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Accessibility Analysis of the Baltic Sea Region

Final Report

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Content

1. Introduction

Currently, the Baltic Sea Region Transnational Programme 2007-2013 is under preparation. One of the topics considered very important by the Joint Programming Committee and its drafting teams is accessibility. In the first draft of the programme "Internal and external accessibility of the BSR" is one of the four priorities (BSR JPC, 2006). This study has been commissioned to support the ongoing analysis of the socio-economic situation in the BSR with maps and interpretations on accessibility.

The objective of this study is to provide an up-to date picture of the accessibility situation of the BSR through a set of appropriate indicators. The study is organised along a number of different accessibility indicators which were partly based on the indicators developed in the transport-oriented studies of the ESPON 2006 Programme. Following the terms of reference for this study, seven accessibility indicators have been elaborated for the BSR:

- Car travel times to rail stations
- Car and rail travel times to commercial airports
- Lorry travel times to transport terminals
- Car and rail travel times to large cities
- Travel times between BSR cities
- Multimodal potential accessibility to population and GDP
- Mobile telephone penetration and internet access

Each accessibility issue is presented in at least one core map showing the indicator values for the BSR and its neighbouring regions and includes a description of the indicator, the data used and an analysis and interpretation of the results.

The analysis was carried out for the territory of the BSR including the eligible areas in Russia and Belarus. In order to allow a straightforward interpretation of the indicators not only in the BSR context but also in the wider European context, the neighbouring territories were included in the analysis. The analysis was mainly conducted at the NUTS-3 level for the territory of the European Union and corresponding spatial units for non-EU member states. Selected indicators were calculated and are presented at even smaller units (raster cells of 2x2 km), but were also aggregated to the NUTS-3 level. The indicators on mobile telephone penetration and internet access were not available at regional level and are therefore presented at national level for which the data exists.

The report has the following structure. First, a classification of accessibility indicators is given (Chapter 2). Then, the database used and further developed for this study is presented (Chapter 3). The main part of the report is the presentation and discussion of the different accessibility indicators in Chapter 4. Finally, the findings are summarised and related to the Baltic Sea Region Transnational Programme.

2 Accessibility Indicators

The task of transport infrastructure is to enable spatial interaction, i.e. the mobility of persons and goods for social, cultural or economic activities. In the context of spatial development, the quality of transport infrastructure in terms of capacity, connectivity, travel speeds etc. determines the quality of locations relative to other locations, i.e. the competitive advantage of locations which is usually measured as accessibility. Investments in transport infrastructure lead to changing locational qualities and may induce changing spatial development patterns.

There are numerous definitions and concepts of accessibility. A general definition is that "accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where 'area' may be a region, a city or a corridor" (Wegener et al., 2002). Accessibility indicators can differ in complexity:

- Simple accessibility indicators take only transport infrastructure in the area itself into account. This is measured then as total length of roads, motorways or rail lines, number of railway stations or motorway exits or as travel time to the nearest nodes of high-level networks. These indicators express important information about the area itself, i.e. about the transport infrastructure endowment, but do not reflect that many destinations of interest are outside the area.

- More complex accessibility indicators take account of the connectivity of transport networks by distinguishing between the network itself and the activities or opportunities that can be reached by it. These indicators include in their formulation always a spatial impedance term which describes the ease of reaching destinations of interest. Impedance can be measured in terms of travel time, cost or inconvenience.

The more complex accessibility indicators are 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. That is, both are necessary elements of accessibility. A_i is the total of the activities reachable at j weighted by the ease of getting from i to j.

The more complex accessibility indictors can be classified by their specification of the destination and the impedance functions (Schürmann et al., 1997, Wegener et al, 2002):

- Travel cost indicators measure the accumulated or average travel cost to a pre-defined set of destinations, for instance, the average travel time to all cities with more than 500,000 inhabitants.

- Daily accessibility is based on the notion of a fixed budget for travel in which a destination has to be reached to be of interest. The indicator is derived from the example of a business traveller who wishes to travel to a certain place in order to conduct business there and who wants to be back home in the evening (Törnqvist, 1970). Maximum travel times of between three and five hours one-way are commonly used for this indicator type.

- Potential accessibility is based on the assumption that the attraction of a destination increases with size and declines with distance, travel time or cost. Destination size is usually represented by population or economic indicators such as GDP or income.

The different accessibility types all have advantages and disadvantages (Spiekermann and Neubauer, 2002). Travel time indicators and daily accessibility indicators are easy to understand and to communicate but lack partly a theoretical foundation. Potential accessibility is founded on sound behavioural principles but contain parameters that need to be calibrated and their values cannot be expressed in familiar units.

In this study, sample indicators for all types of accessibility indicators were developed for the BSR. Infrastructure endowment indicators are represented by access times to rail stations, airports and terminals, but also by the mobile phone penetration and internet access indicators. Travel cost indicators are represented by travel times to larger cities. Daily accessibility indicators are represented by travel times between the BSR cities. Finally, the potential accessibility indicator type is represented by multimodal potential accessibility to population and GDP.

3. Database

The calculation of the different accessibility indicators for this study is facilitated by the availability of a detailed GIS database of trans-European transport networks, covering all countries of Europe and including all modes of transport.

The RRG GIS Database (RRG 2006) which is utilised for this study provides digital data for 38 countries in Europe (all countries of the European Union as well as Switzerland, Norway, Iceland, Albania, Rumania, Bulgaria, the European part of Turkey, countries of former Yugoslavia and the countries of the European part of the former USSR) in standard GIS format. This includes information on the pan-European road and rail networks, including railway stations; information on inland waterway networks, ferry routes and short sea shipping routes, including inland ports and seaport; information on European airports and flight connections; information on administrative boundaries for all countries at different spatial levels (NUTS 0 – 3, boundaries of cooperation areas etc.), and on city locations of all European cities with more than 50,000 inhabitants. The different categories of the database are stored as individual layers in the GIS database.

The GIS database is utilised to calculate the various accessibility indicators, and is also been used to illustrate the indicator results in map form at various spatial levels. The relevant layers of this database used for the present accessibility study are:

(i) Road network layer
The road network layer includes all TEN and TINA roads, E-roads, motorways and highways, dual-carriageway roads, as well as other trunk roads and other important national roads and road ferries. For many regions in Europe, also secondary and regional roads are available. Figure 1 illustrates the trunk road network in the BSR. The TEN and TINA road outline plans are also coded in this database. Information on the TEN and TINA links and outline plans are taken from different recent EC publications (European Communities 1996; European Commission 1995; 1998; 1999; 2002a; 2002b; 2003; 2004a; 2004b; 2005; HLG 2003; TINA Secretariat 1999; 2002).

(ii) Railway network layer
The railway network layer includes all railway lines under operation today, including all sections of the TEN and TINA rail networks and all sections of the *Dedicated Rail Freight Network*, as specified by recent EC documents. In addition, new planned railway lines based on the TEN and TINA outline plans, and selected railway links currently closed for operation are also included as well as rail ferries; however, some privately owned railway tracks are not included in the database. Along with the rail links, also the railway stations are coded (Railfaneurope.net 2004). The railway links and stations are visualised in Figure 2. Based on web-based timetable information systems of the respective national railway companies, rail travel times have been updated to reflect the train services in 2006.

(iii) Airports and flight networks
All airports of Europe offering scheduled flight services are covered by the RRG GIS Database,. A database on flight routes for scheduled flights in spring 2006 between these airports was developed based on information provided by OAG (OAG 2004; 2005a; 2005b; 2006). The information coded includes flight times and frequencies Figure 3 shows the airports classified by the number of destinations reached by direct flights and the air network classified by frequency of flight services.

(iv) Intermodal terminals

Intermodal terminals are defined as infrastructure facilities where containers, semitrailers, trailers and lorries and railway carriages can be transhipped from one mode to the other, e.g. from roads to railways (“rolling road trains”, “iron highways”) or from road or rail to ships. Intermodal terminals are represented in the RRG GIS database by seaports and inland ports for the whole of Europe (Binnenschiffahrts-Verlag 1995; 1997; UN 1994), and by dedicated intermodal container terminals (ICT) and combined road/rail transhipment terminals. The combined transport stations were derived from the database of the *International Union of Combined Road-Rail Transport Companies* (UIRR, 2006). This database includes the location of combined transport stations for several countries such as Austria, Belgium, Czech Republic, Denmark, France, Germany, Hungary, Italy, the Netherlands, Norway, Poland, Portugal, Slovakia, Spain, Sweden, and Switzerland and the UK; however, the three Baltic countries, Finland, Belarus and Russia are not included. Another limitation of the UIRR database is that it only contains terminals of its members, which means that even for the countries considered a full coverage of all Intermodal terminals is not available. Therefore, for Germany also Intermodal terminals of the *Deutsche Umschlaggesellschaft Schiene-Straße* (DUSS, 2006) were coded. Again, this data source only includes those terminals operated by DUSS, and thus is not providing a full picture of all terminals.

The geographical location of the intermodal terminals used for the accessibility calculations is illustrated in Figure 4.

(v) Cities in Europe and region boundaries

The RRG GIS Database contains also different point layers representing all cities in Europe with more than 50,000 inhabitants and polygon layers representing boundaries of administrative and statistical regions based on the NUTS system of regions (Eurostat 1999a; 1999b; 2004). The city locations (‘city centres’) will be used as the reference co-ordinates to calculate a number of accessibility indicators as described in the next chapter. In the BSR also smaller cities with less than 50,000 inhabitants are included if they host facilities for higher education (universities, polytechnics). It has to be noted that smaller cities have different functional roles in national urban systems in the northern part of the BSR compared with cities of that size in the southern part. Figure 5 shows the urban system of the BSR.

(vi) Regional socio-economic data

The database contains also the development of regional GDP and population. This information was updated in order to use the latest available data for the study (Eurostat, 2006b).

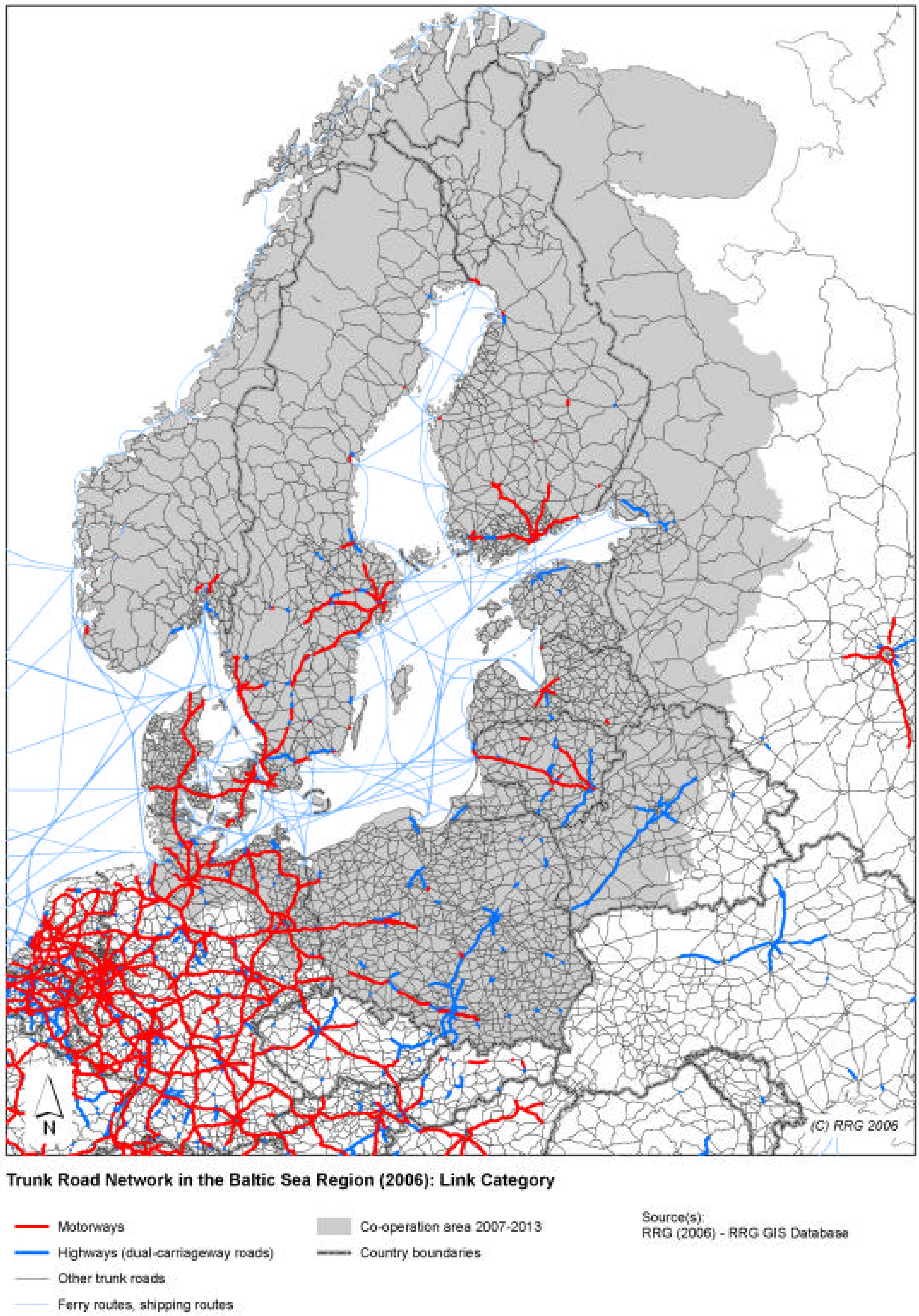

Figure 1. Road network database.

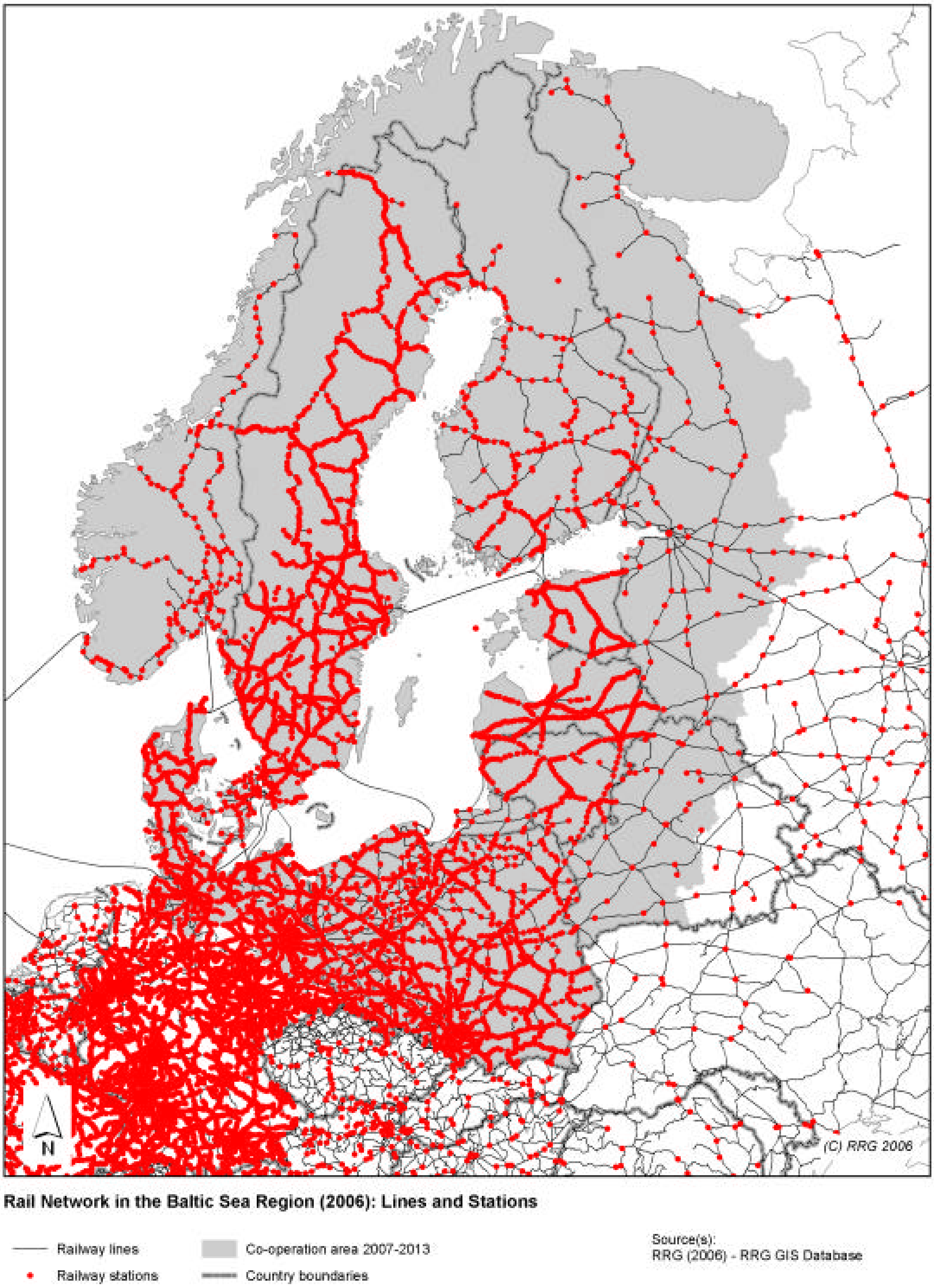

Figure 2. Rail network database.

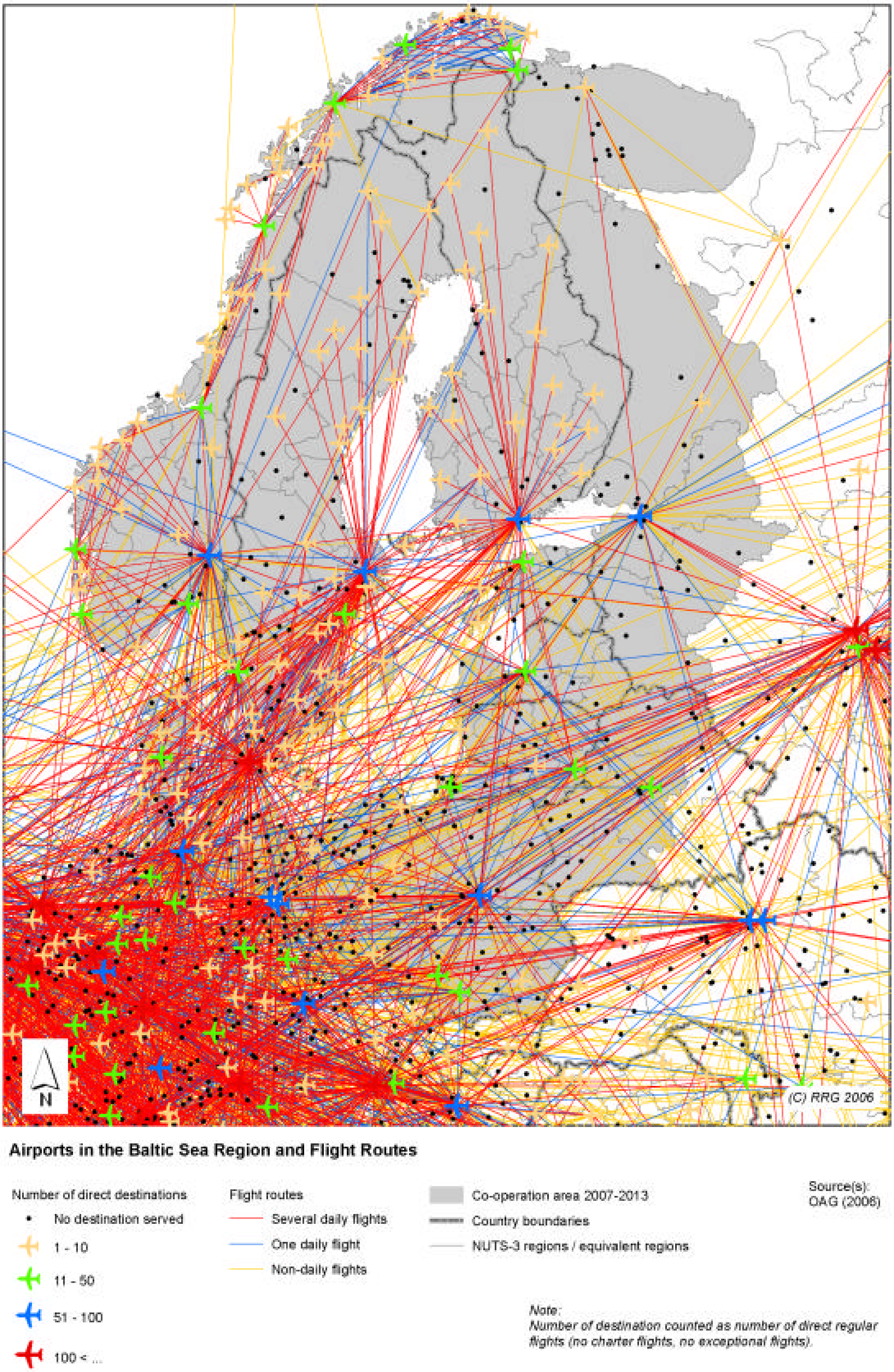

Figure 3. Air network database.

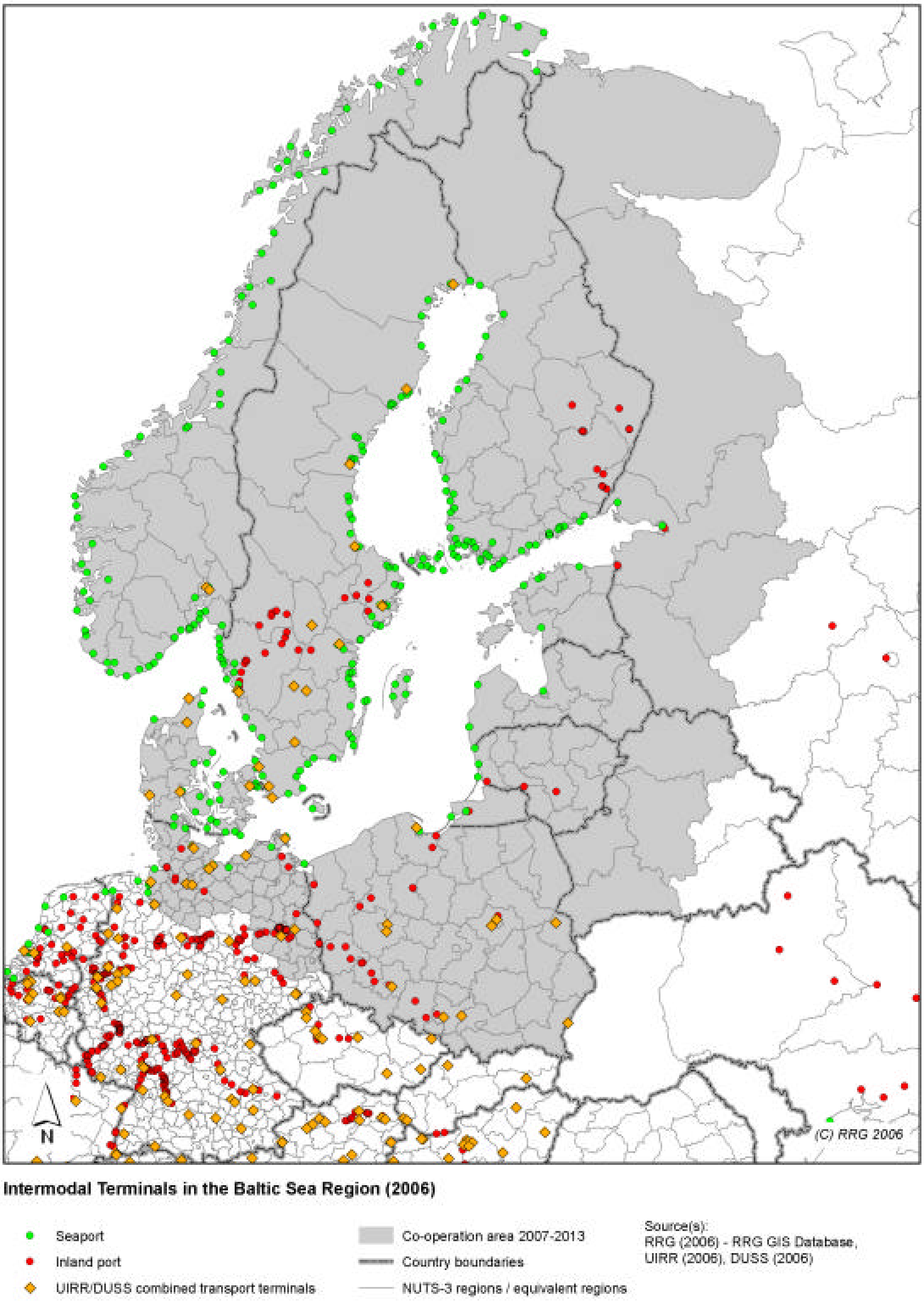

Figure 4. Intermodal transport terminal database.

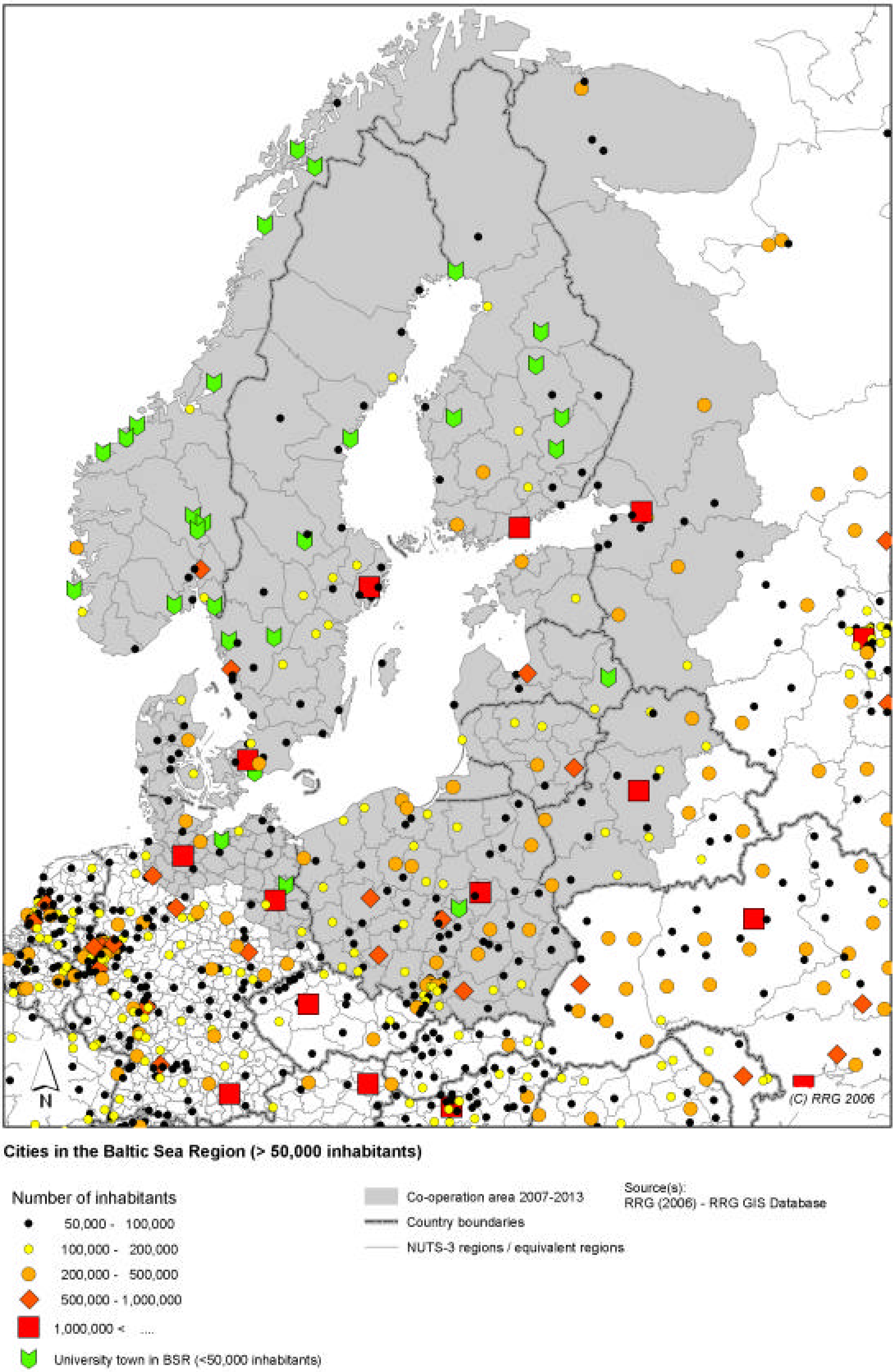

Figure 5. BSR urban system.

4. New Accessibility Indicators for the BSR

In this chapter the main results of the study, the new accessibility indicators for the BSR are presented. First, the transport infrastructure and ICT endowment indicators are presented. Then, the selected representatives for the accessibility types travel cost, daily accessibility and potential accessibility follow.

4.1 Car Travel Times to Rail Stations

This accessibility indicator is of the endowment type. It shows the access time by car to rail stations. Information on the importance – or hierarchy – of railway stations is not available for all countries. Also information on the frequency of rail services is not included, which means that the surrounding of a train station which has only one or two trains per day is coloured the same way as the surrounding of a train station with frequent services. Due to lack of data, for some countries outside the BSR only a selection of most important railway stations are taken into account as destinations, while for the remaining countries all railway stations are used for the analysis.

Access time to railway stations is calculated as the car travel time from each raster cell to the next station. A raster system with a cell size of 2x2 km is applied. In a second step the information at the raster cell level is aggregated to NUTS-3 regions by calculating the average of all raster cells belonging to a region, in order to facilitate comparison with other regional accessibility indicators.

The indicator results are illustrated in Figure 6 at raster cell level and Figure 7 at NUTS-3 level. Apparently Denmark, Germany and Poland as a whole stand out with very good rail access, as from all parts of the countries the next railway station can be reached within 45 minutes, in many parts even in less then 30 or 15 minutes. In other countries of the BSR the railway corridors become visible with good access times to the next rail stations, but regions outside these corridors experience medium to long access times, e.g. in parts of Finland and Russia with access times of 90 to 150 minutes. Areas in western and northern Norway, in northern Sweden and Finland and also areas in the remote parts of Russia do not have rail infrastructure leading to access times of more than three hours.

The aggregation of the data to NUTS-3 regions leads to the recognition of some general spatial patterns (Figure 7). In Denmark and Germany the whole countries show very good access to rail stations, i.e. very short access times. In Poland a divide between western (very good access) and eastern Poland (relatively good access) can be observed. For Sweden and Finland clear south-north gradients can be seen, with good and very good access in the southern parts of the countries and poor access in the northern regions. Belarus and the southern parts of Russia show medium to good access to rail stations, while the access times increases going further north with extremely poor access in the Murmansk region. The three Baltic countries in general have a good access to rail stations due to the relative high station density while at the same time representing relative small territories, with the exception of Lääne-Eesti, a NUTS-3 region comprising also many islands. Finally, Norway is the country with the greatest disparities in access to rail stations: While the Oslo area experiences very good access, the two northernmost regions of Troms and Finmark have extremely poor access to stations.

Table 1 gives aggregate results at country level. Norway and Russia turn out to have longest average access times with 120 and 114 minutes, respectively. Both countries also experience the longest maximum access times with more than 600 minutes. Consequently also the standard deviation is highest in these countries. Denmark, Germany and Poland are at the other end of the spectrum with average access times of less than 26 minutes. Notably, Latvia and Lithuania also rank high with mean travel times of 24 and 26 minutes, respectively, and small standard deviations demonstrating a rather even level of access to rail stations throughout these two countries.

*Table 1. Car travel time to rail stations.**

Country	Average travel time (min)	Standard deviation travel time (min)	Maximum travel time (min)
Belarus **	43	18	149
Denmark	20	21	200
Estonia	49	62	268
Finland	76	65	366
Germany **	12	7	96
Latvia	24	14	75
Lithuania	26	12	67
Norway	120	107	604
Poland	19	10	123
Russia **	114	120	678
Sweden	49	49	373
BSR area	*70*	*86*	*678*

* *statistics calculated are based on raster cells*
** *only those parts of the countries considered which are eligible under BSR Programme*

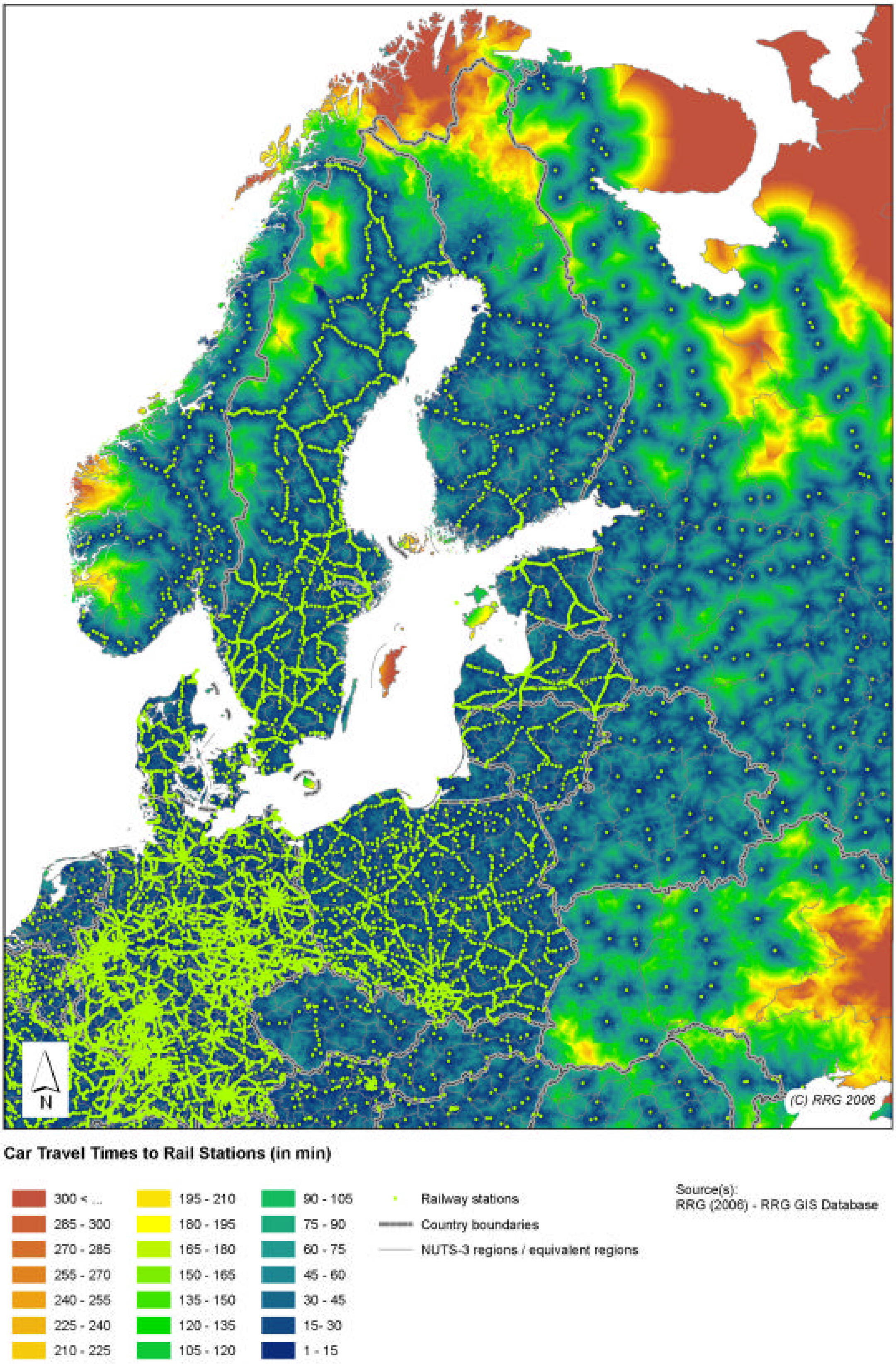

Figure 6. Car travel time to rail stations (raster level).

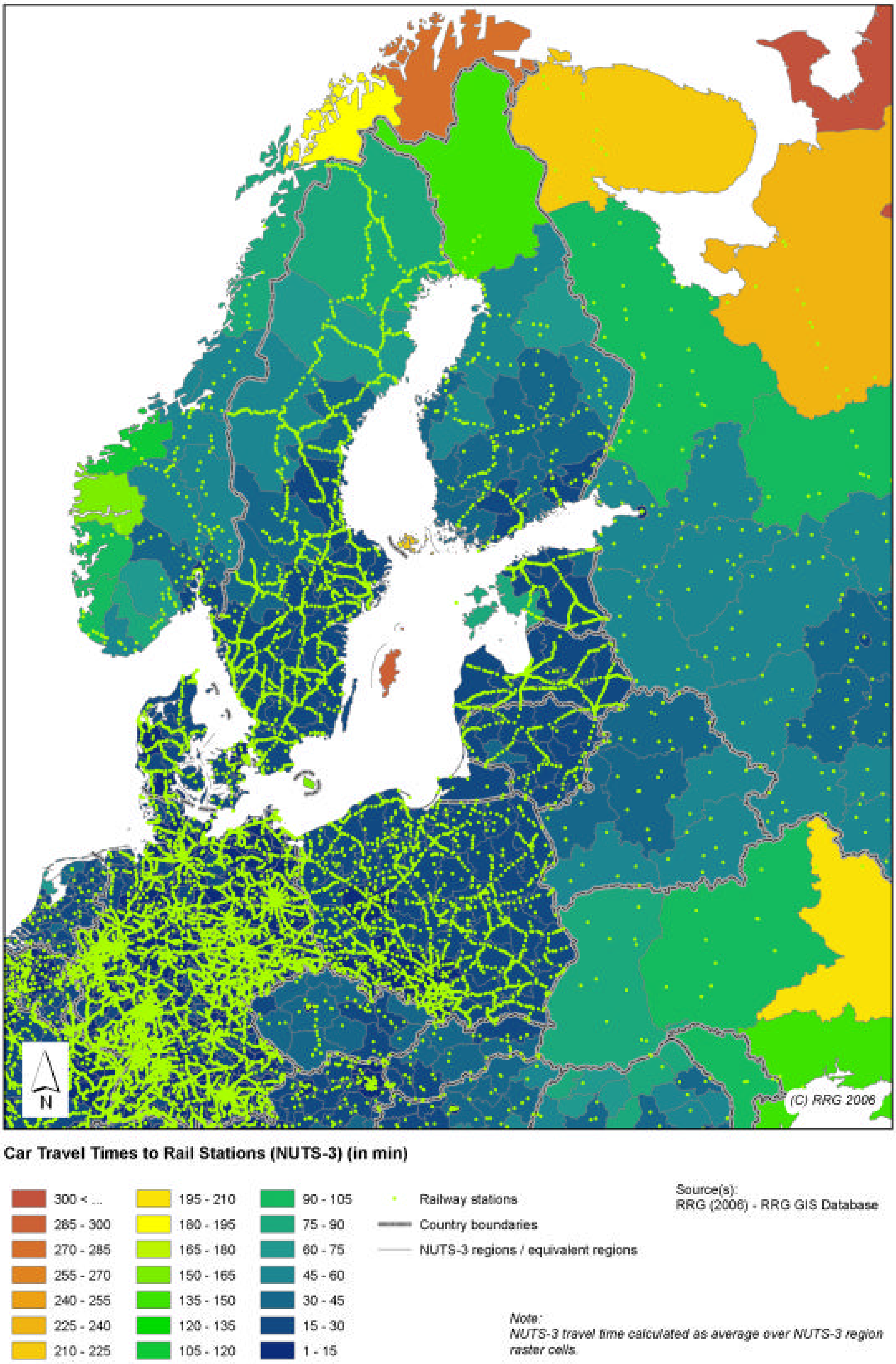

Figure 7. Car travel time to rail stations (NUTS-3 level).