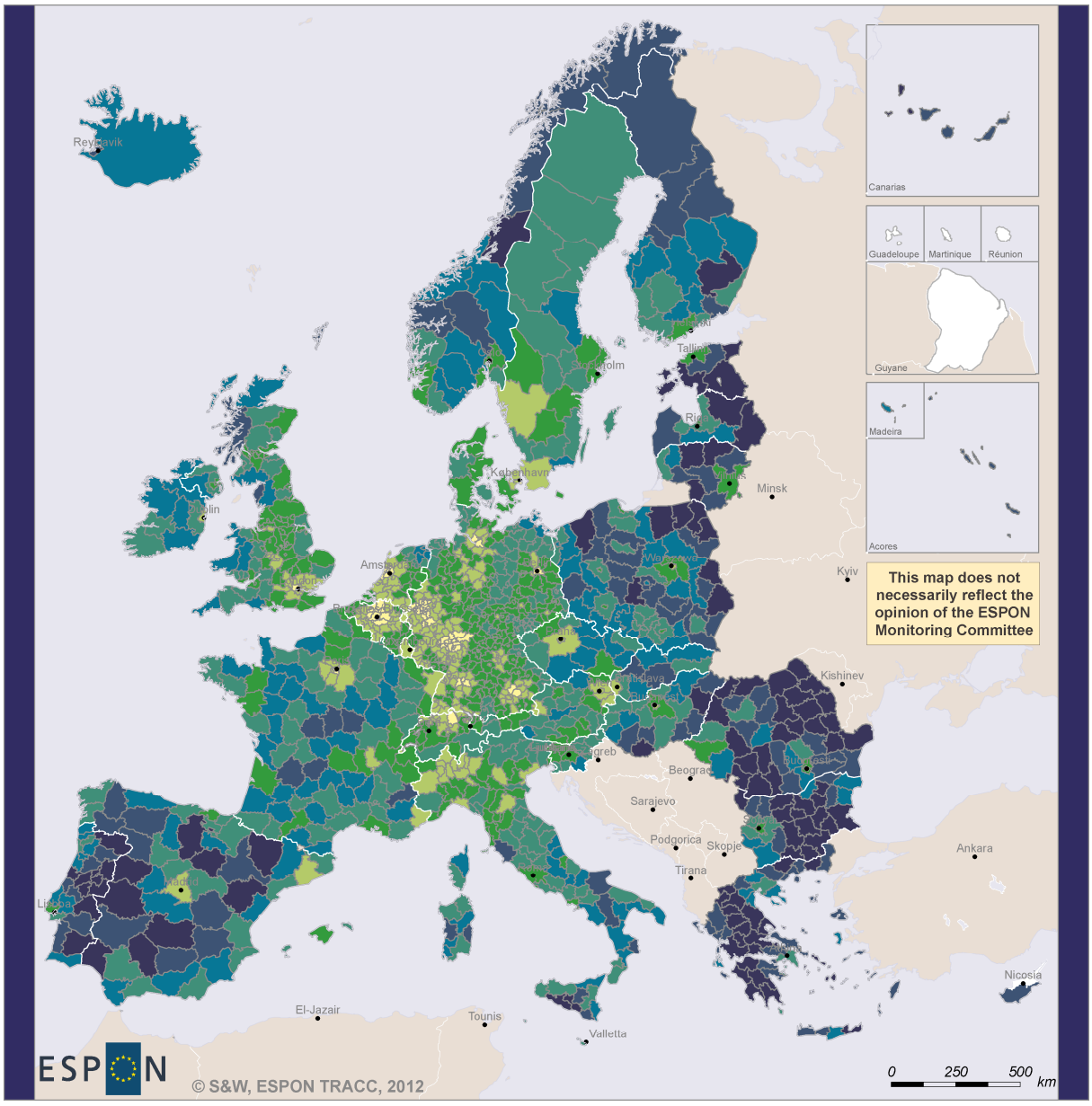
Flight network: S&W flight network

Top MEGA: ESPON 1.1.1 of ESPON Programme 2006

Spatial pattern and main observations

Figure 3.1 displays the average travel time value for the European regions. In correspondence with the location of top MEGAs across Europe, lowest average travel time are in regions located in the highly urbanised belt stretching from the UK via Benelux, western Germany and

Switzerland to Northern Italy. From here, travel time continuously increase towards the regions at the edge of the ESPON space. However, remarkable exceptions are regions around top MEGAs in those remote areas. The range of average travel time is from less than five hours to about twelve hours.



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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Average fastest travel time to top MEGAs

- 249 - 300
- 301 - 360
- 361 - 420
- 421 - 480
- 481 - 540
- 541 - 600
- 601 - 787
- no data

Figure 3.1. Access to top group of MEGAs by fastest mode

3.2 European daily accessibility travel

Indicator name European daily accessibility travel		
Spatial context European	**Basic characteristics** Travel	**Generic type** Cumulated opportunities
Spatial level NUTS-3 regions	**Origins** NUTS-3 regions	**Destinations** NUTS-3 regions and regions of neighbouring countries
Modes Road, rail, fastest mode (of road, rail, air)		

Description and rationale

How many people can be reached from a region within a day's round trip or how many people can visit my region within a day's round trip. This indicator of the cumulative opportunities group of accessibility indicators sums up the number of persons in other European regions that can be reached within a one way travel time of five hours (door-to-door). Five hours maximum travel time is used to allow for at least five hours of activities at the destinations before returning back in the evening, i.e. a maximum travel time of 15 hours; therefore the indicator is labelled as daily accessibility.

Equation

$$A_i = \sum_j P_j\, c \qquad c = 1 \quad if \;\; c_{ijm} \leq c_{max}$$
$$c = 0 \quad if \;\; c_{ijm} > c_{max}$$

Where:

A_i is the accessibility indicator value for region *i*, i.e. the daily accessibility value

Pj is the number of inhabitants living in region *j*

c_{ijm} is the shortest travel time between region *i* and the region *j* by mode *m*

c_{max} is the threshold value for the maximum travel time between regions

Details on the indicator calculation

For each NUTS-3 region the shortest travel times by road, rail and fastest mode (road, rail, air) to all other NUTS-3 regions in Europe and regions in neighbouring countries are calculated. If another region is within a maximum travel time of five hours, the population living in that region are added to the regional daily accessibility indicator of the origin region.

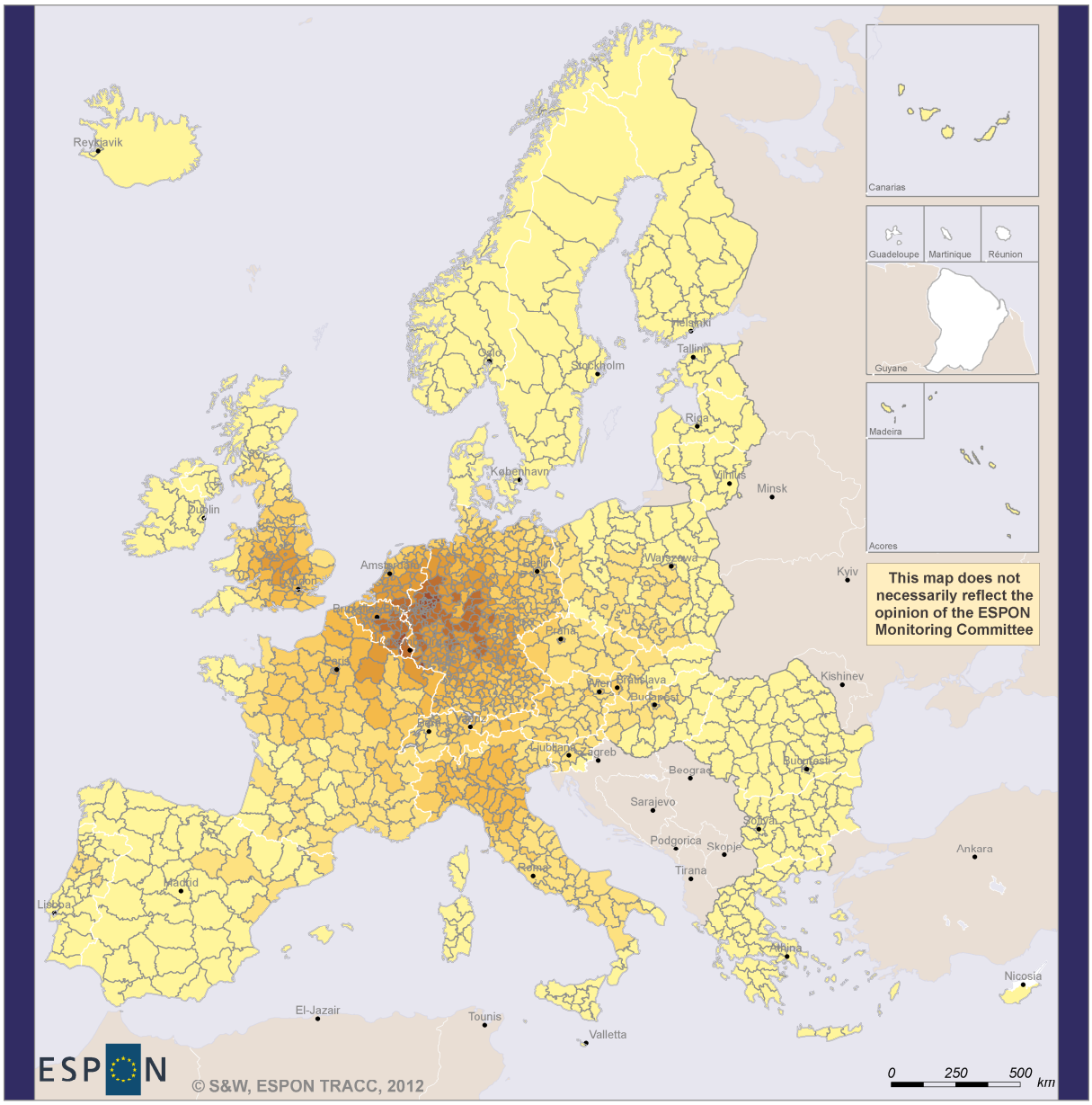
Database

Road and rail networks: RRG GIS database

Flight network: S&W flight network

Spatial pattern and main observations

Figures 3.2 to 3.4 show for road, rail and fastest mode chains that the range of daily accessibility values is between a few thousand persons reachable in rather remote areas and up to about 180 million people reachable from the best connected metropolitan areas in the UK, France, the Benelux countries, Germany and Switzerland



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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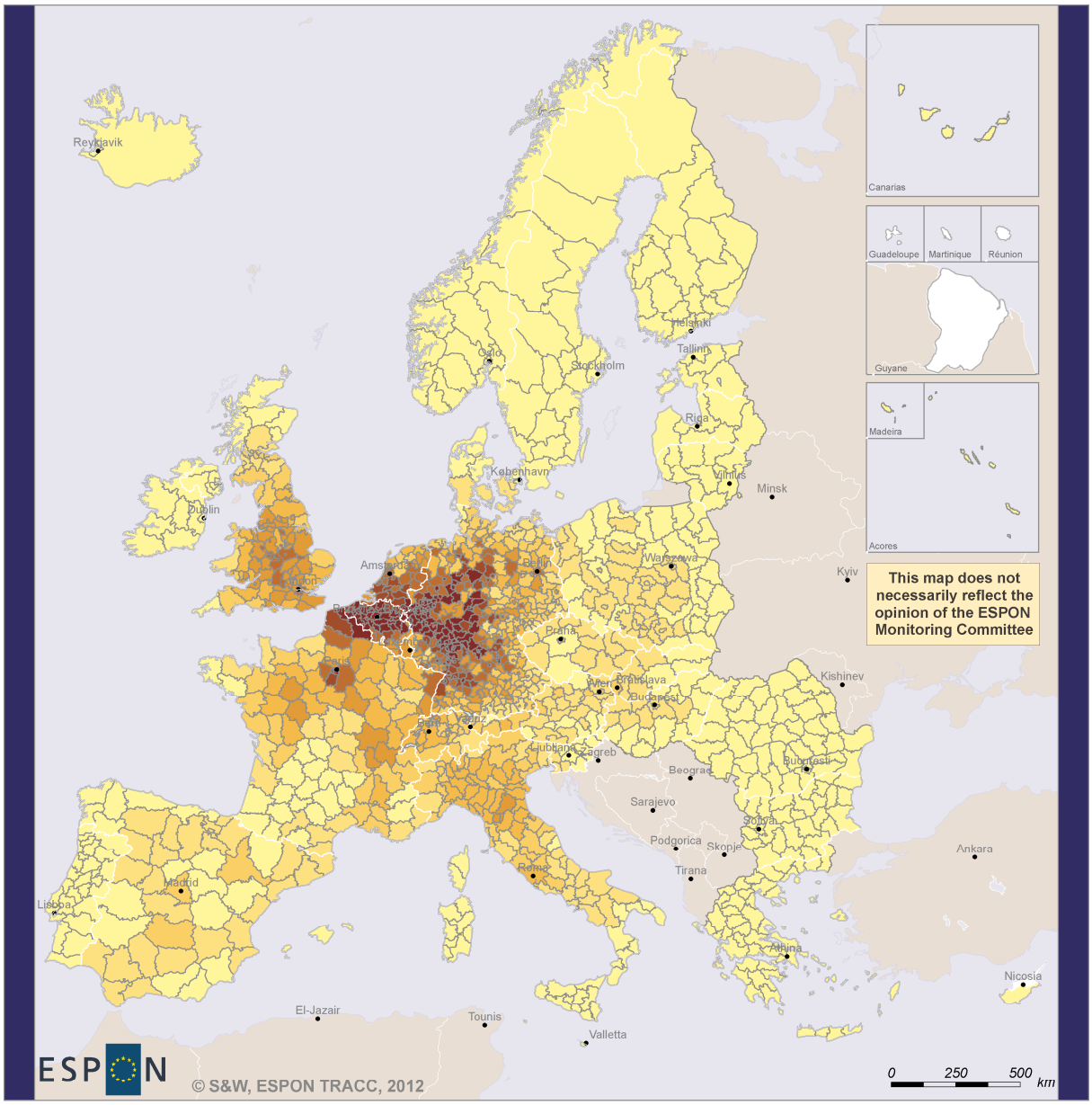
Population accessible within 5h by road

- ... - 10000000
- 10000001 - 20000000
- 20000001 - 30000000
- 30000001 - 40000000
- 40000001 - 50000000
- 50000001 - 60000000
- 60000001 - 70000000
- 70000001 - ...
- no data

Figure 3.2. European daily accessibility travel by road



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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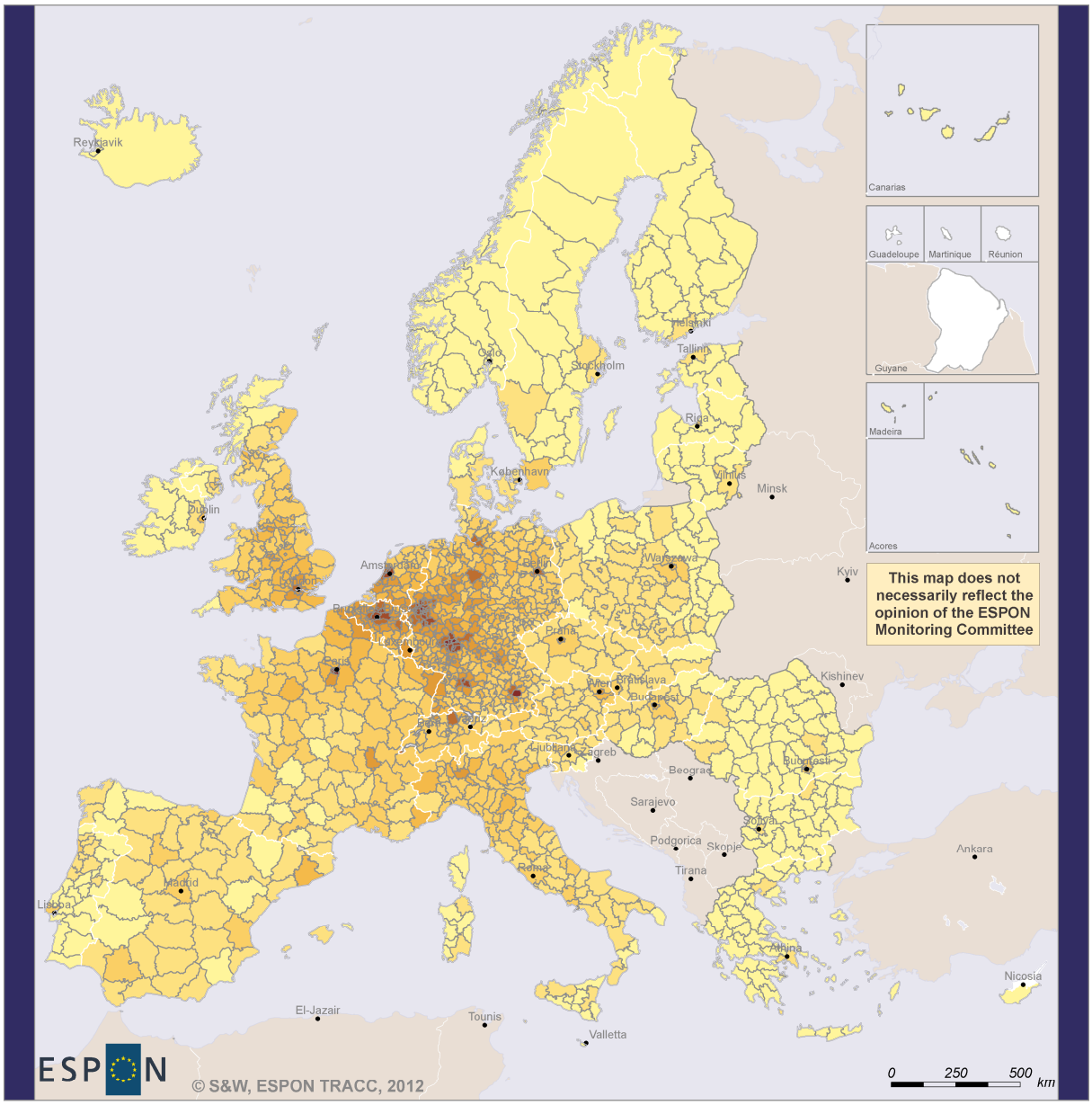
Population accessible within 5h by rail

- ... - 10000000
- 10000001 - 20000000
- 20000001 - 30000000
- 30000001 - 40000000
- 40000001 - 50000000
- 50000001 - 60000000
- 60000001 - 70000000
- 70000001 - ...
- no data

Figure 3.3. European daily accessibility travel by rail



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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Population accessible within 5h by fastest mode

- 72800 - 10000000
- 10000001 - 25000000
- 25000001 - 50000000
- 50000001 - 75000000
- 75000001 - 100000000
- 100000001 - 125000000
- 125000001 - 150000000
- 150000001 - 182420560
- no data

Figure 3.4. European daily accessibility travel by fastest mode

3.3 European potential accessibility travel

Indicator name European potential accessibility travel		
Spatial context European	**Basic characteristics** Travel	**Generic type** Potential
Spatial level NUTS-3	**Origins** NUTS-3	**Destinations** NUTS-3 regions and regions of neighbouring countries
Modes Road, rail, air, multimodal		

Description and rationale

Accessibility potential indicators are based on the assumption that the attraction of a destination increases with size and declines with distance or travel time or cost. Therefore both size and distance of destinations are taken into account. Population in the destination regions reflect the size, travel time the impedance.

The accessibility potential indicators reflect the relative competitive position of European regions towards European destinations.

Equation

$$A_i = \sum_j P_j \, exp(-\beta \, c_{ijm})$$

Where:

A_i is the accessibility indicator value for region *i*, i.e. the European accessibility potential travel

P_j is the population of region *j*

c_{ijm} is the shortest travel time between region *i* and the region *j* by mode *m*

Details on the indicator calculation

For each NUTS-3 region the population in all destination regions is weighted by the travel time to go there. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. All indicator values are expressed as index, i.e. related to the ESPON average. The potential accessibility indicator is calculated for road, rail, air and as an multimodal aggregate.

Database

Road and rail networks: RRG GIS database

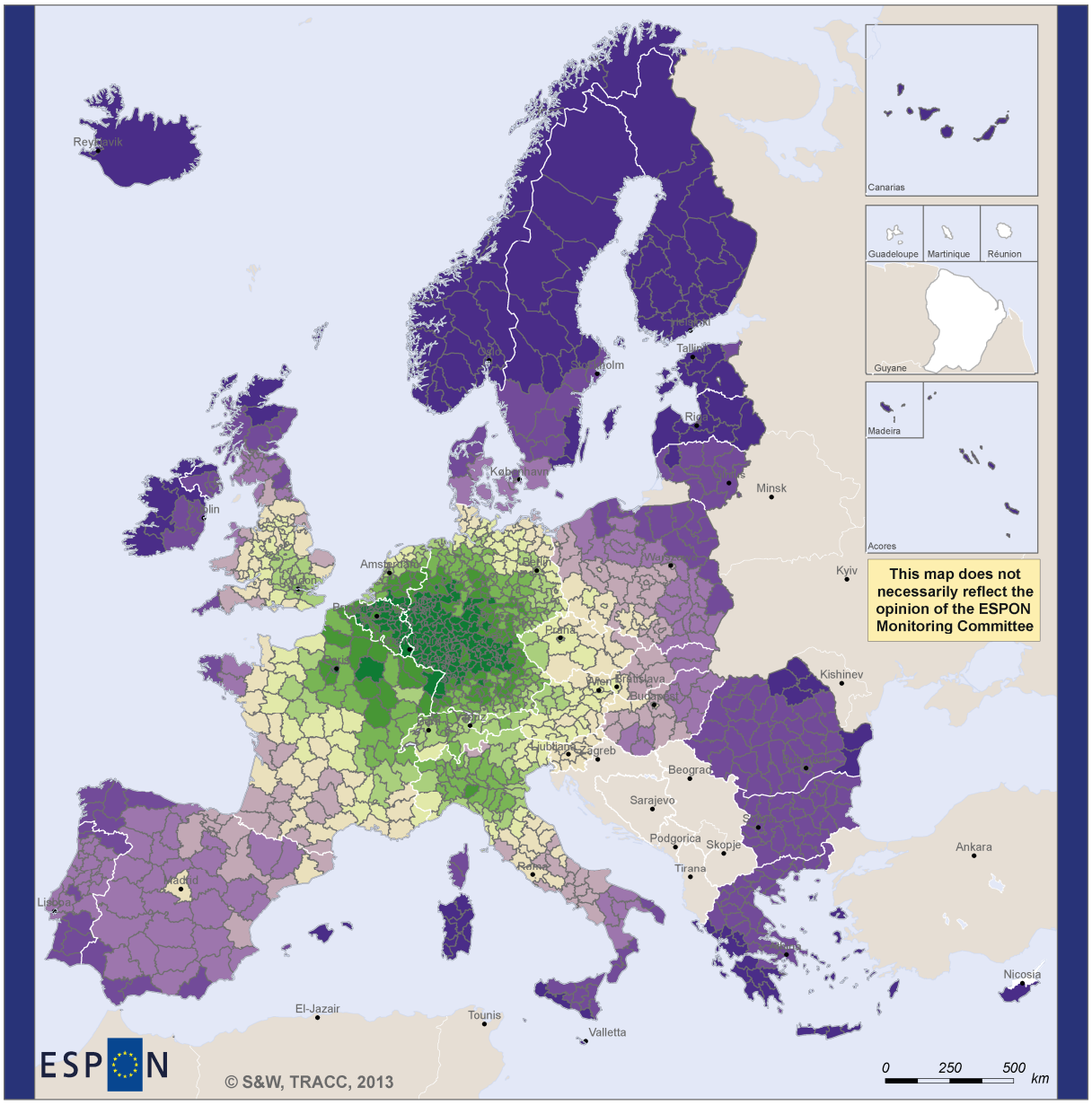
Flight network: S&W flight network

Spatial pattern and main observations

Accessibility potential by road and rail show the traditional core-periphery pattern in Europe with highest accessibility in Belgium and neighbouring regions of Germany (Figures 3.4 and 3.5). Because high-level road infrastructure serves all regions there, highest accessibility forms a plateau. High-speed rail serves hubs and corridors, so, highest accessibility is visible along major corridors. In addition, high-speed rail is able to extent the areas of high accessibility to the outside. This is in particular visible in France with the corridors of high accessibility towards the Atlantic and the Mediterranean Sea. For both transport modes, accessibility goes gradually down when coming to regions more apart from those high-accessibility areas.

Accessibility potential by air shows a distinct picture (Figure 3.6). The major airport regions and

their close surroundings have highest accessibility. This is also true in countries that have lower accessibility for other modes. Disparities in accessibility are now visible between but also within countries. Multimodal accessibility as a combination of the three modal accessibilities shows a somewhat intermediate spatial pattern (Figure 3.7). It can be seen that regions that are not served by good air connection might be compensated by other good transport links for road and in particular rail. However, this is true for regions in France, Germany etc., but not for regions in Eastern Europe.



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Regional level: NUTS 3
Source: Spiekermann and Wegener
Urban and Regional Research (S&W), 2013
Origin of data: S&W Accessibility Model, 2013
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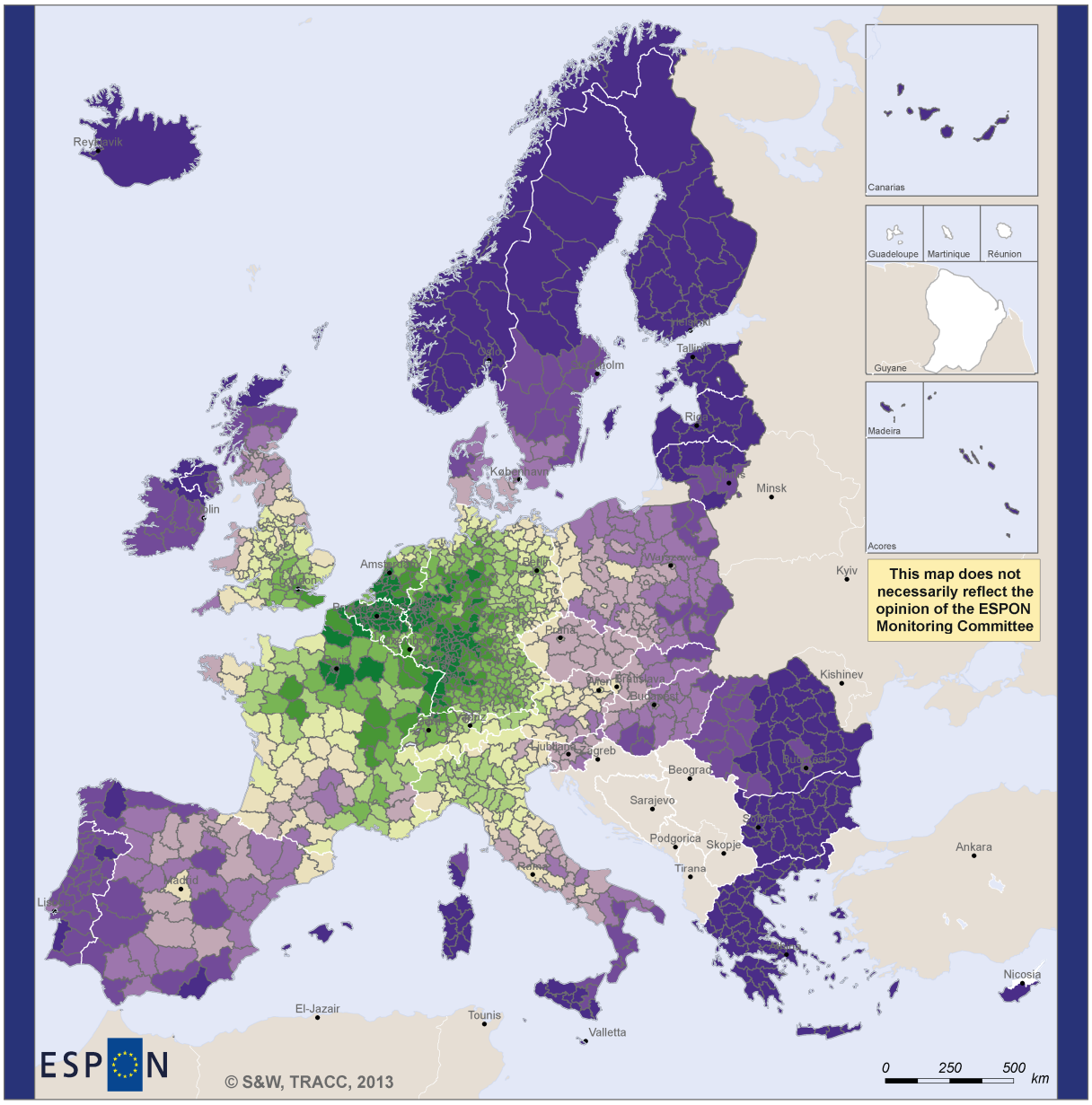
Accessibility potential, road (ESPON = 100)
2011

0 - 20	very peripheral
21 - 40	
41 - 60	peripheral
61 - 80	
81 - 100	intermediate
101 - 120	
121 - 140	central
141 - 160	
161 - 180	very central
181 - ...	

no data

Figure 3.5. European potential accessibility travel by road



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Regional level: NUTS 3
Source: Spiekermann and Wegener Urban and Regional Research (S&W), 2013
Origin of data: S&W Accessibility Model, 2013
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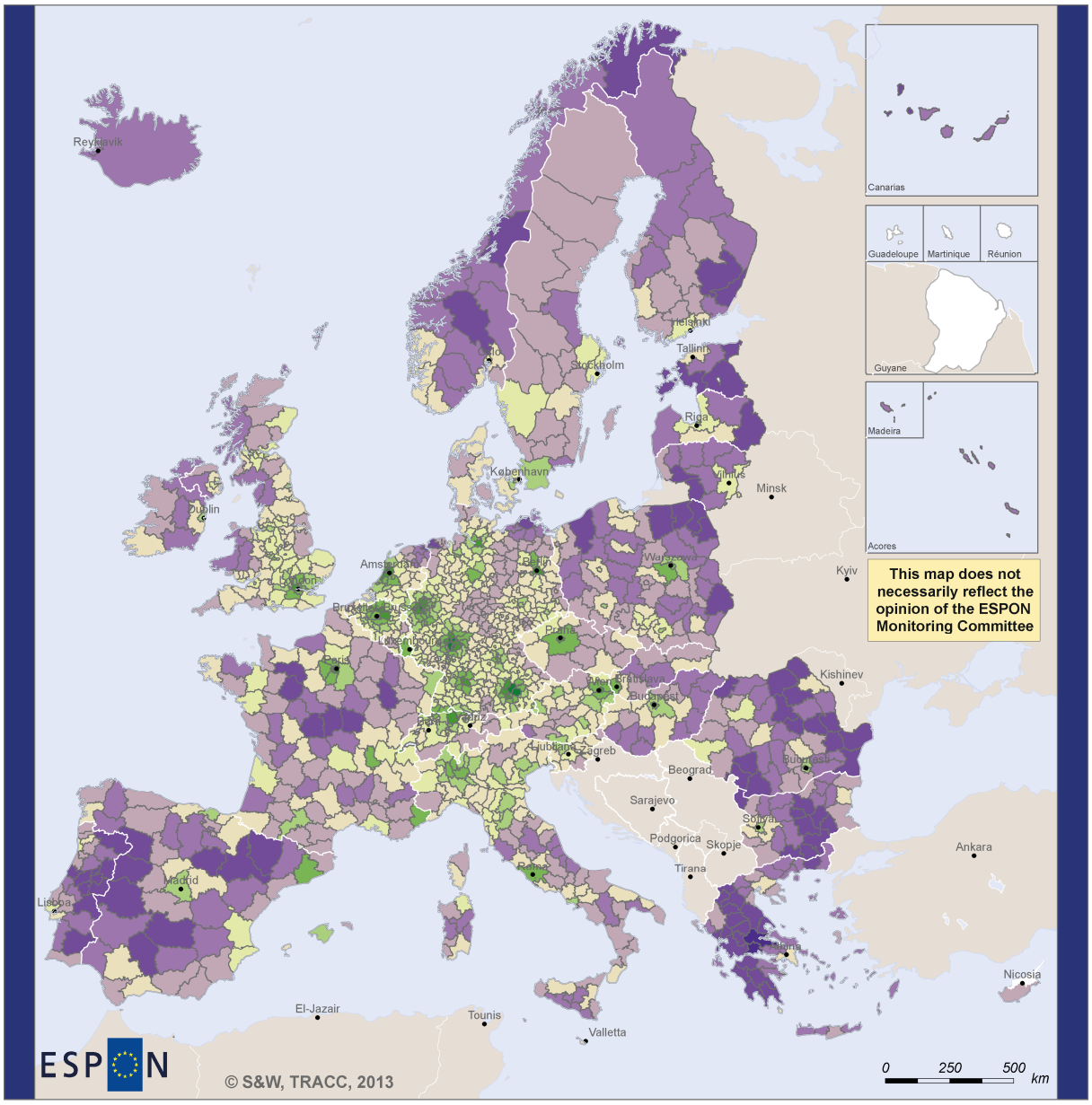
Accessibility potential, rail (ESPON = 100)
2011

0 - 20	very peripheral
21 - 40	
41 - 60	peripheral
61 - 80	
81 - 100	intermediate
101 - 120	
121 - 140	central
141 - 160	
161 - 180	very central
181 - ...	

no data

Figure 3.6. European potential accessibility travel by rail



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Regional level: NUTS 3
Source: Spiekermann and Wegener Urban and Regional Research (S&W), 2013
Origin of data: S&W Accessibility Model, 2013
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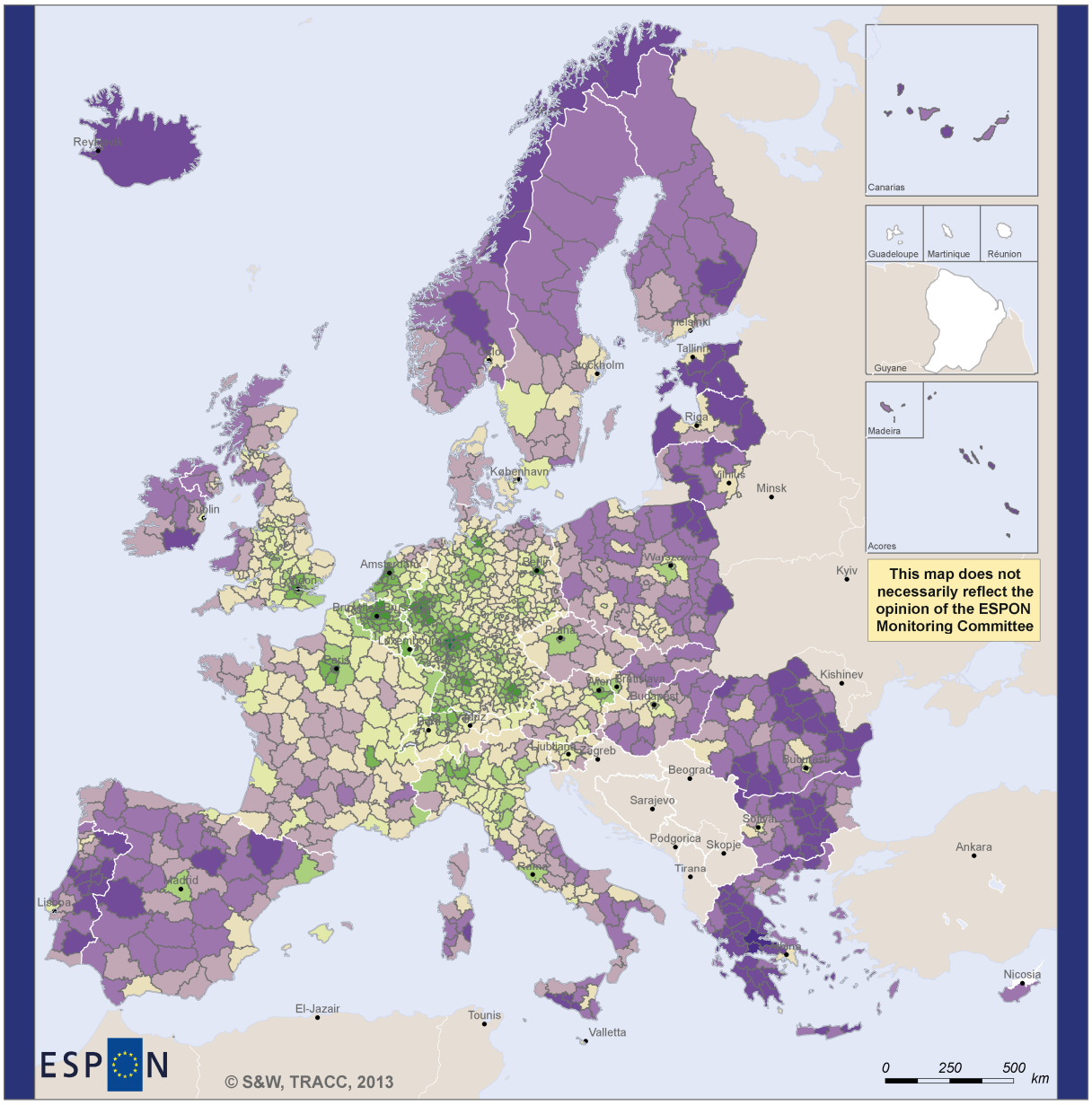
Accessibility potential, air (ESPON = 100)
2011

0 - 20	very peripheral
21 - 40	
41 - 60	peripheral
61 - 80	
81 - 100	intermediate
101 - 120	
121 - 140	central
141 - 160	
161 - 180	very central
181 - ...	

no data

Figure 3.7. European potential accessibility travel by air



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Regional level: NUTS 3
Source: Spiekermann and Wegener
Urban and Regional Research (S&W), 2013
Origin of data: S&W Accessibility Model, 2013
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Accessibility potential, multimodal (ESPON = 100)
2011

0 - 20	very peripheral
21 - 40	
41 - 60	peripheral
61 - 80	
81 - 100	intermediate
101 - 120	
121 - 140	central
141 - 160	
161 - 180	very central
181 - ...	

no data

Figure 3.8. European potential accessibility travel multimodal

3.4 Travel Speed

Indicator name Travel speed		
Spatial context European	**Basic characteristics** Travel	**Generic type** Travel cost
Spatial level NUTS-3 regions	**Origins** NUTS-3 regions	**Destinations** NUTS-3 regions
Modes Road, rail		
Description and rationale What is the average travel speed to serve regional transport demand? The rationale of this indicator is based on the assumption that transport policy cannot provide the same degree of accessibility everywhere in Europe, but might provide the same quality of the infrastructure by delivering comparable speeds to the regional transport demand. First, regional transport demand will be calculated by a negative exponential model in which the number of trips from the region to all other regions is estimated. Then, the travel time to the destination regions will be converted to airline speeds. Finally, the average travel speed of a region will be calculated as the trip-weighted average speed to all other regions. This will be done for rail and road modes.		
Equation indicator not implemented		
Details on the indicator calculation First, regional transport demand is calculated by a negative exponential model in which the number of trips from the region to all other regions is estimated. Then, the travel time to the destination regions is converted to airline speeds. Finally, the average travel speed of a region is calculated as the trip-weighted average speed to all other regions.		
Database indicator not implemented		
Spatial pattern and main observations indicator not implemented		

3.5 Urban connectivity

Indicator name Urban connectivity		
Spatial context Europe	**Basic characteristics** Travel (new)	**Generic type** Cumulated opportunities
Spatial level Cities	**Origins** Cities >50,000 inhabitants	**Destinations** Cities > 50,000 inhabitants
Modes Road, rail, air, intermodal		

Description and rationale

What opportunities or restrictions does transport infrastructure provide to city citizens? The more cities that can be reached from a city within five hours travel time, the greater the opportunities are for business activities, networking or for social interaction.

Equation

For each city of that minimum size travel time to all other cities of that minimum size will be calculated. Urban connectivity is given if the travel time is less than 300 minutes (5 hours).

Details on the indicator calculation

City-to-city travel times of more than 300 minutes are excluded. The intermodal indicator is defined as the fastest city-to-city travel time of the three modes road, rail and air. Due to the large number of city pairs, the indicator maps are divided into domestic maps and international maps. While the first one is restricted to show the city-to-city within one country, the latter one only illustrates the cross-border relations.

Database

The trans-European road and rail networks as well as the location of 1,760 cities with more than 50,000 inhabitants in Europe are taken from the RRG GIS Database. Relevant road and rail ferries are included in this database. The flight network was generated by using information of flight schedules provided by the OAG in relation to the airport locations provided by the RRG GIS Database.

Spatial pattern and main observations

The urban connectivity is both a function of the number and density of regional cities, and the density and quality of the transport networks.

Urban connectivity in the domestic domain is highest for road and rail (Figures 3.9 and 3.10) for the Benelux countries, Western Germany, Italy, England and for Northern France and for the relation Paris-Lyon. In the New EU Member States, only Hungary and parts of Poland yield high connectivity. The other East European countries, so as Scandinavia, Ireland and also Portugal show poorer levels of city connectivity, mostly due to on average much longer travel times. Adding domestic passenger flights changes the picture significantly (Figure 3.11). In particular connectivity of cities in the far North (mainly connecting the smaller cities with their capitals), in the UK (connecting Scottish cities and the islands with the cities in the south), in Spain, and in Portugal and Greece (adding connectivity between many far-distant cities and with the islands) increased drastically, leading altogether to a fairly good urban connectivity in Europe, where for most city-to-city relations the citizens can at least choose one of the modes to reach the destination in less than five hours (Figure 3.12).

But also some negative evidences remain, even when looking at intermodal connectivity: Cities in the far North of Norway, Sweden and Finland only have air connectivity, and in most cases

only to the capital. City-to-city relations to other cities than the capital from these origins are very scarce, limiting accessibility between the northernmost regions. Also, in many East European countries the urban connectivity is rather poor. Though many city-to-city relations lie within the five hours threshold, the travel time tend to be longer compared to Western Europe due to the relatively poor transport networks and the absence of high-level transport infrastructures. Thus, what would be a one-hour trip in the old EU Member States becomes a two or three hour or even longer trip in Bulgaria, Romania, or the countries of former Yugoslavia. Austria and Switzerland, on the other hand, having dense and high-quality transport networks, ensure high urban connectivity with rather low travel times, despite the difficult topography.

International urban connectivity for road and rail (Figure 3.13 and 3.14) is mainly restricted to neighbouring countries: Relations within the Benelux countries and towards Northern France and Western Germany are those with highest accessibilities, so as relations between Portugal and Spain, Spain and France, France and Switzerland and Italy. For road, there are also many fast city-to-city relations along the former Iron Curtain between East Germany and Poland and the Czech Republic, between Austria and Slovakia and Hungary, as well as between Italy and Slovenia and Croatia. Interestingly, rail travel times for these latter connections are much longer compared to road illustrating the poorer cross-border rail connections in these areas. High-speed train services in turn also offer cities in great distance to national borders accessibility to other agglomerations within 300 minutes. For instance, cities in southern Italy are connected to cities in Southern France or in Slovenia, cities in the Brittany are connected through fast trains with cities in Belgium and Germany, and many Danish cities can for instance reach Stockholm, Gothenburg or even Oslo by fast train services. The Channel tunnel also connects many English cities by train to Benelux and to Northern France, including Brussels and Paris.

Passenger flights (Figure 3.15) add another dimension of urban connectivity on top of fast train services. Within five hours, the majority of European cities can be reached with each other, ensuring connectivity of peripheral and outermost regions such as Northern Scandinavia and Iceland, Cyprus and Malta, Portuguese, Spanish and Greek islands, and cities in East Europe. Consequently, the intermodal international urban connectivity (Figure 3.16) is dominated by passenger flights and high-speed train services. Road mode is fastest in short-distance cross-border traffic, however, while fast train services ensure connectivity in medium ranges.

Even though the intermodal urban connectivity looks quite promising in general, in detail there are still some interesting observations:

- Even though many East European cities can be reached quite well from Western Europe, connectivity between cities in the East is significantly lower. The number of city-to-city relations below 300 minute threshold within Eastern Europe is much lower compared to Western Europe, and if they exist travel times are on average much longer.
- Similarly, international urban connectivity between the Nordic countries is poor. Cities in the northernmost territories are mainly well connected by flights to the capitals, but not between themselves.
- For all modes results clearly visualise the ‘blue banana’, i.e. the area in Europe with highest accessibilities ranging from London via Benelux and Paris, along the river Rhine valley towards Northern Italy. Clearly for road and rail, but even for passenger flights o/d relations within this part of Europe show by far shortest travel times. This of course is first of all due to the rather dense network of cities (and consequently the short geographical distances between them), but also the high-standard transport infrastructures in these areas contribute to these high connectivities.
- Despite recent efforts to overcome the Pyrenees barrier, the Iberian Peninsula is still suspended from rest of Europe. For road and rail only very few o/d-relations are below five hours threshold, but even for passenger flights average travel times from Portugal or Spain to other countries are quite long.

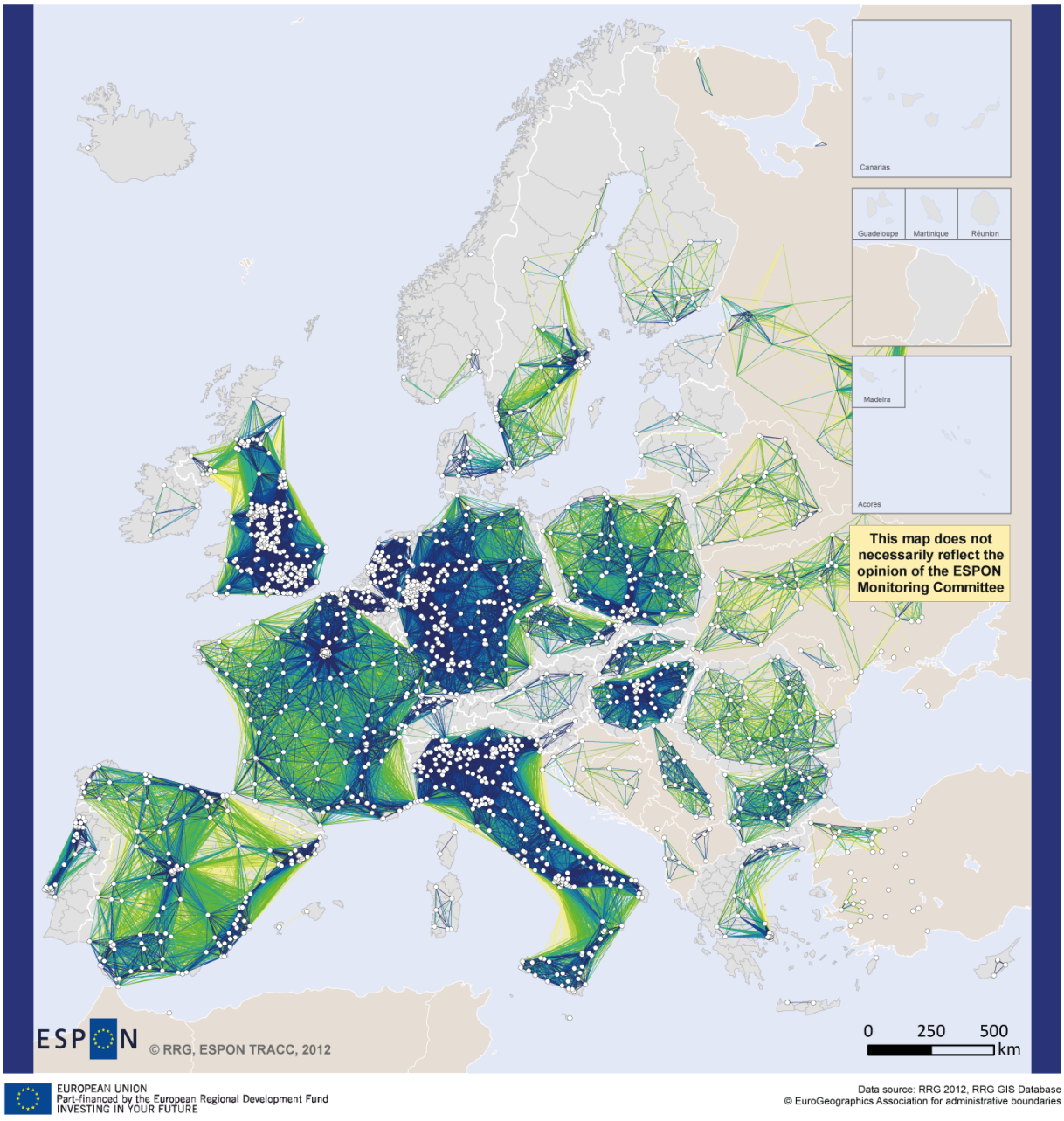


Figure 3.9. Urban connectivity, road, domestic

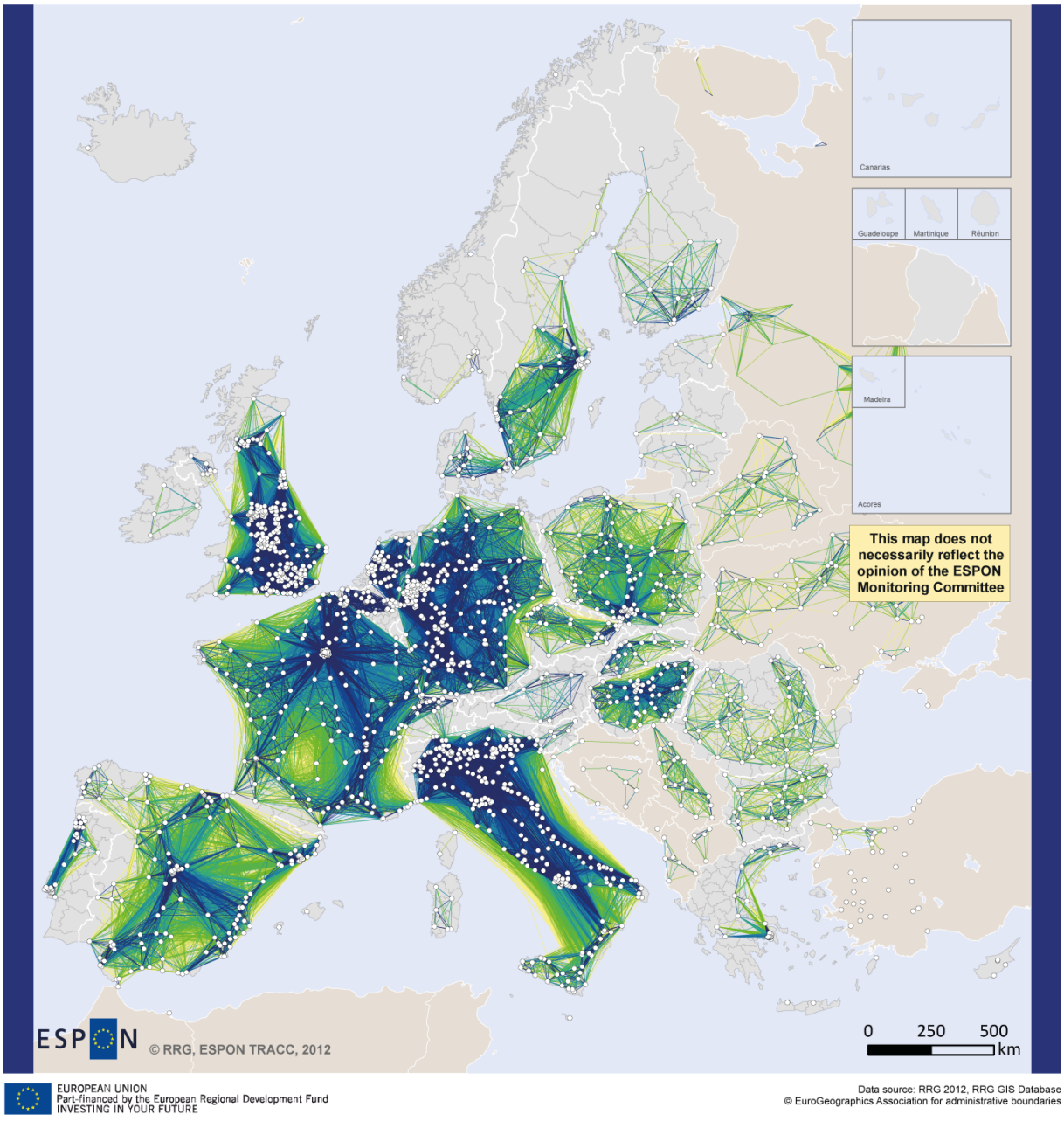


Figure 3.10. Urban connectivity, rail, domestic

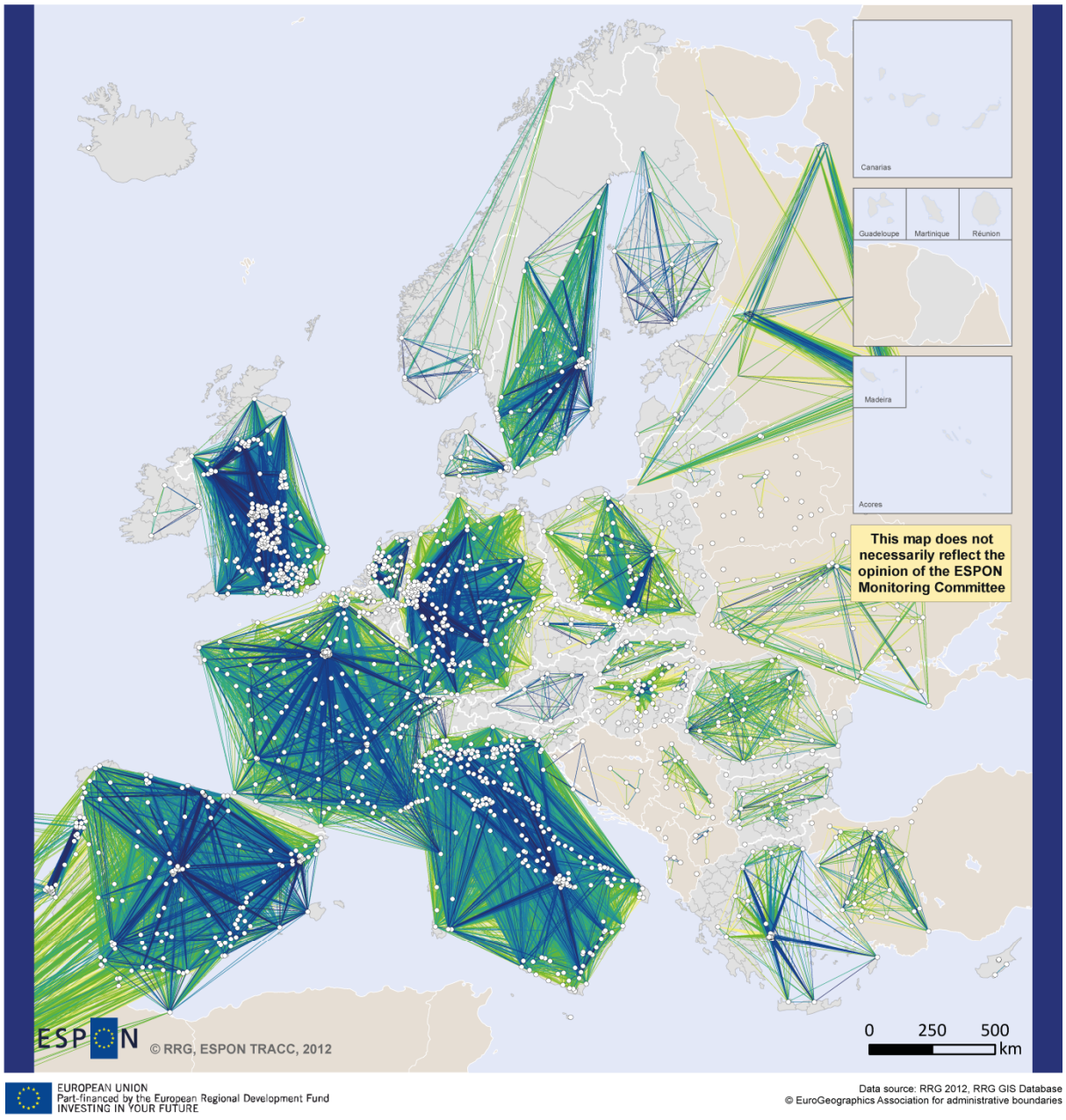


Figure 3.11. Urban connectivity, passenger flights, domestic

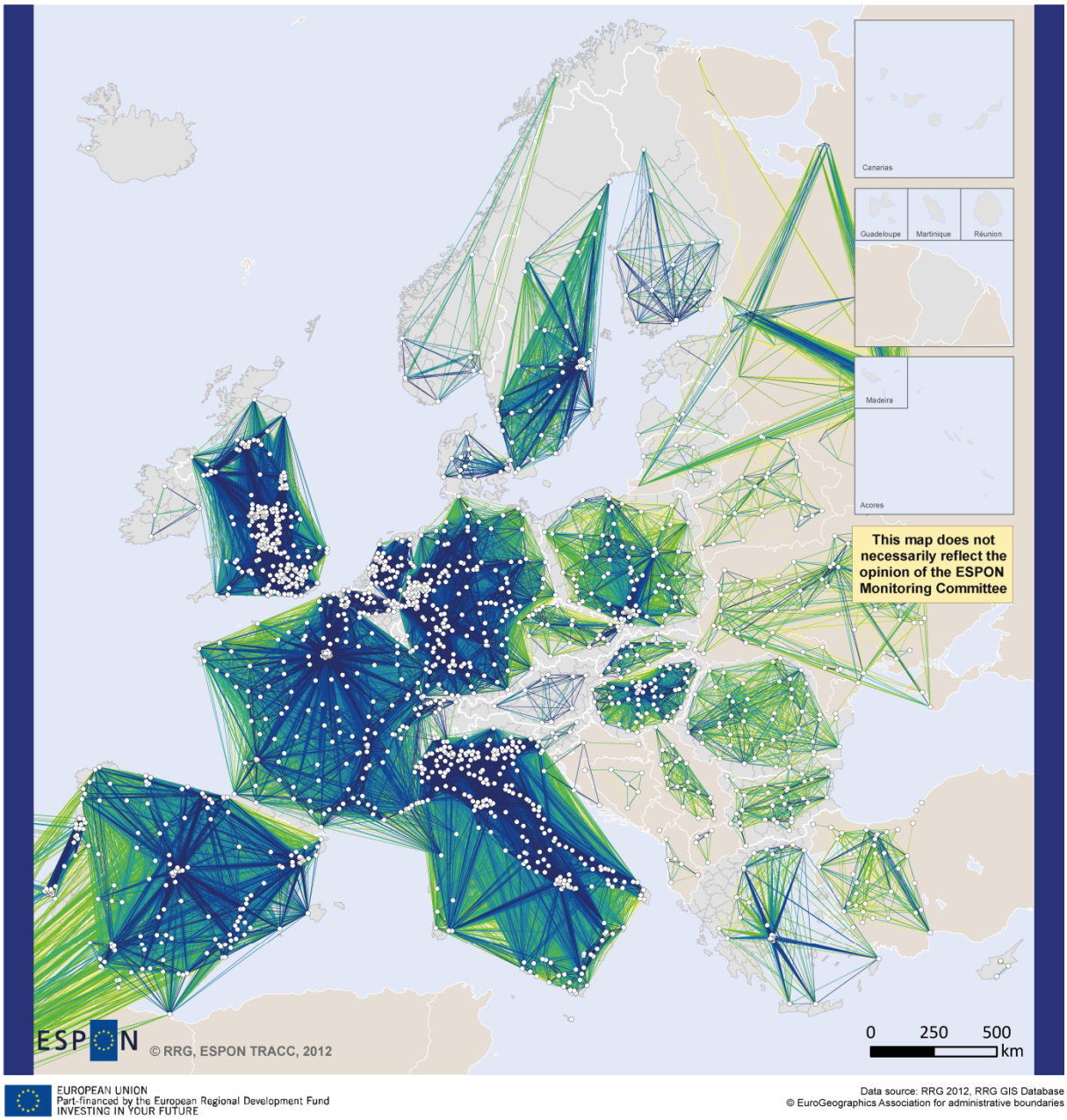


Figure 3.12. Urban connectivity, intermodal, domestic

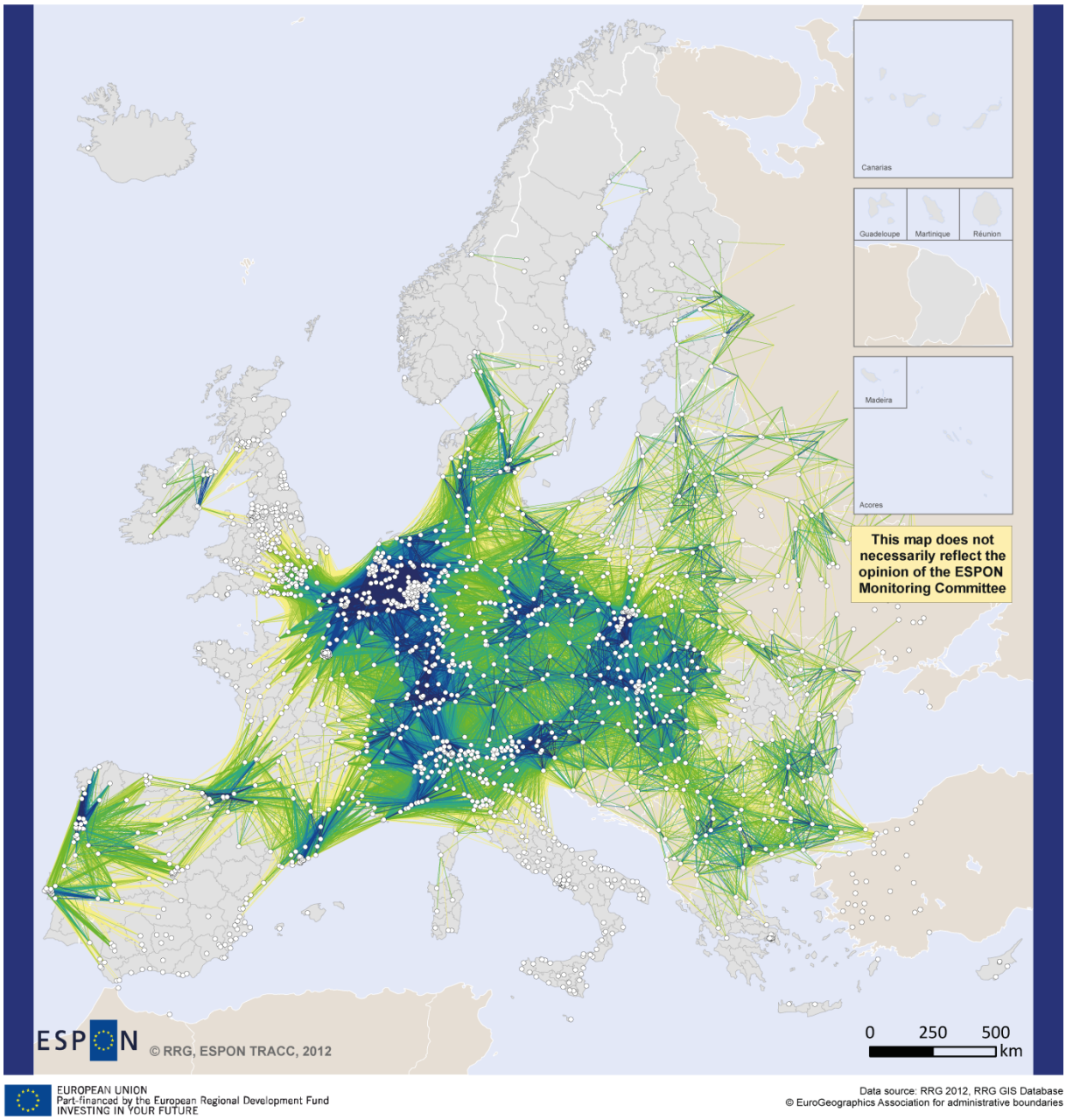


Figure 3.13. Urban connectivity, road, international

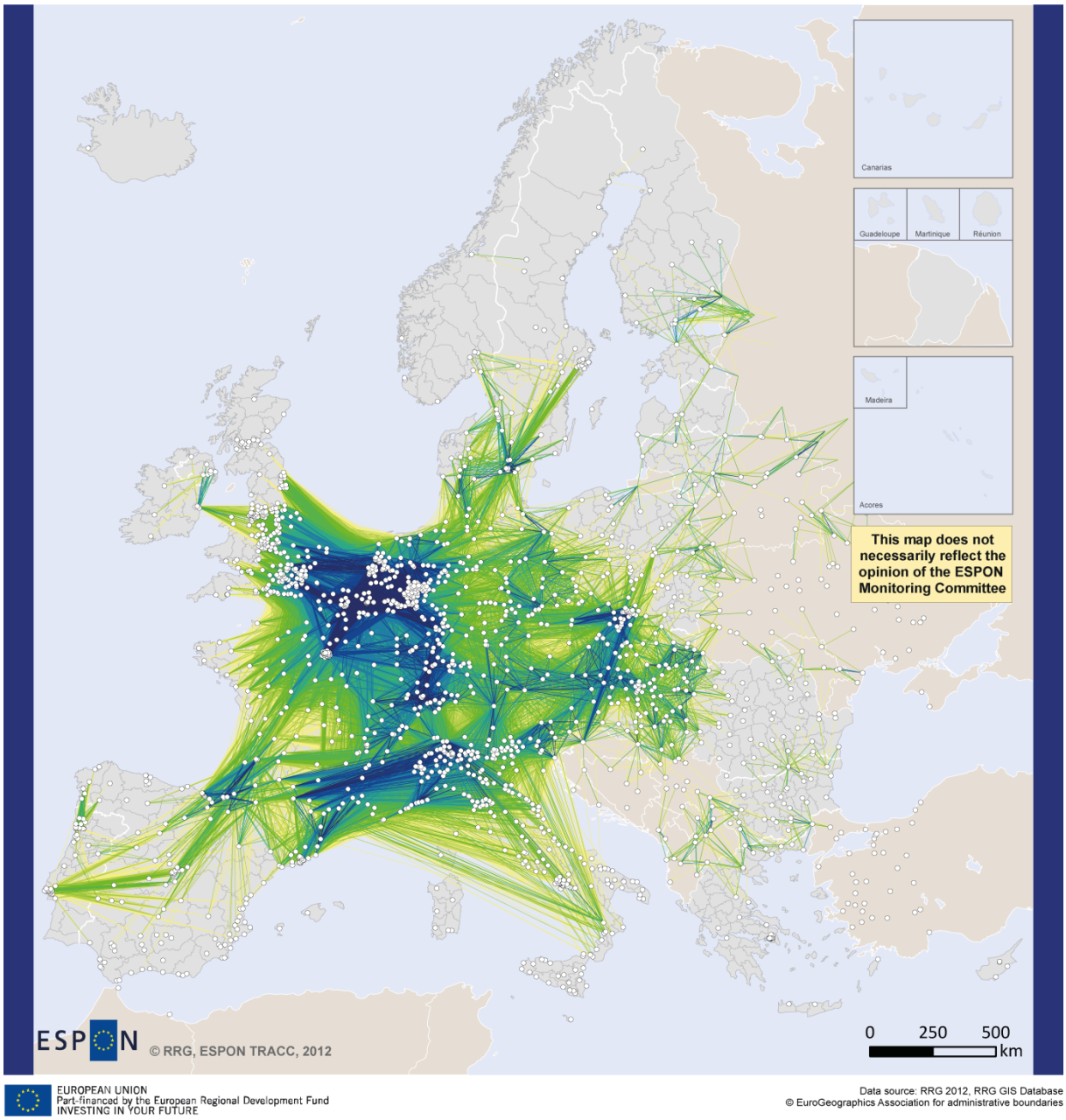


Figure 3.14. Urban connectivity, rail, international

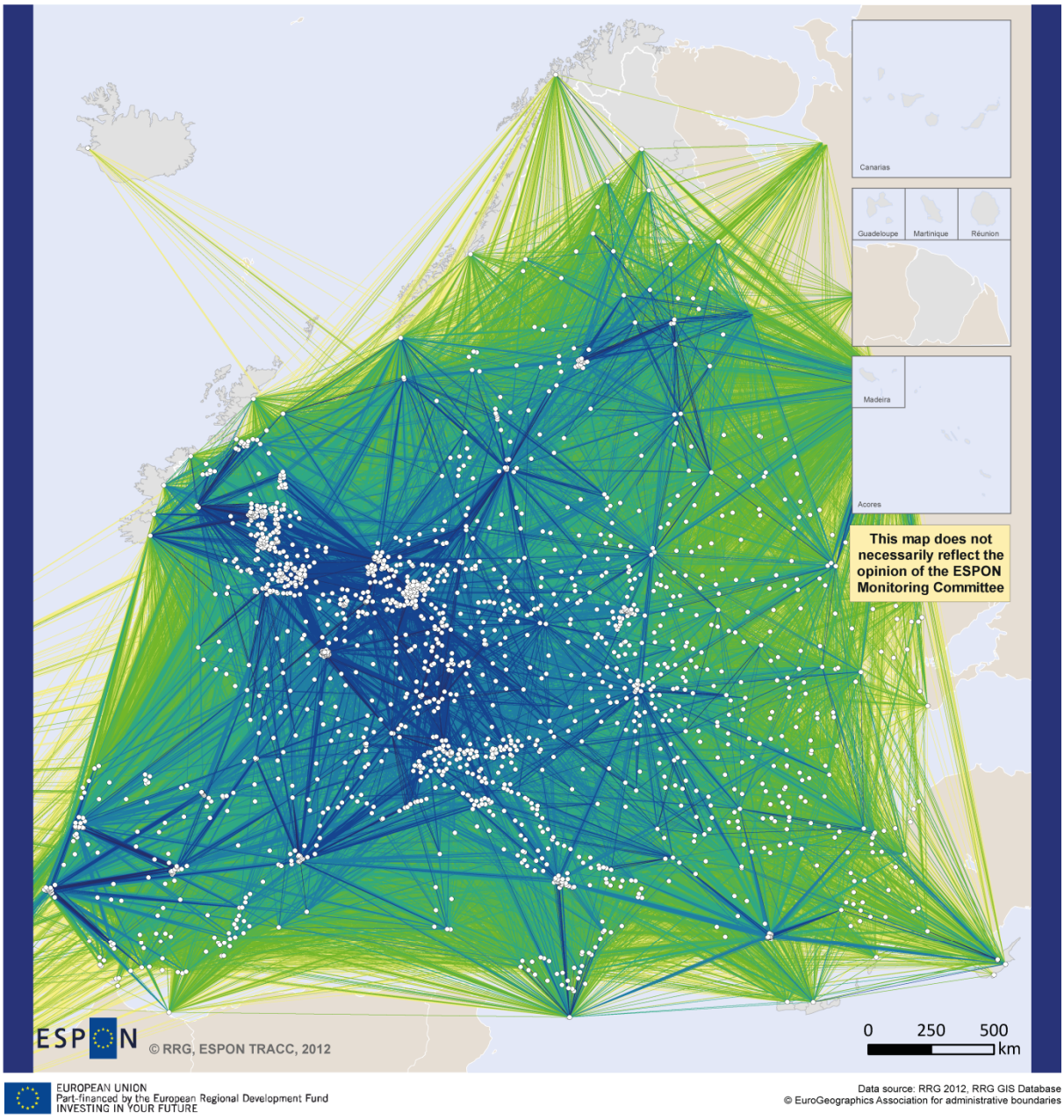


Figure 3.15. Urban connectivity, passenger flights, international

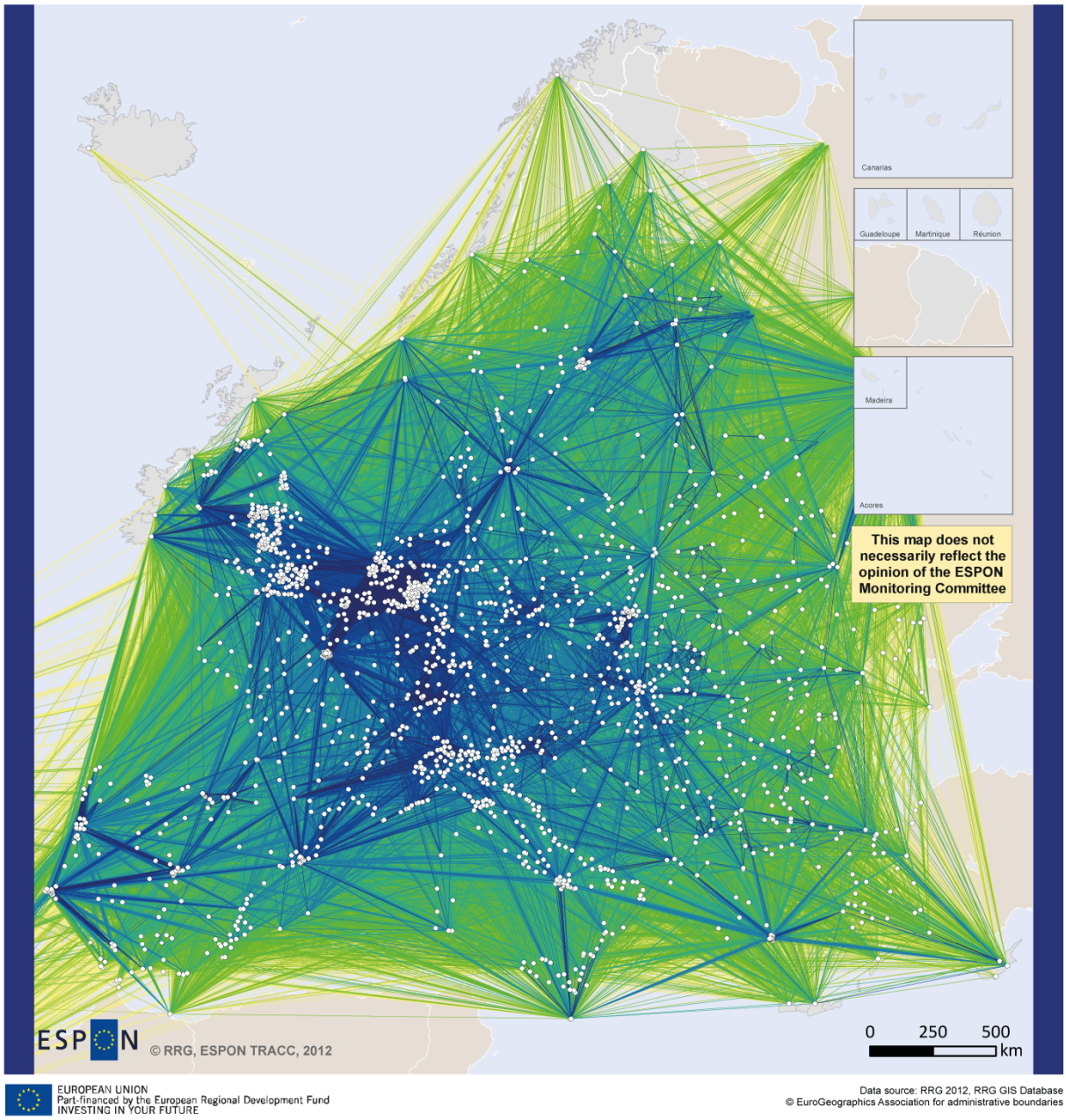


Figure 3.16. Urban connectivity, intermodal, international

3.6 European potential accessibility, Intermodal travel

Indicator name European potential accessibility intermodal travel		
Spatial context European	**Basic characteristics** Travel	**Generic type** Potential
Spatial level NUTS-3	**Origins** NUTS-3	**Destinations** NUTS-3 regions and regions of neighbouring countries
Modes Intermodal (road, air)		

Description and rationale

Accessibility potential indicators are based on the assumption that the attraction of a destination increases with size and declines with distance or travel time or cost. Therefore both size and distance of destinations are taken into account. Population in the destination regions reflect the size, travel time the impedance.

The accessibility potential indicators reflect the relative competitive position of European regions towards European destinations.

Equation

$$A_i = \sum_j P_j \, exp(-\beta \, c_{ijm})$$

Where:

A_i is the accessibility indicator value for region *i*, i.e. the European accessibility potential travel

P_j is the population of region *j*

c_{ijm} is the shortest travel time between region *i* and the region *j* by intermodal trip chains *m*

Details on the indicator calculation

For each NUTS-3 region the population in all destination regions is weighted by the travel time to go there. Travel time is calculated as the shortest intermodal travel time using road and air. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. The potential accessibility indicator is calculated for road, rail, air and as an multimodal aggregate.

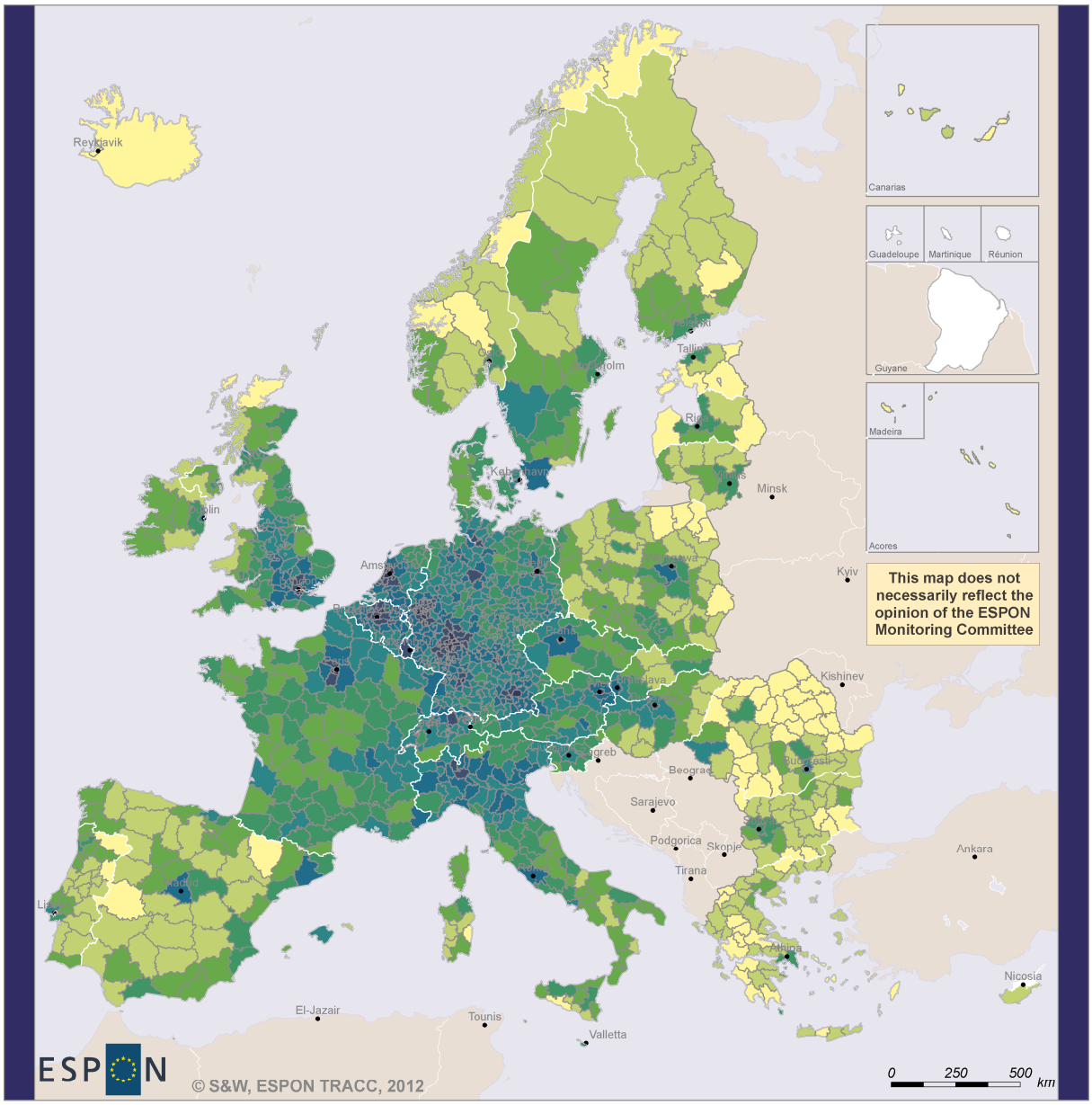
Database

Road and rail networks: RRG GIS database

Flight network: S&W flight network

Spatial pattern and main observations

Intermodal accessibility potential is highest in those regions that are near to an international airport and which have good road and rail accessibility. Lowest accessibility is to be found in south-eastern Europe and some regions in Poland, the Baltic States, northern Europe and Spain and Portugal.



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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European potential accessiblity, intermodal (ESPON = 100)

- 0 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 187
- no data

Figure 3.17. European potential accessibility travel intermodal

3.7 Access to nearest maritime ports

Indicator name Access to nearest maritime port		
Spatial context Europe	**Basic characteristics** Freight	**Generic type** Travel cost
Spatial level NUTS3 to port	**Origins** NUTS3 capitals	**Destinations** Closest port *(> 4 million tonnes yearly)*
Modes Road		

Description and rationale

For each NUTS3 the indicator is the total generalised travel cost to reach the nearest maritime port at less than 10 hours. Travel cost is computed to the nearest port according to shortest-cost path for an average commodity with a price of 500 euros per TEU. Modes considered include road, rail and inland waterways (IWW). Shortest paths between NUTS3 and ports are calculated using optimal intermodal combinations. Only ports with activity over 4 million tones yearly are considered. The indicator provides an integrated measure of the level of accessibility of regions with respect to maritime freight terminals, as an important element in the economy to allow exports of local commodities and imports.

Equation

$$AFMP_i = TC_{i,j}$$

Where:

$AFMP_i$ = Access to nearest maritime ports from NUTS3 i

$TC_{i,j}$ = Travel cost form NUTS3 i to port j

i → each NUTS3 in Espon space

j → nearest port to NUTS3 with activity over 4 million tonnes

Cost functions to compute shortest paths will be an addition of the following elements:

- Infrastructure price (for road, rail and IWW) in euros/kilometre
- Road tolls, in euros
- Manipulation costs (for transfers between modes), in euros/unit of commodity
- Inventory cost, accounting for the cost of having commodities travelling in Europe and not being sold. Inventory cost is proportional to the value of commodities transported, and can be formulated as $IC = \%d \cdot V_{€} \cdot time$, being *%d* a depreciation factor (i.e. 5% annual), $V_{€}$ the value of commodities in euros and *time* travel time.
- Time penalties for truck driver obligatory rest (9,75 hours rest per 14,5 hours drive)

Details on the indicator calculation

Database

NUTS3 centroids located in capital cities' geographic location (MCRIT), road network (TRANS-TOOLS), rail network (TRANS-TOOLS), IWW (TRANS-TOOLS)

Spatial pattern and main observations

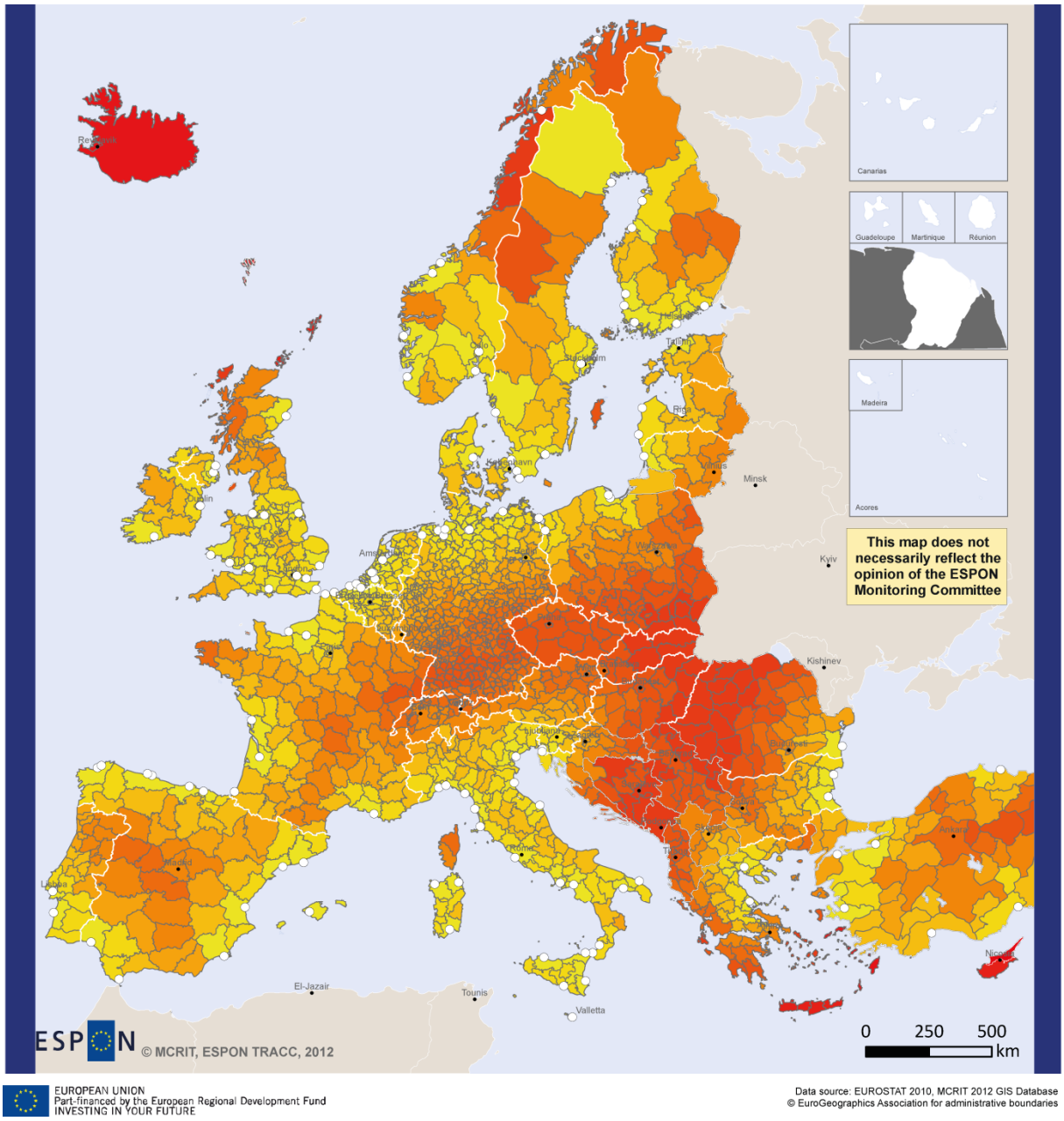


Figure 3.18. Travel Cost to access nearest maritime port (euros)

3.8 European daily accessibility freight

Indicator name European daily accessibility freight		
Spatial context European	**Basic characteristics** Freight	**Generic type** Cumulated opportunities
Spatial level NUTS3 regions	**Origins** NUTS3 regions	**Destinations** NUTS3 regions
Modes Road		

Description and rationale

The indicator equals to the total Gross Domestic Product that can be reached within the maximum allowed daily driving time of a lorry driver.

Assuming that driving limits are tightly enforced, the level of economic activity (which basically is proxy for suppliers and customers) that can be reached without resting times or additional drivers is a relevant indicator of positional competitiveness of regions as they enjoy a significantly lower driving costs.

Equation

$IND_i = \Sigma_{j \in J} GDP_j$

Where:

J = set of European NUTS3 zones that can be reached within the legal driving time from zone *i.*

GDP_i = Gross Domestic Product of NUTS3 zone *j*

Details on the indicator calculation

The travel time for each NUTS3 to NUTS3 origin-destination pair is computed by means of modelling assignment. The travel time includes loading and unloading because this activities are considered in the definition of maximum daily work time of lorry drivers. Indeed, this time consists of maximum 9 driving hours plus a break of 45 minutes and 3 hours of other work.

The model search for the most convenient path based on the generalised cost of the consignment, i.e. the monetary travel cost plus the equivalent of travel time in monetary terms. The route choice rule is therefore not the same used for the definition of the indicator. Therefore it can happen that zones theoretically reachable within the legal driving time are not included because the optimal path is a slower one. However, this is not a methodological problem for two reasons. First, minimising generalised cost to search the route is a realistic description of actual behaviour. Second, for road transport minimising travel time is quite important so while it is frequent that the optimal route is not the cheapest one, it is very infrequent that it is not the fastest one.

Database

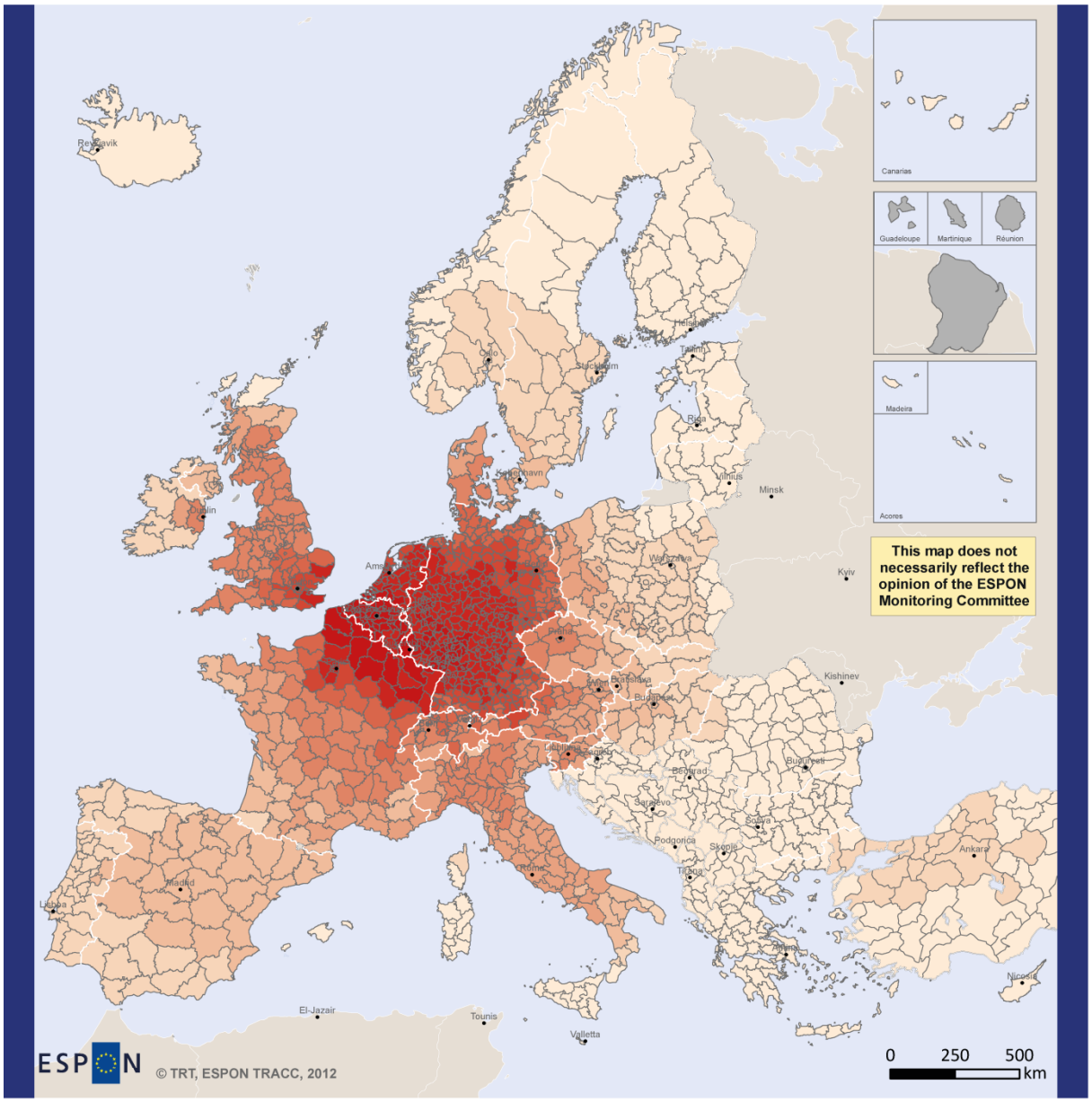
NUTS-3 region boundaries come from (ESPON database). Road transport network comes from the TRANS-TOOLS model. Data about GDP by NUTS3 zone is taken from the ESPON database with some integrations from TRANS-TOOLS database and from EUROSTAT. The definition of maximum driving time is taken from VOSA (Vehicle & Operator Services Agency), namely from the document “Rules on Drivers’ Hours and Tachographs, Goods vehicles in the UK and Europe”.

Spatial pattern and main observations

The spatial pattern of the indicator clearly reflects more the distribution of GDP in the European

countries than the availability of infrastructures. Regions of the richest countries in the heart of Europe can reach a much higher share of GDP than regions in south and eastern Europe. The position negatively affects the European daily accessibility of Scandinavian regions, whose GDP is generally above the average but can hardly reach regions in other rich countries within the legal driving time.

The map also shows that in some European countries there are significant disparities in terms of daily accessibility. For instance, regions in north-east of France are at the top of the ranking while regions in the south-west of the same country are much less accessible. The disadvantage of southern Italy or eastern Poland also emerges clearly. However, the zones with lower European daily accessibility freight are not those with the lowest GDP per capita, which suggests that this indicator alone cannot be used to appraise the economic performance of regions.



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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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European daily accessibility freight (2011):
GDP (MIO EURO) accessibile within allowed lorry driving time (13h)

- 1 - 250 000
- 250 001 - 600 000
- 600 001 - 1 000 000
- 1 000 001 - 1 600 000
- 1 600 001 - 2 300 000
- 2 300 001 - 3 000 000
- 3 000 001 - 3 500 000
- 3 500 001 - 4 300 000
- 4 300 001 < ...
- n.a.

• *Capital cities*

Figure 3.19. European daily accessibility freight

3.9 European potential accessibility freight

Indicator name European potential accessibility freight		
Spatial context European	**Basic characteristics** Freight	**Generic type** Potential accessibility
Spatial level NUTS3 regions	**Origins** NUTS3 regions	**Destinations** NUTS3 regions
Modes Road – Rail – Water (coastal sea shipping and inland navigation) – Air freight – multimodal		

Description and rationale

The indicator is a construct of two functions:

- attractiveness of NUTS3 regions measured by their Gross Domestic Product
- generalised cost needed to reach destination regions from the origin regions using a given mode

This indicator allows to identify a ranking of the regions according to their proximity to the higher levels of economic activity. Regions with a high potential accessibility have more opportunities to arrange a spatially distributed value chain, have more alternatives in terms of supply and demand market and so on.

Equation

$IND_{img} = \Sigma_j GDP_j^{\alpha} GTC_{ijmg}^{-\beta}$

Where:

GDP_i = Gross Domestic Product of NUTS3 zone *j*

GTC_{ijmg} = Generalised cost (in €/ton) to reach zone *j* from zone *i* using mode *m* for handling category *g*

α,β = Calibration parameters

Details on the indicator calculation

The travel time for each NUTS3 to NUTS3 origin-destination pair is computed by means of modelling assignment. The model search for the most convenient path based on the generalised cost of the consignment, i.e. the monetary travel cost plus the equivalent of travel time in monetary terms. For each mode an independent assignment is performed. For rail and water separate runs are made for two handling categories: “unitised” and “non-unitised”. The difference between the two handling categories is that different parameters are used in the model (e.g. value of travel time) and that unitised flows need the availability of specific infrastructures (e.g. intermodal centres). For road and air freight the separation between handling categories is not relevant. Travel time includes any fixed time, e.g. loading, transhipment during intermodal chains. Also resting time for truck drivers is considered in the calculation. Resting times depend on the truck trip duration as reported in the following table:

Travel time (h)	Resting time (h) added to OD travel time
<=13	0
>13 and <=26	11
>26 and <=39	22
>39 and <=52	33
>52 and <=65	44
>65 and <=78	55
>78 and <=91	90
>91 and <=104	101
>104 and <=117	112
>117	118

Multimodal indicator is computed using the logsum of the generalised cost of single modes:

$GTC_{ih} = -1/\lambda * ln\Sigma_m \, exp(-\lambda * GTC_{ihm})$

The λ parameter has been set to 0.5

The value of the indicator depends on the calibration parameters α,β. As usual the α parameter is set to 1 (i.e. the attractiveness of the ports is measured by the pure value of their intercontinental throughput). The β is set to 1 as this value has proved to provide the most convincing distribution of values across zones.

The mapped values are ratios with respect to the average (for each mode the own average has been considered).

Database

NUTS-3 region boundaries come from (ESPON database). Transport networks come from the TRANS-TOOLS model (road, rail), the RRG GIS Database (inland navigation, air freight) and the TRUST model (maritime). Data about GDP by NUTS3 zone is taken from the ESPON database with some integrations from TRANS-TOOLS database and from EUROSTAT. The definition of maximum driving time is taken from VOSA (Vehicle & Operator Services Agency), namely from the document “Rules on Drivers’ Hours and Tachographs, Goods vehicles in the UK and Europe”

Spatial pattern and main observations

The spatial pattern of road freight European potential accessibility shows a progressive transition from above to below the average accessibility starting from the central western Europe regions and moving to all directions. Germany, Benelux, most of UK and part of France are in the upper part of the ranking whereas peripheral regions have a lower accessibility. The lowest values are found in north Scandinavian regions, Iceland and Turkey. It can be clearly recognised that western regions of eastern Europe countries benefit from their proximity to the richest European countries.

The pattern is much less regular when unitised rail is considered. Here, the proximity to intermodal centres becomes a significant accessibility factor. Therefore, despite an overall decrement moving from the centre to periphery can still be observed, there are some regions in Italy or south France or Czech Republic with levels of European potential accessibility higher than

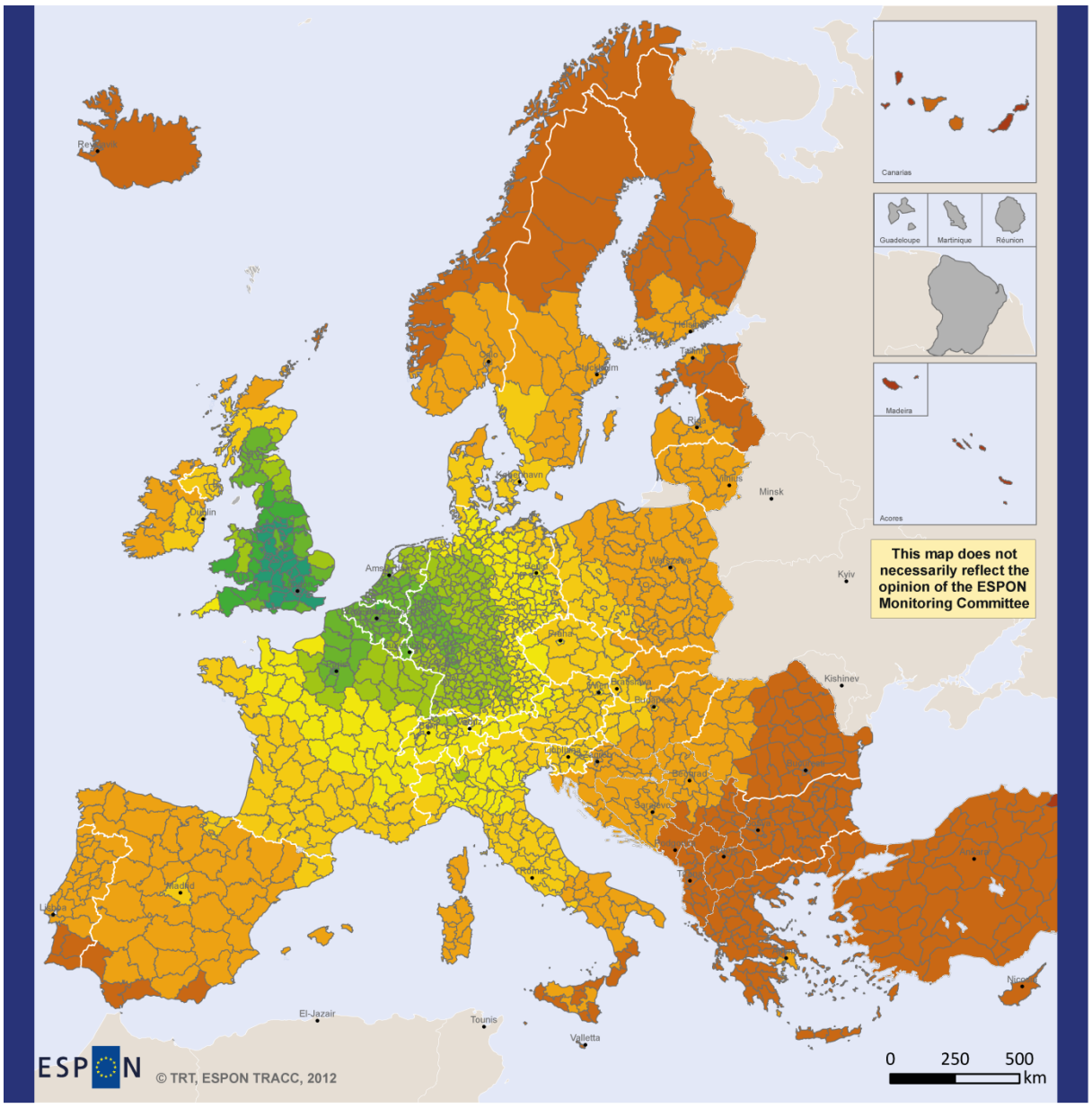
some German regions thanks to the availability of intermodal facilities.

This diversity is not found in the distribution of non-unitised rail, which does not need intermodal centres, but just of the rail network, which is quite homogenously available over the whole European territory.

For unitised water again the overall pattern is changed by the distribution of sea and inland ports where container can be loaded and unloaded. Coastal zones are clearly advantaged. Interestingly, southern Italy results more accessible than northern Italy or eastern Romania regions score better than western Romania regions. This is one of the few indicators of European accessibility providing this result.

For non-unitised water the differences with respect to unitised water are limited. The slightly different pattern is explained just by ports specialisation.

Finally, air freight accessibility shows a particular spatial pattern where the major European cargo airports are clearly recognisable. The geographical position is less important than for road or rail accessibility for two reasons. First, air travel speed is faster and so the weight of distance is more limited. Second, air freight is used only for consignments over a certain travel distance (indeed, air freight for intra-Europe trade is uncommon) so that the GDP of neighbouring NUTS3 zones is irrelevant for the indicator. Therefore, being located in rich regions of central European countries is not an advantage.



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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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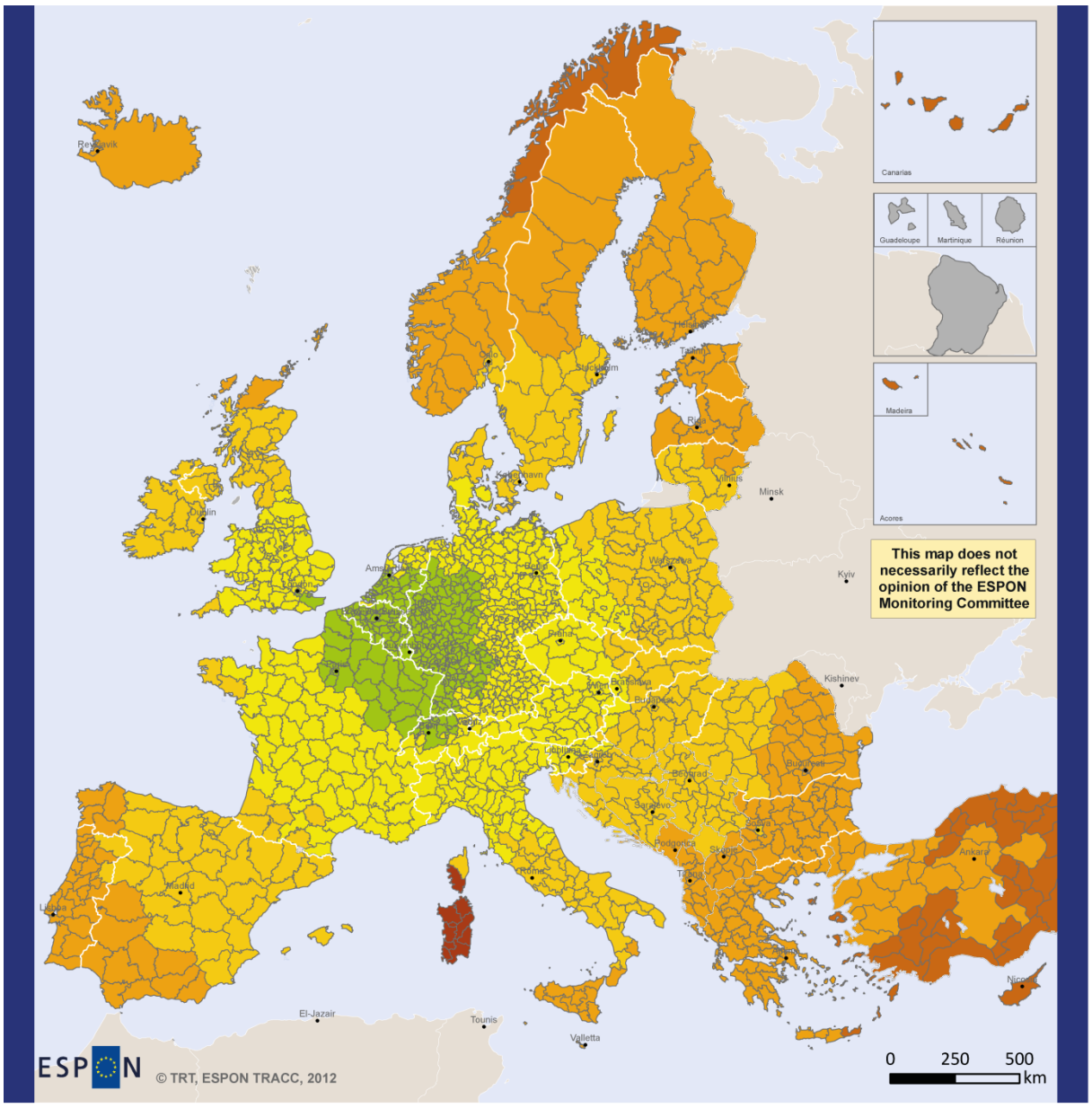
European potential accessibility freight (2011):
Accessibility potential to GDP by road
(percentage of average accessibility by road of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

• *Capital cities*

Figure 3.20. European potential accessibility freight by road



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Data source: TRUST Accessibility Model (TRT 2012), Road/Rail Network: TransTools (2005), GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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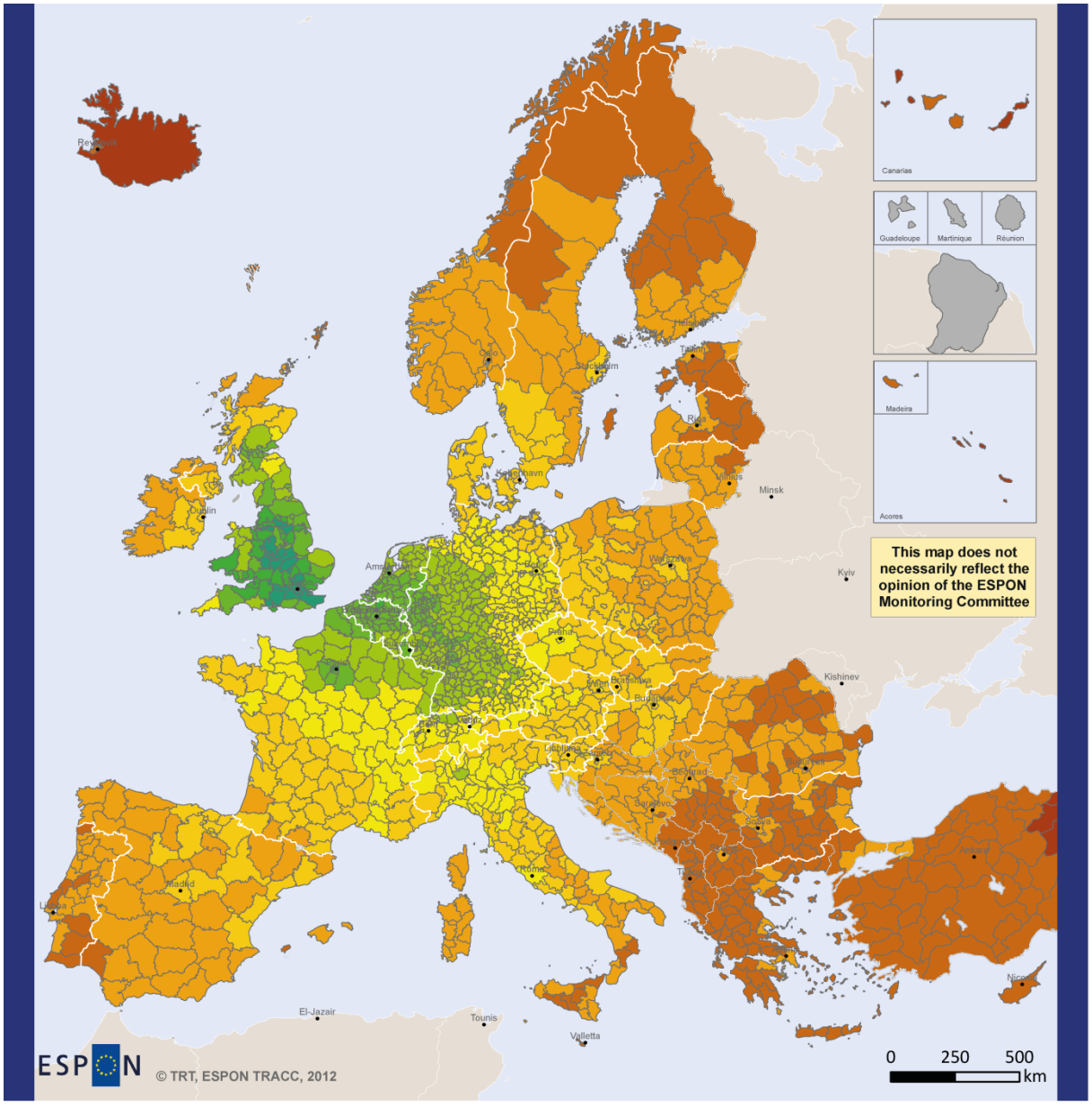
European potential accessibility freight (2011):
Accessibility potential to GDP by rail (non unitised)
(percentage of average accessibility by rail (non unitised) of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

• *Capital cities*

Figure 3.21. European potential accessibility freight by rail



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Source: TRUST Accessibility Model (TRT 2012), Maritime Network: TRUST Model, Road/Rail Network: TransTools (2005), IWW/Air Network: RRG GIS Database, GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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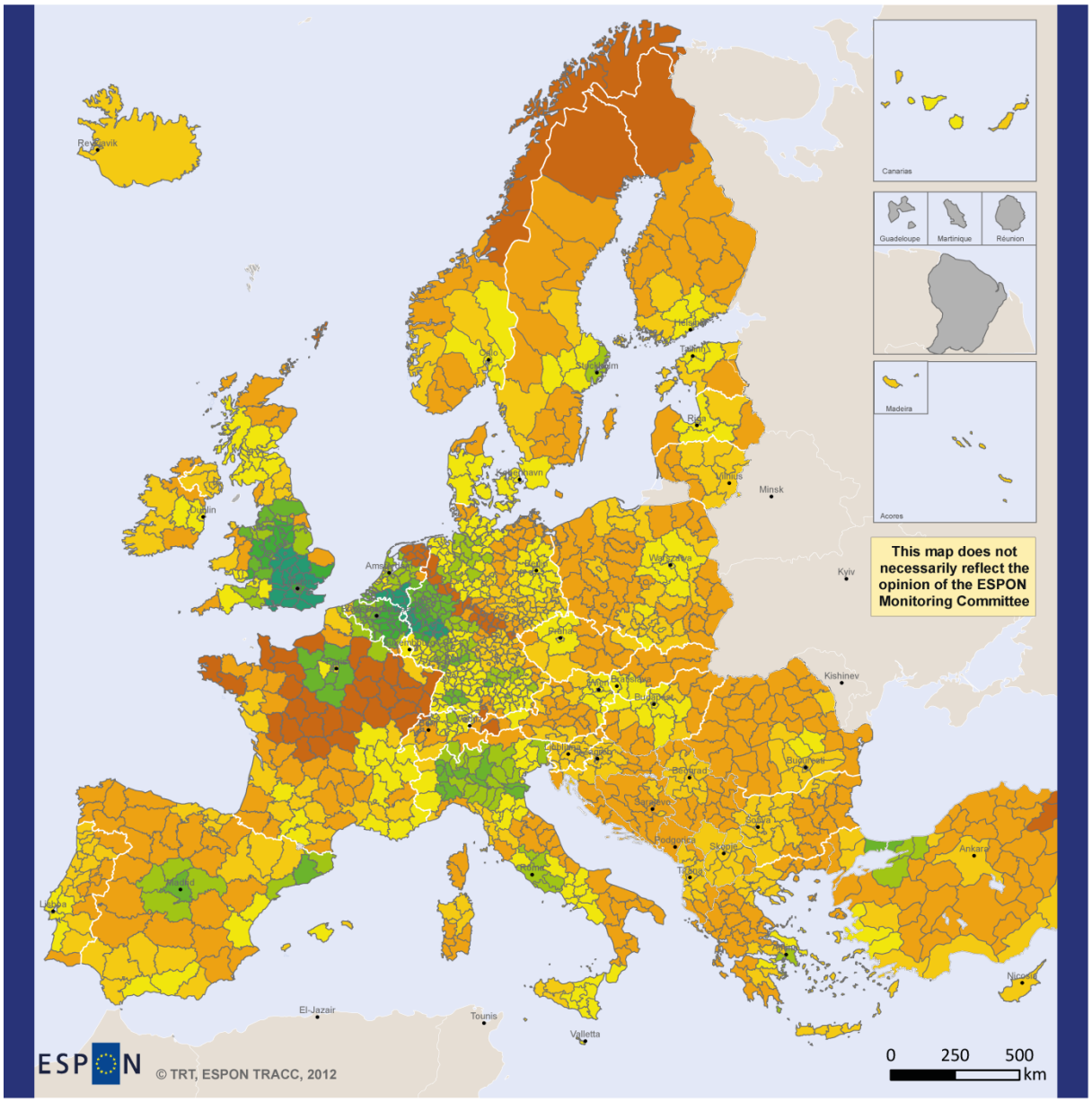
Multimodal European potential accessibility freight (2011):
Accessibility potential to GDP (unitised)
(percentage of average accessibility of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

• *Capital cities*

Figure 3.22. European potential accessibility freight multimodal



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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), Air Network: RRG GIS Database (2011), GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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European potential accessibility freight (2011):
Accessibility potential to GDP by Air Freight
(percentage of average accessibility by Air Freight of all areas)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

• *Capital cities*

Figure 3.23. European potential accessibility freight by air

4 Regional accessibility indicators – Europe wide

4.1 Accessibility to high-level transport infrastructure

<table>
<tr><td colspan="3">Indicator name
Access to high-level passenger transport infrastructure</td></tr>
<tr><td>Spatial context
Europe</td><td>Basic characteristics
Travel</td><td>Generic type
Travel cost</td></tr>
<tr><td>Spatial level
Raster cells and NUTS3</td><td>Origins
Raster cells</td><td>Destinations
Motorway gateways, rail stations and airports</td></tr>
<tr><td>Modes
Road</td><td colspan="2"></td></tr>
<tr><td colspan="3">Description and rationale
This indicator reports connectivity of territorial units (raster cells) to passenger transport networks.
Connectivity is defined as an average access time to transport networks, all modes within reach included. Destination points are motorway gateways, rail stations and airports; access time is based on travel time by road; following the ICON approach, times to different networks and transport terminals are aggregated and averaged considering their relative utility (within a transport network, all access points within reach are considered).
The conceptual basis of the connectivity methodology lies in the fact that the development of transportation systems as integrated networks at different scales is deeply changing their operation and the way they induce urban and regional development patterns. The conventional definition of "distance between places" seems not sufficient nowadays. A connectivity approach, focused on measuring the "distance to the networks" is needed to measure how transportation networks influence locational decisions and induce spatial development, in the context of current economic and technological changes.
According to many transportation analysts (e.g. Chisholm, 1992) one of the most common fallacies about transport costs is that they vary with location to the extent that geographical peripherality implies a substantial cost burden over more central locations. Empirical observations (e.g. Diamond and Spence, 1989, Plassard 1992) have verified the increasing insensitivity of most economic activities to transportation costs in developed areas. Places equally connected to transportation networks, independently of their geographical situation, show no significant differences in their transportation costs. These cost are, in general, less and less dependent on the total length of the trip.
As a result, the distance between two places (in time, cost or psychological perception), and the opportunity to establish relations between them, is increasingly dependent on the kind of transport and communication networks to which they are connected rather than the physical distance between them (Distler, 1986). Contemporary economic landscape can be therefore represented by the superimposition of two increasingly independent geographies: the geography of places and the geography of communication networks (Beauchard, 1991), both with different logics.
For further reference on this indicator, www.mcrit.com/IGIS/ICON.htm</td></tr>
<tr><td colspan="3">Equation</td></tr>
</table>

$$ICON = \sum_{i=1}^{N} ICON_i \cdot P_i$$

$$ICON_i = tam_i + \delta_i \cdot (tax_i - tam_i)$$

$$\delta_i = \frac{1}{1 + a_i \cdot e^{-b_i \frac{S_x - U_i}{S_x - S_o}}} \qquad U_i = S_i \cdot e^{-\beta(t_i)}$$

With $ICON_i$, the ICON value to the network i
p_i , the weight or relative proportion of the network i

(a) and (b) and (beta) are parameters to be fixed for each network, and U_i is the utility of a specific transport gateway (service provision above pre-determined quality level)

Details on the indicator calculation

For each network i=1...n (i.e. road, rail and air networks) a network-specific value of ICON is calculated. These partial values are summed up in proportion to their relative contribution to transport endowment. This relative contribution can be determined considering the relative economic weight of each mode (P_i) –added value of each mode-, or in a simplified way, the relative proportions (p_i) will be estimated according to current modal split. The aggregated value of ICON is then:

$$ICON = \sum_{i=1}^{N} ICON_i \cdot P_i$$

With $ICON_i$, the ICON value to the network i
p_i , the weight or proportion of the network i

$ICON_i$ is calculated as the addition of the minimum access time by road to the closest connection node in the network plus an additional time which encapsulates a measure of the deficit of utility (in relation to a pre-defined quality level) not obtained from all available alternatives: this additional time can be called “generalised waiting time”.

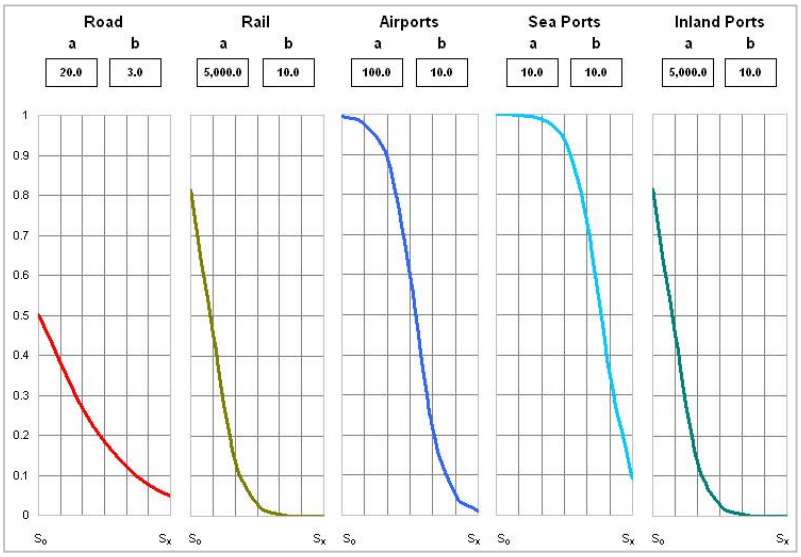
$$ICON_i = tam_i + \delta_i \cdot (tax_i - tam_i)$$

With tam_i the minimum access time to reach the closest transportation node in the network
tax_i the minimum access time necessary to reach the closest node with a service provision above a pre-determined quality level

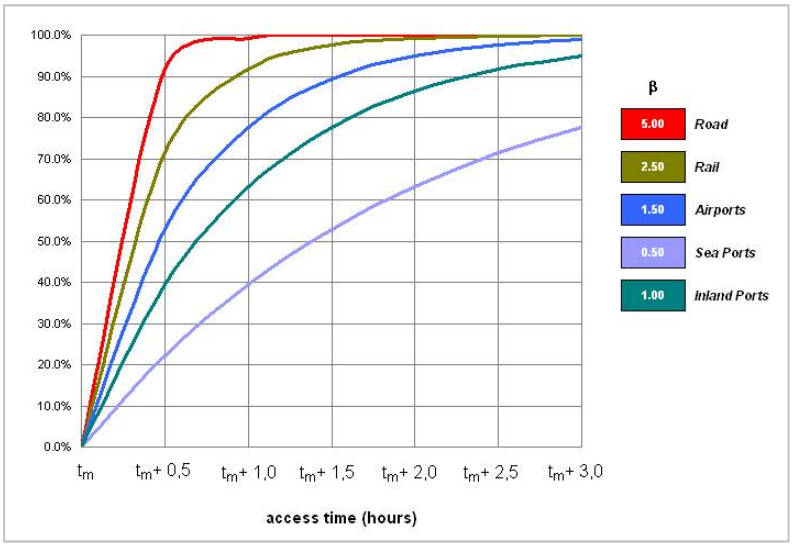
$$\delta_i = \frac{1}{1 + a_i \cdot e^{-b_i \frac{S_x - U_i}{S_x - S_o}}} \qquad U_i = S_i \cdot e^{-\beta(t_i)}$$

where (a) and (b) and (beta) are parameters to be fixed for each network, and U_i is the utility obtained in the considered gateway (service provision above pre-determined quality level)

According to this formulation, for any point (any location in Europe), ICON provides the measure of its connectivity to the transportation networks, basically considering the relative economic weight of each mode (P_i) and the minimum time (or cost) required to reach the closest node in each network (tam_i) increased by the additional generalised waiting times in each node ($\delta_i(tax_i - tam_i)$) to get a pre-determined utility (Ux_i).



δ_i value for different modes in function of U_i value



Ui values for different modes in function of access time to connection

The minimum value of $ICON_i$ in a point should be the access time to reach by road the closest transportation node in the network i (tam_i), and the maximum value of $ICON_i$ should be, by definition, the minimum access time (taxi) necessary to reach by road the closest node of the network i with a service provision above a pre-determined quality level (Sx_i). (So_i) is the minimum service level acceptable for any node or terminal to be included in the network i

Database

Travel time based on time from raster cells to transport network gateways.

Indicator computed over a road graph for all Europe with transport terminals included.

Access times calculated on a shortest cost path, taking into account different speeds for different road links in a European graph (TRANS-TOOLS road graph, with transport terminals included).

- Motorway entrances are defined as intersections between motorways and other roads.
- Rail stations from EIB IGIS database
- Airports from TRANS-TOOLS air network

Relative utilities

- Motorway utilities based on motorway speed and traffic (TRANS-TOOLS)
- Rail utilities based on rail speed and services available (TRANS-TOOLS)
- Airport utilities based on airport traffic (anna.aero database)

Indicator calculated at raster level: Raster cells 5x5 km

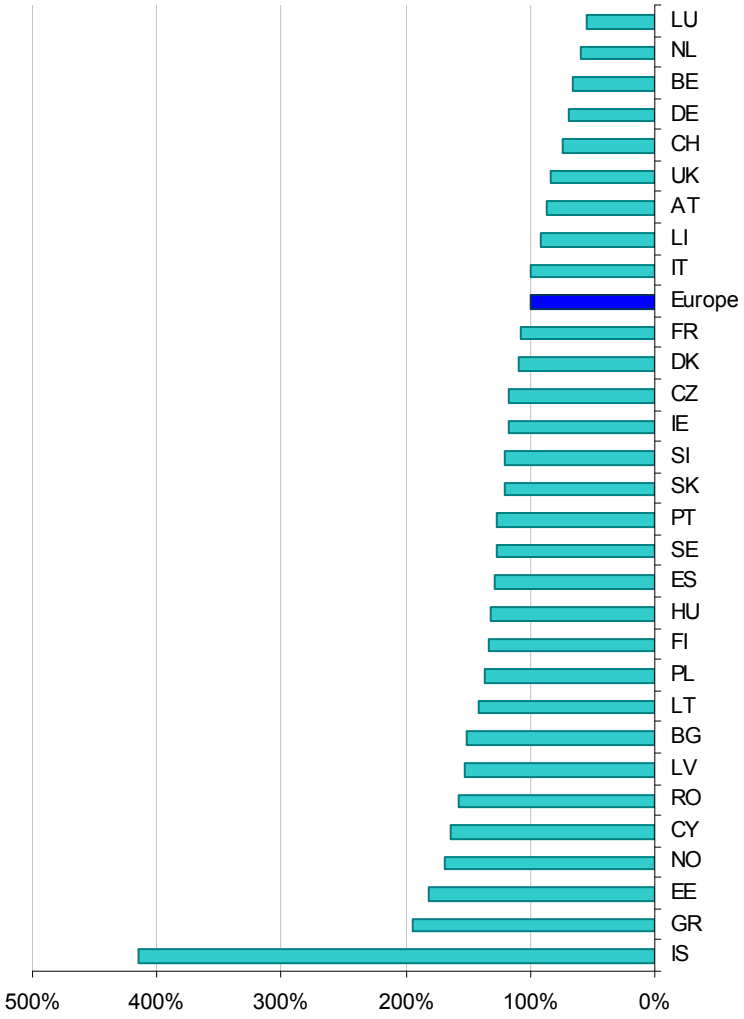
Indicator calculated at NUTS3 level: population average from raster cells

Spatial Pattern

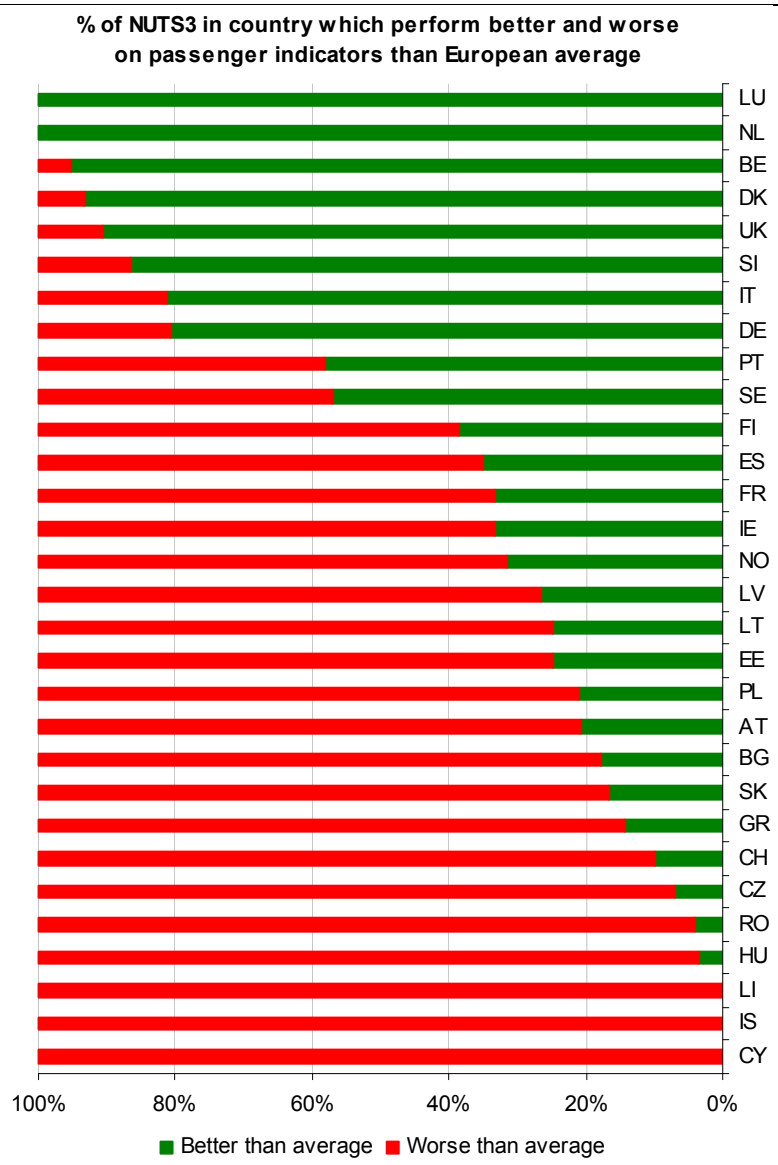
Core areas in Europe clearly show higher levels of connectivity to passenger transport networks than peripheral areas. The denser network of motorways in Germany, the Benelux and Northern Italy, also in the UK, and the fact that most intercontinental air hubs are located in this area (Heathrow, Paris, Amsterdam, Frankfurt, Munich…) is the main reason for these higher values of the indicator.

Beyond the European core areas, major relational corridors (which concentrate population and transport infrastructure), can still be tracked: the Mediterranean arch from Southern Spain to Italy; the Rhone valley, the Scandinavian west coast corridor from Copenhagen to Gothenburg and Oslo, with extensions to Stockholm. In France and Spain, it is possible to identify the major HSR and motorway corridors linking intermediate cities.

Average travel time to high-level passenger transport infrastructure, per country. ICON formulation.

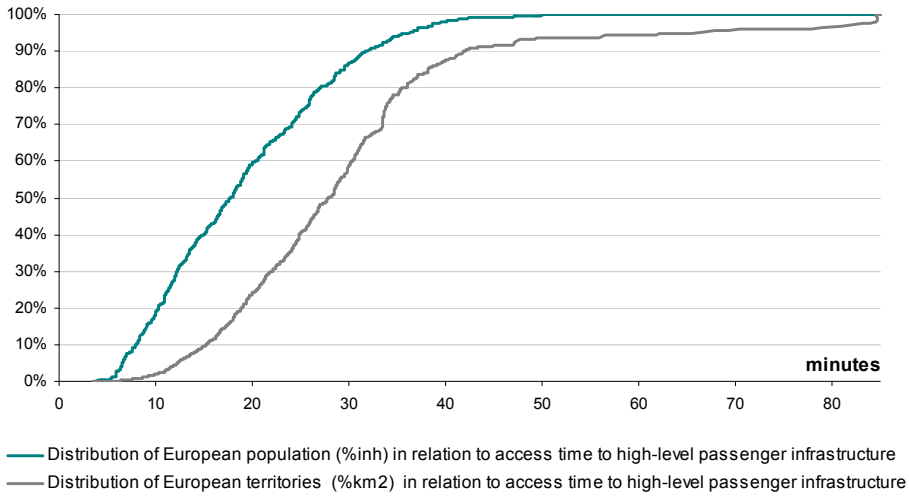


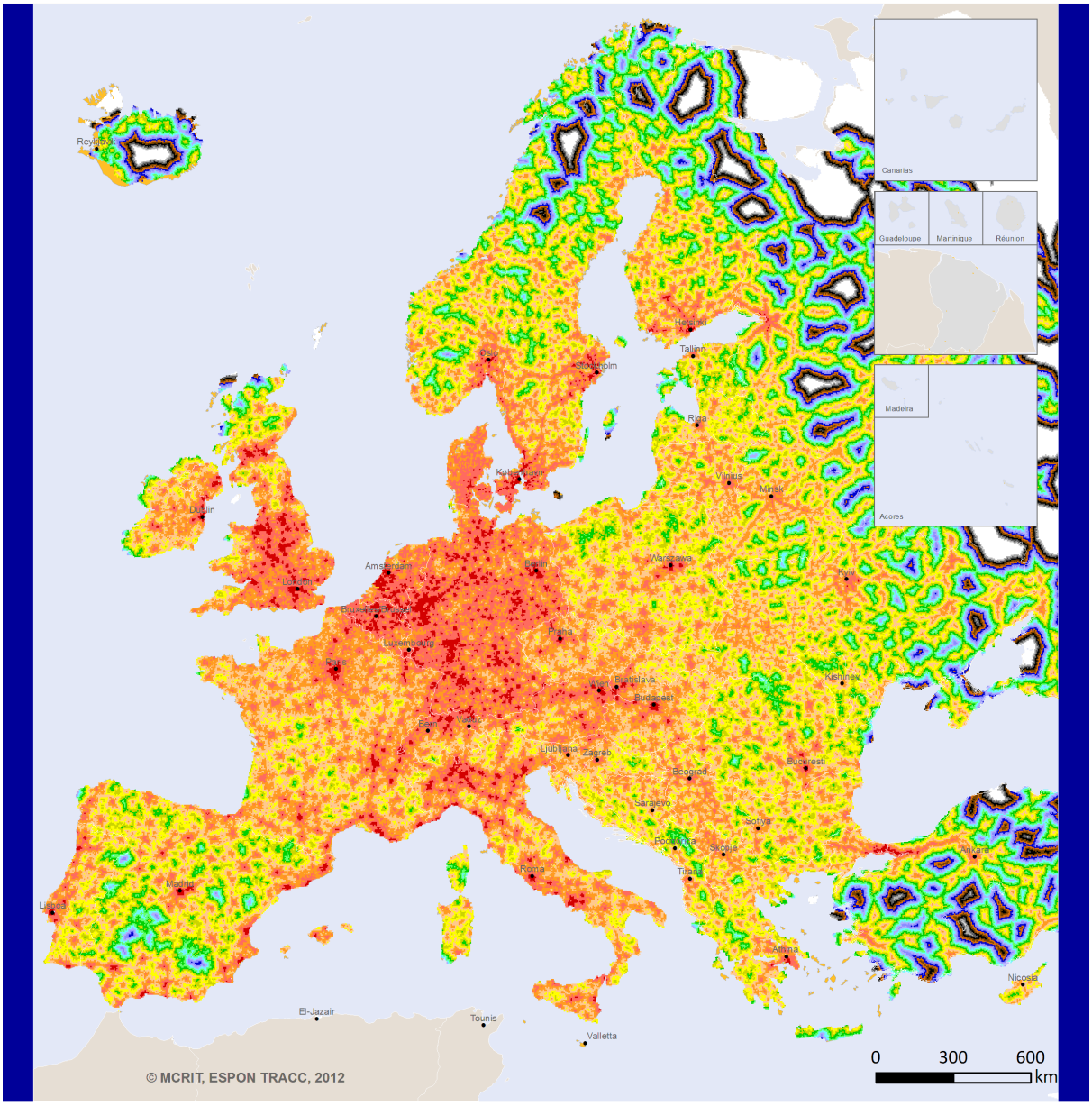
Countries having on average lower travel times to high-level transport infrastructure than mean values for all NUTS3 in Europe (countries performing better) belong all to the European core: Luxemburg, the Netherlands, Belgium, Denmark, Switzerland, the UK, Austria, Lichtenstein, and Italy.



10 European countries have at least 50% of their NUTS3 performing better than average in connectivity to passenger transport networks. These states are all located in the Core of Europe: Luxembourg, Lichtenstein, the Netherlands, Belgium, Germany, Denmark, the UK, Switzerland, Italy and Austria. On the other side of the spectrum, 10 European countries have more than 80% of their NUTS3 performing worse than average: Cyprus, Estonia, Island, Bugaria, Greece, Romania, Lithuania, Czech Republic, Eslovenia and Poland.

50% of European population resides within 18 minutes or less (on average) of high-level passenger transport infrastructure. This population is comprised in 16% of the European territory.





Data source: MCRIT 2012, TRANSTOOLS Transport Network
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Access to high-level passenger transport infrastructure

ICON indicator,defined as relative connectivity to available transport networks (in minutes)

http://www.mcrit.com/IGIS/ICON.htm

0 - 10	91 - 100	no data
11 - 20	101 - 110	
21 - 30	111 - 120	
31 - 40	121 - 130	
41 - 50	131 - 140	
51 - 60	141 - 150	
61 - 70	151 - 160	
71 - 80	161 - 170	
81 - 90	>170	

Figure 4.1. Access to high-level passenger transport infrastructure by 5x5 grid cells

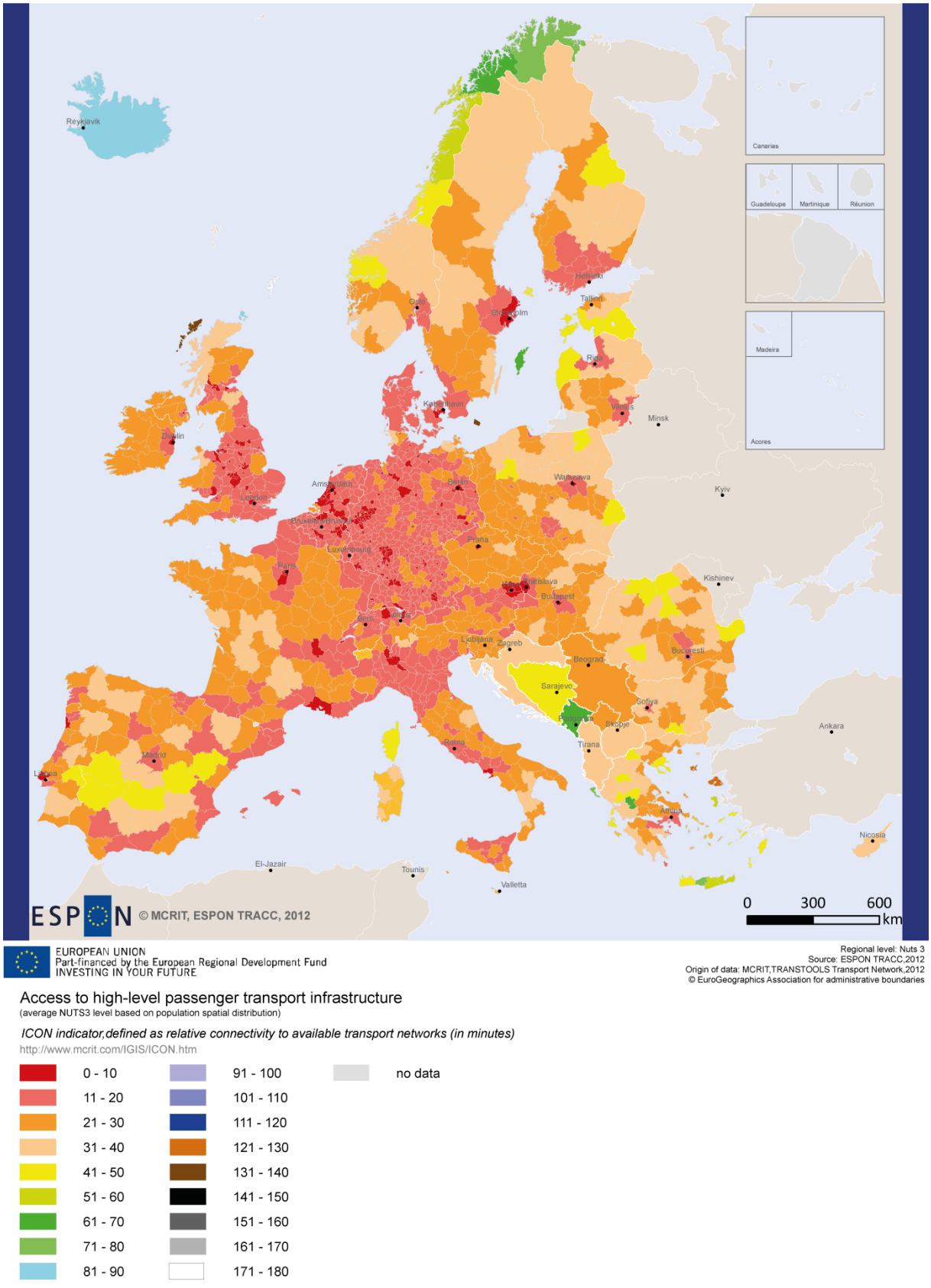


Figure 4.2. Access to high-level passenger transport infrastructure by NUTS3

4.2 Availability of urban functions

Indicator name Availability of urban functions		
Spatial context Regional	**Basic characteristics** Travel (Europe-wide)	**Generic type** Cumulated opportunities
Spatial level Raster, NUTS-3	**Origins** Raster cell, NUTS-3 centroid	**Destinations** Cities > 50,000 inhabitants
Modes Road, rail		

Description and rationale

What amount of urban functions can be reached from any point in Europe in reasonable travel time in a regional context? By looking at road and rail, it will be assessed which functions of cities with more than 50,000 inhabitants can be reached. The higher the number of cities is that can be reached, the greater opportunities are provided for economic and social activities and interaction.

Equation

For each raster cell the travel time to all cities of more than 50,000 inhabitants will be calculated. If the travel time is less than 60 minutes, the destination is within reach and is added to the number of destinations.

Details on the indicator calculation

In a first step the travel time from each raster cell of the 2.5x2.5 km grid system to all selected cities will be calculated, and the number of destinations within 60 minutes will be summed up. In a second step, the raster results will be aggregated to NUTS-3 level as population-weighted averages.

Database

The trans-European road and rail networks, the raster grid (origins) as well as the location of 1,760 cities with more than 50,000 inhabitants in Europe (destinations) are taken from the RRG GIS Database. Relevant road and rail ferries are included in this database. Information on grid population was transferred from the EEA population grid (EEA, 2012). The NUTS-3 region layer obtained from ESPON Database Project was updated in different aspects.

Spatial pattern and main observations

For both road and rail (Figures 4.3 and 4.5), this indicator highlights the agglomerated areas in Europe. Accessibility is highest in the Ruhr area, England, Paris, in the Benelux countries and in Northern Italy. Some capital city regions in other countries (for instance, Stockholm, Madrid, Budapest or Athens) also stand out, so as other selected regions such as Oslo-Gothenburg-Malmö-Copenhagen, Barcelona-Valencia-Murcia, Lyon, Saxony, Naples, Upper Silesia with city systems.

From most locations in Western and Central Europe, at least one regional city can be reached by road within 60 minutes, from many places even more than ten. In Eastern Europe, mostly only one or two cities are within reach. Locations from where only one city can be reached provide basic urban services. Usually, people from there do not have any option to go to one or the other cities to enjoy certain facilities, but they are bound to just one closest city. Locations from where more than one city can be reached, offer options to visit different cities offering a wider range of services, i.e. these locations provide more freedom of choice and thus more op-

portunities.

The raster results furthermore clearly highlight those regions in Europe that do not have access to urban functions at all in reasonable time. Interestingly, such areas are not only located in the far North (Northern peripheral sparsely populated areas) or in the Alpine space, as expected, but they also cover so-called 'inner peripheries' which for road (Figure 4.3) can be found basically in all European countries. Prominent examples of these are Mecklenburg-Vorpommern (Germany), many parts in France or Spain, or areas in Poland or Czech Republic. For rail (Figure 4.5) the extent of these areas is even bigger in almost all countries.

In consequence, while the road indicator tends to form seamless coverages at raster level (Figure 4.3), for rail the major railway axes become clearly visible (Figure 4.5).

The aggregated maps at NUTS-3 level (Figures 4.4 and 4.6) basically show the same results. The high availability of urban functions in the well-known agglomerations is visually even more pronounced in this map type. In the contrary, the rather poor availability in many East European regions becomes also more evident, i.e. for many NUTS-3 regions on average only one urban centre can be reached within 60 minutes travel time – for both road and rail.

Interestingly, even at NUTS-3 level, although to some degree levelled out compared to the raster maps, some inner peripheries persist: For road (Figure 4.4), NUTS-3 regions in Norway, Finland, but also at the Balkans lack access to urban functions. For rail, (Figure 4.6), additional regions in Spain, Portugal, Austria, Croatia, Latvia or Lithuania do not have access to regional cities.

As by intention this indicator was defined in a way to look at regional cities (and not just major agglomerations) which offer daily and medium-term public and private services to the people, a lack of access to such cities even at NUTS-3 level should be alarming, as the supply of important public and private services may not be guaranteed, forcing people to accept long travel times if they want to enjoy or if they need certain types of services.

The main findings of this indicator can be summarised as follows:

- From most locations in Europe at least one regional city can be reached in less than 60 minutes travel time.
- Only people in Western Europe have options to visit more than five different cities in that time (i.e. enjoy greater freedom of choice and thus greater opportunities).
- In the contrary there are also 'inner peripheries' even within Central Europe lacking access to regional cities.
- Disparities are greater for rail as for road, so are the inner peripheries much larger for rail than for roads. In other words, people bound to public transport (pupils, young, elderly, retired etc.) have less accessibility compared to car users.
- The results confirm the well-known urban-rural dichotomy, in addition to East-West and also North-South divide.

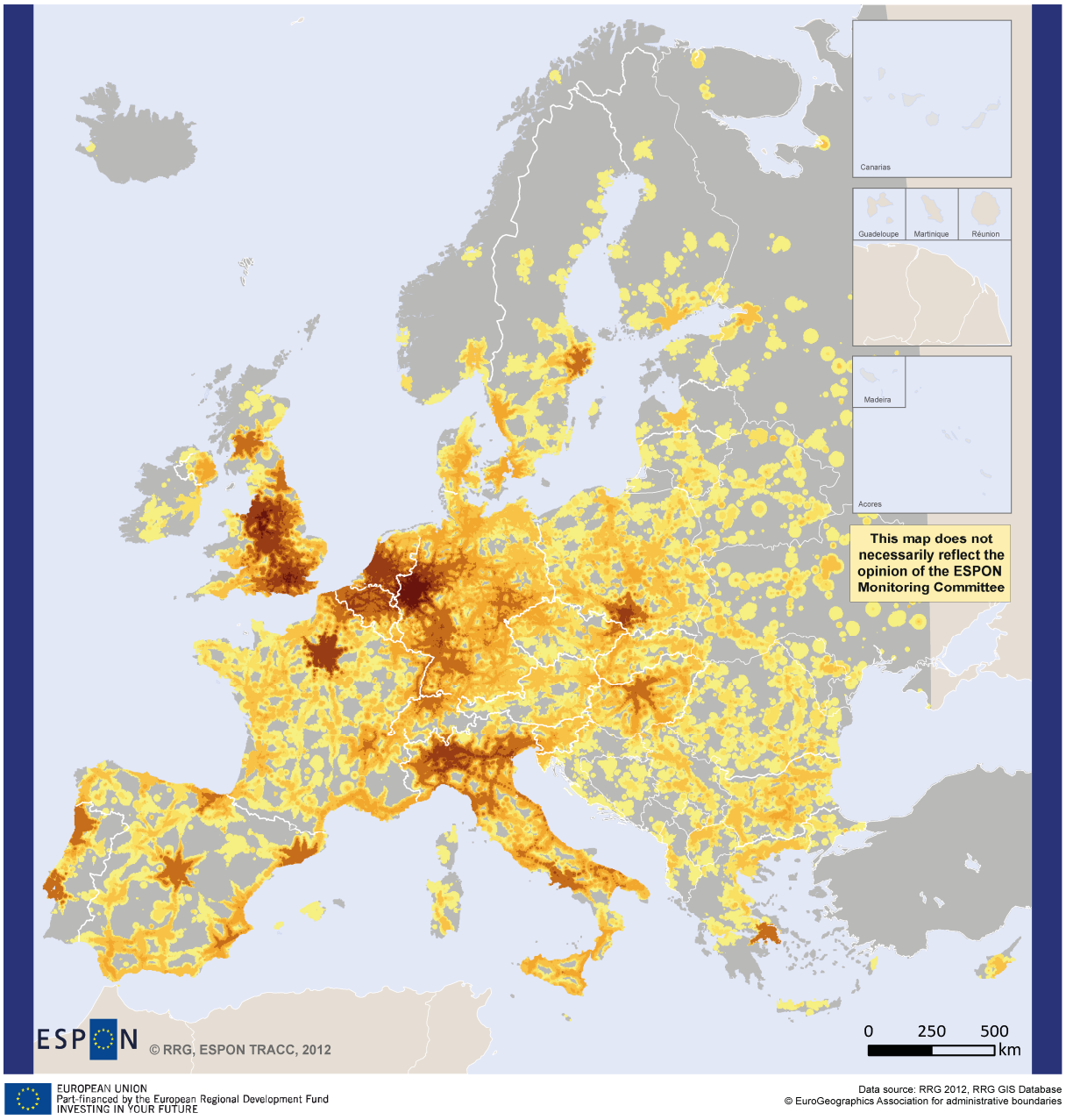


Figure 4.3. Availability of urban functions, road, grid

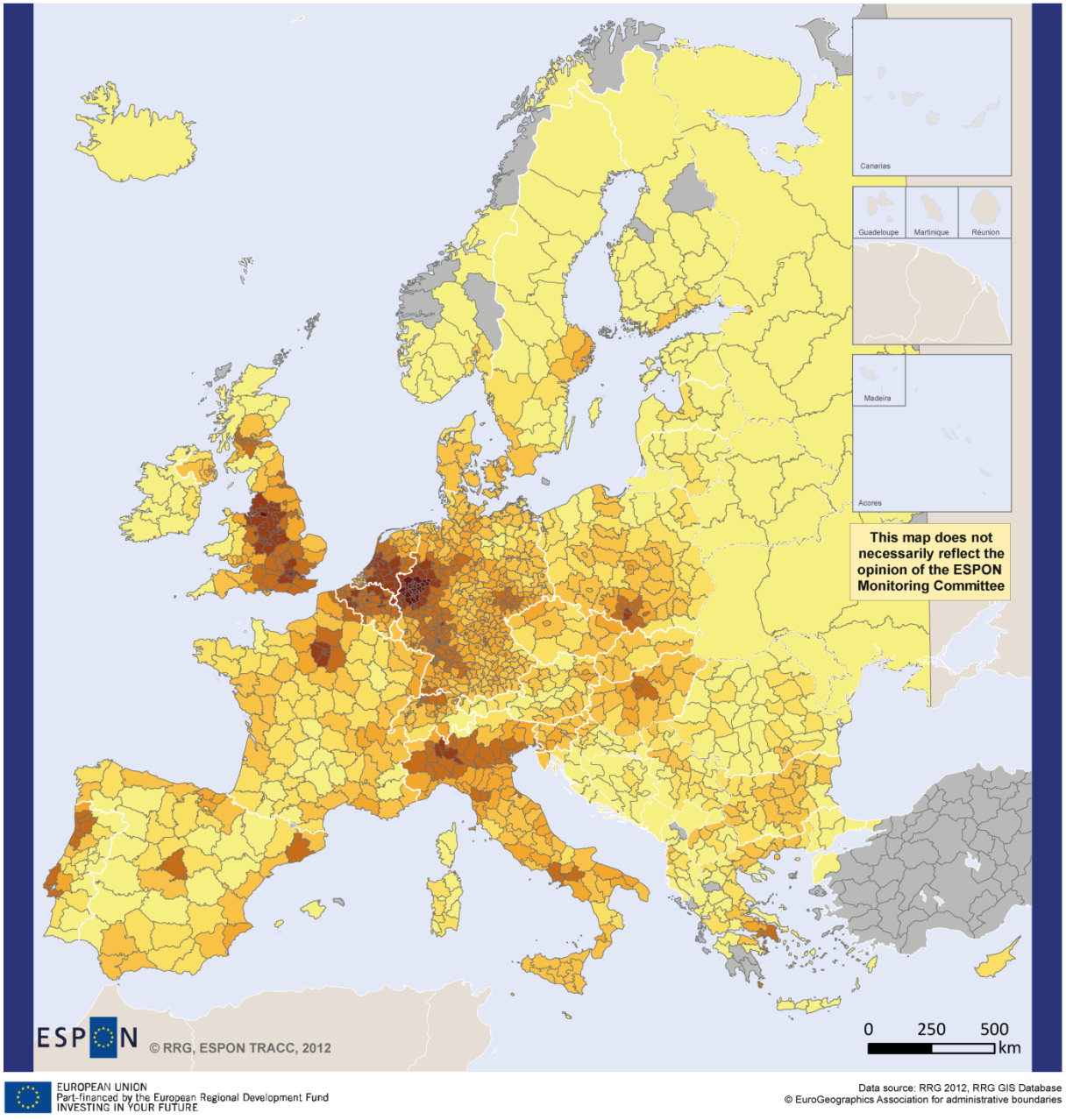


Figure 4.4. Availability of urban functions, road, NUTS-3

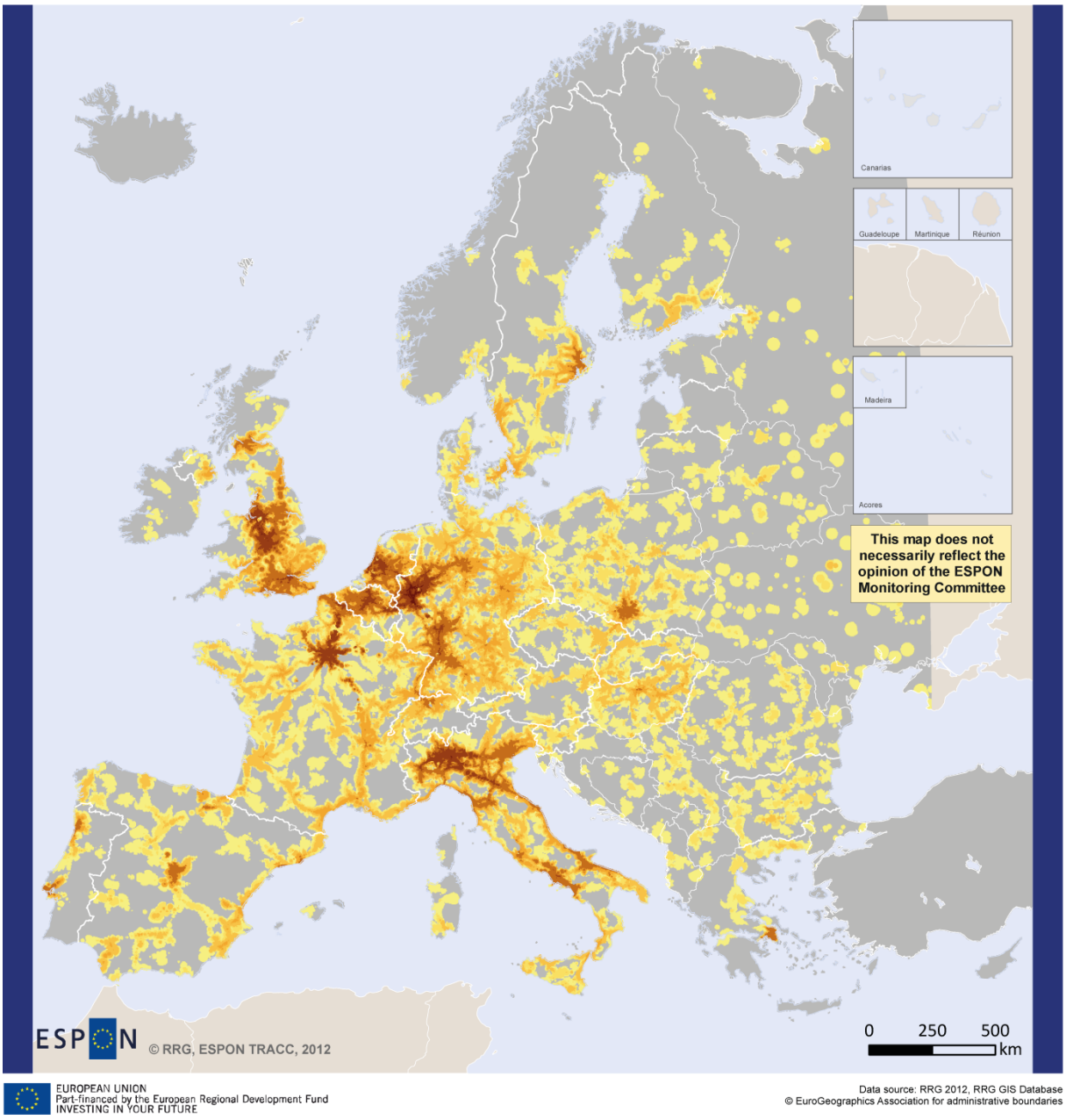


Figure 4.5. Availability of urban functions, rail, grid

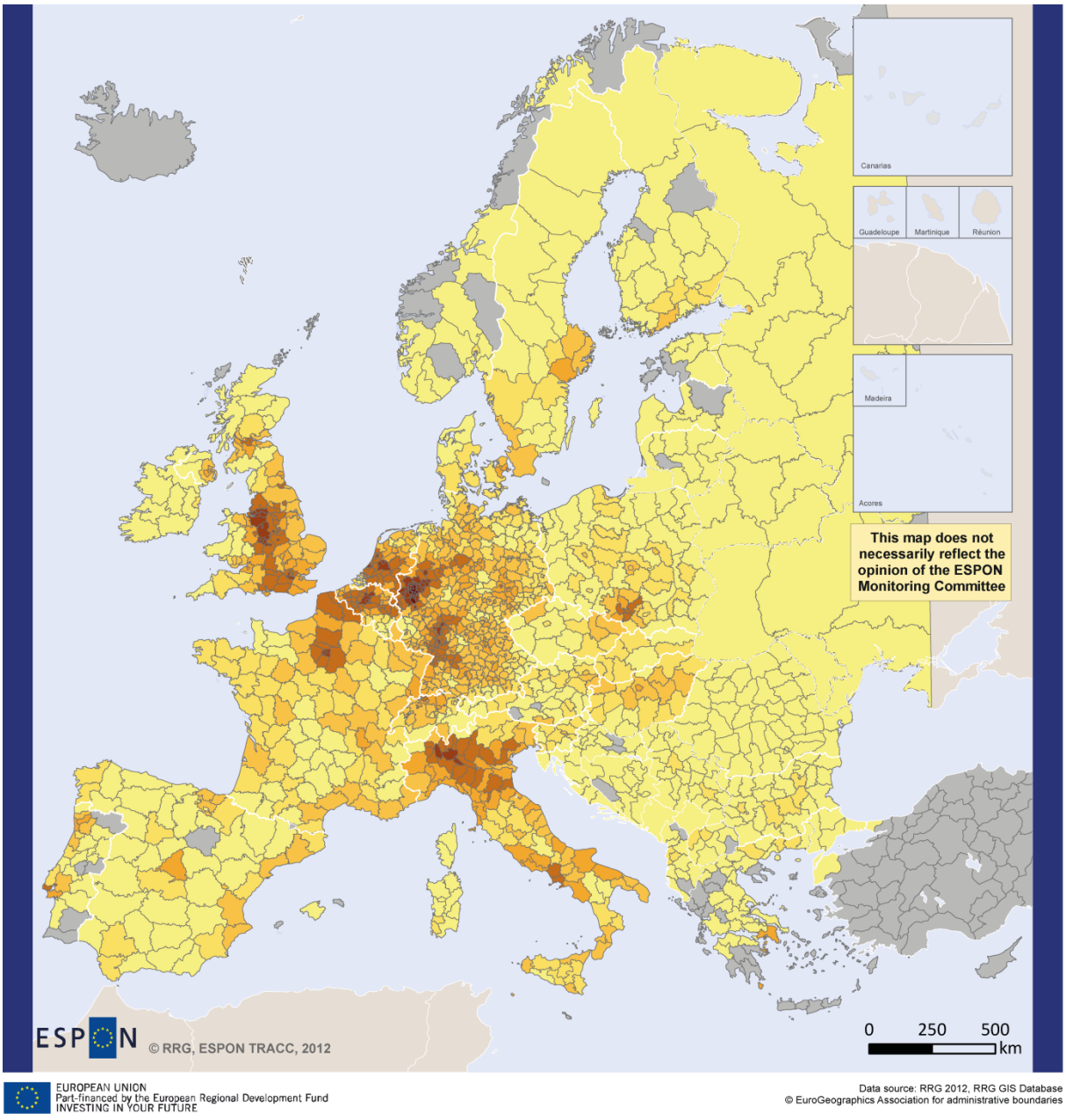


Figure 4.6. Availability of urban functions, rail, NUTS-3

4.3 National potential accessibility travel

Indicator name National potential accessibility travel		
Spatial context Regional	**Basic characteristics** Travel	**Generic type** Potential
Spatial level NUTS-3	**Origins** NUTS-3	**Destinations** NUTS-3 regions of same country as origin
Modes Road, rail		

Description and rationale

National potential accessibility for a specific NUTS-3 region is a construct of attractiveness of all other NUTS-3 regions in the country and travel time needed to reach these regions from the origin region. As the analysis is performed on a strict national basis, country borders are forced impermeable so foreign NUTS-3 regions become inaccessible from another country. Regions with a high potential accessibility have more opportunities to arrange a spatially distributed value chain in the domestic economy, have more alternatives in terms of national supply and demand market and so on. Thus, the national accessibility potential indicators reflect the relative competitive position of regions in the national context.

Equation

$$A_i = \sum_j W \, exp(-\beta \, c_{ijm}) \qquad W = 0 \;\; if \;\; country_j \neq country_i \qquad W = P_j \;\; if \;\; country_j = country_i$$

Where:

A_i is the accessibility indicator value for region *i*, i.e. the European accessibility potential travel

P_j is the population of region *j*

c_{ijm} is the shortest travel time between region *i* and the region *j* by intermodal trip chains *m*

Details on the indicator calculation

For each NUTS-3 region the population in those destination regions that belong to the same country as the origin is weighted by the travel time to go there. Travel time is calculated as the shortest travel time by road and by rail. The weighted population is summed up to the indicator value for the accessibility potential of the origin region. The national potential accessibility indicator is calculated for road and rail. All indicator values are standardised to the national average which is set to 100.

Database

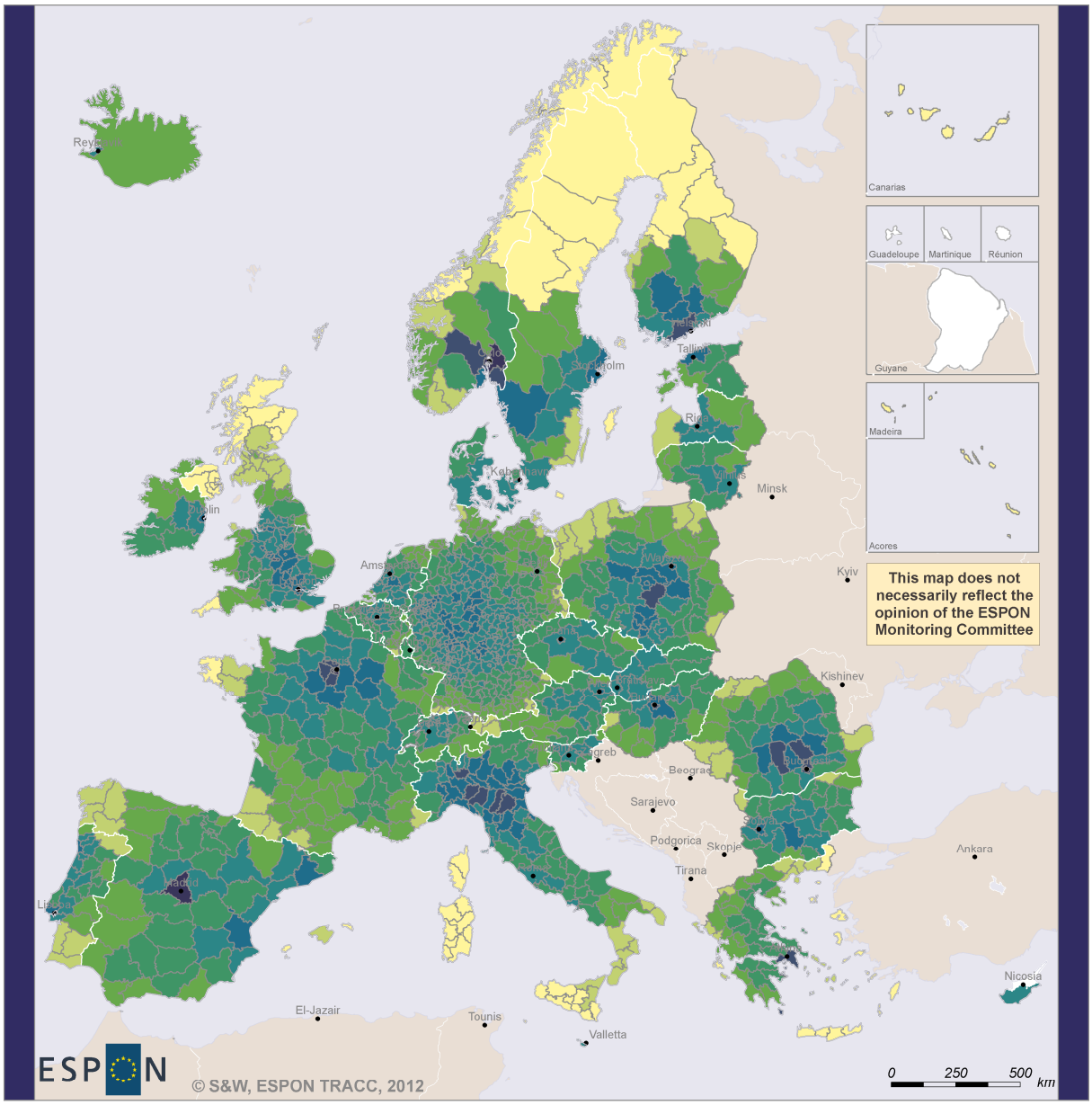
Road and rail networks: RRG GIS database

Flight network: S&W flight network

Spatial pattern and main observations

Figures 4.7 and 4.8 show the spatial pattern of national potential accessibility for road and rail. Each country has its highly accessible areas and its own peripheral areas. However, the pattern differs across Europe. Most of the countries in eastern and northern Europe have a clear core periphery pattern in which mostly the capital region performs best and the border regions have lowest accessibility. In other countries, there are larger corridors of higher accessibility; a consequence of a more polycentric distribution of population and network

design or a consequence of the effects of high-speed rail services. In some countries such as Italy or Germany, highest accessibility is not to be found in the capital regions but around other important agglomerations. In some countries such as Poland or the Czech Republic areas that are located closer to the European core and thus have a fairly good European rail accessibility are rather peripheral when considering the national context.



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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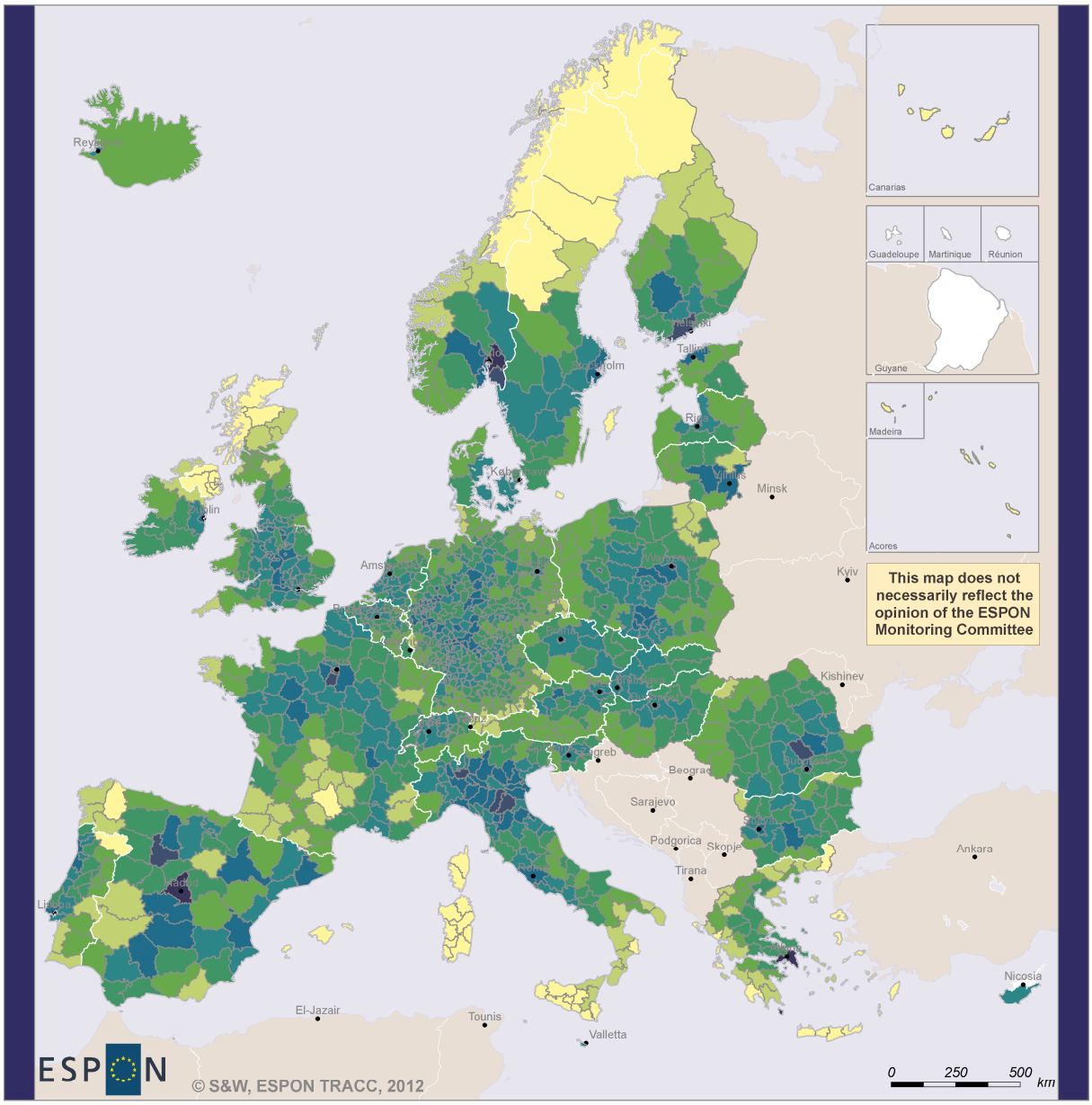
National potential accessibilty, road (ESPON = 100)

- 0 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 187
- no data

Figure 4.7. National potential accessibility travel by road



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Regional level: NUTS-3
Source: RRG GIS Database
S&W Flight Network
Origin of data: S&W Accessibility model, 2012
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National potential accessibilty, rail (ESPON = 100)

- 0 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 140
- 141 - 160
- 161 - 187
- no data

Figure 4.8. National potential accessibility travel by rail

4.4 Access to freight terminals

<table>
<tr><td colspan="3">Indicator name
Access to high-level freight transport infrastructure</td></tr>
<tr><td>Spatial context
Europe</td><td>Basic characteristics
Freight</td><td>Generic type
Travel cost</td></tr>
<tr><td>Spatial level
Raster cells and NUTS3</td><td>Origins
Raster cells</td><td>Destinations
Motorway gateways, freight villages and ports</td></tr>
<tr><td>Modes
Road</td><td colspan="2">Database
Road network (TRANS-TOOLS), freight villages (RGG), ports (MCRIT), port traffic (MCRIT), Corine land-cover database</td></tr>
<tr><td colspan="3">Description and rationale
This indicator reports connectivity of territorial units (raster cells) to freight transport networks.
Connectivity is defined as an average access time to transport networks, all modes within reach included. Destination points are motorway gateways, freight villages and ports; access time is based on travel time by road; following the ICON approach, times to different networks and transport terminals are aggregated and averaged considering their relative utility (within a transport network, all access points within reach are considered).
The conceptual basis of the connectivity methodology lies in the fact that the development of transportation systems as integrated networks at different scales is deeply changing their operation and the way they induce urban and regional development patterns. The conventional definition of "distance between places" seems not sufficient nowadays. A connectivity approach, focused on measuring the "distance to the networks" is needed to measure how transportation networks influence locational decisions and induce spatial development, in the context of current economic and technological changes.
According to many transportation analysts (e.g. Chisholm, 1992) one of the most common fallacies about transport costs is that they vary with location to the extent that geographical peripherality implies a substantial cost burden over more central locations. Empirical observations (e.g. Diamond and Spence, 1989, Plassard 1992) have verified the increasing insensitivity of most economic activities to transportation costs in developed areas. Places equally connected to transportation networks, independently of their geographical situation, show no significant differences in their transportation costs. These cost are, in general, less and less dependent on the total length of the trip.
As a result, the distance between two places (in time, cost or psychological perception), and the opportunity to establish relations between them, is increasingly dependent on the kind of transport and communication networks to which they are connected rather than the physical distance between them (Distler, 1986). Contemporary economic landscape can be therefore represented by the superimposition of two increasingly independent geographies: the geography of places and the geography of communication networks (Beauchard, 1991), both with different logics.
For further reference on this indicator, www.mcrit.com/IGIS/ICON.htm</td></tr>
<tr><td colspan="3">Equation
$$ICON = \sum_{i=1}^{N} ICON_i \cdot P_i$$
$$ICON_i = tam_i + \delta_i \cdot (tax_i - tam_i)$$</td></tr>
</table>

$$\delta_i = \frac{1}{1 + a_i \cdot e^{-b_i \frac{S_x - U_i}{S_x - S_o}}} \qquad U_i = S_i \cdot e^{-\beta(t_i)}$$

With $ICON_i$, the ICON value to the network i
p_i , the weight or relative proportion of the network i

(a) and (b) and (beta) are parameters to be fixed for each network, and U_i is the utility of a specific transport gateway (service provision above pre-determined quality level)

Details on the indicator calculation

For each network i=1...n (i.e. road, intermodal freight village and maritime networks) a network-specific value of ICON is calculated. These partial values are summed up in proportion to their relative contribution to transport endowment. This relative contribution can be determined considering the relative economic weight of each mode (P_i) –added value of each mode-, or in a simplified way, the relative proportions (p_i) will be estimated according to current modal split. The aggregated value of ICON is then:

$$ICON = \sum_{i=1}^{N} ICON_i \cdot P_i$$

With $ICON_i$, the ICON value to the network i
p_i , the weight or proportion of the network i

$ICON_i$ is calculated as the addition of the minimum access time by road to the closest connection node in the network plus an additional time which encapsulates a measure of the deficit of utility (in relation to a pre-defined quality level) not obtained from all available alternatives: this additional time can be called “generalised waiting time”.

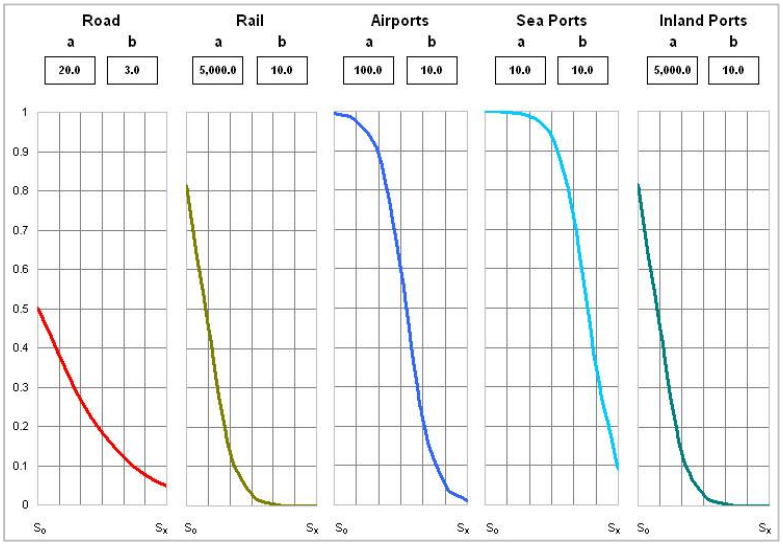
$$ICON_i = tam_i + \delta_i \cdot (tax_i - tam_i)$$

With tam_i the minimum access time to reach the closest transportation node in the network
tax_i the minimum access time necessary to reach the closest node with a service provision above a pre-determined quality level

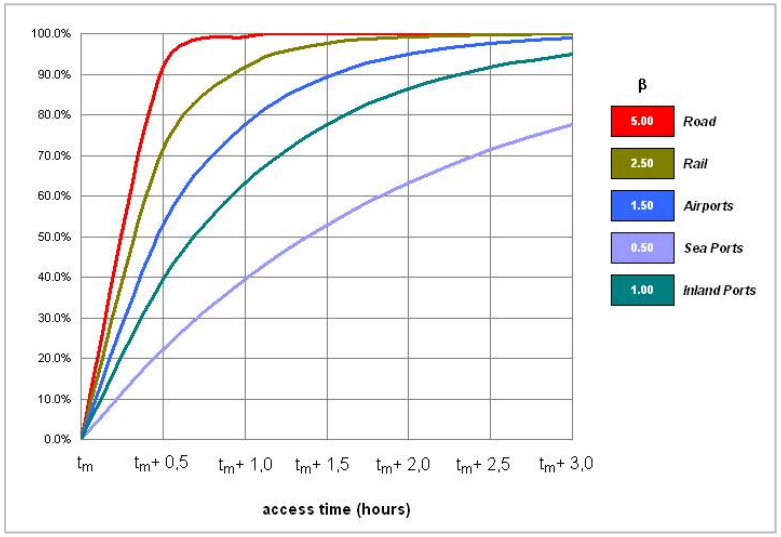
$$\delta_i = \frac{1}{1 + a_i \cdot e^{-b_i \frac{S_x - U_i}{S_x - S_o}}} \qquad U_i = S_i \cdot e^{-\beta(t_i)}$$

where (a) and (b) and (beta) are parameters to be fixed for each network, and U_i is the utility obtained in the considered gateway (service provision above pre-determined quality level)

According to this formulation, for any point (any location in Europe), ICON provides the measure of its connectivity to the transportation networks, basically considering the relative economic weight of each mode (P_i) and the minimum time (or cost) required to reach the closest node in each network (tam_i) increased by the additional generalised waiting times in each node ($\delta_i(tax_i - tam_i)$) to get a pre-determined utility (Ux_i).



δ_i value for different modes in function of U_i value



Ui values for different modes in function of access time to connection

The minimum value of $ICON_i$ in a point should be the access time to reach by road the closest transportation node in the network i (tam_i), and the maximum value of $ICON_i$ should be, by definition, the minimum access time (taxi) necessary to reach by road the closest node of the network i with a service provision above a pre-determined quality level (Sx_i). (So_i) is the minimum service level acceptable for any node or terminal to be included in the network i

Database

Travel time based on time from raster cells to transport network gateways.

Indicator computed over a road graph for all Europe with transport terminals included.

Access times calculated on a shortest cost path, taking into account different speeds for different road links in a European graph (TRANS-TOOLS road graph, with transport terminals included).

- Motorway entrances are defined as intersections between motorways and other roads.
- Freight villages from RRG GIS Database
- Ports from UN Locode database

Relative utilities

- Motorway utilities based on motorway speed and traffic (TRANS-TOOLS)
- Freight Villages utilities based on tributary rail and motorway freight traffics (TRANS-TOOLS database)
- Port utilities based on port container traffic (EUROSTAT)

Indicator calculated at raster level: Raster cells 5x5 km

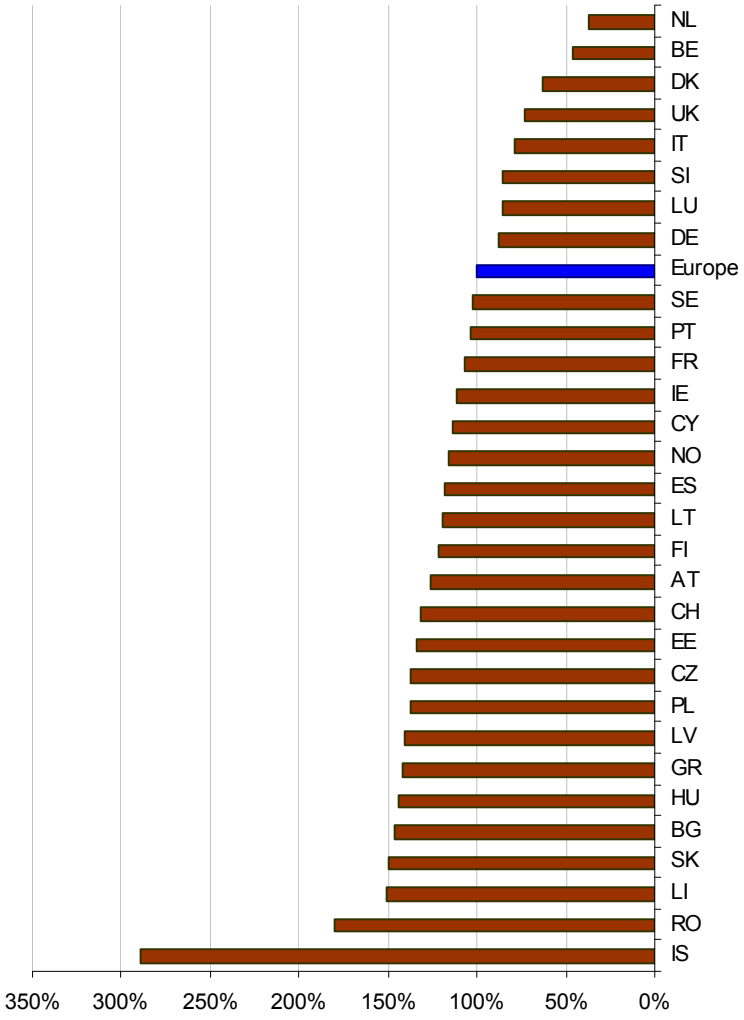
Indicator calculated at NUTS3 level: population average from raster cells

Spatial Pattern

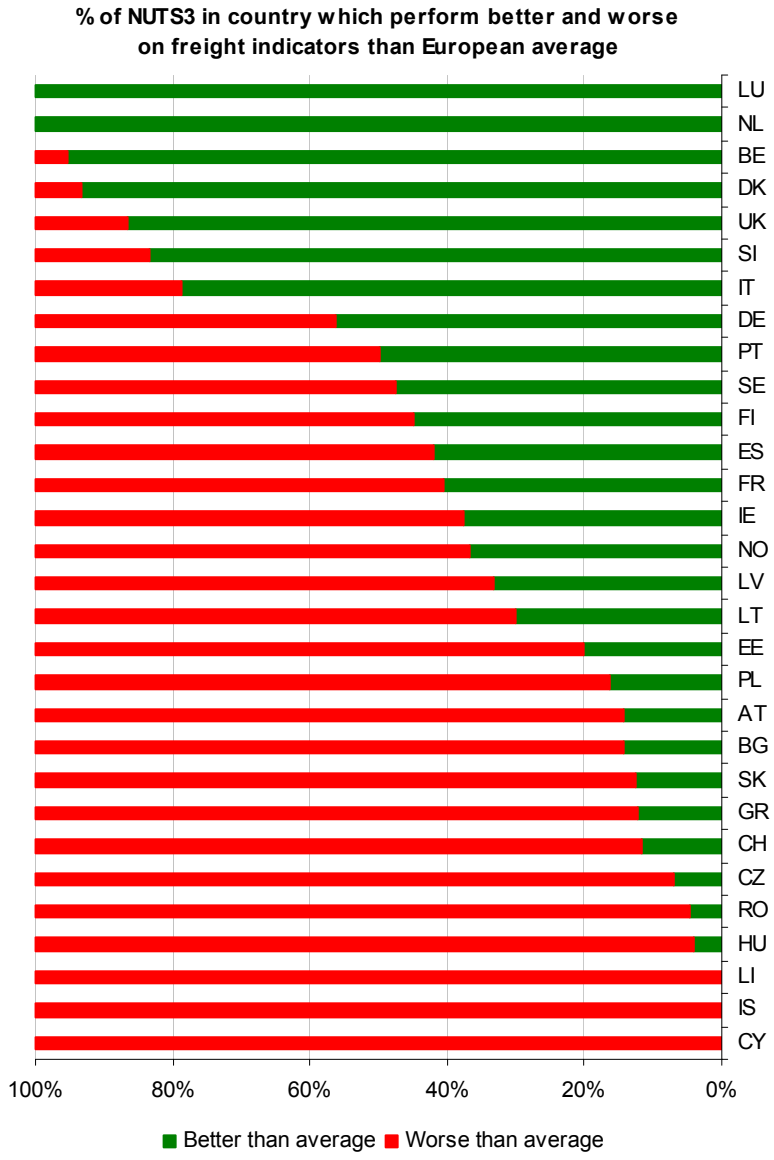
As this indicator is largely driven by accessibility to largest container ports in Europe, altogether with access to motorway networks, and access to intermodal freight villages to a lower extent, it is not surprising that best results are recorded in the Atlantic rim between the Benelux and Germany, where the four busiest container ports in Europe are located (Rotterdam 11,1MTEU; Antwerp 8,5MTEU; Hamburg 7,9MTEU; Bremen 4,9MTEU; in 2010) and motorway, and rail and freight village networks are denser.

The Mediterranean rim is also positively influenced by the presence of large container ports (Valencia 4,2MTEU; Gioia Tauro 2,8MTEU; Algeciras 2,8MTEU; Marsaxlokk 2,3MTEU; Barcelona 1,9MTEU; in 2010). However, less dense motorway and freight village networks in the hinterlands of this area limit highest connectivity values only to coastal areas, to a large extent.

Beyond this general pattern, it is possible to track areas with high levels of freight connectivity around large urban agglomerations (eg. Stockholm, Warsaw, Lyon or Bucharest), and along fluvial axes like the Danube and the Rhine.

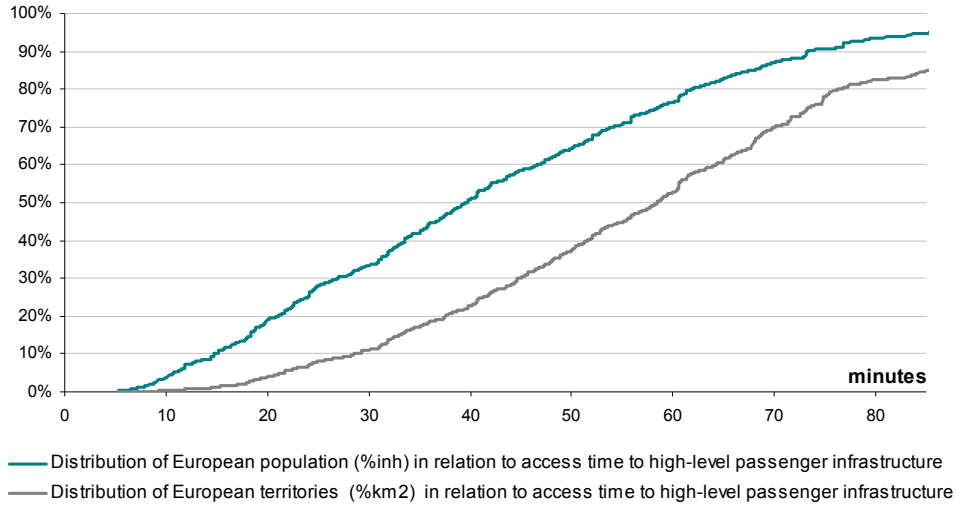


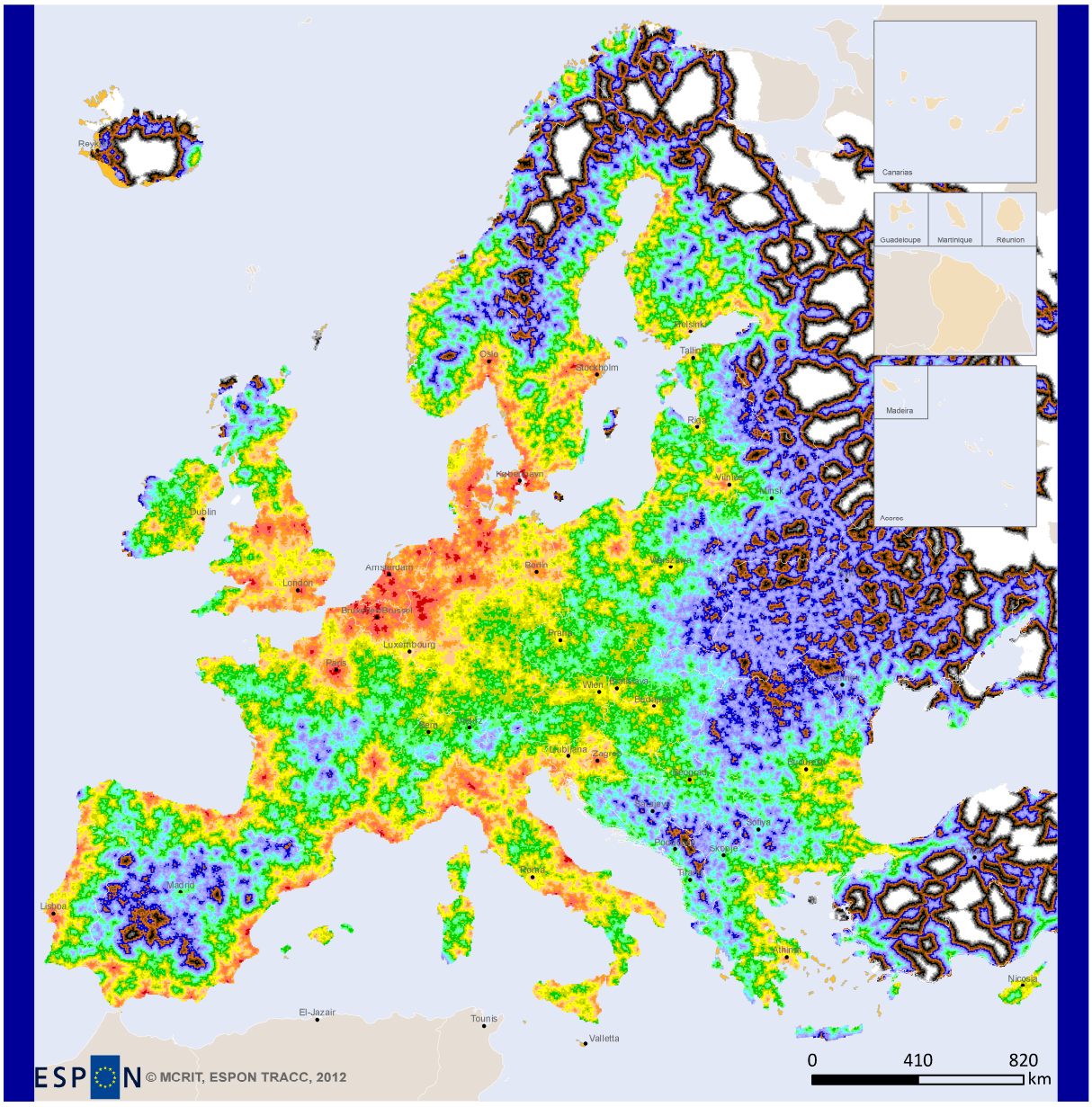
Core areas in Europe show higher levels of connectivity to freight transport networks than peripheral areas. Almost all countries having on average lower average travel times to high-level freight transport infrastructure than mean values for all NUTS3 in Europe (countries performing better) belong to European Core: the Netherlands, Belgium, Denmark, the United Kingdom, Italy (especially northern areas), Luxemburg and Germany. Maritime countries show in general better freight connectivity values than landlocked countries.



7 European countries have at least 80% of their NUTS3 performing better than European connectivity average to freight transport networks: Luxembourg, the Netherlands, Belgium, Denmark, the United Kingdom, Slovenia and Italy, mostly core and maritime countries. On the other side of the spectrum, 13 European countries have more than 80% of their NUTS3 performing worse than average in terms of connectivity to freight transport networks, mostly Eastern and landlocked countries.

50% of European population resides within 40 minutes or less (on average) of high-level freight transport infrastructure. This population is comprised in 22% of the European territory.





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Regional level: Raster 5x5 Km
Source: ESPON TRACC,2012
Origin of data: MCRIT,TRANSTOOLS Transport Network,2012
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Access to high-level freight transport infrastructure

ICON indicator,defined as relative connectivity to available transport networks (in minutes)

http://www.mcrit.com/IGIS/ICON.htm

	0 - 10		91 - 100		no data
	11 - 20		101 - 110		
	21 - 30		111 - 120		
	31 - 40		121 - 130		
	41 - 50		131 - 140		
	51 - 60		141 - 150		
	61 - 70		151 - 160		
	71 - 80		161 - 170		
	81 - 90		>170		

Figure 4.9. Access to high-level freight transport infrastructure by 5x5 grid cells

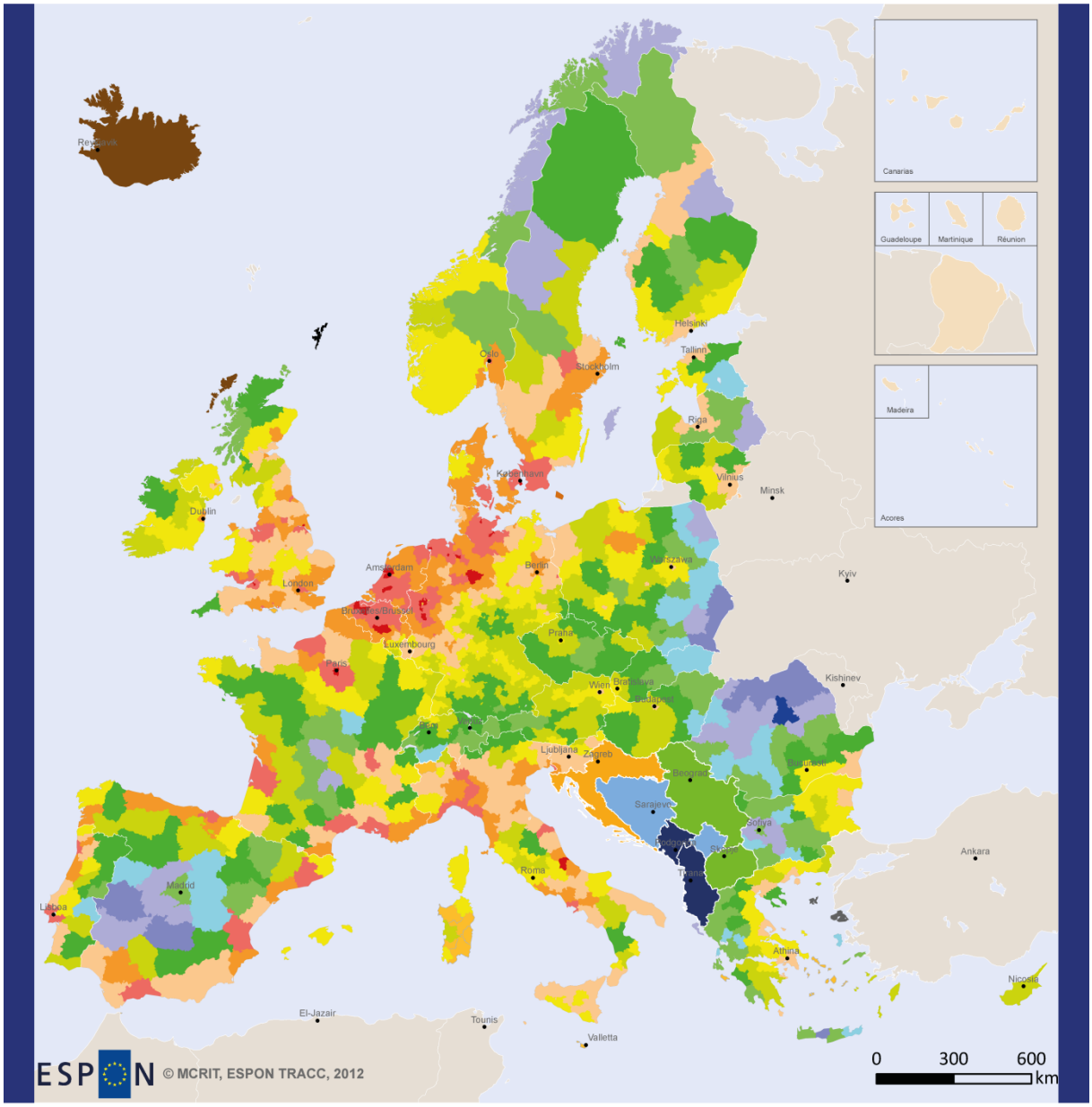


Figure 4.10. Access to high-level freight transport infrastructure by NUTS3

4.5 Availability of freight terminals

Indicator name Availability of freight terminals		
Spatial context Regional	**Basic characteristics** Freight (Europe-wide)	**Generic type** Cumulated opportunities
Spatial level Raster, NUTS-3	**Origins** Raster cell, NUTS-3 centroid	**Destinations** Freight terminals
Modes Road		

Description and rationale

What amount of options do have regions with respect to freight logistic centres? By looking at road transport, it will be assessed which number of freight terminals can be reached within a lorry travel time of two hours maximum. A wider definition of freight terminals is used, including all transhipment points from one cargo mode to another. Thus, freight terminals used for this indicator comprise cargo seaports and cargo inland ports, airports with cargo turnover, freight villages, and specific road-rail interchange terminals. Freight terminals are not only important employers, but all the more they act as gateways for the local and regional economy to market their products national, Europe or worldwide, and to obtain fabricated materials from world markets for producing their own products. Successful freight terminals are thus considered as triggers for the regional economy.

Equation

For each raster cell the travel time to all freight terminals will be calculated. If the travel time is less than 120 minutes, the destination is within reach and is added to the number of destinations.

Details on the indicator calculation

In a first step the travel time from each raster cell of the 2.5x2.5 km grid system to all freight terminals will be calculated, and the number of destinations within 120 minutes will be summed up. In a second step, the raster results will be aggregated to NUTS-3 level as averages.

Database

The trans-European road network, the raster grid (origins) as well as the location of the freight terminals in Europe (destinations) are taken from the RRG GIS Database. Relevant road ferries are included in this database. The NUTS-3 region layer obtained from ESPON Database Project was updated in different aspects.

Spatial pattern and main observations

The range of numbers of freight terminals throughout Europe is quite significant. While many areas have access to one or two terminals (mainly coastal areas), most accessible areas in Europe have access to more than 120 freight terminals within 120 minutes travel time (Figure 4.11). The latter ones are concentrated in the Benelux countries, Rhine-Ruhr area and Rhine-Main area in Germany, as well as in Northern Italy (Torino). Other important logistic regions are the Greater Stockholm area, the area between Turku and Helsinki, the coastal area between Oslo and Copenhagen, Greater Paris area, and the Midlands area in England (Liverpool, Manchester, and Sheffield).

Furthermore, main inland waterway axes such as Rhine, Danube and Elbe corridors, and the canal systems in North Germany including main seaports of Bremerhaven and Hamburg, and the further canal system in East Germany all the way to Odra river, also provide high accessi-

bilities for the regions due to its dense network of inland ports.

In contrary, there are also large territories that do not have access at all to any freight terminal. Such areas are mainly sparsely populated, landlocked hinterland regions in Scandinavia, France, Portugal and Spain as well as the Balkans. Aggregates at NUTS-3 level (Figure 4.12) hide these inner peripheries, as they are levelled out through averaging.

Results of this indicator confirm the expectation that the Benelux countries and West Germany are the main logistic turntables in Europe. Interestingly, with some exceptions the correlation of this indicator with potential population indicator is significant, supporting the assumption that logistic activities follow population concentrations.

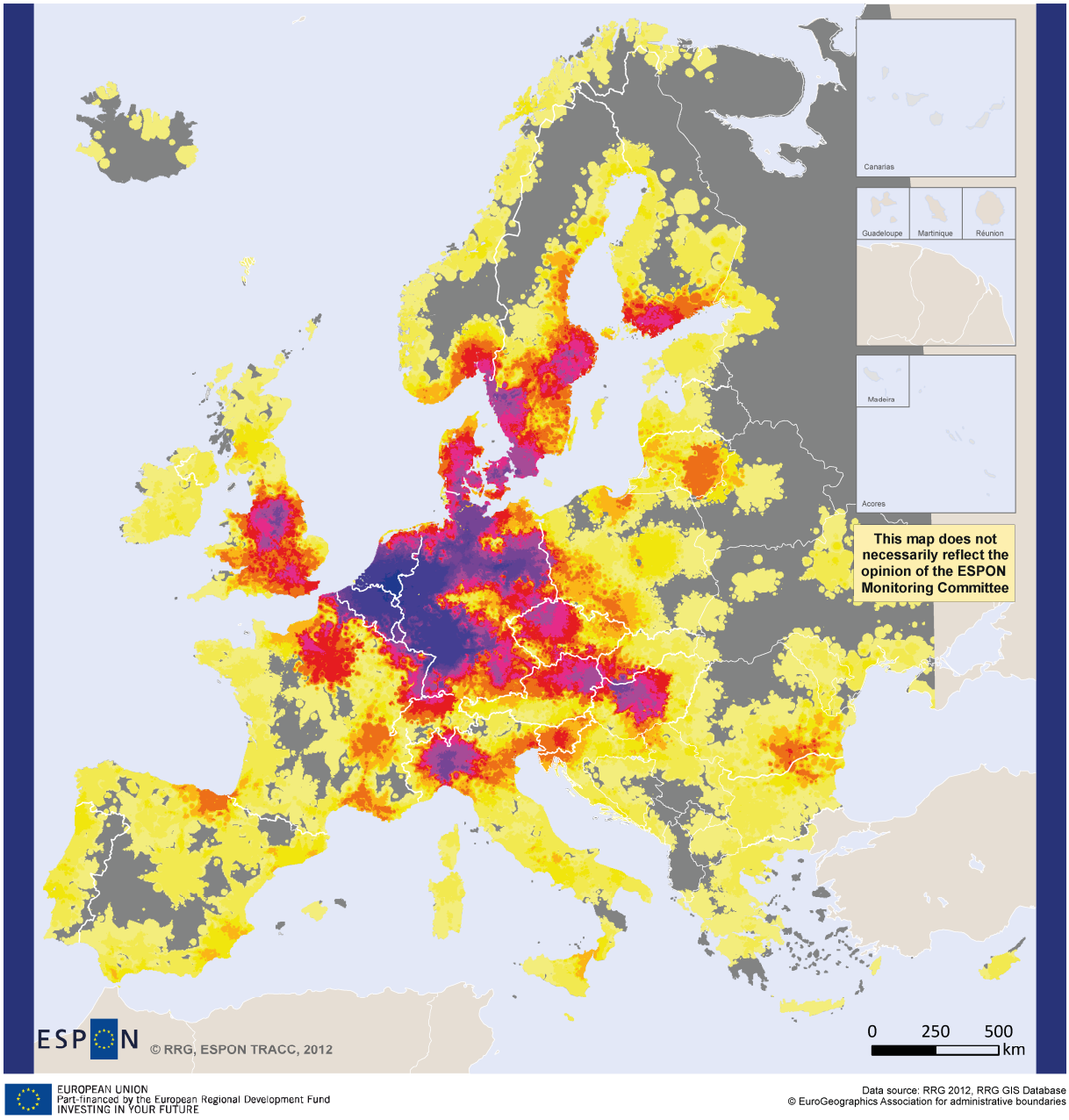


Figure 4.11. Availability of freight terminals, lorry, grid

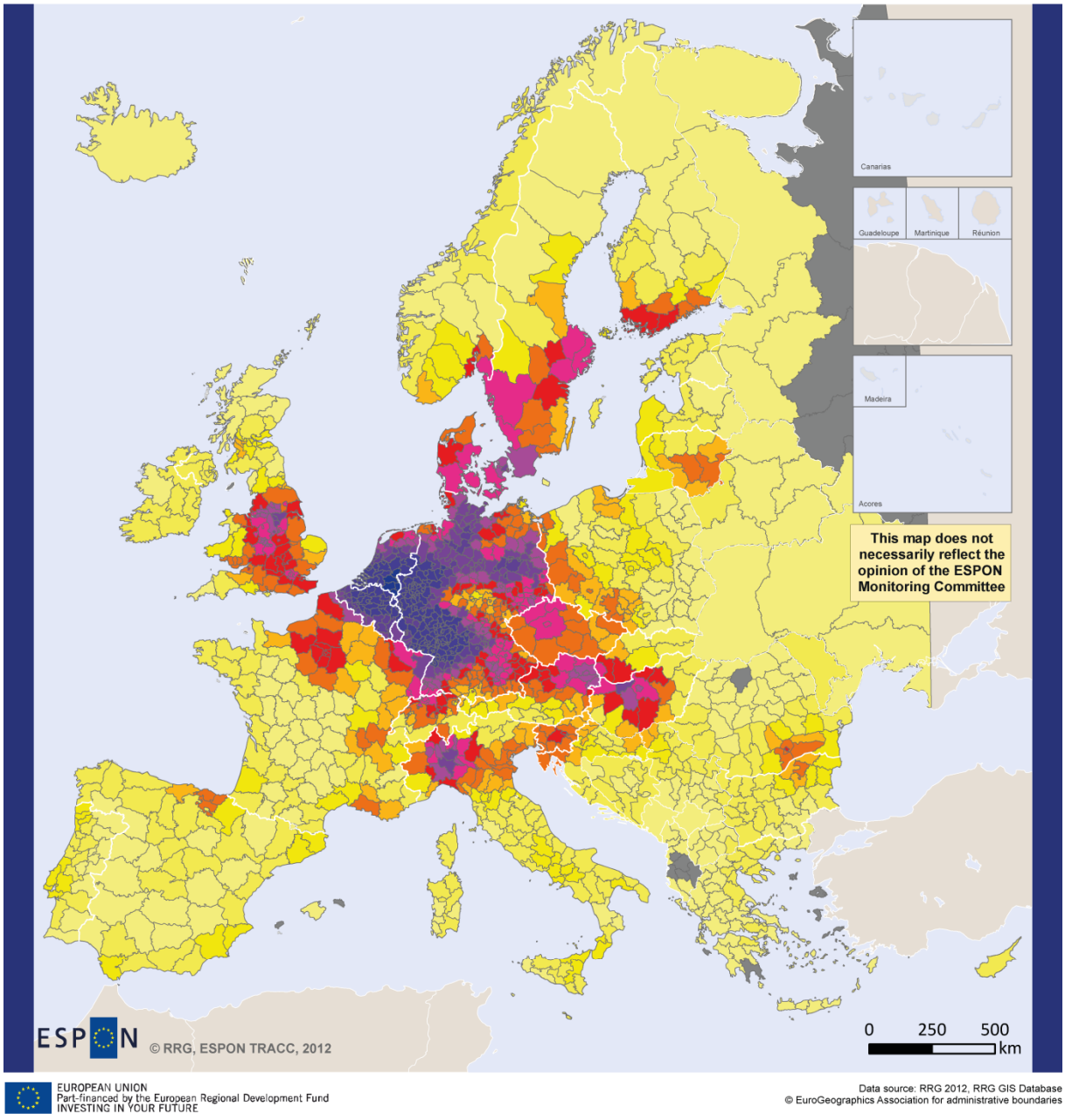


Figure 4.12. Availability of freight terminals, lorry, NUTS-3

4.6 National potential accessibility freight

Indicator name National potential accessibility freight		
Spatial context European	**Basic characteristics** Freight	**Generic type** Potential accessibility
Spatial level NUTS3 regions	**Origins** NUTS3 regions	**Destinations** NUTS3 regions in the same country of origins
Modes Road		

Description and rationale

The indicator is a construct of two functions:

- attractiveness of NUTS3 regions of the same country measured by their Gross Domestic Product
- generalised cost needed to reach destination regions from the origin regions using a given mode

This indicator allows to identify a ranking of the regions according to their proximity to the higher levels of national economic activity. Regions with a high potential accessibility have more opportunities to arrange a spatially distributed value chain in the domestic economy, have more alternatives in terms of national supply and demand market and so on.

Equation

$IND_{img} = \Sigma_{j \in NJ} \; GDP_j^{\alpha} \, GTC_{ijmg}^{-\beta}$

Where:

NJ = NUTS3 zones belonging to the some country of zone i

GDP_i = Gross Domestic Product of NUTS3 zone j

GTC_{ijmg} = Generalised cost (in €/ton) to reach zone j from zone i using mode m for handling category g

α,β = Calibration parameters

Details on the indicator calculation

The travel time for each NUTS3 to NUTS3 origin-destination pair is computed by means of modelling assignment. The model search for the most convenient path based on the generalised cost of the consignment, i.e. the monetary travel cost plus the equivalent of travel time in monetary terms. Resting time for truck drivers is considered in the calculation. Resting times depend on the truck trip duration as reported in the following table:

Travel time (h)	Resting time (h) added to OD travel time
<=13	0
>13 and <=26	11
>26 and <=39	22

The value of the indicator depends on the calibration parameters α,β. As usual the α parameter

is set to 1 (i.e. the attractiveness of the ports is measured by the pure value of their intercontinental throughput). The β is set to 0.8 as this value has proved to provide the most convincing distribution of values across zones.

The mapped values are ratios with respect to the average. For each country the own average has been considered and each country has been considered as an island, i.e. accessibility to neighbouring regions of other countries has not been considered.

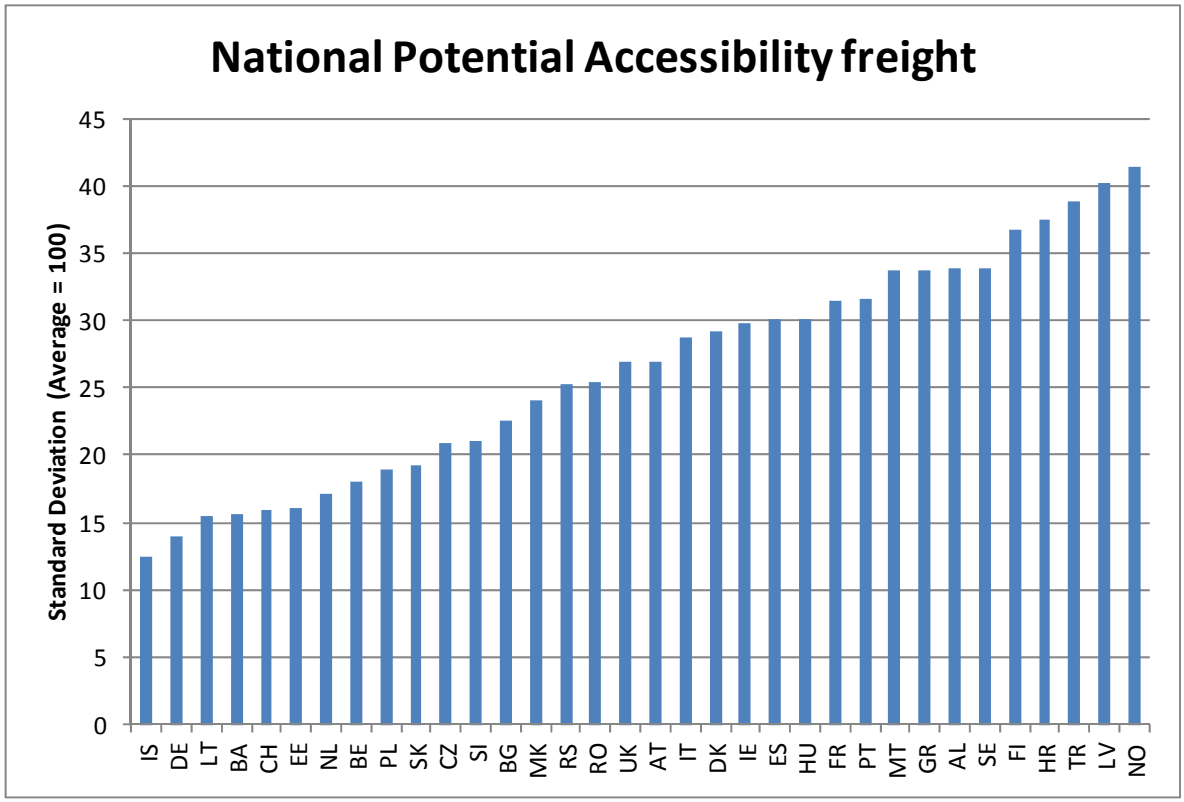
Database

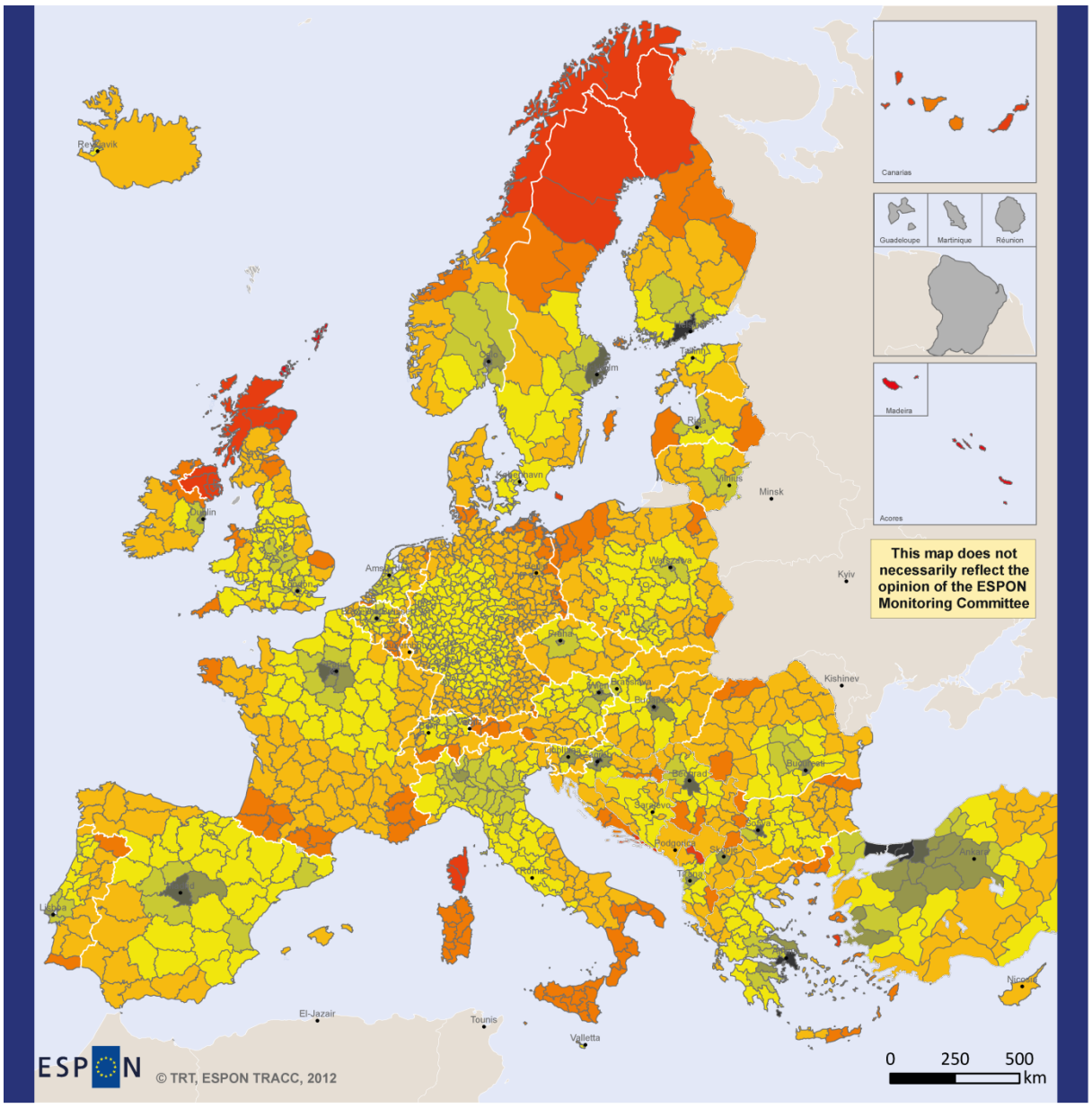
NUTS-3 region boundaries come from (ESPON database). Road transport network comes from the TRANS-TOOLS model. Data about GDP by NUTS3 zone is taken from the ESPON database with some integrations from TRANS-TOOLS database and from EUROSTAT. The definition of maximum driving time is taken from VOSA (Vehicle & Operator Services Agency), namely from the document "Rules on Drivers' Hours and Tachographs, Goods vehicles in the UK and Europe"

Spatial pattern and main observations

The spatial pattern of the indicator shows very clearly the position of the economic heart of each country. This heart corresponds to the capital region in most countries, but there are remarkable exceptions like Germany – where the highest potential accessibility is in the western part – or Italy – where the highest potential accessibility belongs to the northern regions.

As shown in the graph below, the differences among regions are smaller or larger country by country. The average level of GDP per capita does not seem correlated to the variability. Instead, smaller differences are found especially in smaller countries closer to central Europe – e.g. Germany, Netherlands, Switzerland, Lithuania – while larger differences show up mainly in bigger peripheral countries – Norway, Turkey, Finland. There are some exceptions. Iceland is an exception as it is the most peripheral but also the most homogenous country (but it includes just two NUTS3 regions). Croatia is an exception, being a small and not too peripheral country but with significant variability.





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Source: TRUST Accessibility Model (TRT 2012), Road Network: TransTools (2005), GDP regional data (ESPON data 2005/2006, TransTools data 2005, Statistical Offices data)
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National potential accessibility freight (2011):
Accessibility potential to National GDP by road
(percentage of average accessibility by road of all areas of the same country)

- 0 - 25.0
- 25.1 - 50.0
- 50.1 - 75.0
- 75.1 - 100.0
- 100.1 - 125.0
- 125.1 - 150.0
- 150.1 - 175.0
- 175.1 - 200.0
- 200.1 < ...
- n.a.

• *Capital cities*

Figure 4.13. National potential accessibility freight

5 Regional accessibility indicators for case studies

5.1 Access to regional centres

Indicator name Access to regional centres		
Spatial context Case studies	**Basic characteristics** Travel	**Generic type** Travel cost
Spatial level LAU2 / raster cells	**Origins** LAU-2 / raster cells	**Destinations** Regional centres (cities larger than 50,000 inhabitants and NUTS3 capitals)
Modes Road // Public transport		

Description

For a given municipality, proximity to an urban centre is relevant in terms of labour supply and services provide (banking, education, health care, commerce, leisure, etc).

For each LAU2, minimum travel times by road and by public transport are calculated to the closest regional centre. Regional centres are defined in TRACC as LAU2 units with more than 50.000 inhabitants or being NUTS3 capitals. This threshold has already been used in the literature as reflecting urban centres being able to articulate territorial networks around them of considerable size (e.g. Dijkstra and Poelman for DG Regio in 2008)[1].

Equation

$$A_i = TravelTime_{\text{Re}\,gionalCent\,re} \forall LAU\,2_i$$

Details on the indicator calculation

For each LAU2, minimum travel times by road and by public transport are calculated to the closest regional centre. Travel time is the output of the calculation of shortest paths from each LAU2.

Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

- Rail: commercial speed of services are used, which include time spent in programmed stops. Therefore, speed does not only reflect the physical features of the link.
- Bus: simulated introducing reduced speeds on the road network taking into account average commercial speeds and average frequency of services

Database

The population of regional centres is obtained from local statistics institutes.

Spatial pattern

For the Czech Republic case study, the analysis reveals significant geographic differentiation

[1] Dijkstra,L and Poelman,H. (2008); *Remote Rural Regions. How proximity to a city influences the performance of rural regions.* European Union Regional Policy.

of communities in respect of time accessibility. On one hand they highlight the hinterland of all agglomerations where the mobility of residents is of significance (dominated by commuting to work, school and services). Disparities in time accessibility are affected by the current state of the road infrastructure in the Czech Republic. In the map, radial express and high-capacity roads can be observed in the hinterland of Prague, in particular. On the other hand the results show the most distant and peripheral areas located primarily at the borders with Poland (Krkonoše and Jeseníky Mts.) and Bavaria (Šumava Mts.). There are also so-called inner peripheries in the Czech Republic, which can be found around the borders of the NUTS3 regions (mainly around the Central Bohemian Region and between Bohemia and Moravia). These areas are predominantly characterised by the decline in the resident population and other socio-economic indicators of a below-average level. Here, the important factor is the transport-related exclusion of the residents. This is for example the interface of the Central Bohemian and South Bohemian Regions or the border between the Pardubice and Vysočina Regions.

Time accessibility by communities of the nearest regional centre with more than 50 000 residents via public transport shows a similar spatial pattern as the previous map. The main difference is the size of the hinterland with time accessibility of up to 30 minutes and its concentric shape resulting from the lower transportation speed of public mass transport (PMT). The results also show much more peripheral communities where travelling by public transport takes more than 80 minutes. For most of these communities it is typical that there is an above-average number of vehicles in households as it partially compensates for the insufficient offer of PMT. Although the Czech Republic has a relatively good and stabilised offer of public transport (compared to other European states), competition from private vehicles is very important and more and more people prefer to commute by car instead of public transport. Nevertheless, integrated transportation systems have been introduced to most areas around regional metropolises in the Czech Republic and the position of public transport in the hinterland of large regional centres is very strong. On the other hand, the transport-related exclusion of variously disadvantaged groups of residents of peripheral communities (considered in terms of transport) is becoming a significant threat for the future

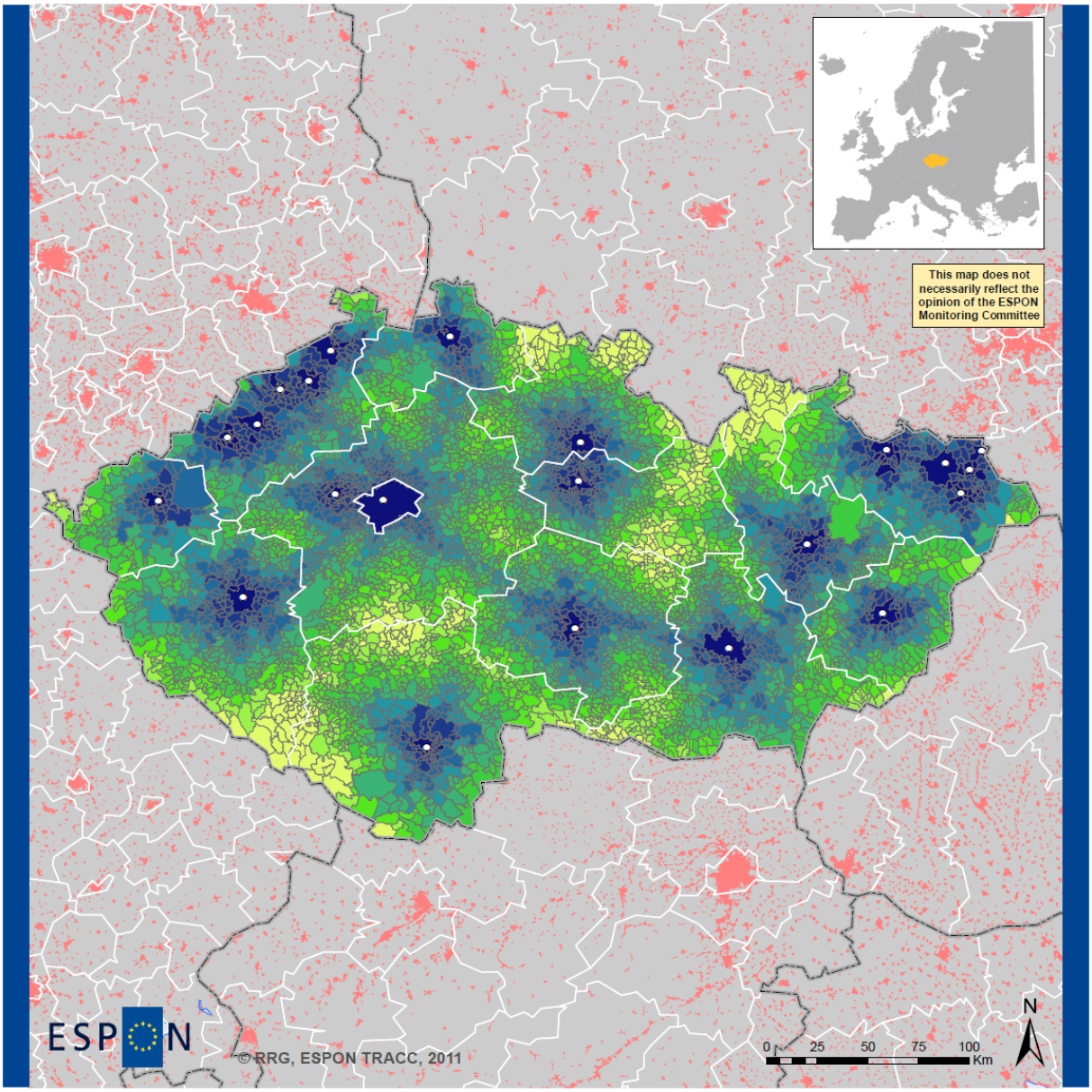


Figure 5.1. Travel time by car to closest regional centre from each LAU2, in minutes

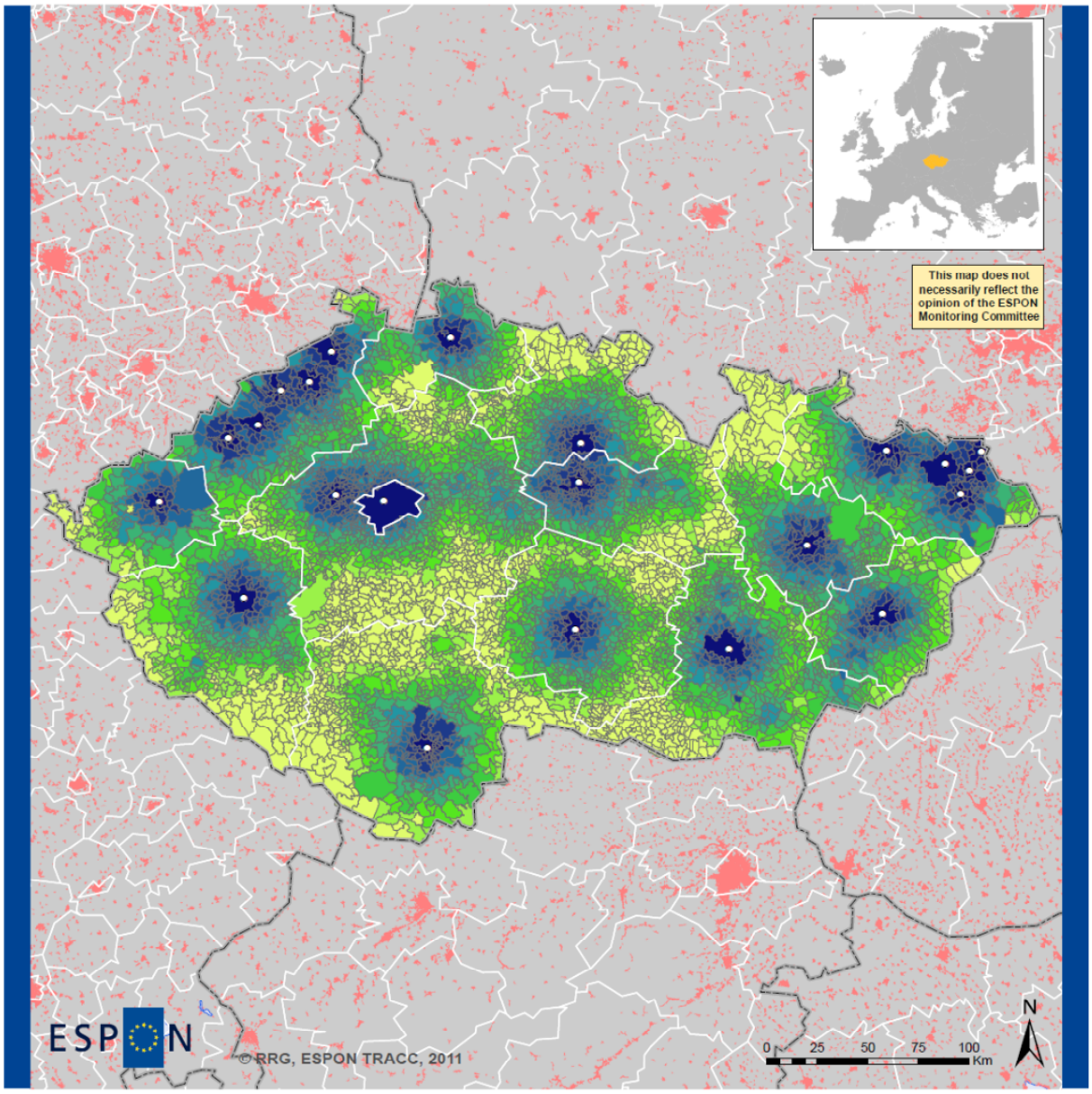


Figure 5.2. Travel time by public transport to closest regional centre from each LAU2, in minutes

5.2 Daily accessibility of jobs

Indicator name Daily accessibility of jobs		
Spatial context: Case studies	**Basic characteristics** Travel	**Generic type** Cumulated opportunities
Spatial level LAU2 / raster cells	**Origins** All LAU2 / raster cells	**Destinations** LAU2 / raster cells closer than 60 minutes
Modes Road // Public transport		

Description

The "accessible jobs" indicator is defined as the amount of activity reachable from each LAU2 in less than 60min travel time. Using 60 minutes as a threshold for the daily accessibility indicator seems reasonable as it can be considered to represent maximum daily commuting time (Marchetti 1994)

Equation

$$A_i = \sum_j Jobs_j, \forall j : TravelTime_{i,j} < 60\,\text{min}; \forall LAU2_i$$

Details on the indicator calculation

Travel time is the output of the calculation of shortest paths from each LAU2. If a given LAU2 is reachable with a travel time below 60 minutes, the number of jobs in that LAU2 will be considered. Otherwise, it will be omitted.

When labour markets are integrated, jobs supply in neighbouring municipalities to the case study region may also be considered as destinations.

Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

- Rail: commercial speed of services are used, which include time spent in programmed stops. Therefore, speed does not only reflect the physical features of the link.
- Bus: simulated introducing reduced speeds on the road network taking into account average commercial speeds and average frequency of services

Database

The number of jobs in each LAU2 is obtained from local statistics institutes when possible, or estimated when data is not available from regional activity rates

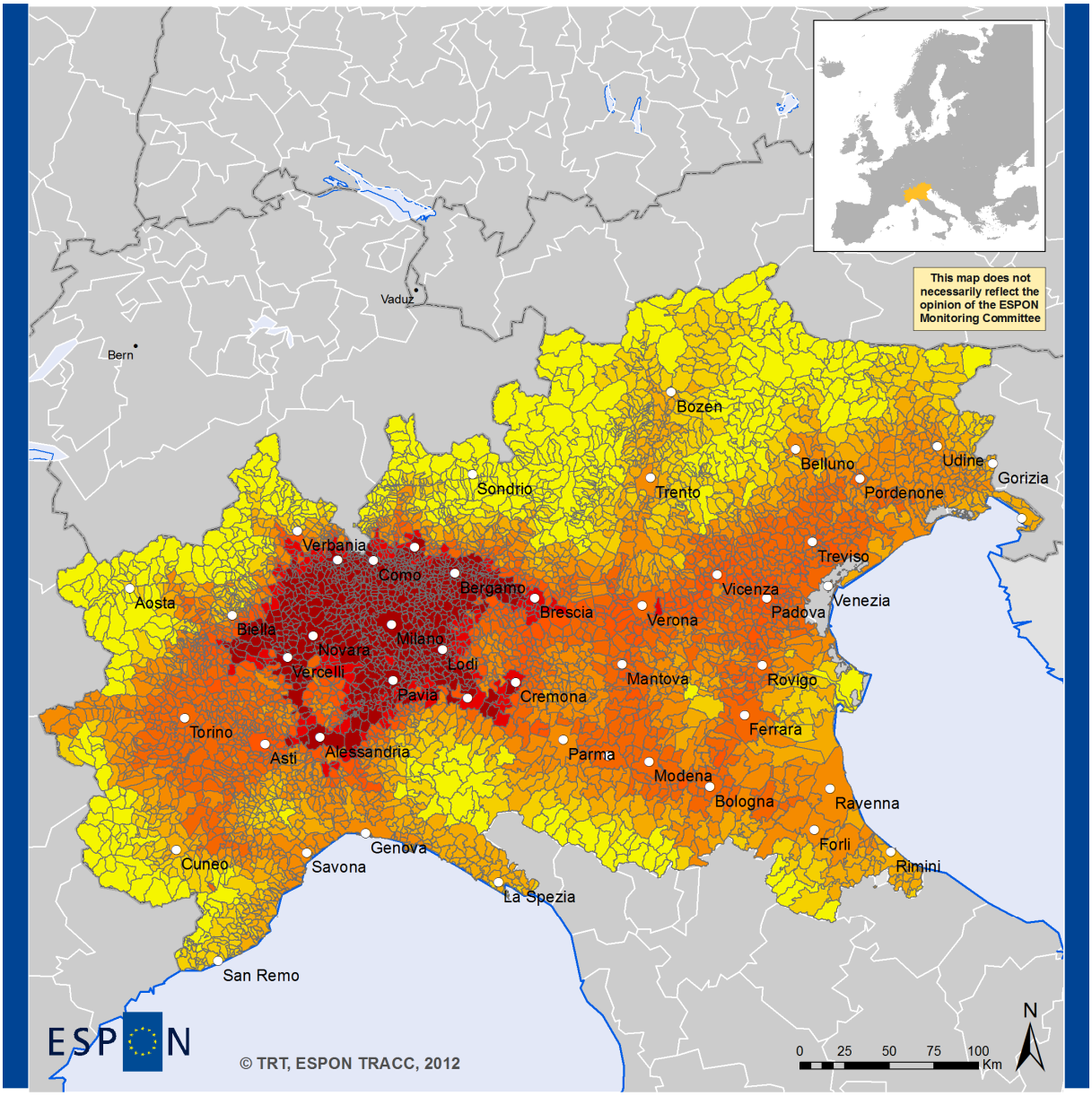
Spatial pattern

The Northern Italy area is rich of economic activities spreading over most of its territory rather than concentrated in a few spots, even if the density of activities (as well as of population) is especially high in the sub-region surrounding the metropolitan area of Milan. As result of this level of density, nearly one half of zones and two thirds of population can reach more than 1 million of jobs in less than one hour by car. Only a small share of population, living in a minority of zones mainly located in mountain areas, can reach less than 100,000 jobs within 60 minutes.

Accessibility by public transport follows basically the same pattern of jobs accessibility by car,

but with a distribution shifted downwards, i.e. the number of workplaces that can be reached within 60 minutes by public transport is generally lower than by car.

The difference of accessibility patterns among different territorial typologies is important. On average, accessibility in urban agglomerations is several times larger than in remote areas. Another advantage of urban areas is that public transport accessibility is not always worse than car accessibility. Instead, in intermediate zones the difference is much larger and moving by public transport means a clear drop in median accessibility.



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Workplaces (2001)
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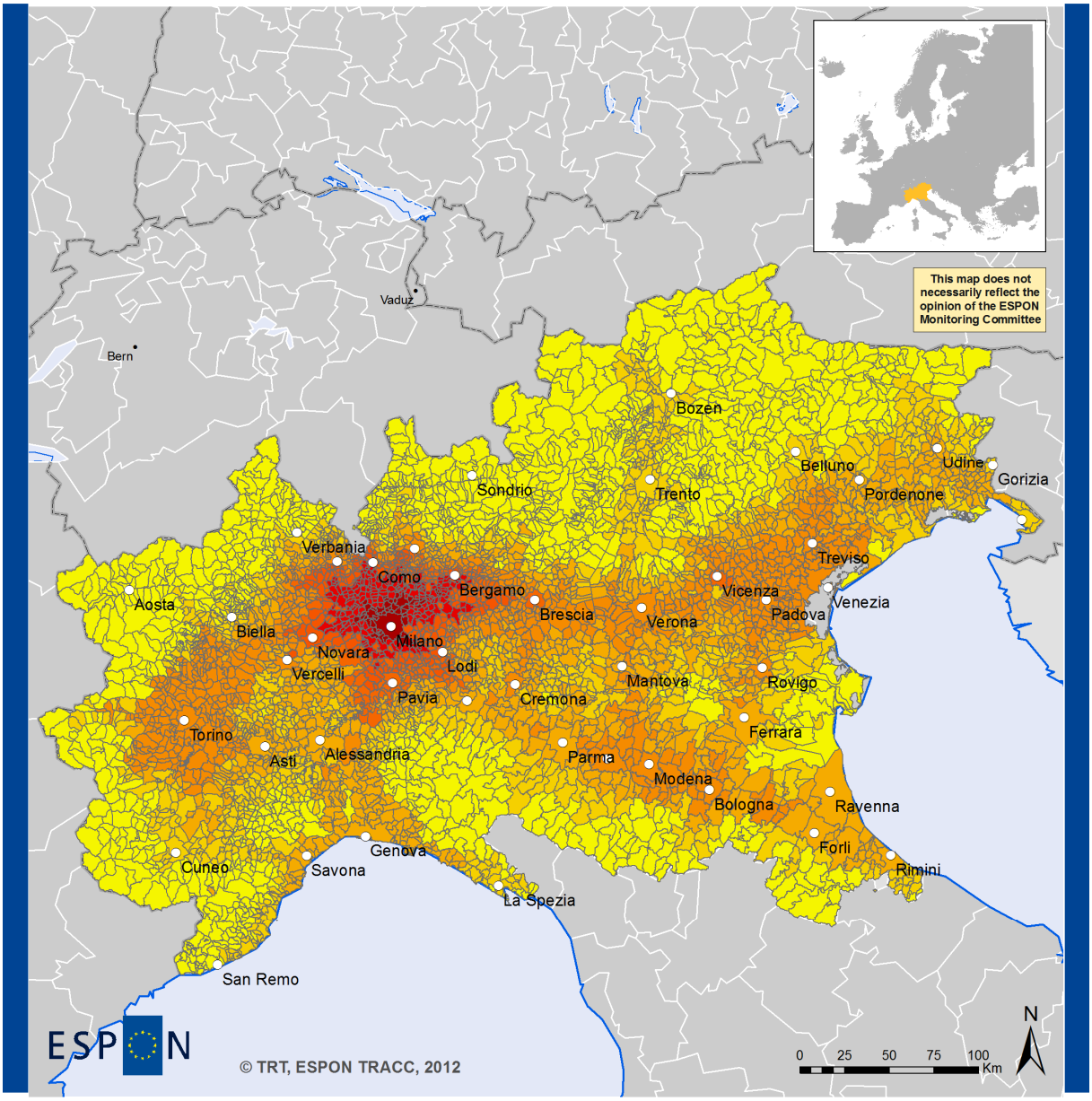
Northern Italy Case Study (2011)
Daily accessibility of jobs: Jobs (ths.) accessibile within 60 minutes by road

- 0 - 100
- 101 - 250
- 251 - 500
- 501 - 1 000
- 1 001 - 1 500
- 1 501 - 2 000
- 2 001 - 2 500
- 2 501 < ...

○ *NUTS3 Capital*

Figure 5.3. Jobs accessible by car within 60 minutes



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Source: TRT Accessibility model (2012), Rail Network: RRG GIS Database (2011), Road Network: OSM (2011), Italian Statistical Office (ISTAT)- Workplaces (2001)
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Northern Italy Case Study (2011)
Daily accessibility of jobs: Jobs (ths.) accessibile within 60 minutes by public transport

- 0 - 100
- 101 - 250
- 251 - 500
- 501 - 1 000
- 1 001 - 1 500
- 1 501 - 2 000
- 2 001 - 2 500
- 2 501 < ...

○ *NUTS3 Capital*

Figure 5.4. Jobs accessible by public transport within 60 minutes

5.3 Regional potential accessibility

Indicator name		
Regional potential accessibility to population		
Spatial context Case studies	**Basic characteristics** Travel	**Generic type** Potential
Spatial level LAU2 / raster cells	**Origins** All LAU2 / raster cells	**Destinations** All LAU2 / raster cells
Modes Road // Public transport		

Description

Potential accessibility is based on the assumption that the attraction of a destination increases with its utility and declines with distance or travel time or travel cost to it. Therefore both size and distance of destinations are taken into account. The population potential is calculated as the sum of people in destination areas weighted by the travel times to go there.

In order to evaluate the different locations within a region from the viewpoint of economic actors, e.g. firms assessing the regional labour market, or retail industries assessing the market area, the population potential of each municipality or raster cell within the case study region is calculated.

Equation

$$A_i = \sum_j \mathrm{g}(W_j)\ \mathrm{f}\ (c_{ij})$$

$$A_i = \sum_j Population_j^{\alpha} \cdot \exp(-\beta \cdot TravelTime_{i,j}), \forall j; \forall LAU2_i$$

With α = 1 and β = 0,035

Details on the indicator calculation

In general terms, accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them:

$$A_i = \sum_j \mathrm{g}(W_j)\ \mathrm{f}\ (c_{ij})$$

where A_i is the accessibility of area *i*, W_j is the activity *W* to be reached in area *j*, and c_{ij} is the generalised cost of reaching area *j* from area *i*. The functions g(W_{ij}) and f(c_{ij}) are called *activity functions* and *impedance functions*, respectively. They are associated multiplicatively, i.e. are weights to each other.

For accessibility potential, the impedance function is a negative exponential function of the form

$$f(c_{ij}) = \exp(-\beta c_{ij})$$

This equation can be transformed to calculate the beta parameter:

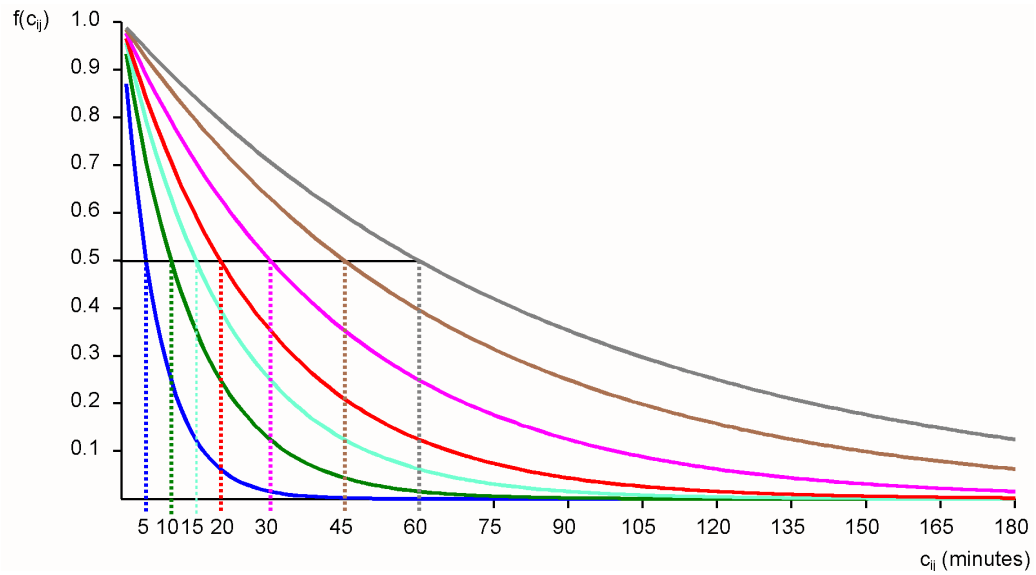
$$\beta = -\frac{\ln(f(c_{ij}))}{c_{ij}}$$

The beta parameter can be calculated for different travel times which should be used as a

weight of 0.5 for the impedance function. The table below presents different travel times for the halftime value, the resulting beta and also resulting travel times at which the weight of the impedance functions will be 0.75, 0.25 and 0.1.

Halftime value c_{ij} (minutes)	β parameter	c_{ij} (minutes) if f(c_{ij}) equals		
		0.75	**0.25**	**0.1**
5	0.138629	2.1	10.0	16.6
10	0.069315	4.2	20.0	33.2
15	0.046210	6.2	30.0	49.8
20	0.034657	8.3	40.0	66.4
30	0.023105	12.5	60.0	99.7
45	0.015403	18.7	90.0	149.5
60	0.011552	24.9	120.0	199.3

To read an example from above: a halftime value of 20 minutes, i.e. a destination 20 minutes travel time apart, would be weighted with 0.5 of its size and would result in a beta of 0.034657. Applying this beta would mean that destinations 8.3 minutes away would be weighted by a factor of 0.75 and destinations 66.4 minutes apart would be weighted still with a factor of 0.1. Figure below shows the resulting weighting curves for the 7 different halftime values, respectively betas.



Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

- Rail: commercial speed of services are used, which include time spent in programmed stops. Therefore, speed does not only reflect the physical features of the link.
- Bus: simulated introducing reduced speeds on the road network taking into account

average commercial speeds and average frequency of services

Potential indicators are mapped in a standardised form, i.e. the regional average is set to an index value of 100. Regional averaging is done as a population weighted average, not as municipality weighted average.

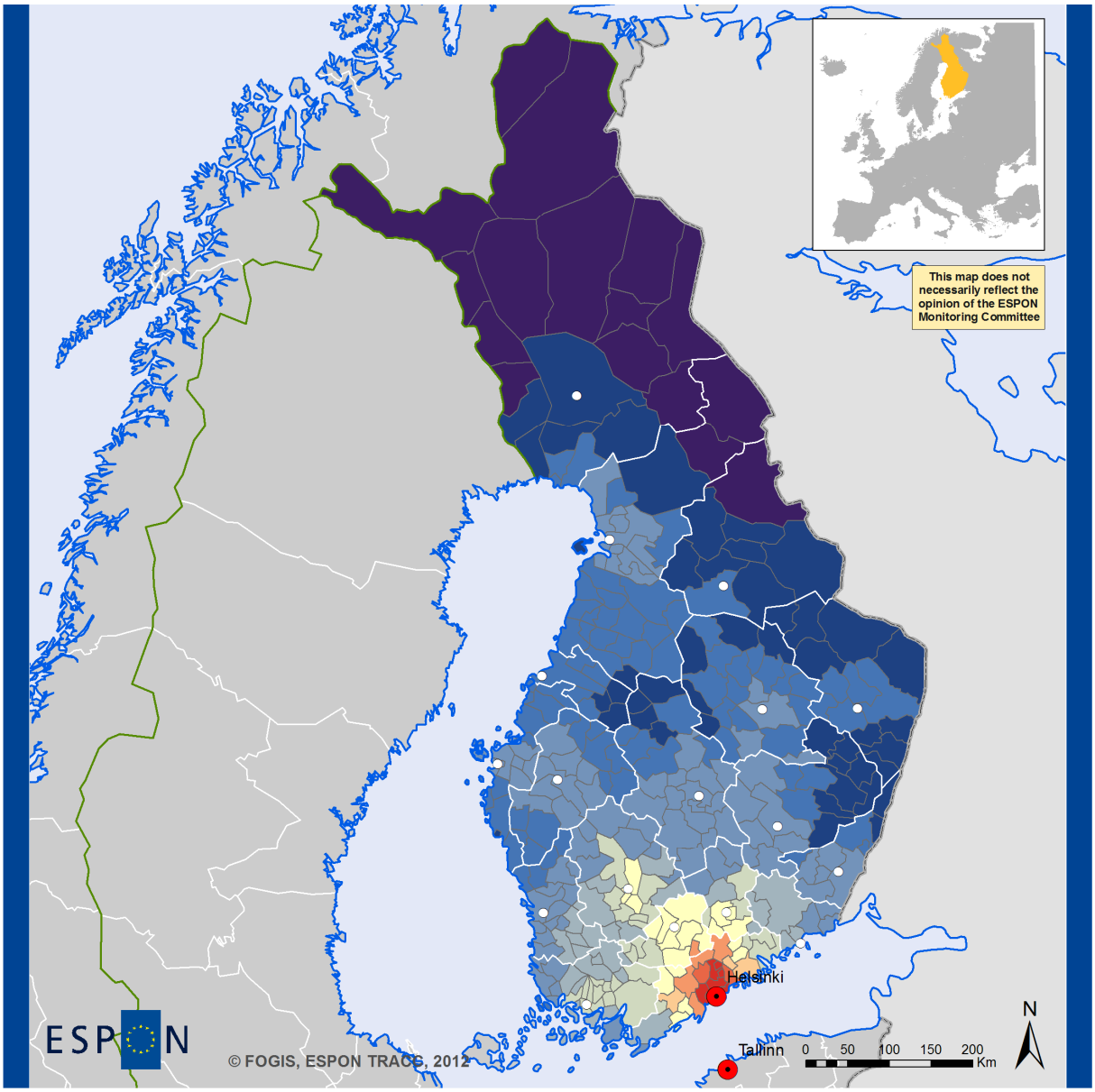
Database

Population of LAU2 units is obtained from local statistics institutes.

Spatial pattern

In Finland, the dominance of a few cities in the South, particularly the capital region, forms the major pattern in the regional accessibility potentials. The centre-periphery polarisation in Finland is particularly evident. Only the accessibility around regional centres is an exception to the pattern in remote peripheries. All municipalities in the Lapland region belong to the most peripheral category. Eastern regions are also characterised by low accessibility. The grid cell analysis also shows the significance of the main roads between the capital and major cities.

Accessibility potentials by public transport are even more polarised than that by car. Absolute values show that car accessibility is generally better, as expected. The Oulu region is in the most accessible class by public transport. By grid cell map it is possible to notice how in terms of the land area, most of Finland is poorly accessible by public transport, while the population centres are served pretty well.



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Data source: Finnish Transport Agency, 2012, Statistics Finland, 2011, 2010
Origin of data: ESPON Databank Project, 2010/2011
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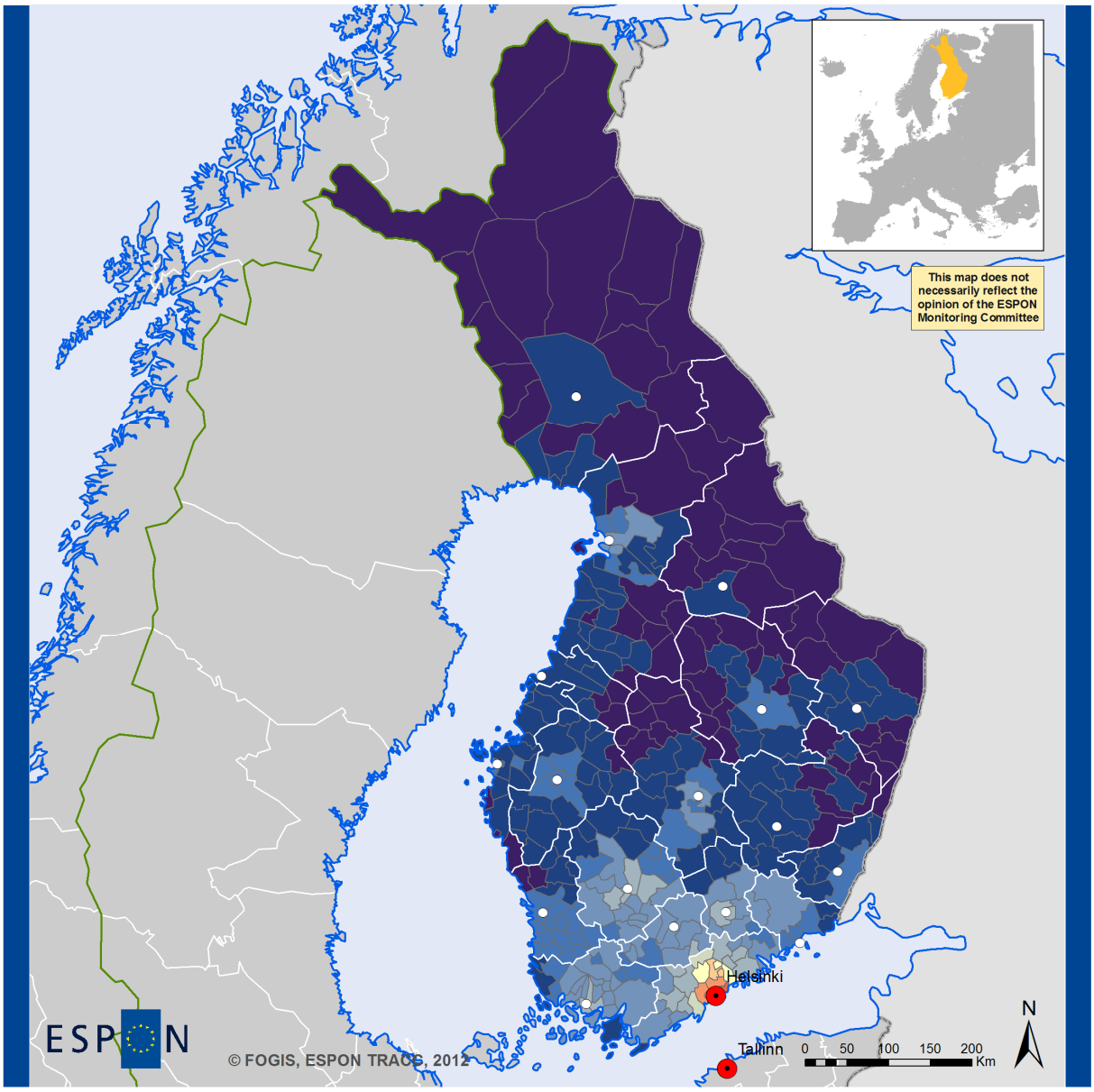
Finland Case Study
Potential accessibility to population by car (municipality averages)

0.0 - 5.0	100.1 - 125.0
5.1 - 15.0	125.1 - 150.0
15.1 - 25.0	150.1 - 175.0
25.1 - 50.0	175.1 - 200.0
50.1 - 75.0	200.1 < ...
75.1 - 100.0	

100 (population weigted average) = 302283.4
Maximum: 780418.8
Minimum: 508.2

Figure 5.5. Potential accessibility to population by car



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Data source: Finnish Transport Agency, 2012, Statistics Finland, 2011, 2010, Oy Matkahuolto Ab, 2012
Origin of data: ESPON Databank Project, 2010/2011
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Finland Case Study
Potential accessibility to population by public transport (municipality averages)

0.1 - 5.0	100.1 - 125.0
5.1 - 15.0	125.1 - 150.0
15.1 - 25.0	150.1 - 175.0
25.1 - 50.0	175.1 - 200.0
50.1 - 75.0	200.1 < ...
75.1 - 100.0	

100 (population weigted average, car) = 302283.4
Maximum: 549916.1
Minimum: 206.0

Figure 5.6. Potential accessibility to population by public transport (standardised on road average)

5.4 Access to health care facilities

Indicator name		
Access to reference health care facilities		
Spatial context Case studies	**Basic characteristics** Travel	**Generic type** Travel cost
Spatial level LAU2 / raster cells	**Origins** All LAU2 / raster cells	**Destinations** Hospitals
Modes Road // Public transport		

Description

For each LAU2, minimum travel times by road and by public transport are calculated to the closest reference hospital. Travel times from each municipality show the spatial diversity in access to important health care facilities.

Reference hospitals are defined as those allowing at least for surgery, regardless of being publicly or privately managed.

Equation

$$A_i = TravelTime_{Hospital} \forall LAU2_i$$

Details on the indicator calculation

For each LAU2, minimum travel times by road and by public transport are calculated to the closest reference hospital. Travel time is the output of the calculation of shortest paths from each LAU2.

Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

- Rail: commercial speed of services are used, which include time spent in programmed stops. Therefore, speed does not only reflect the physical features of the link.
- Bus: simulated introducing reduced speeds on the road network taking into account average commercial speeds and average frequency of services

Database

Hospital locations are obtained from regional databases.

Spatial pattern

In Spain, the public health system has seen a very important development in the last decades. Almost each NUTS4 capital is provided with a public hospital (county hospitals). In Catalonia, the regional administration has provided with hospitals to 30 of the 41 counties (73%). In the Valencia autonomous community and in the Balearic islands, the sanitary endowment is also high.

The levels of accessibility to hospitals are much better than those of accessibility to regional cen-tres, reflecting that hospital endowment is made available to municipalities under wider criteria than established by ESPON TRACC to consider regional centres (cities larger than 50.000 in-habitants and capitals of NUTS3). 39% of population lives within 15 minutes to hospital (vs 18% to regional centres), 81% of population lives within 30 minutes (vs 52% to regional centres), and 95% of population lives within 45 minutes (vs 78% to regional centres). The terri-

torial pattern shows a higher territorial homogeneity than the pattern for accessibility to regional centres, re-vealing the important role county hospitals in the case study region

The pattern obtained with public transport is similar to the one obtained by private transport, but the influence of hospitals in the territory is more limited, especially in most peripheral re-gions. Ex-amples of this are for instance Requena -in the backcountry of Valencia- or in Vielha and Tremp in the Catalan Pyrenees. 16% of population lives within 15 minutes of a hospital using public transport, 47% within 30 minutes, 74% within 45 minutes, and 88% of the case study population lives within 1 hour from a hospital.

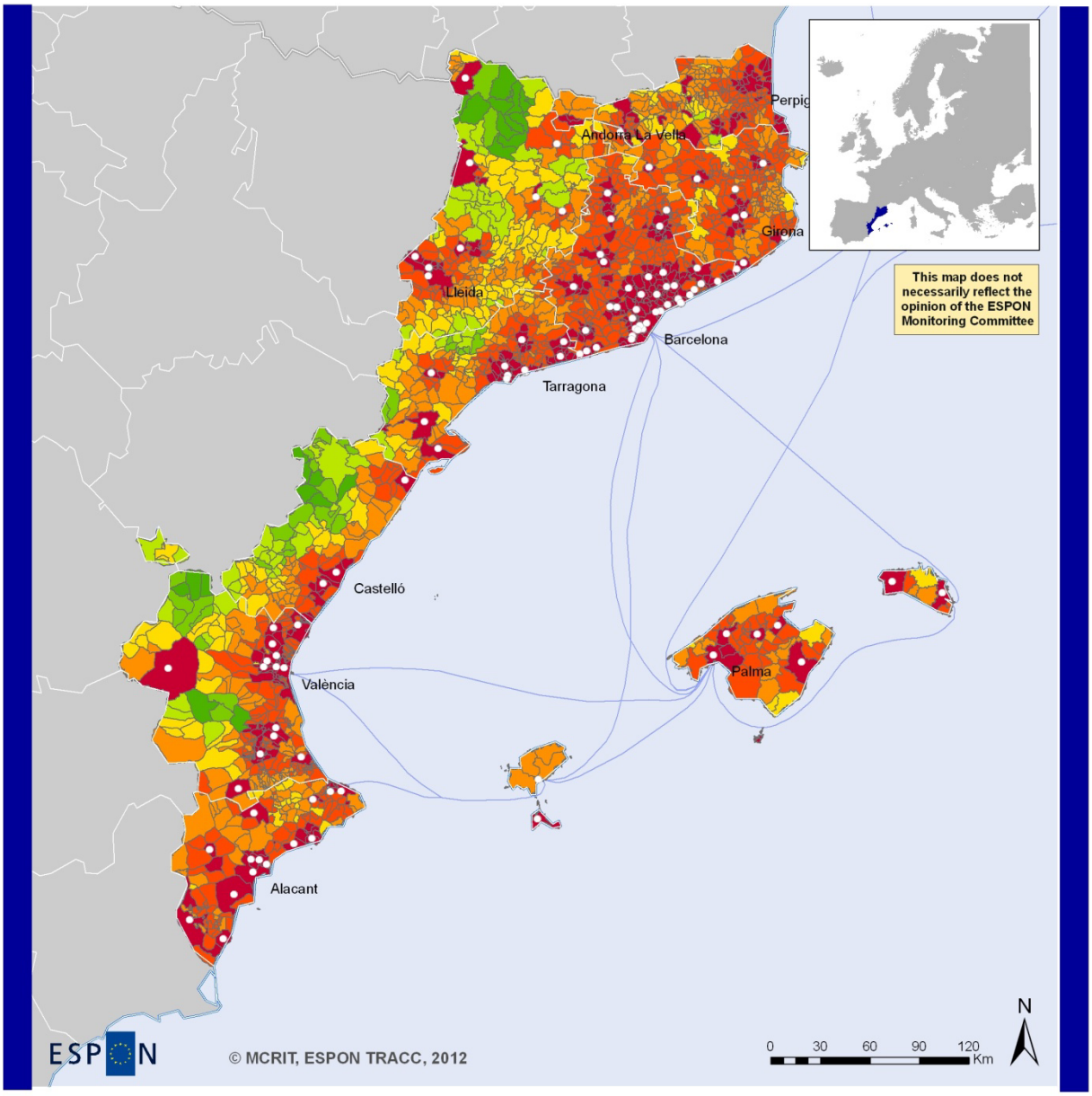


Figure 5.7. Car travel time to next hospital

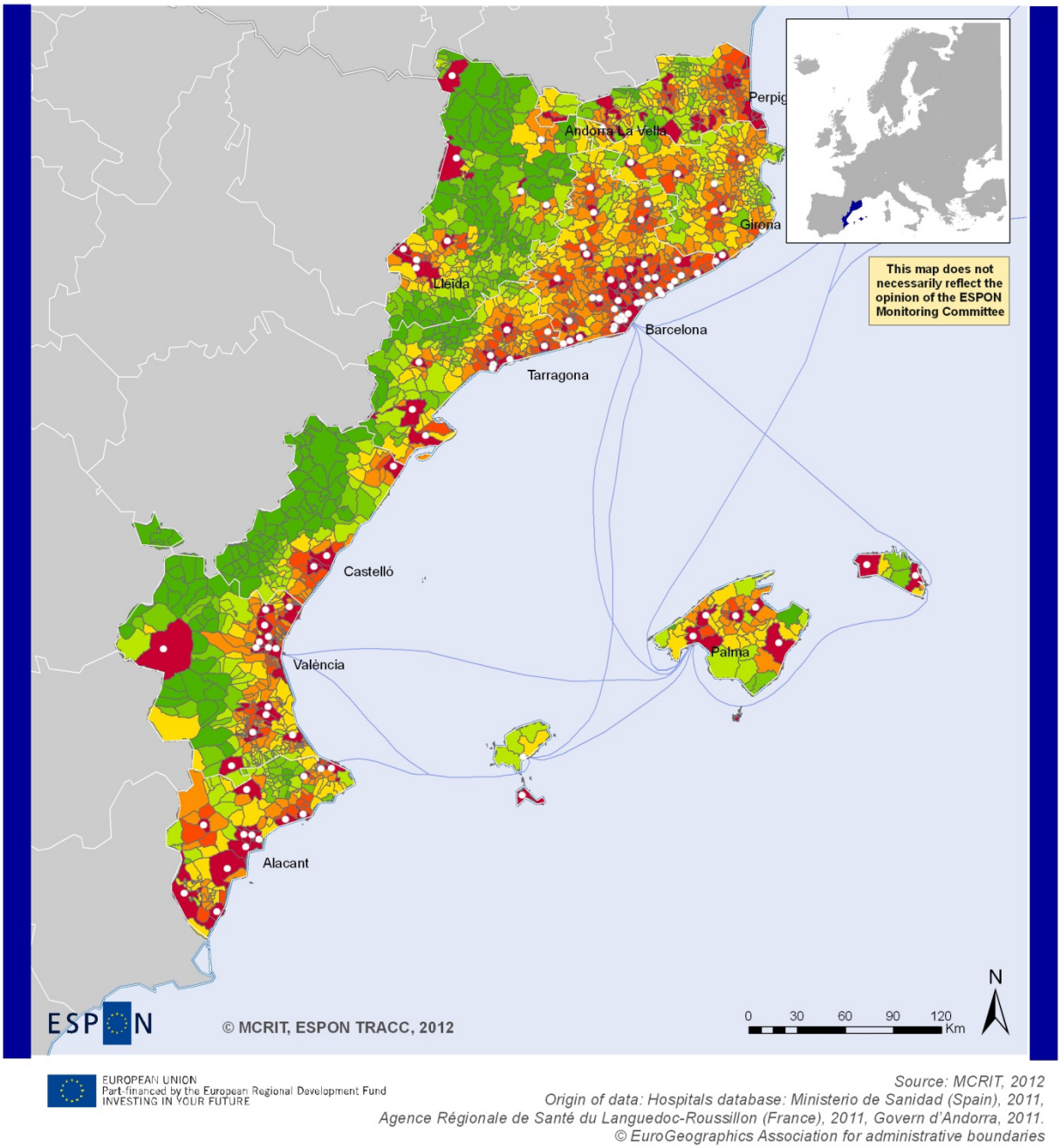


Figure 5.8. Public transport travel time to next hospital

5.5 Availability of secondary schools

Indicator name		
Daily accessibility of secondary schools		
Spatial context Case studies	**Basic characteristics** Travel	**Generic type** Cumulated opportunities
Spatial level LAU2 / raster cells	**Origins** All LAU2 / raster cells	**Destinations** LAU2 / raster cells at less than 30 minutes
Modes Road // Public transport	**Database** Each partner to determine for its case study	

Description

Do I have access to secondary schools in reasonable travel time and do I have a freedom of choice to select between different options? For each municipality or raster cells travel time contours of 30 minutes travel time by road and by public transport are calculated, and it is checked how many secondary schools are reachable within this travel time.

Equation

$$A_i = \sum_j SecondarySchools_j, \forall j : TravelTime_{i,j} < 30\,\text{min}$$

Details on the indicator calculation

Travel time is the output of the calculation of shortest paths from each LAU2. If a given LAU2 is reachable with a travel time below 30 minutes, the number of schools in that LAU2 will be considered. Otherwise, it will be omitted.

Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

- Rail: commercial speed of services are used, which include time spent in programmed stops. Therefore, speed does not only reflect the physical features of the link.
- Bus: simulated introducing reduced speeds on the road network taking into account average commercial speeds and average frequency of services

Database

The number of schools in each LAU2 is obtained from local statistics institutes or public administration databases when possible, or estimated when data is not available from regional school to population ratios

Spatial pattern

Secondary schools in the Czech Republic are mainly situated in communities of at least micro-regional importance (about 10.000 residents and more). However, secondary school students cannot drive a passenger vehicle to get to school before they are 18 and, therefore, the maps show rather theoretical opportunities of the accessibility of secondary schools. The highest accessibility of secondary schools within the range of 30 minutes is of course in the hinterland of the largest Czech agglomerations (Prague, Brno, Ostrava, Olomouc etc.). Judging by accessibility, communities in the hinterland of the agglomerations in the eastern part of the Czech Republic (Brno, Olomouc, and Ostrava) have a larger potential than communities in Bohemia.

The results of accessibility by public transport show a significantly lower number of secondary

schools within the 30-minute time accessibility. It is even possible to identify several dozens of communities which do not have any secondary schools within the 30-minute distance. In particular, this is the case of border communities and, surprisingly, of some inland areas (in so-called inner peripheries) which are distant from major residential centres. Again, the highest number of available secondary schools is in Prague and its hinterland, in the area of basin districts in North Bohemia and in the major agglomerations in Moravia (Brno, Olomouc, and Ostrava). In terms of travel behaviour it is necessary to point out that most secondary school commuters use public transport.

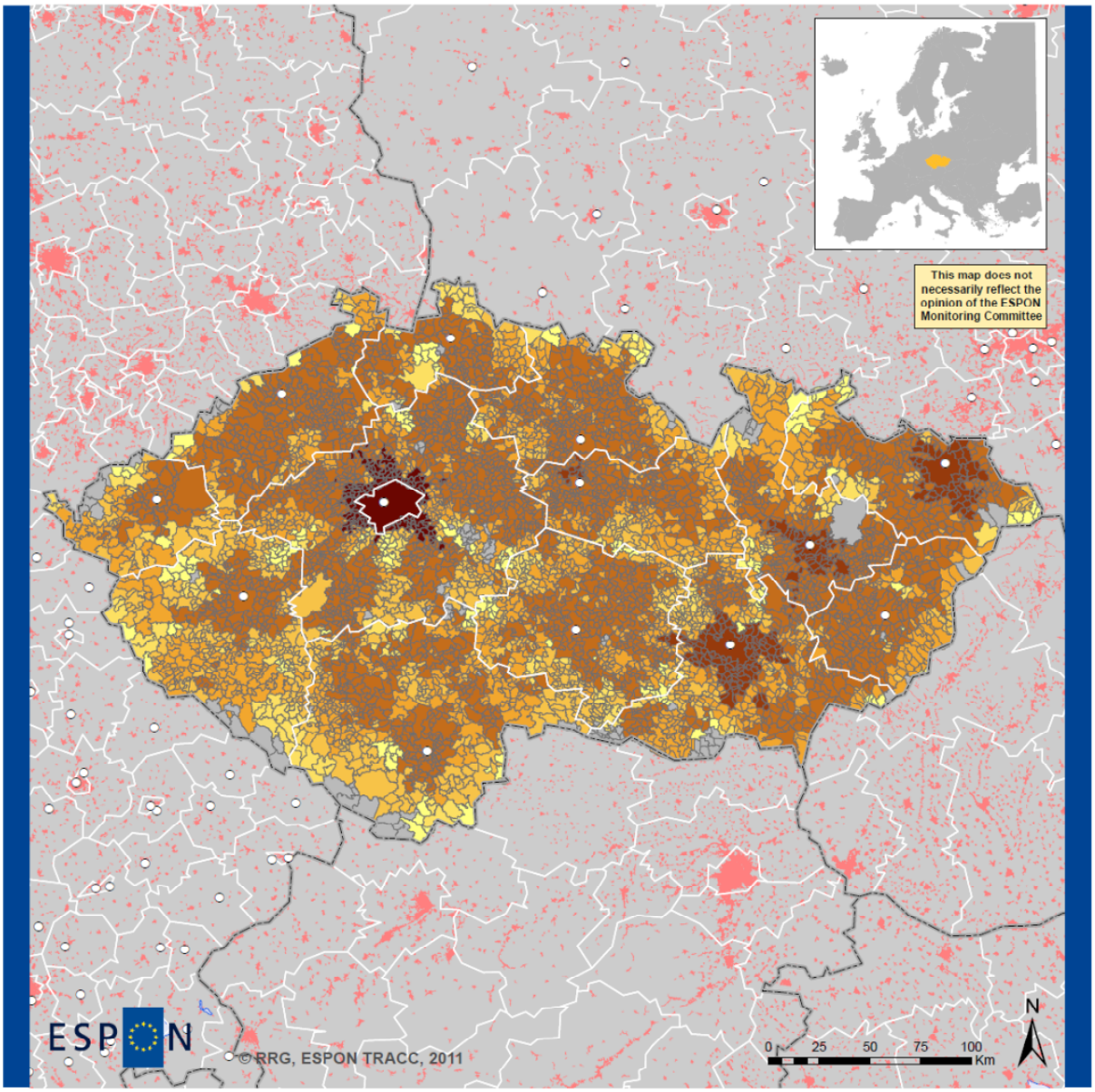


Figure 5.9. Number of secondary schools accessible by car in less than 30 minutes from each LAU2

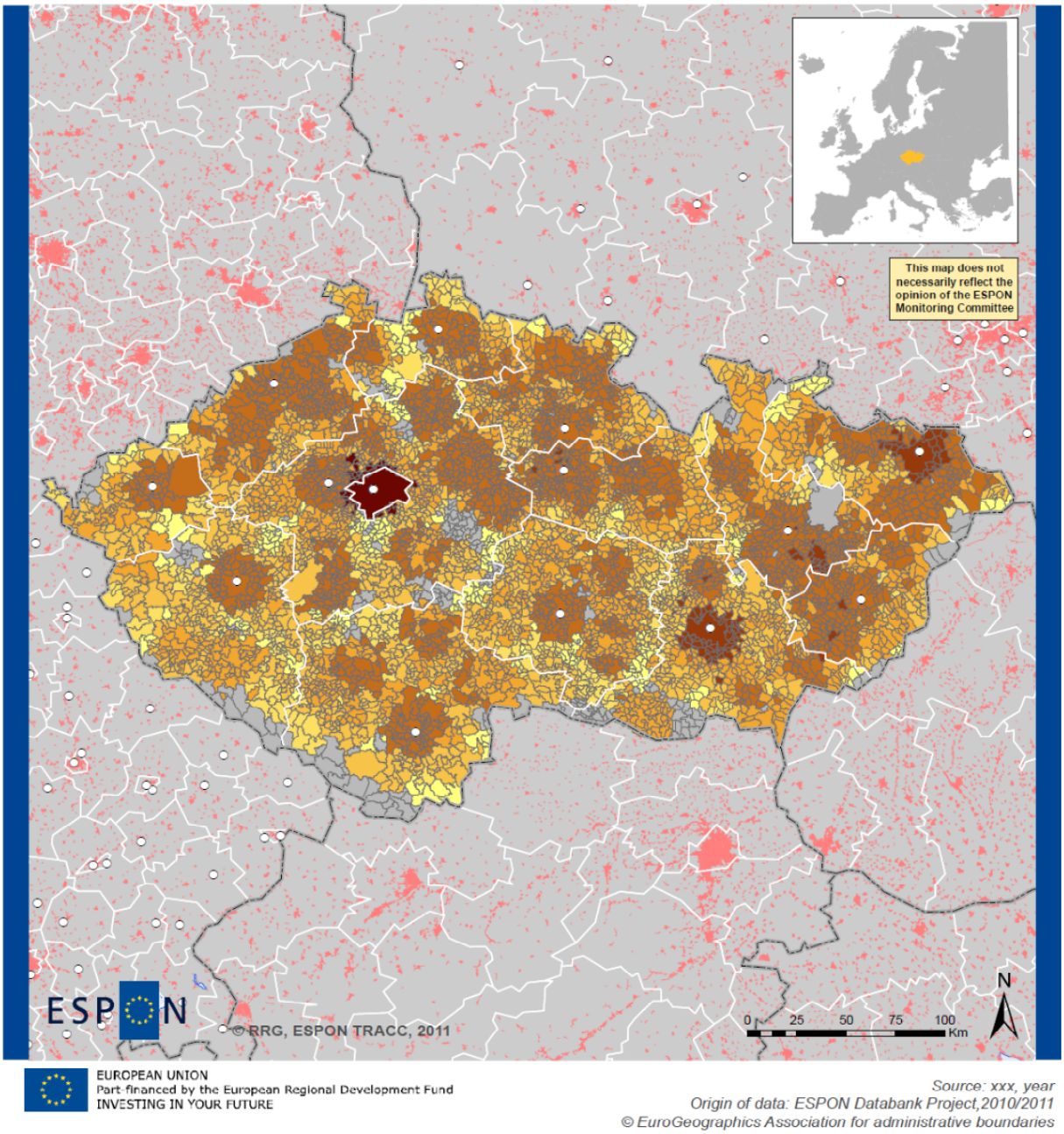


Figure 5.10. Number of secondary schools accessible by public transport in less than 30 minutes from each LAU2

5.6 Potential accessibility to basic health care

Indicator name		
Regional potential accessibility to basic health care		
Spatial context Case studies	**Basic characteristics** Travel	**Generic type** Potential
Spatial level LAU2 / raster cells	**Origins** All LAU2 / raster cells	**Destinations** All LAU2 / raster cells
Modes Road // Public transport		

Description

What is my locational quality with respect to basic health care? Using doctors as a destination activity in a potential accessibility indicator allows assessing the relative distribution of health care provision of different areas within the case study region.

Potential accessibility is based on the assumption that the attraction of a destination increases with its utility and declines with distance or travel time or travel cost to it. Therefore both size and distance of destinations are taken into account. The health care potential is calculated as the sum of doctors in destination areas weighted by the travel times to go there.

Equation

$$A_i = \sum_j \mathrm{g}(W_j)\ \mathrm{f}\ (c_{ij})$$

$$A_i = \sum_j Doctors_j^{\alpha} \cdot \exp(-\beta \cdot TravelTime_{i,j}), \forall j$$

With α = 1 and β = 0,046

Details on the indicator calculation

In general terms, accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them:

$$A_i = \sum_j \mathrm{g}(W_j)\ \mathrm{f}\ (c_{ij})$$

where A_i is the accessibility of area *i*, W_j is the activity *W* to be reached in area *j*, and c_{ij} is the generalised cost of reaching area *j* from area *i*. The functions g(W_{ij}) and f(c_{ij}) are called *activity functions* and *impedance functions*, respectively. They are associated multiplicatively, i.e. are weights to each other.

For accessibility potential, the impedance function is a negative exponential function of the form

$$f(c_{ij}) = \exp(-\beta c_{ij})$$

This equation can be transformed to calculate the beta parameter:

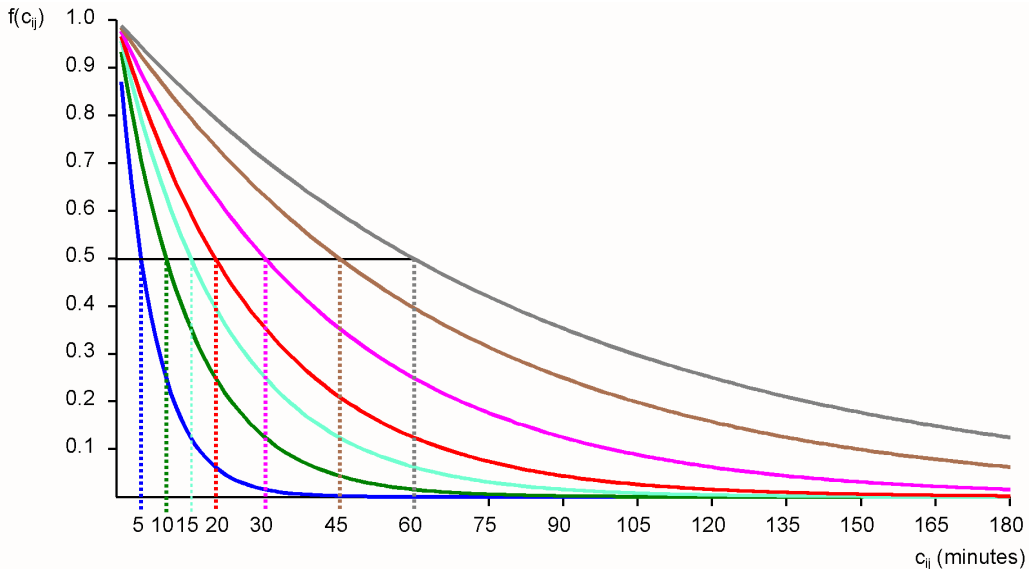
$$\beta = -\frac{\ln(f(c_{ij}))}{c_{ij}}$$

The beta parameter can be calculated for different travel times which should be used as a weight of 0.5 for the impedance function. The table below presents different travel times for the

halftime value, the resulting beta and also resulting travel times at which the weight of the impedance functions will be 0.75, 0.25 and 0.1.

Halftime value c_{ij} (minutes)	β parameter	c_{ij} (minutes) if f(c_{ij}) equals		
		0.75	**0.25**	**0.1**
5	0.138629	2.1	10.0	16.6
10	0.069315	4.2	20.0	33.2
15	0.046210	6.2	30.0	49.8
20	0.034657	8.3	40.0	66.4
30	0.023105	12.5	60.0	99.7
45	0.015403	18.7	90.0	149.5
60	0.011552	24.9	120.0	199.3

To read an example from above: a halftime value of 20 minutes, i.e. a destination 20 minutes travel time apart, would be weighted with 0.5 of its size and would result in a beta of 0.034657. Applying this beta would mean that destinations 8.3 minutes away would be weighted by a factor of 0.75 and destinations 66.4 minutes apart would be weighted still with a factor of 0.1. Figure below shows the resulting weighting curves for the 7 different halftime values, respectively betas.



Speeds on the road network defined for each case study and each link to represent real driving speeds in the network.

Speeds on the public transport network defined according to the following criteria, when real information on transport services is not available:

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- Bus: simulated introducing reduced speeds on the road network taking into account average commercial speeds and average frequency of services

Potential indicators are mapped in a standardised form, i.e. the regional average is set to an index value of 100. Regional averaging is done as a population weighted average, not as municipality weighted average.

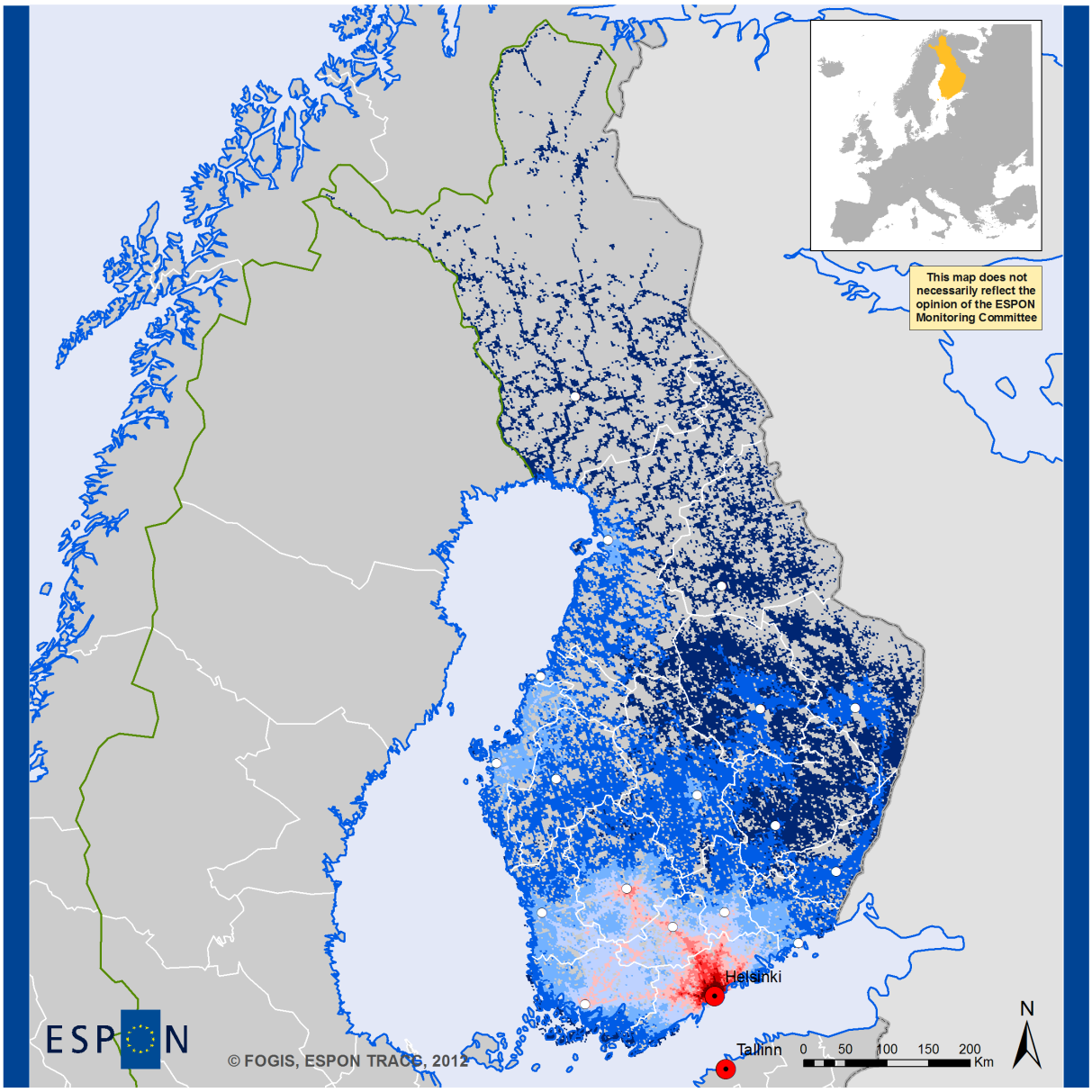
Database

The number of doctors in each LAU2 is obtained from local statistics institutes or public administration databases when possible, or estimated when data is not available from doctor to population ratios

Spatial pattern

There are marked differences in the accessibility potential to basic health care in Finland. In the South-Western Finland, the potential accessibility to medical doctors by car is relatively good, while the situation is considerably worse in the eastern and northern parts of Finland. This is related to the longer distances and lower availability of medical services in the peripheral parts of the country.

The analysis of accessibility potential by public transport provides a very similar picture. The accessibility potential is good in the south-western part of Finland and in the biggest municipalities, while remaining low in regions poorly served by public transport



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Data source: National Institute for Health and Welfare/HILMO, 2011, Finnish Transport Agency, 2012, Statistics Finland, 2011, 2010
Origin of data: ESPON Databank Project, 2010/2011
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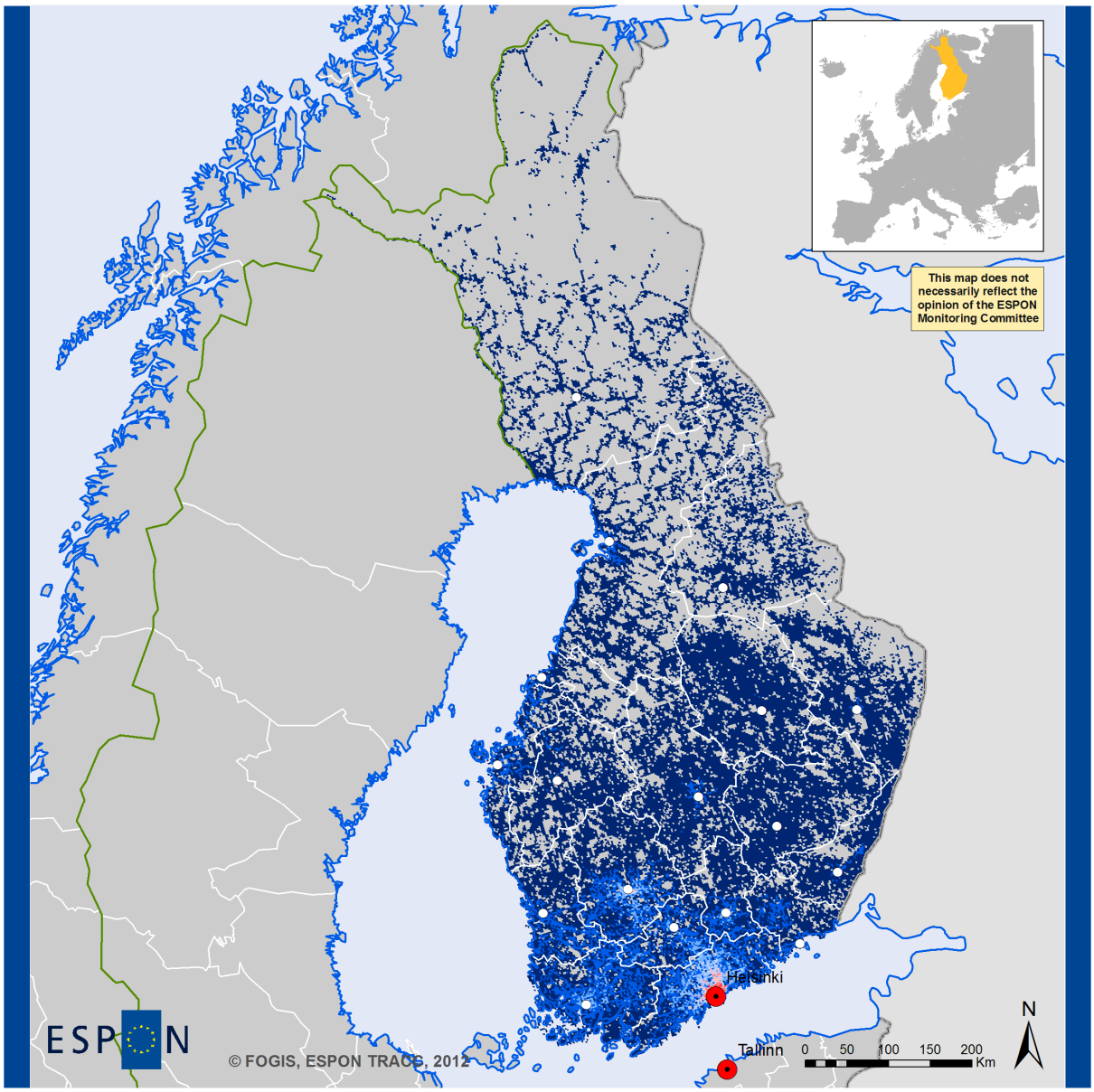
Finland Case Study
Potential accessibility to medical doctors by car (raster level)

- 0 - 25
- 25.1 - 50
- 50.1 - 75
- 75.1 - 100
- 100.1 - 125
- 125.1 - 150
- 150.1 - 175
- 175.1 - 200
- 200.1 < ...

100 (population weigted average) = 16.0
Maximum: 41.9
Minimum: 0.002

Figure 5.11. Potential accessibility to medical doctors by car



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Data source: National Institute for Health and Welfare/HILMO, 2011, Finnish Transport Agency, 2012, Statistics Finland, 2011, 2010 Oy Matkahuoto Ab, 2012
Origin of data: ESPON Databank Project, 2010/2011
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Finland Case Study
Potential accessibility to medical doctors by public transport (raster level)

- 0.0 - 25
- 25.1 - 50
- 50.1 - 75
- 75.1 - 100
- 100.1 - 125
- 125.1 - 150
- 150.1 - 175
- 175.1 - 200
- 200.1 < ...

100 (population weigted average, car) = 16.0
Maximum: 30.1
Minimum: < 0.000001

Figure 5.12. Potential accessibility to medical doctors by public transport

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The ESPON 2013 Programme is part-financed by the European Regional Development Fund, the EU Member States and the Partner States Iceland, Liechtenstein, Norway and Switzerland. It shall support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory.

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