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European transport integration: recent trends in the EU15 and the EU10 Member States' transport systems

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European transport integration: reconciling accessibility and environmental concerns

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Abstract

The European Union faces the important challenge of increasing Europe's accessibility while limiting the social, energy and environmental pressures caused by transport. This challenge takes place as the European economies and their transport system integrate. The process entails the integration of two historically different transport systems: the one of the EU10 countries and of the EU15 ones. The former relying more on rail and buses and the latter or private vehicles, both for goods and people. On the bases of the available empirical evidence, it is concluded that the EU10 countries seem to be catching up towards the EU15 model. Their accessibility, mobility and safety levels are getting closer to the ones of the EU15 countries, although they are still quite lower. This has potentially serious consequences in terms of energy consumption and environmental impacts.

1. Introduction[1]

As the report "Keep Europe moving"- prepared by the Commission of the European Communities (2006) – states, the objectives of EU transport policy are:

- to improve mobility throughout the Union with efficient and effective transport systems;
- to protect the environment, to ensure energy security, to promote minimum labor standards for the sector and to protect the passenger and the citizen;
- to innovate in support the first two aims of mobility and protection by increasing the efficiency and sustainability of the growing transport sector;
- to connect internationally, projecting the Union's policies to reinforce sustainable mobility, protection and innovation (CEC, 2006, p. 3-4).

Additionally the report states that:
"*The internal market has already brought benefits to the road and aviation sectors and this is expected to be the case also for rail and waterborne transport in the future. […] Mobility must be disconnected from its negative side effects using a broad range of policy tools. Therefore, the future policy will have to optimize each mode's own potential to meet the objectives of clean and efficient transport systems. The potential for technology to make transport more environmentally friendly must be enhanced, in particular in relation to greenhouse gas emissions. […] Shifts to more environmentally friendly modes must be achieved where appropriate, especially on long distance, in urban areas and on congested corridors. At the same time each transport mode must be optimized. All modes must become more environmentally friendly, safe and energy efficient. Finally, co-modality, i.e. the efficient use of*

[1] Many data and figures quoted in this paper can be found in Danielis *et al.* (2008), which represents longer version of this paper.

different modes on their own and in combination, will result in an optimal and sustainable utilization of resources." (CEC, 2006, p.4)

Although these objectives remained stable over time, the general EU context has changed:

- enlargement has given the EU a continental dimension. The extension of the main trans-European network axes creates more corridors that are particularly suitable for rail and waterborne transport;
- the transport industry has changed. Consolidation has taken place at European level, especially in aviation and maritime transport. The internal market has contributed to create competitive international road haulage and to increase rail operations. Moreover, the last five years have shown the effects of globalization leading to the creation of large logistics companies with worldwide operations;
- transport is fast becoming a high-technology industry, making research and innovation crucial to its further development;
- international environmental commitments, including those under the Kyoto Protocol, must be integrated into transport policy;
- transport policy must contribute to the achievement of the objectives of European energy policy as laid down in the conclusions of the European Council of March 2006, in particular as regards security of supply and sustainability;
- the sustained threat of terrorism has likewise impacted transport more than any other sector;
- European governance is evolving. The basic internal market legal framework is largely in place (CEC, 2006, p. 4-6).

Besides, the European transport system integration is particularly challenging as underlined by the Term Report 2002 (p. 3) *"…the main challenge for the accession countries is to maintain the advantage they still have in certain aspects of transport and environment compared to the EU, and at the same time meet societal needs for improved standards of living and consequent increased mobility demands. With a rail share still well above the EU average, lower transport energy use and pollutant emissions per capita and less fragmentation of their land, the accession countries still have lower environmental pressures arising from transport than is currently the case in the EU. It would be highly regrettable if this opportunity were lost. Current trends in the accession countries are however worrying. The modal split is evolving towards a predominance of road transport typical in the EU. After a significant decrease following the economic recession of the early 1990s, transport volumes are on the rise again, and so are the sector's energy consumption and greenhouse gas emissions. Of equal concern is the high number of road fatalities; safety improvements are more and more offset by transport growth. Many of these trends indicate that the accession countries risk ending"*.

The aim of this paper is to describe and interpret the main trends characterizing the European transport integration process in order to predict its effects regarding mobility, accessibility, energy consumption and environmental sustainability. In section 2 we will compare the most recent data available for the EU15 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom) and the EU10 (Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia) countries. Specifically we will try to answer to the following questions: Will the two transport systems converge? What will be their convergence point? What will be the effect of the economic integration on the transport systems? We will then focus in section 3 on the implications of their differences regarding accessibility verifying if these differences are significant, at what level, how they are evolving, and how they effect economic growth. Finally in section 4 we will analyze the social, energy and environmental impact of the two transport systems with regards to accidents, energy consumption, CO_2 and local air emissions and concentrations. Conclusions and policy implications will follow in section 5.

2. Differing transport systems

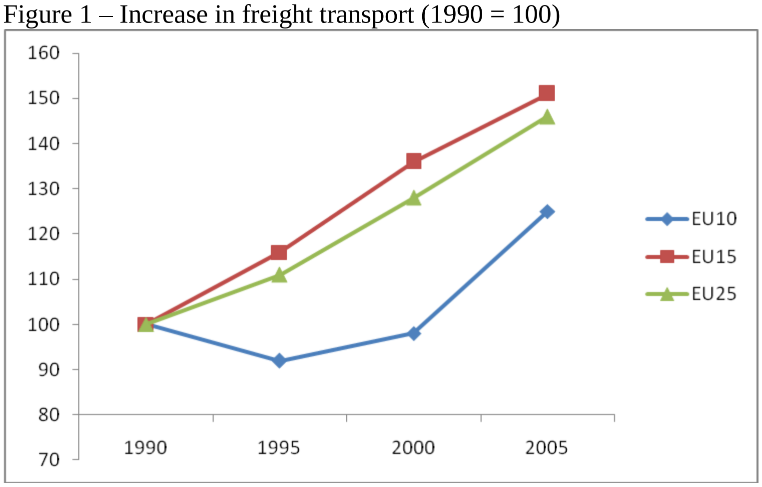
In this section we describe the EU15 and the EU10 transport systems, focusing on the main differences regarding transport volumes, transport intensity, modal shares in freight and passenger transport and car ownership.

2.1 Transport flows and modal share

Freight transport

In the period 1990-2005 the EU25 freight transport flows increased by 46%, but the trends of the EU15 and the EU10 countries are quite different (Figure 1).

Figure 1 – Increase in freight transport (1990 = 100)



Data Source: EUROSTAT, 2008

The EU15 countries increased their freight transport flows by an almost constant rate, slightly higher than the EU25 average. Specifically they increased their flows by 16%, 36% and 51% in 1995, 2000 and 2005, respectively (see Table A1 in Danielis *et al.* 2008).
The EU10 values, instead, decreased their flows by 8% in the 1990-1995 period, because of the recession faced during their political and economical transition, and started increasing their flows again by the year 2000, by 2%, and in later by 2005, by 25% (see Table A1 in Danielis *et al.* 2008). Therefore, in the 2000-2005 period had been faster for the EU10 countries than for the EU15.
With specific regard to road freight transport, the most important component of the transport system, it is worth noting that in the period 2000-2004 it increased by 31.8% in EU10 countries, especially because of international flows, versus an increase of 10.5% in the EU15 countries (Table 1).

Table 1 – Road freight transport growth 2000-2004 (%)

	National	International	Total
EU15	8.3	16.9	10.5
EU10	16.6	47.7	31.8
EU25	9.0	23.0	12.9

Source: Commission of the European Communities (2006, p. 25)

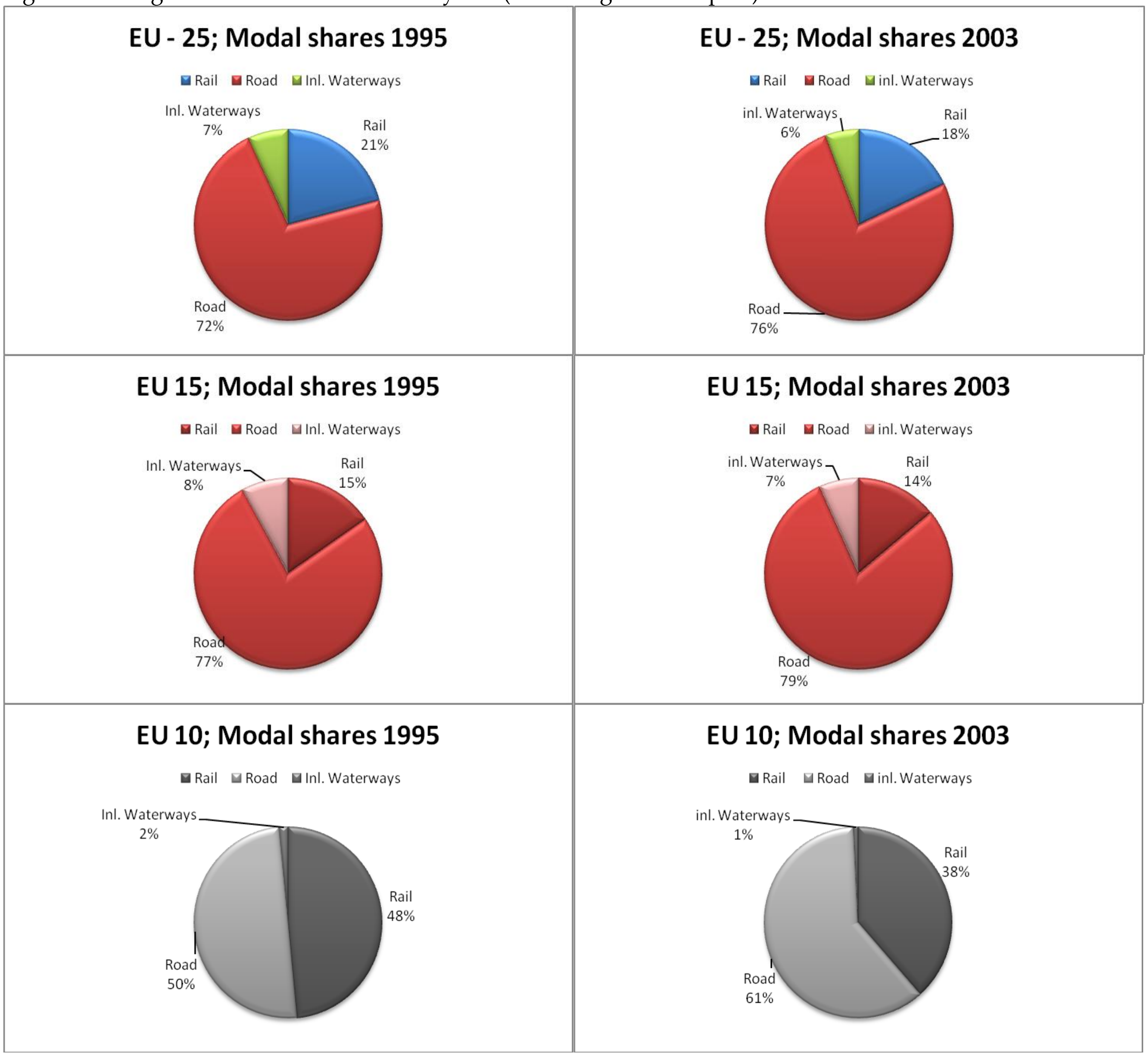
In 2006 the EU27 countries increased their freight transport flows by inland modes[2] over 2005 values equal to 5%, reaching 2,595 billion tkm (tons times kilometers). The highest increases were recorded in Greece (+42%), Hungary (+16%) and the Czech Republic (+13%), and the largest decreases were observed in Cyprus (-16%), Denmark (-8%), Estonia and Ireland (both -3%).

At EU25 level, in the period 1995-2003, rail freight transport share decreased from 21% to 18%, inland waterways from 7% to 6% while road increased from 72% to 76%. Distinguishing between the EU10 and the EU15 countries, the latter changed their modal distribution only slightly (road from 77% to 79%, rail from 15% to 14%), whereas the EU10 countries changed more dramatically. Rail decreased from 48% to 38% and road increased from 50% to 61%, with inland waterways having a share of 1% (Figure 2).

The overall picture of the modal share for freight transport is therefore a strengthening of the successful role played by road transport, which reinforced its leading position in the EU15 countries and gained dramatically over rail in the EU10 countries, where its share is rapidly moving towards the one of the EU15 countries. There is no sign of modal shift toward more sustainable transport modes as promoted by the Commission's documents. Road transport gains market share over all other modes, with the exception of sea transport. This is most likely to have an impact in terms of congestion, energy consumption and environmental emissions.

[2] Rail, road, inland waterways and oil pipelines

Figure 2 – Freight modal shares in various years (excluding sea transport)

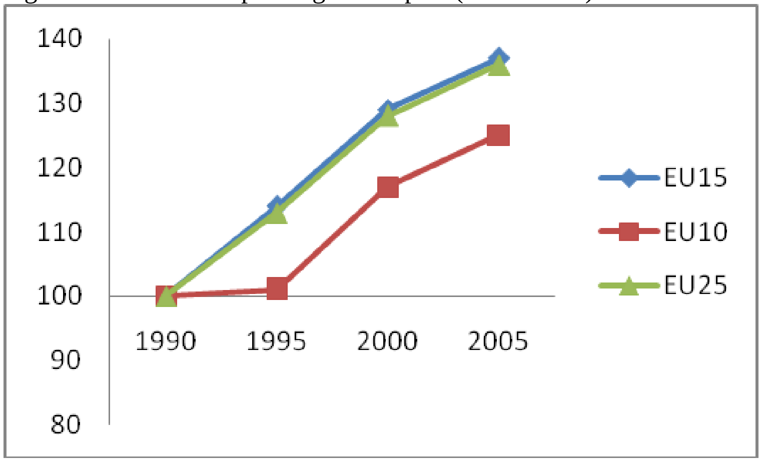


Data Source: EUROSTAT, 2008

Passenger transport

In the 1990-2005 period the passenger transport rate of the EU25 countries increase by 40%. The EU15 countries determined the overall trend, while the EU10 countries presented a halt in the 1990-1995 period and a high growth rate, similar to the EU15 one, from 1995 onwards. As a result, nowadays the differences between the EU15 and the EU10 passenger mobility trends are smaller than those related to freight mobility (Figure 3). A detail summary of the growth rates at country level is presented in Table A2 in Danielis *et al.* (2008).

Figure 3 – Increase in passenger transport (1990 = 100)



Data Source: EUROSTAT, 2008

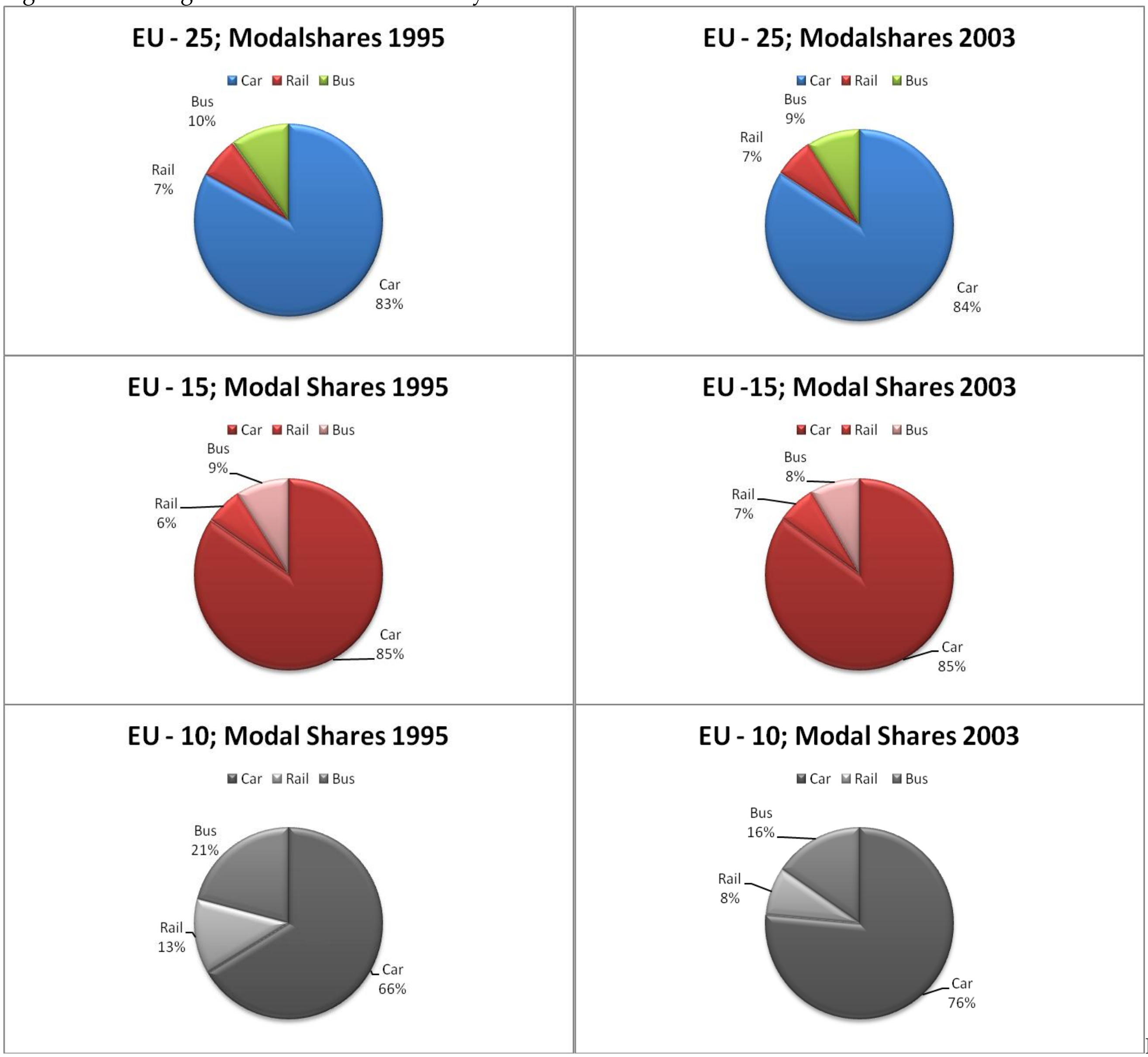
During the 1990-2005 period at the EU25 level all passenger transport modes, with the exception of sea transport, showed an increasing trend. Specifically air passenger travel registered the highest growth rate (+49%)[3], most probably because of the holiday air traffic increase induced by higher personal incomes and cheaper airline tickets. Passenger car use grew by 18% and in 2004 was responsible for 74% of all passenger transport, while rail passenger transport growth was much smaller (+9%). It should be noted, however, that while in the EU15 countries, in the 1995-2005 period, rail transport volumes grew by 17%, in the EU10 countries they decreased by 49%. Similarly, while in the EU15 countries the bus transport trend increased by 10%, in the EU12 (only 10 of them were EU members in 2004) it decrease by 11%.

With regard to the modal share for passengers (Figure 4), at the EU25 level, the passenger car share, 84%, had been almost constant over the period 1995-2003. Rail is constant at 7% and bus decreased from 10% to 9%. The EU15 countries have a passenger car share of 85%, constant from 1995 to 2003. Rail increased from 6% to 7%, whereas bus decreased from 9% to 8%. More relevant changes in modal share took place in the EU10 countries. Road increased from 66% to 76%, rail decreased from 13% to 8%, and bus from 21% to 16%. Hence, the trends in private transport confirm those characterizing the freight transport: more flexible modes are used at the expense of energy efficiency and social and environmental impacts. While the EU15 countries reached a modal share stability, the EU10 countries moved towards "western" standards.

The modal shift from public to private transport modes registered for the EU10 countries, although somehow expected, most likely worsens the energy and environmental efficiency of the EU10 transport systems and leads to the loss of the competitive advantaged described in the Term Report 2002 quoted in the introduction.

[3] Aviation's share of total pkm traveled increased from 6% in 1995 to around 8% in 2004 (data refer to domestic and intra EU25 aviation only).

Figure 4 – Passenger modal shares in various years

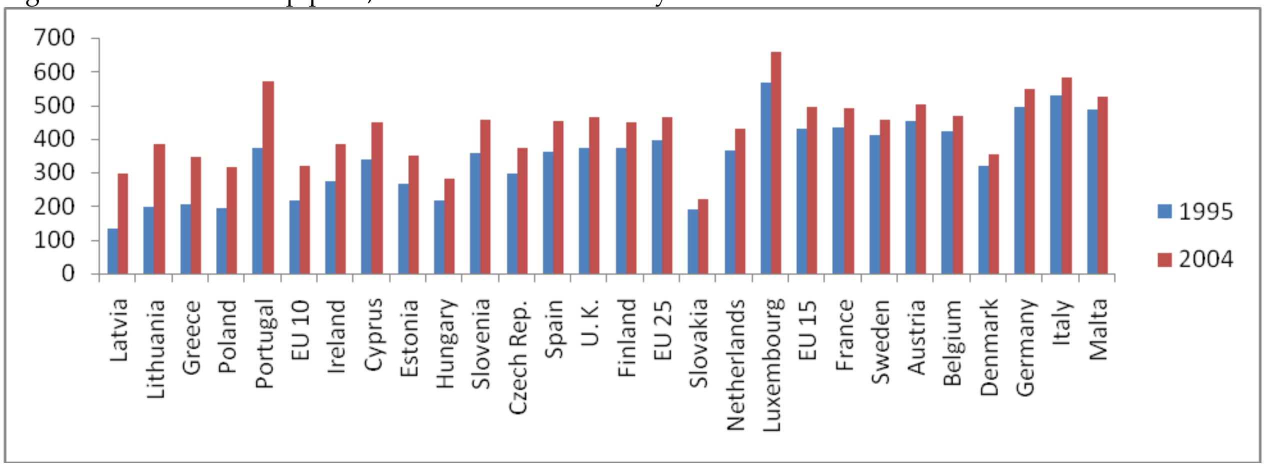


Data Source: EUROSTAT, 2008

2.2 Car ownership

The passenger transport trends can be explained by looking at car ownership indices (Figure 5, picturing countries in descending order on the basis of the growth rates in car ownership). In the period 1995-2004, at EU25 level (see also Table A3 in Danielis *et al.* 2008), the car ownership index increased from 394 to 463 cars for 1,000 inhabitants (+17%), indeed all countries faced increasing indexes. But while for the EU15 countries the index increased by 15%, with an average of 495 cars for 1,000 inhabitants in 2004, for the EU10 countries the index increased by 47% (Latvia had the highest increase, that is 122%), with an average of 218 for 1,000 inhabitants in 1995 and an average of 320 for 1,000 inhabitants in 2004.

Figure 5 – Car ownership per 1,000 inhabitants sorted by rate of increase



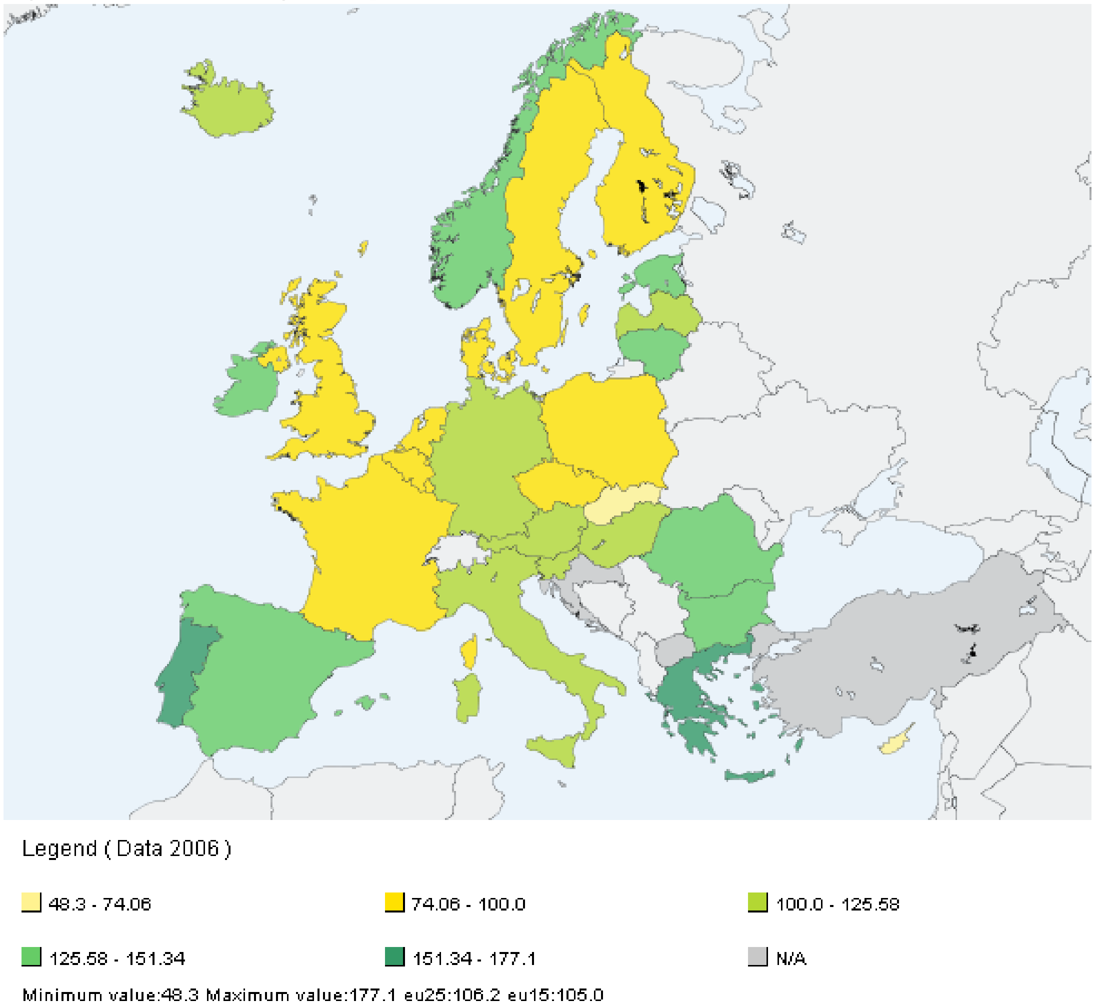
Data Source: EUROSTAT, 2008

2.3 Transport intensity

Transport intensity is defined as the ratio of freight and passengers movements (gross mass movement, Peake, 1994) to the value of goods and services produced (GDP). The amount of goods movements is measured by the index tkm (tons times kilometers), whereas the passengers index is pkm (passengers times kilometers). Among the most frequently quoted EU policy there is the goal to decouple traffic and GDP growth, in order to reduce some of the undesirable traffic side-effects, but without damaging the prospects for economic growth.

The empirical evidence for the EU25 countries however, shows no decoupling trends for freight transport (see Figure 6). On the contrary, since 1995 there has been a 6% increase in the freight transport intensity index (see Table A4 in Danielis *et al.* 2008). The EU 15 index overall increased by 5%, while the EU10 one increased by more than 6%. Actually, this index is quite differentiated by country, as Portugal, Spain, Greece, Bulgaria, Ireland, Estonia, Romania and Austria show very high intensity indexes, whereas Slovakia, Cyprus, Denmark, Finland, Belgium and the U.K have decreasing indexes, but the EU10 countries seem to be more often among the non-virtuous ones.

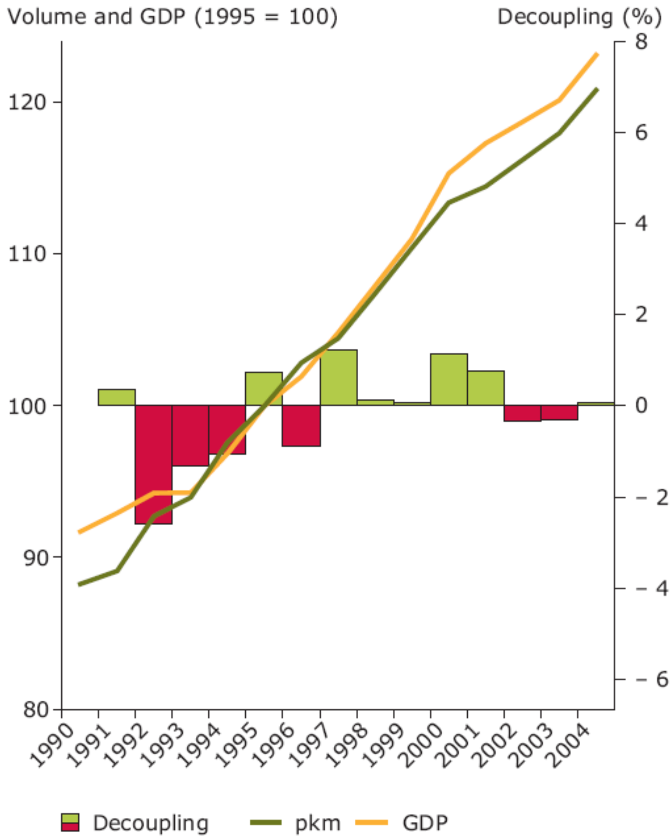
Figure 6 – Volume of freight transport



Source: EUROSTAT, 2008

Passenger transport growth of the EU25 countries in the period 1995-2004 has been slower on average than the economic growth.

Figure 7 – Passenger transport intensity



Source: EEA, 2008, p. 15

The decoupling indicator displayed in Figure 7 is expressed as the change in transport intensity compared to the previous year, and it is green if there is a percentage decline in transport intensity index since the previous year.

3. Accessibility

Accessibility to the in terms of time and cost either for freight or for passenger transport is also given respect by the European Commission as the EEA states: "*An important goal of the European spatial development policy (European Commission, 1999) is to ensure economic and social cohesion, and a more balanced competition between European regions, by improving the regional accessibility level, while preserving natural resources and cultural heritage*." EEA (2002, p. 4)

3.1 Definition

Accessibility can be defined as the ease (in terms of time and cost) of reaching economically important assets (for example, buyers of products, or potential employees) by various modes (road, rail, aviation). Accessibility to population is an indicator of the size of market areas for suppliers of consumer goods and services; accessibility to economic activity (expressed by gross domestic product) is an indicator of the size of market areas for suppliers of high-level business services (business to business).

3.2 Accessibility indicators

Accessibility can be measured in very different ways, according to the type of flows concerned: people, goods and information. It has to be measured at different territorial scales, just as decisions on accessibility improvements are also taken by governments at different territorial scales.
It can be measured in various ways and has many dimensions.

- Modal accessibility
- Multimodal accessibility
- Hub (airport or seaport) accessibility
- Network accessibility
- City accessibility
- Information and communication technology (ICT) accessibility

A discussion of these indices is provided in Appendix B in Danielis *et al.* (2008), together we some figures derived from the ESPON documents illustrating the main empirical results.

3.3 Relationship between accessibility and economic performance

Accessibility, quality of transport and communication infrastructures are traditional issues in territorial development and cohesion. Good accessibility is often considered to be a prerequisite for attracting investors, maintaining employment, facilitating the building of cities networks and clusters, and for developing tourism. Mode choice is influenced *inter alia* by mode-specific differences in accessibility. Hence, enhancing equal accessibility of different transport modes in some region can improve the modal split.
In addition to the physical mobility of people and goods, flows of information supported by telecommunication facilities are rapidly growing in importance. Steeply rising energy prices make access to energy a new key factor in regional accessibility, with important consequences for physical mobility and economic development.

As mentioned in EEA (2008) the Maastricht Treaty, the White Paper on Growth, Competitiveness and Employment (European Commission, 1993), and the Treaty of Amsterdam state that better transport, and particularly the completion of a basic high-quality infrastructure network, serves as means of reducing the costs of EU industry and improving its competitiveness in world markets, and of reducing the disparities between regions by improving overall accessibility levels.

The European spatial development perspective (European Commission, 1999) stresses the importance of strengthening a polycentric and more balanced system of metropolitan regions, city clusters and city networks through closer cooperation between structural policy and the trans-European networks (TENs) policy and through the improvement of the links between international/national and regional/local transport networks.

"The relationship *between access to markets and local economic performance is rather diffuse. Overlaying the map of regional accessibility by road with the regional GDP map suggests a correlation between the two phenomenon. Central areas seem to be more accessible and to be wealthier then peripheral ones. However, a detailed analysis has not been made. According to the SPESP (European Commission, 2000), the relationship between access to markets and local economic performance is mixed:*

- *highly accessible regions do not seem to be particularly wealthy in terms of GDP per capita;*
- *regions that are highly accessible by road tend to be more productive (having a higher GDP per employee than other regions);*
- *economic strength (a composite indicator based on factors such as GDP and employment rate) is highly correlated with accessibility by road and, to a lesser extent, by air. A simple explanation is not available. One possibility is that many people who work in highly accessible and productive regions live in less productive regions."*EEA (2002, p. 4)

Analysis by ESPON (2006, p.37) shows that "*the hotspots of multimodal accessibility are in no way homogenous economically. Some, like the central regions of Spain around Madrid, under-perform compared to their location advantages, whereas Catalonia performs better economically than its transport location might predict. Similarly, in the capital cities and main economic centres of the eastern countries GDP per capita is very low compared to the rankings in terms of accessibility. Extensive parts of Germany and the north central part of France as well as the English southeast and the northwest also have very high accessibility values that are not reflected in their economic performance. In contrast, many regions in the Nordic, and especially their capital regions, but also many regions in Switzerland have very high GDP compared to the indices that describe their accessibility. Denmark and Ireland as well as many regions in Switzerland and western Austria further support this finding. In the central parts of the pentagon in Belgium, the Netherlands and Germany, where potential multimodal accessibility is high, the only regions that perform even better economically than might be expected from their advantages in accessibility are some economically strong urban regions. Good accessibility does contribute to potential competitive advantage, but does not by itself guarantee that the potential is realised*".

3.4 The accessibility level of European regions

Accessibility to European markets varies significantly among the EU regions — similarly to GDP — and it is higher in northwestern Europe. This is mainly due to high infrastructure densities in that area. Studies on the relationship between transport infrastructure and services and regional development are inconclusive as regards the extent to which transport infrastructure actually leads to growth in economic welfare and to strengthened cohesion among regions. In this subsection, we will summarize the main findings.

In terms of road accessibility, there is a clear distinction between the centre and the peripheries of Europe (see Figure 11 in Danielis *et al.* 2008), as consequence of the disparity in road infrastructure endowment (see Figure 12 in Danielis *et al.* 2008)[4]. Such a disparity is mainly due to the economic disparity between the central and the peripheral European areas (ESPON, 2006)[5].

The potential accessibility by rail adds some complexity to the picture. Rail transport has a less flexible infrastructure. It is less attractive both for passenger and freight transport, but it is quantitatively more evenly distributed between the centre and the peripheral regions. The highest rail accessibility levels, however, are in medium-big cities serving as main nodes in the high speed rail networks and along major corridors. Moreover, high speed trains have been mostly organized in western core countries, leading again to a somewhat imbalanced accessibility picture.

The potential accessibility by air (see Figure 13 in Danielis *et al.* 2008) is concentrated in the areas surrounding major airports. These are quite dispersed across Europe, although the most important ones are mainly concentrated in the western core countries, thus reproducing the already underlined accessibility imbalance. The recent success of low cost carriers and the use of secondary airports, however, have enhanced the air accessibility of peripheral regions at least for passenger transport.

Sea accessibility, because of its special nature, conveys a different story. Transport infrastructures and services are fairly well distributed along European coastal regions, although some areas of the more peripheral regions are less well-served. Coastal regions in the core of Europe, along the English Channel and the North Sea, have the highest connectivity values and the most efficient connections from ports to their hinterlands. This high accessibility to commercial sea ports decreases towards Poland and the Baltic States, because networks of motorways and expressways at present are less developed in the eastern part of Europe. Towards the Black Sea, Romanian and Bulgarian regions have remarkable high levels of connectivity to their sea infrastructure. Connectivity to commercial seaports is lower around the Mediterranean coasts and islands, with the exception of Cyprus and Sicily. In particular, the Spanish regions facing the Mediterranean Sea show lower levels of maritime connectivity mainly because of underdeveloped coastal road networks. On the contrary the French Atlantic coast shows a better connectivity towards inland regions.

When we consider of set of accessibility indicators related to road, rail, and air transport, the centre-periphery model is confirmed. Belgium, the Netherlands, the western regions of Germany and the Paris region have an above-average accessibility level. The regions bordering with this central area have a moderately above-average accessibility level, whereas the peripheral regions of Portugal, Spain, Southern Italy, Greece, Latvia, Lithuania and the northern regions of Finland, Sweden, Norway and Scotland have a well below-average accessibility level.

One arrives to similar conclusions when the potential multimodal accessibility level of the European regions is considered. Indeed, with the exception of the capital cities (which are nodal points in the air and rail networks), Portugal, Spain, Greece, Finland, Norway, Ireland and all the EU10 countries have a below-average accessibility level.

Such conclusion is also confirmed when the local network accessibility indices are calculated and the the accessibility to transport terminals is evaluated. Most regions enjoy good connectivity to transport

[4] Since road transport is by far the most important transport mode (because of its ability to connect many points in space and the flexibility of road vehicles), the imbalanced quantity and quality of its infrastructures are to be considered the major factors causing the overall accessibility imbalance between the two areas.

[5] The TEN/TINA project are most likely going to partly remedy the road imbalance and the 2008 picture, though not available to us, is certainly different from the 2001 one.

terminals, although western regions perform generally better than those of member countries which joined the EU in 2004.
Moreover, the accessibility level of the urban areas can be calculated. Not surprisingly, the urban areas belonging to the core regions enjoy the largest accessibility levels, whereas those of the peripheral regions have lower accessibility indices.
Similar indices and figures can be produced with regards to ICT[6] accessibility (ESPON, 2006, p.42) . It results that not all regions are gaining and using telecommunication infrastructure and services at the same rate, although the territorial roll-out of telecom's infrastructures and services is progressing much faster than the development of transport infrastructure. Territorial disparities are now insignificant for fixed-line telephony. The mobile telephony is manly developed in the Nordic and Southern periphery more than in the European core, although the new member countries are catching up, but they still have lower levels of uptake than western Europe. Similar differences do exist with regards to PC use and in e-commerce activities. The territorial dispersion of ICT technology and use is strongly influenced by market forces. Telecommunications investments follow the population distribution, modified by variations in wealth and by concentrations of corporate business users.

3.5 The changing picture

What is the projected picture of the European accessibility for the year 2020? Not surprisingly, the EU10 are the countries in which road transport flows are forecasted to increase the most, together with rail flows on specific corridors. Rail flows are on the rise also on many core regions' corridors (see Figure 23 in Danielis *et al.*, 2008)
This projection will be influenced by the European transport policies and by the congestion of the European corridors. Indeed, the TEN\TINA projects - developed and financed to improve the connectivity of European regions with a special attention to the eastern European countries - are estimated to have a positive impact on the GDP. The beneficiary are consequently mainly the eastern European regions.
It should also be stressed that increasingly overloaded transport corridors in the context of changing transportation flows are becoming an important issue for accessibility, reducing the efficiency of the transport systems and changing the accessibility picture drawn thus far. It is estimated that road passenger flows for the year 2020 in comparison to the base year 2000 will grow by almost 43%. At the same time, in the context of very ambitious investment programs, the rail transport flows of passengers will also increase. The spatial interactions that generate traffic will mainly concentrate on urbanized regions and on networks between major centers. They will pass through rural areas, which will increasingly take over a large load of traffic. Unsurprisingly, the core regions will suffer congestion more than the periphery regions. It is consequently quite likely that the gap in accessibility between the core and the periphery regions will decrease as a result of higher congestion on core regions corridors.
Congestion is not the only factor limiting the efficiency and increasing the vulnerability of transport networks. Natural hazards (such as flooding) or technical hazards (such as accidents in tunnels) may interrupt traffic on important corridors. Such situations are more frequent in mountain areas where natural hazards are not exceptions and the number of corridors is limited. In such cases, traffic is diverted towards other corridors.

To summarize:

[6] ICT is the information and communication tecnologie

- accessibility is a complex concept which can be measured with many indices and can be referred to people, goods or information;
- the accessibility level across European regions and within European countries is quite imbalanced, both with regards to transport and use of ICT. Accessibility is higher in high-income areas (the core regions vs. the periphery regions) but this phenomenon might be the cause and/or the effect of the high income levels;
- the accessibility imbalance is most likely to change rapidly due to organizational (such as the low-cost air fares) and technological factors, the development new infrastructures and the EU policies;
- the effects of improving connectivity among areas is still theoretically uncertain;
- infrastructures are subject to rapid congestion which is actually the case in most core regions;
- passenger and freight transport flows generate environmental and human costs.

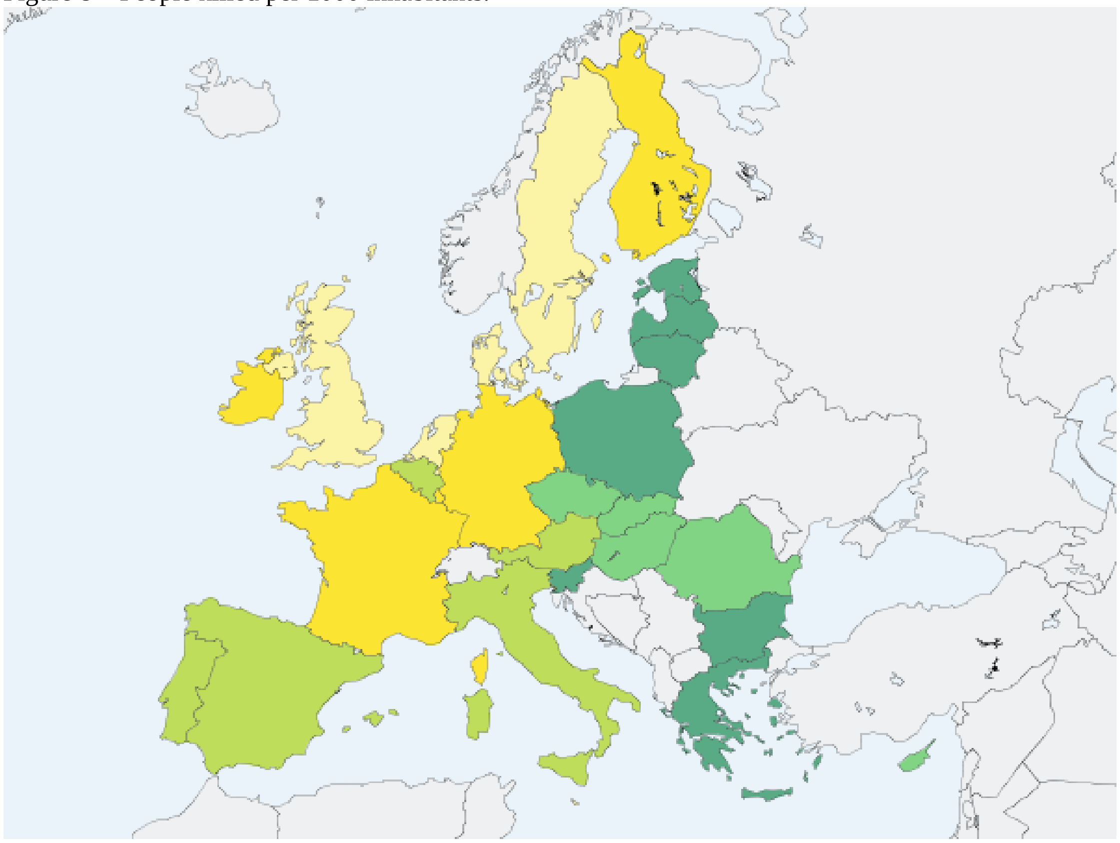
4. Social and environmental impact of transport

Transport is essential to carry out social and economic activities, but generates social and environmental costs that reduce both the quality of life of a territory and its investment attractiveness. Accidents, energy consumption, air emissions, land consumption and fragmentation are the most important negative impacts of transport which counterbalance the benefits of mobility. In the next sections we will analyze some of these problems comparing the available data among the European regions.

With regards to accidents, the EU25 countries can be divided into three groups (Figure 8): the northwestern countries with the lowest number of people killed per thousand inhabitants, the southwestern countries (including Belgium) with an intermediate number of people killed per thousand inhabitants and the north-, central and southeastern countries with the highest levels of people killed per thousand inhabitants.
The number of people killed in 2006 decreased by –36% in the EU15 and by –23% in the EU10 if compared with the 1995 values (see Table A5 in Danielis *et al.* 2008). The richest countries of the west, hence, reduced the most the number of deaths, whereas the lower income countries of the east improved at a slower rate. It should be noticed, however, that in the EU10 countries the increase of both car use and car ownership have been much higher than in the EU15 countries. It is most likely, hence, that the higher amount of resource available for road improvement and maintenance activities, together with the possibility of investing in safer vehicles are the main factors determining road safety.

4.1 Accidents

Figure 8 – People killed per 1000 inhabitants.



Legend (Data 2006)

25.0 - 56.0 | 56.0 - 87.0 | 87.0 - 102.0

102.0 - 130.0 | 130.0 - 223.0 | N/A

Minimum value:25.0 Maximum value:223.0 eu25:Not available eu15:Not available

Source: EUROSTAT, 2008

4.2 Energy consumption

According to EEA (2002), energy consumption — in particular the consumption of fossil fuels — is a major policy concern as it is closely linked to greenhouse gases emissions and to energy supply sustainability. In 1999 the share of energy consumed by transport by the EU10 member states was 19%, while in the EU15 it was much larger, that is 34%.

Table 2 shows that the EU15 population, which represents the 84% of the total EU25 population, is responsible for 91% of the total transport energy consumption. In 1995 the per-capita consumption in the EU15 countries was 741 toe x 1,000 inhabitants, almost three times as much as in the EU10 countries. In 2006 the EU15 per capita consumption increased to 849 (+20% if compared to 1996 values), while the EU10 increased to 439 (+64% if compared to 1996 values). The gap is thus decreasing but it is due to the rapid growth in energy per capita use of the EU10 countries, rather than to higher energy consumption efficiency, implying a fast growing environmental pressure both in terms of depletion of non-renewable resources and in terms of air pollution.

At country level, in 2006, all EU10 countries but Cyprus have a toe x 1,000 inhabitants lower than the average EU 15 level, the most energy efficient countries are Slovakia and Poland, while the most energy consuming countries are Cyprus, Slovenia and Malta. Within the EU15 countries, the least energy consuming countries are Portugal, Italy and Greece, while the least energy efficient ones are Luxembourg, Ireland and Denmark.

Table 2 - Energy consumption of transport.

	2006	*2000*	*2006*	1995	2006
geo\time	1000 toe	(1995=100)	(1995=100)	Toe x 1000 inhab.	Toe x 1000 inhab.
EU15	**330,663**	**113**	**120**	**741**	**849**
Belgium	9,626	114	113	840	916
Denmark	5,339	106	120	855	984
Germany	63,311	105	100	774	768
Ireland	5,373	171	229	653	1.277
Greece	8,502	112	132	608	764
Spain	40,822	126	156	665	933
France	50,859	116	115	747	807
Italy	44,194	110	117	664	752
Luxembourg	2,631	144	201	3.232	5.726
Netherlands	15,62	111	126	806	956
Austria	7,659	117	147	655	927
Portugal	7,142	134	147	486	676
Finland	4,956	107	119	816	943
Sweden	8,569	106	112	871	947
U.K.	56,06	111	119	812	928
EU10	**32,51**	**116**	**164**	**264**	**439**
Czech Rep.	6,318	153	221	276	616
Estonia	797	118	162	340	593
Cyprus	929	114	124	1.165	1.212
Latvia	1,177	105	165	286	513
Lithuania	1,503	101	145	285	442
Hungary	4,68	123	176	257	464
Malta	294	78	96	826	727
Poland	13,426	111	162	214	352
Slovenia	1,554	99	117	668	776
Slovakia	1,832	103	129	264	340
EU25	**363,173**	**113**	**123**	**663**	**783**

Eurostat: This indicator covers the consumption of energy in all modes of transport, with the exception of maritime and pipelines.
Source: EUROSTAT, 2008

4.3 Greenhouse gas emissions

EEA(2008, p. 8) states that "*during the period 1990–2004, global emissions of CO_2 increased by 27%, from 20463 to 26079 million tonnes CO_2 (Mt CO_2). Energy demand from the transport sector — an indicator of global transport emissions — increased by 37% over the same period. The two largest greenhouse gas emitters world-wide are USA and China. […] In the EU27, total greenhouse gas emissions in 1990 were 5,621 Mt CO_2-equivalent, falling to 5,177 Mt CO_2-equivalent in 2005 (a decrease of 7.9%). In the same period, emissions from the transport sector increased by 26%. In 2005 they represented 22% of total EU27 greenhouse gas emissions*[7]*. Had transport sector emissions followed the same reduction trend as in society as a whole, total EU27 greenhouse gas emissions during the period 1990–2005 would have fallen by 14% instead of 7.9 %.*" .

Focusing the analysis on transport only (Table 3), in the period 1994-2004, despite technology improvements and numerous proposal and protocols aimed at reducing atmospheric pollution, greenhouse gas (GHG) emissions at the EU25 level had increased by 18%. It should be noticed that while the EU15 countries had a 17% increase, the EU10 countries registered a much higher increase, i.e. 32%. However, the EU10 countries, hosting 16% of the total EU25 population, are responsible for 8% of the total emissions. Moreover, while in 2004 the EU10 countries emitted on average 1.1 ton CO_2-equivalent per capita, the EU15 countries emitted 2.3 ton CO_2-equivalent per capita. Similarly to energy consumption, hence, the EU10 contribution is much lower than the EU15, but it is a rapidly catching up the western levels.

At country level, the countries that increased at faster rates in the period 1994-2004 are a mix of EU15 (Ireland, Luxembourg, Austria, Portugal, Spain) and EU10 countries (Czech Republic, Latvia, Hungary, Cyprus, Estonia). Interestingly, Germany, Sweden, the United Kingdom, France, Finland, and Denmark have succeeded in containing emissions growth below average level thanks to successful GHG reducing policies, although data on CO_2 emissions per km from new passenger cars (see Figure 29 in Danielis *et al.,* 2008) show that Nordic countries buy bigger cars with more energy consumption and CO_2 emissions per passenger and that the car technology divide is not very large when it comes to new vehicles.

[7] The transport sector presented here consists of road transportation, domestic civil aviation, railways, national navigation and other transportation. It excludes emissions from international aviation and maritime transport (which are not covered by the Kyoto Protocol or current EU policies and measures). Road transport is by far the biggest transport emission source.

Table 3 - Greenhouse gas emissions from transport

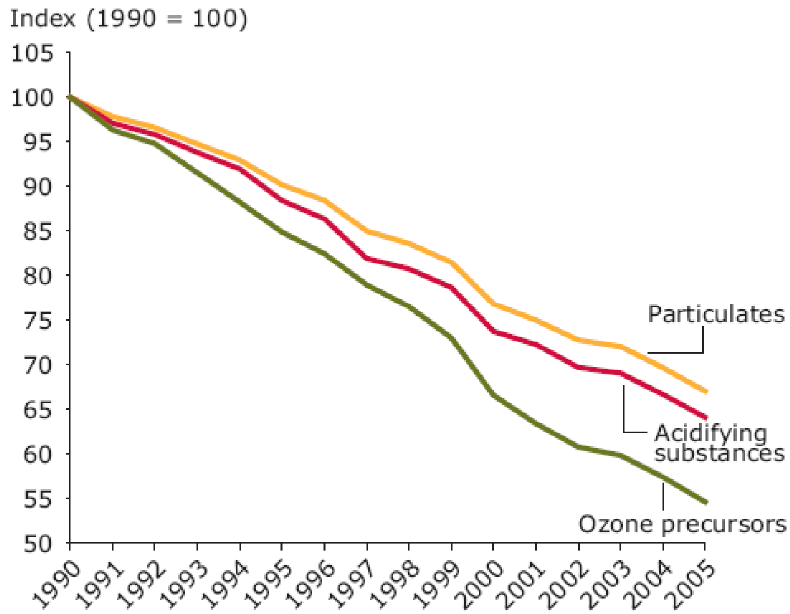
geo\time	*2003* 1,000 tonnes of CO2 equiv.	*2004* 1,000 tonnes of CO2 equiv.	*2000* (1994=100)	*2004* (1994=100)	1995 tonnes of CO2 equiv. x inh.	2004 tonnes of CO2 equiv. x inh.
EU15	**870,032**	**884,431**	**112**	**117**	**2,058**	**2,297**
Belgium	26,136	27,348	111	122	2,217	2,631
Denmark	13,081	13,346	108	116	2,296	2,473
Germany	171,961	172,755	105	99	2,193	2,093
Ireland	11,85	12,578	175	207	1,83	3,123
Greece	21,861	22,302	115	130	1,634	2,02
Spain	98,045	102,011	132	155	1,704	2,409
France	146,363	146,839	109	113	2,236	2,359
Italy	130,428	132,631	110	117	2,025	2,291
Luxembourg	6,083	7,053	136	190	8,624	15,503
Netherlands	34,805	35,379	113	121	1,928	2,176
Austria	23,178	23,765	125	164	1,871	2,92
Portugal	20,11	20,042	152	157	1,344	1,913
Finland	13,692	14,083	106	114	2,384	2,698
Sweden	19,929	20,138	102	107	2,148	2,244
U.K.	132,506	134,154	106	110	2,093	2,247
EU10	**75,967**	**82,282**	**107**	**132**	**805**	**1,11**
Czech Rep.	14,101	15,907	149	203	948	1,558
Estonia	2,159	2,157	68	141	766	1,597
Cyprus	1,849	1,756	151	151	1,909	2,404
Latvia	2,802	2,896	123	156	783	1,249
Lithuania	3,625	3,967	75	80	1,296	1,151
Hungary	10,171	10,608	128	152	690	1,049
Malta	555	578	116	134	1,2	1,447
Poland	31,217	34,468	96	115	670	903
Slovenia	4,107	4,259	113	127	1,865	2,133
Slovakia	5,377	5,682	106	133	847	1,056
EU25	**946**	**966,714**	**111**	**118**	**1,853**	**2,105**

Eurostat. This indicator shows trends in the emissions from transport (road, rail, inland navigation and domestic aviation) of the greenhouse gases regulated by the Kyoto Protocol. Only three gases are relevant in the context of transport (carbon dioxide, methane, and nitrous oxide) and these have been aggregated according to their relative global warming potentials.
Source: EUROSTAT, 2008

4.4 Air pollution

During the 1990-2005 period in the 32 EEA member countries transport emissions of particulates, acidifying substances, and ozone precursors decreased by 33%, 36%, and 45%, respectively (Figure 9). This occurrence is mainly due to fleet renewal (with vehicles equipped with catalytic converters and particulate traps) and sulfur reduced fuels used in road transport.

Figure 9 - Transport emissions of air pollutants in EEA member countries



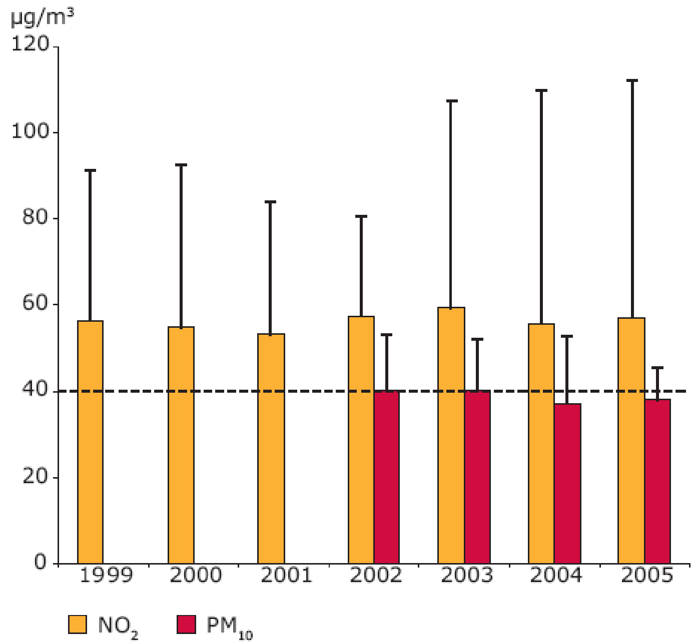
Source: EEA (2008) Climate for a transport change. TERM 2007, p 19

At urban level, data from selected measuring stations close to major traffic arteries indicate that the concentration of nitrogen dioxide (NO_2) and PM_{10} are at or above the European air quality limits (Figure 10). At these sites, between 2000 and 2005, mean NO_2 concentrations have remained relatively stable, while PM_{10} have decreased slightly. There are two explanation for these figures: the increased use of diesel in urban areas and, since 2000, an increase of the fraction of NO_X emitted as NO_2.[8]

In the period 1993-2004, at EU25 level the available data show that total emissions of particulate matter decreased by 36%, and that the EU15 reduction was 38% while the EU10 decrease was 24% (see Table A6 in Danielis *et al.* 2008). Emissions of ozone precursors decreased by 48% in the EU15 countries, and by 37% in the EU10 countries (see Table A6 in Danielis *et al.* 2008). The consistently larger decrease of air pollutants in the EU15 countries is mostly likely due to their ability to buy technologically more advanced vehicles and to their more stringent environmental regulations.
Danielis R. (2006) performed a cluster analysis among 22 countries based on data on PM_{10}, NO_2 and O_3 ambient concentration level and identified 5 groups as illustrated in Table 4.

[8] Oxidation catalysts and regenerative traps in modern diesel vehicles have been found to lead to such increases.

Figure 10 - NO_2 and PM_{10} annual average mean concentrations at traffic monitoring stations



Note: Columns indicate mean values while error bars indicate maximum values.

Source: EEA (2008) Climate for a transport change. TERM 2007, p 19

Table 4- Result of the cluster analysis for three pollution indices

Cluster	Countries	O_3	NO_2	PM_{10}
1	Finland, Iceland, Ireland	40,4	26,5	23,7
2	Great Britain	24,4	55,9	31,6
3	Spain, Hungary, Sweden, Portugal, Denmark, Netherlands, Estonia, Lithuania	37,0	39,8	37,5
4	Austria, Switzerland, Germany, France, Belgium, Greece, Italy	41,5	45,1	34,4
5	Slovenia, Cyprus, Macedonia	51,5	34,9	58,2

The Finland, Iceland, and Ireland group represent the “clean countries” except for of ozone emissions. Great Britain shows low levels of O_3 and PM_{10}, but high levels of NO_2. Spain, Hungary, Sweden, Portugal, Denmark, Netherlands, Estonia, and Lithuania belong to the “moderately clean countries”, while Switzerland, Germany, France, Belgium, Greece, and Italy are “moderately polluted countries”. The countries worse ranking for the three pollutants are Slovenia, Cyprus, and Macedonia.

5. Conclusion and policy implications

The European Union faces an important challenge: to increase Europe's accessibility while limiting the social, energy and environmental pressures caused by transport. This challenge takes place while the European economies and their transport system integrate. The process of European integration entails the integration of two historically different transport systems: the one of the EU15 countries and of the EU10 ones. The transport systems of the EU10 countries are more dependent on state intervention and regulation and more relying on public modes such as rail and buses, with insufficient road infrastructural endowments and low private car availability. The transport systems of the EU15 countries, on the contrary, rely more on private vehicles which use the road infrastructure, both for freight and passenger transport, and, enjoying higher incomes, use more fast means of transport such as air and high-speed trains.

After a transition period from socialist, state planned regimes to market systems and the relative economic slowdown, the EU10 countries – which enjoyed lower accessibility levels than the EU15 countries, as illustrated in Section 3 - underwent a rapid change, accommodated the use of more intensive private road vehicles and abandoned the mainly rail based, public transport means.

At the same time, the European transport policy - reacting to the high economic, social and environmental costs of the western European transport system, characterized by increasing congestion levels due to the rapid traffic growth that can not be accommodated by the existing transport infrastructure - is leading towards a more efficient integrated European transport system and is specially supporting intermodality, or co-modality, switching from the mainly road-based, private vehicle mode to less flexible, but more scale, energy and environmental efficient modes.

The final result of the integration process and of the challenge of reconciliation of the accessibility and social and environmental needs is still uncertain. Will the EU10 converge towards the EU15 system giving priority to the mobility needs over the environmental concerns, or will they maintain high levels of non-road based transport? Will the EU10 adopt the cleaner technologies used by the EU15? Will the production localization in the EU10 countries augment the freight distances which imply a shift towards the rail or sea base transport in the east-west commercial relationships?

The paper provided some empirical evidence on the on-going trends which are summarised in Table 5.

Focusing on the EU10 countries as a term of reference, in 1995 they hosted 17% of the EU25 population, but they had share of freight volume of 20% and of people killed in accidents of 22%. Hence, their contribution to freight volume movement and to fatal accident was larger than their population share. On the contrary, they had a much smaller share of passenger volume (9%), of energy consumption (7%), of GHG emissions (8%), and of particulate (11%) and ozone emissions (11%). Moreover, they had a much smaller GDP per capita (8%).

In the recent years, the picture has changed, although not dramatically. The population share decreased to 16% (2004), possibly due to migration and low birth rates. The freight volume share decreased to 17% (2005), probably because of immaterialization process taking place in most modern economic systems. The share of people killed in accidents worsened, increasing to 25% (2006), but it should be noted that the number of people killed decreased by 23%, which is a particularly good result taking into account the fast-growing rate of passenger volumes by road and of car ownership.

Table 5 - Summary statistics

	EU10	*EU15*	*EU25*	*EU10*	*EU15*
Population in 1995 (in 1,000)	75,203	372,230	445,870	17%	83%
Population in 2004 (in 1,000)	74,124	386,301	460,424	16%	84%
GDP (Billion €) in 2005	665,699	7,313,899	8,011,975	8%	91%
GDP (Billion €) in 2005	980,527	9,803,711	10,755,372	9%	91%
Freight volume in 1990	303	1,241	1,544	20%	80%
Freight volume in 2005	378	1,875	2,253	17%	83%
Passenger volume in 1990	377	4,046	4,423	9%	91%
Passenger volume in 2005	471	5,561	6,032	8%	92%
Cars in 1995 (x1000)	16,374	160,156	176,530	9%	91%
Cars in 2004 (x1000)	23,756	192,648	216,404	11%	89%
People killed in 1995	12,899	46,098	58,997	22%	78%
People killed in 2006	9,918	29,516	39,434	25%	75%
Energy consumption in 1995	19,838	275,728	295,566	7%	93%
Energy consumption in 2006	32,510	330,663	363,173	9%	91%
Greenhouse gases in 1994	62,512	754,993	817,506	8%	92%
Greenhouse gases in 2008	75,967	870,032	946,000	8%	92%
Particulate matter in 1993	761	6,168	6,929	11%	89%
Particulate matter in 2004	577	3,853	4,431	13%	87%
Ozone in 1994	1,885	14,781	16,666	11%	89%
Ozone in 2004	1,188	7,626	8,814	13%	87%

Source: self-provided from data from EUROSTAT and EEA

They still have a much smaller share of passenger volume (9%, 2005), meaning that mobility level increased, but not as much as in the EU15 countries. For what concerns the environment and energy impact, the EU10 countries keep on showing a smaller share of energy consumption (9%, 2006) if compared to their population share, but this index is slightly increasing (it was 7% in 1995). Their share of GHG emissions is constant at 8%, although the quantity of GHG increased by 22% (2008). Their share of particulate matter and of ozone emissions increased to 13% (2004). The latter three findings are, of course, due to the increase in road transport relative to the traditional, more environmentally friendly modes. It should be noticed, however, that the quantities of both particulate matter and ozone decreased by 24% and 37% respectively, mainly due to modern vehicles that produce less emissions.

On the bases of these empirical evidence it seems correct to state that in the last decade the EU10 and EU15 transport systems maintained most of their relative difference, although the EU10 countries are catching up towards the EU15 model. The result is twofold with evident improvements of the EU10 accessibility, mobility and safety levels, although much inferior to the core Member states levels, but with potentially serious consequences in terms of energy consumption and environmental impacts (while the total emission of PM_{10} and O_2 decreased significantly, pollutants concentration levels in urban areas is still a concern).

In conclusion, European transport integration is underway trying to connect countries with quite different accessibility levels and transport systems. The relative differences in accessibility and mobility are slowly decreasing, although they still exist in many respects.

Achieving the right balance at European level between mobility, accessibility, energy and environmental impacts still proves to be a difficult task. For this reason it is important to keep monitoring the European transport integration process, and to strengthen consistent transport policies aimed at balancing mobility with environmental and energy issues. These policies should support:

- modal shift favoring more energy efficient transport modes. Policy has been unable to reverse the decline in market shares of rail and bus transport so far, albeit there are signals that the rate of decline is slowing down, at least in the EU15 countries;
- promotion of environmentally-friendly modes such as cycling and walking. They provide access to public transport and provide alternatives to the use of the passenger car for short local trips;
- behavioral changes like eco-driving campaigns that have generated significant benefits at local level, although their efficiency over time and at regional, national and EU level has to be proven yet;
- coordination and optimal use of different modes of transport;
- internalization of external costs which can help reduce market distortions and emission growth;
- refocusing of transport subsidies;
- reduction of total transport demand (passenger and freight). This can be done through pricing measures or other types of demand management tools;
- efficiency improvements, such as load factor increase, improved freight distribution practices and design/provision of better infrastructure;
- technological advances in transport vehicles, both for passengers and for freight;
- construction and maintenance of infrastructure. This can contribute to changing the attractiveness of different modes, but if construction mainly caters for the growing number of cars it will further support the present growth trend. Changes will anyhow take a long time to materialize.

Finally, to address mobility, environmental and energy issues, transport policies should be coordinated and consistent with measures for the households, industry and service sectors, actually originating transport demand.

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Appendix A . Figures and Tables

Figure 11 – Potential accessibility by road 2001 (source, Espon, 200x, p. xx)

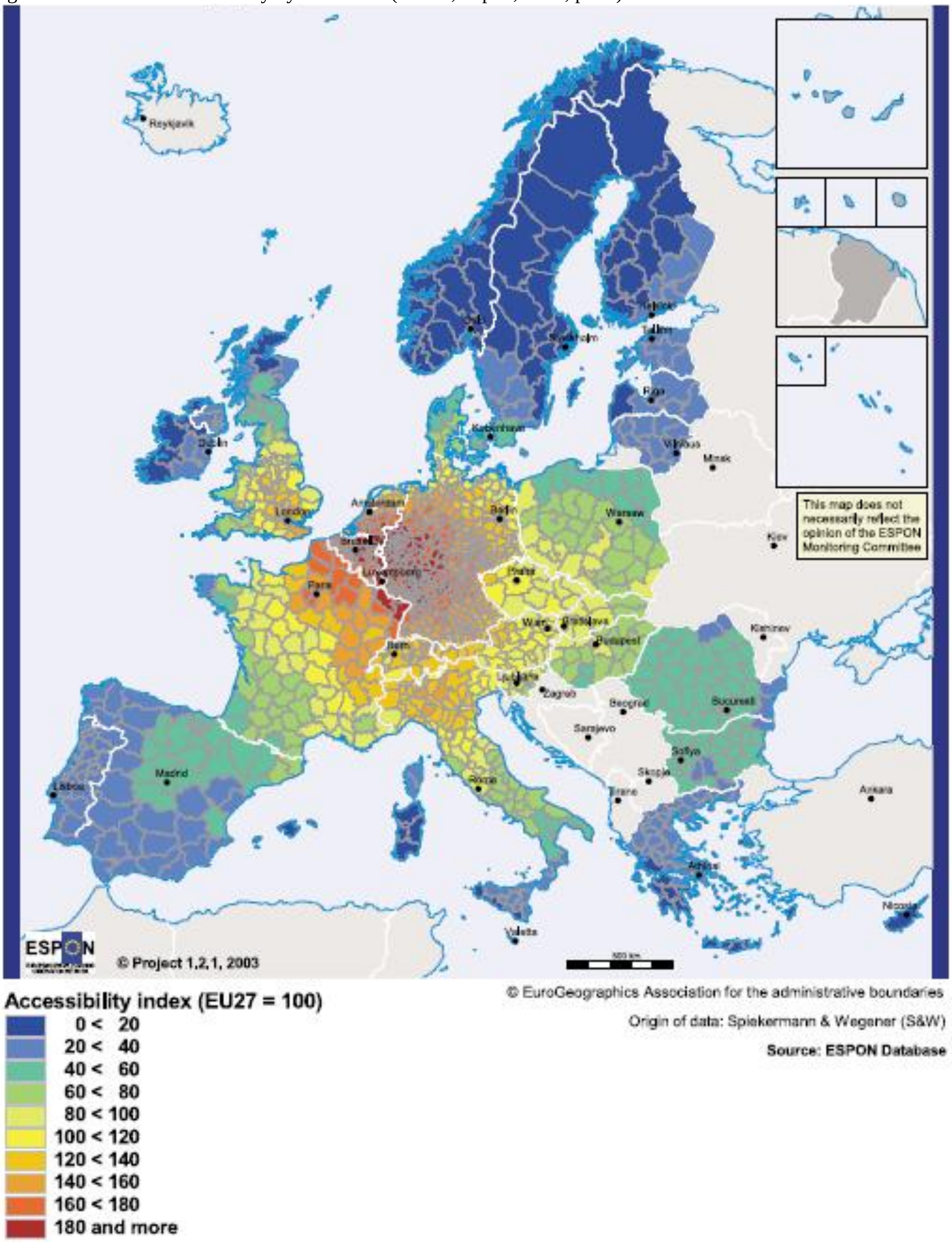


Figure 12 – Motorway network evolution 1981-1991-2001 (source, Espon, 2006d, p. 34)

Figure 13 – Potential accessibility by air, 2001 (source, Espon, 2004, p. 282)

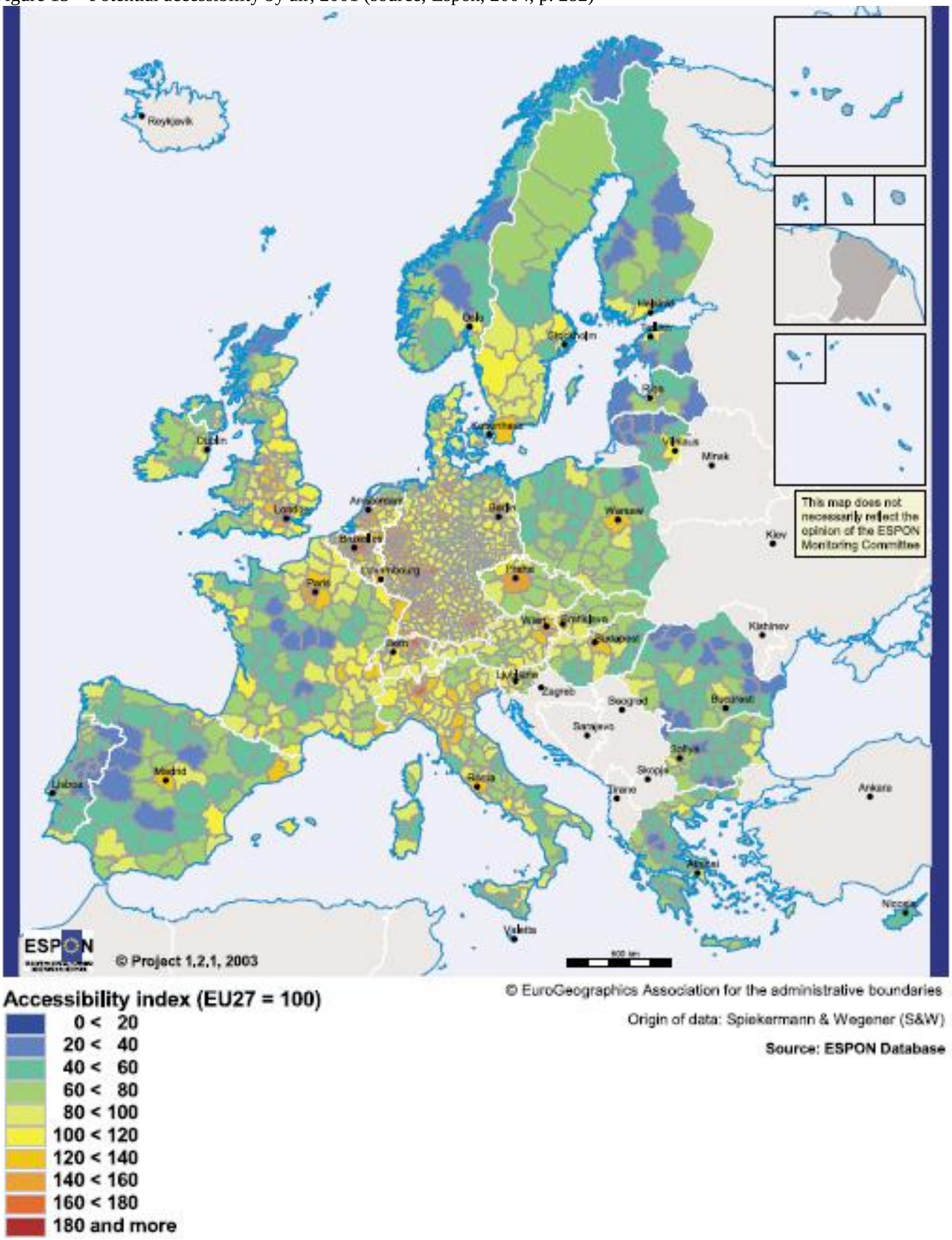


Figure 14 – Global airports, 2000 (source, Espon, 2006c, p. 37)

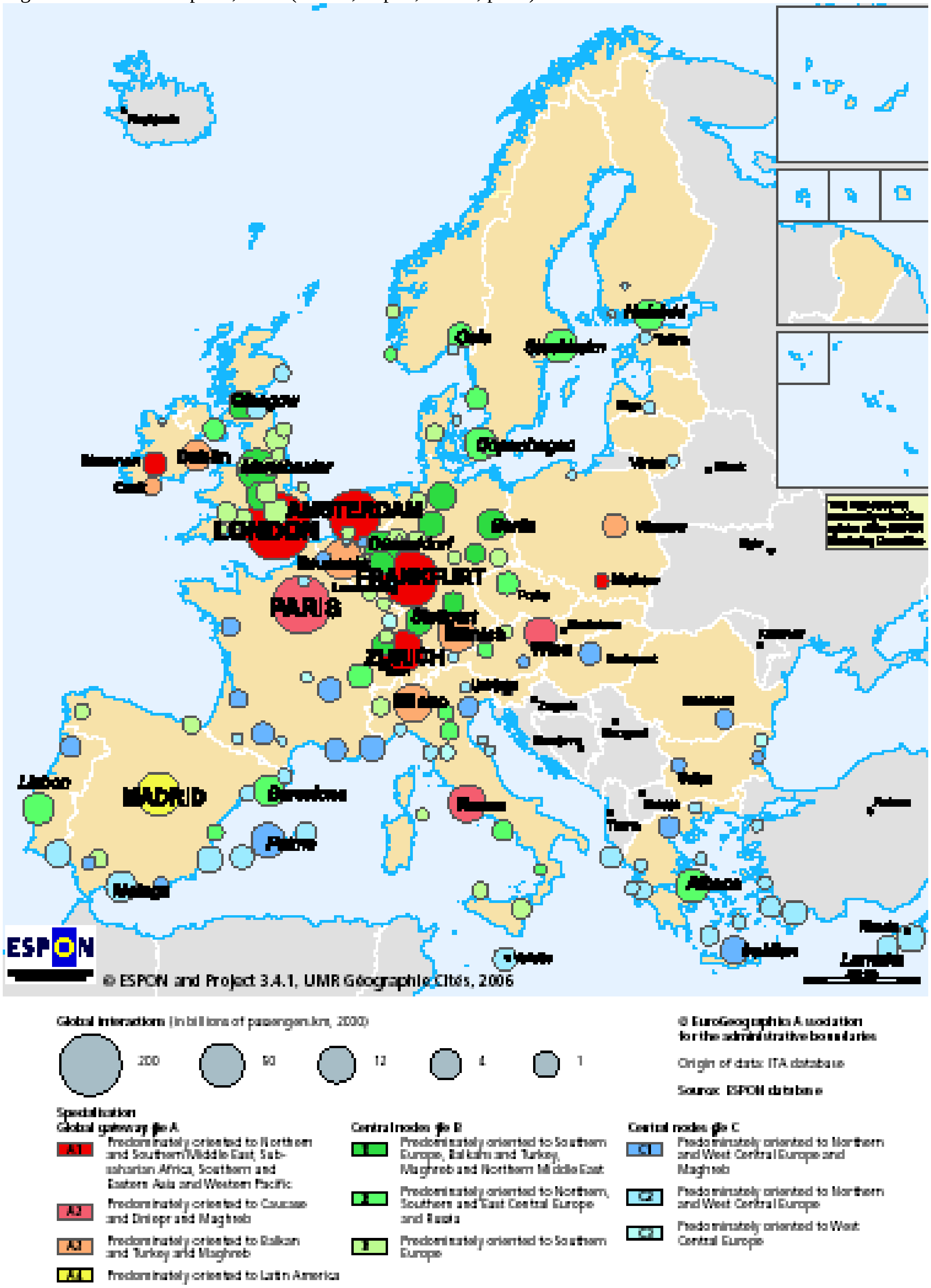


Figure 15 – Accessibility to commercial seaports, 2001 (source, Espon, 2006, p. 19)

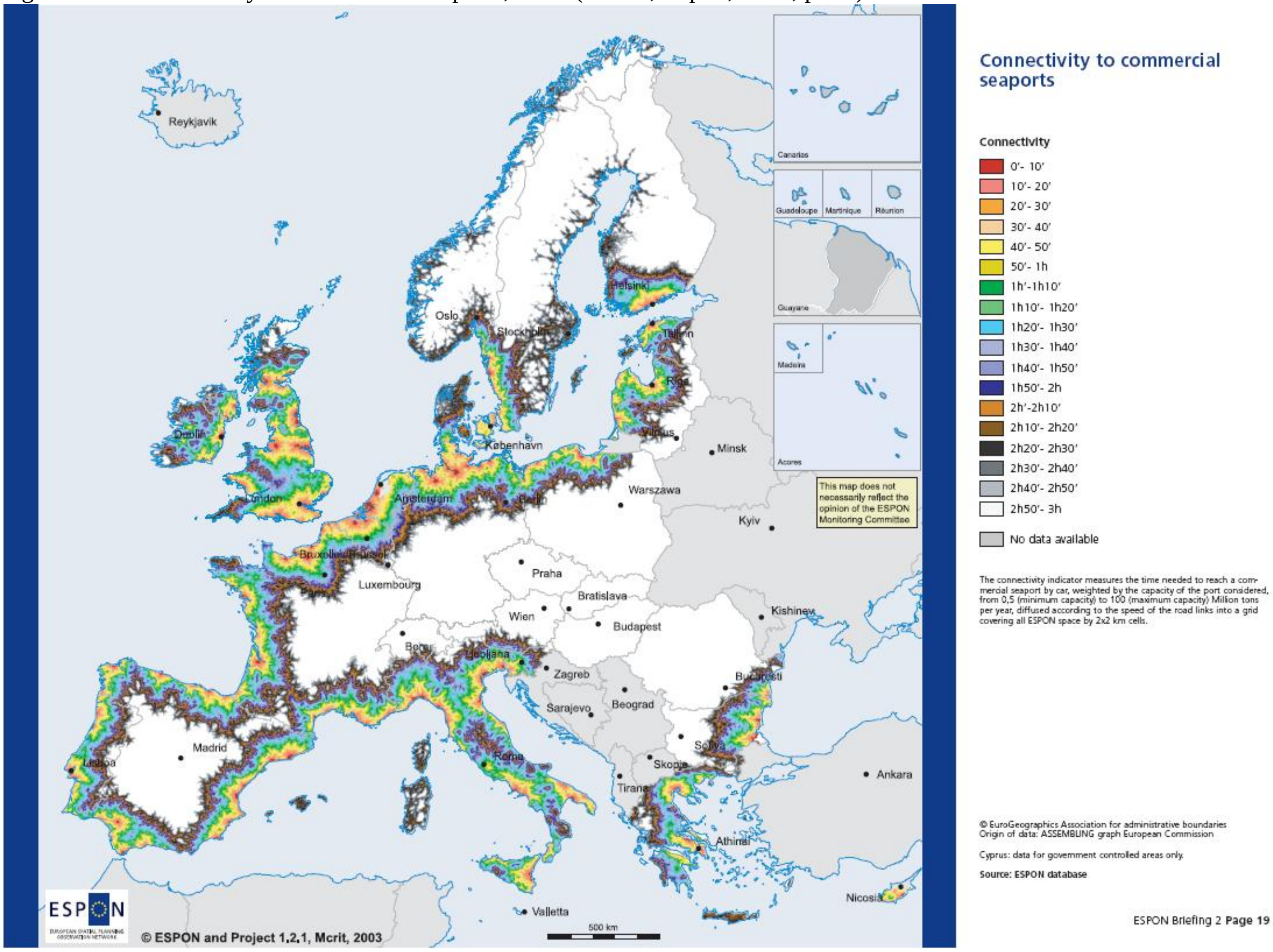


Figure 16 – Potential accessibility as an aggregate of five indicators, 2001 (source, Espon, 2005, p. 33)

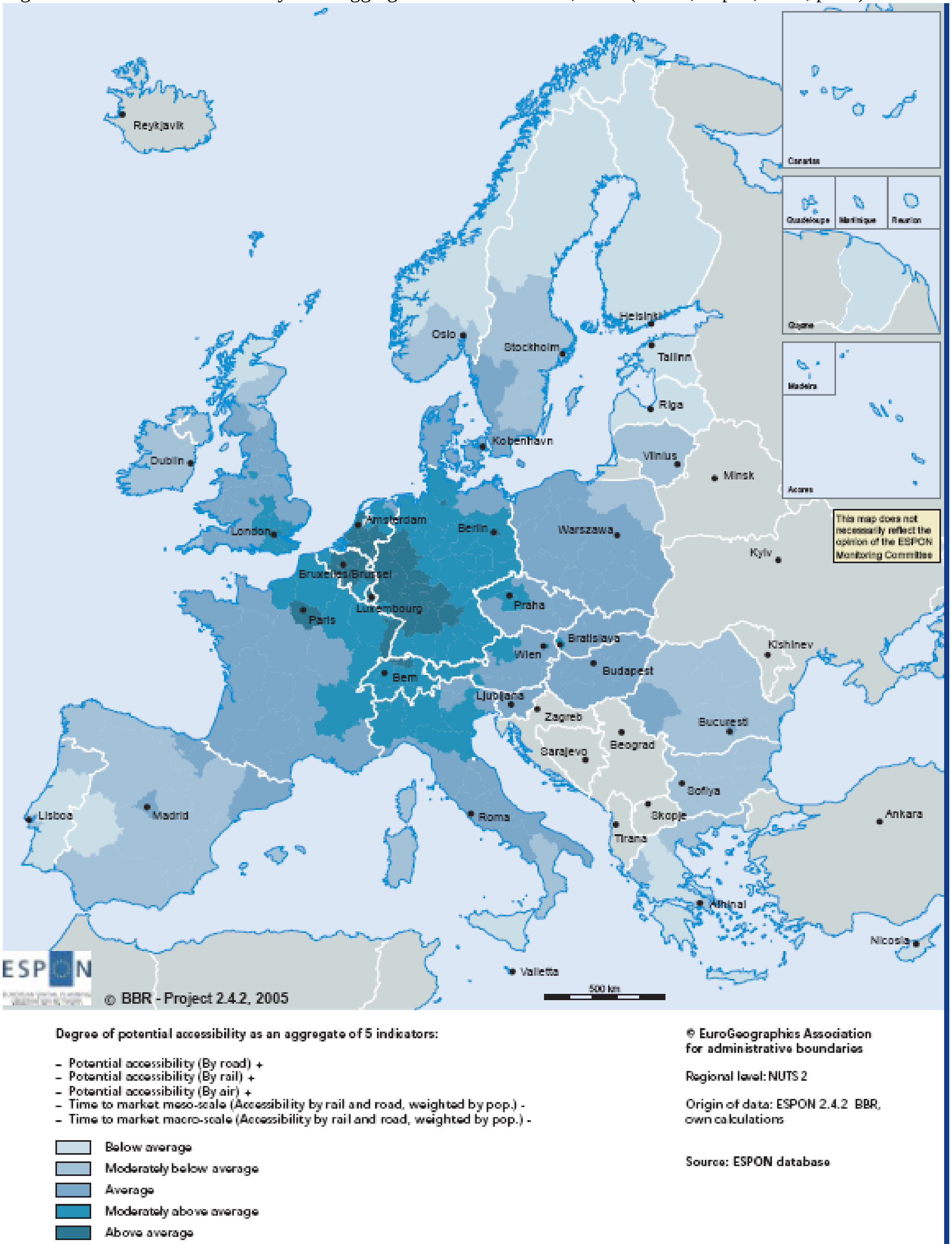


Figure 17 – Potential multimodal accessibility, 2001 (source, Espon, 2004, p. 13)

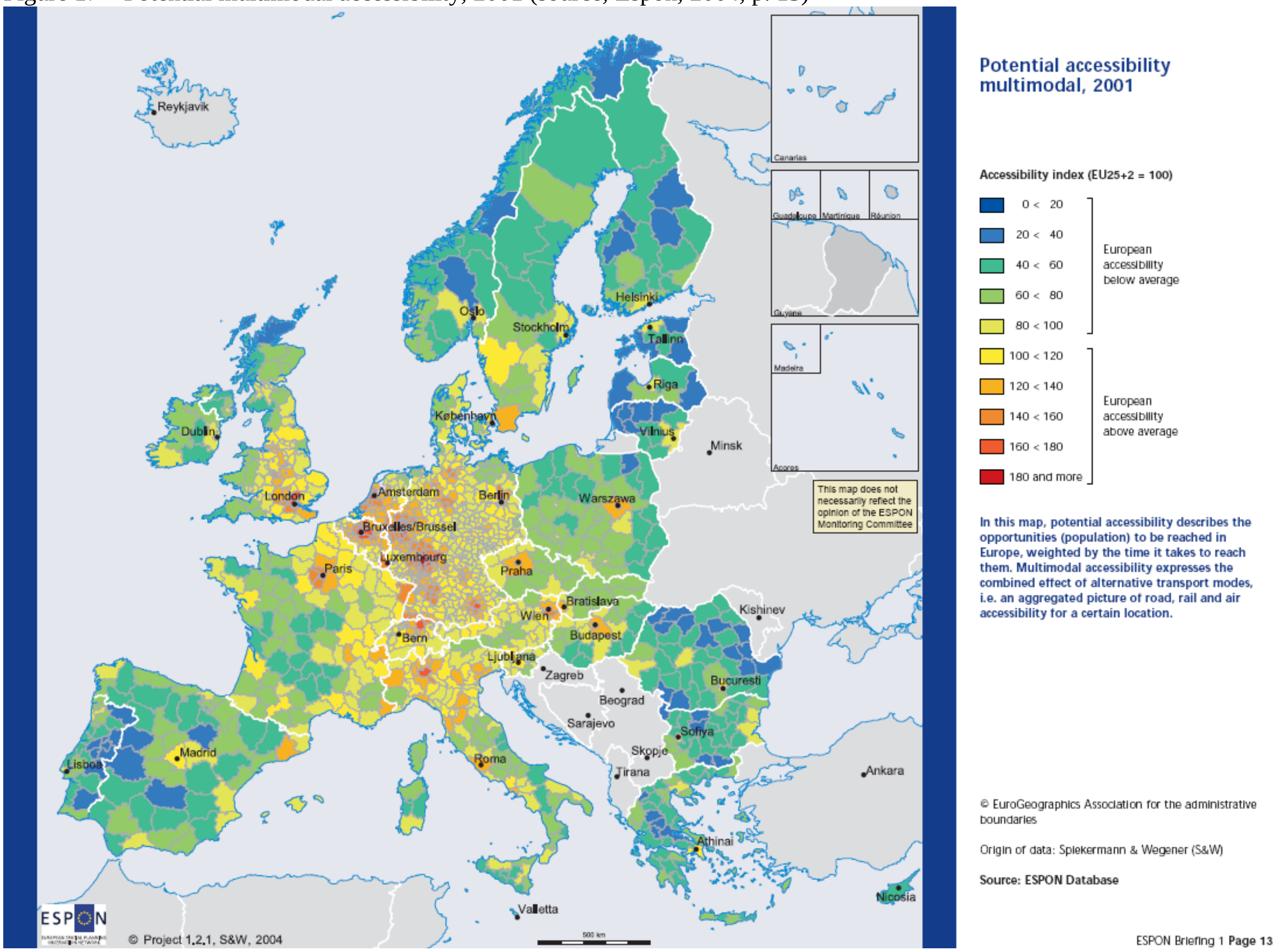


Figure 18 – Accessibility to transport terminals, 2001 (source, Espon, 2006c, p. 67)

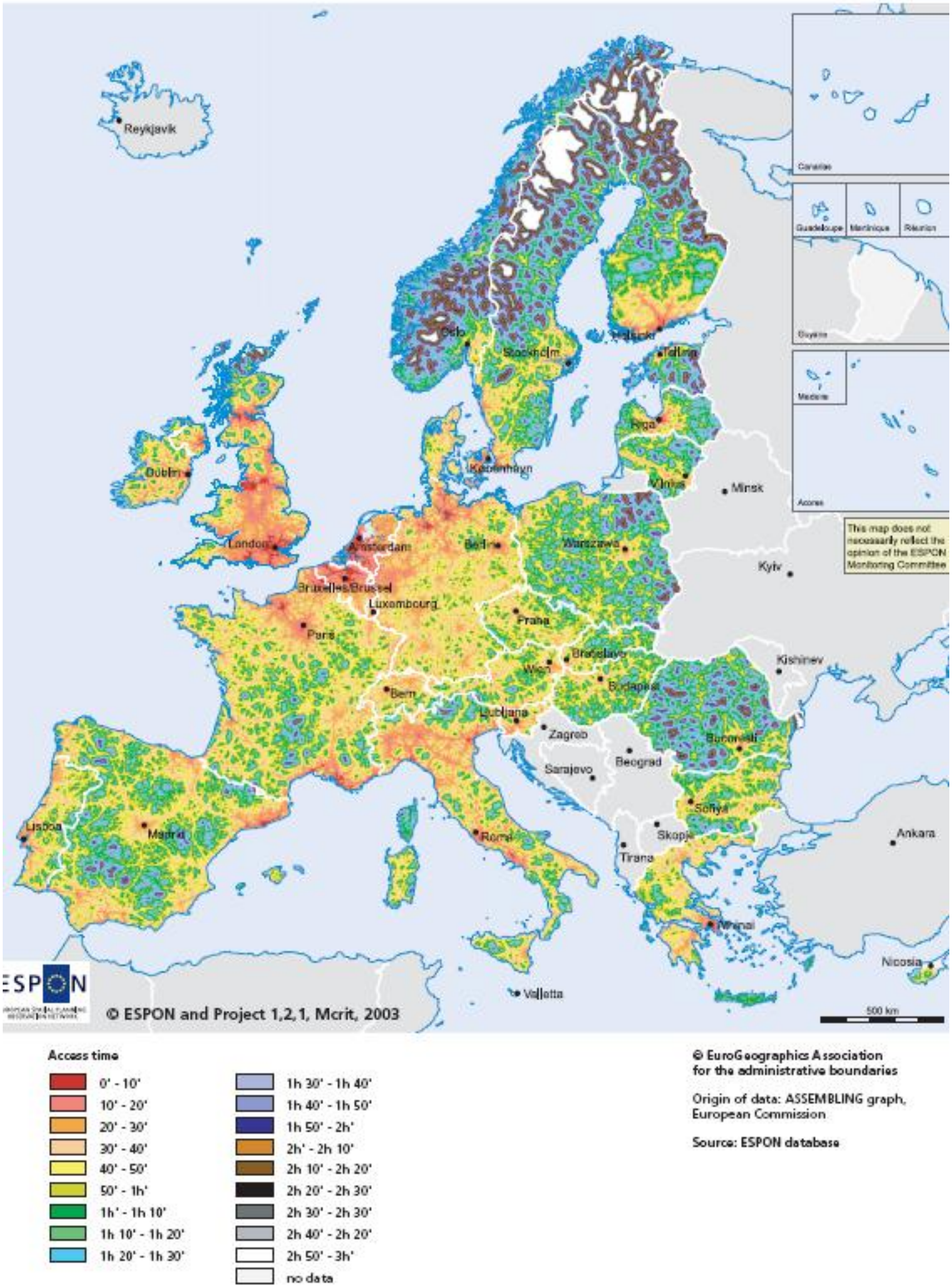


Figure 19 – Mulitmodal accessibility of Funcional Urban Areas, 2001 (source, Espon, 2003, p. 20)

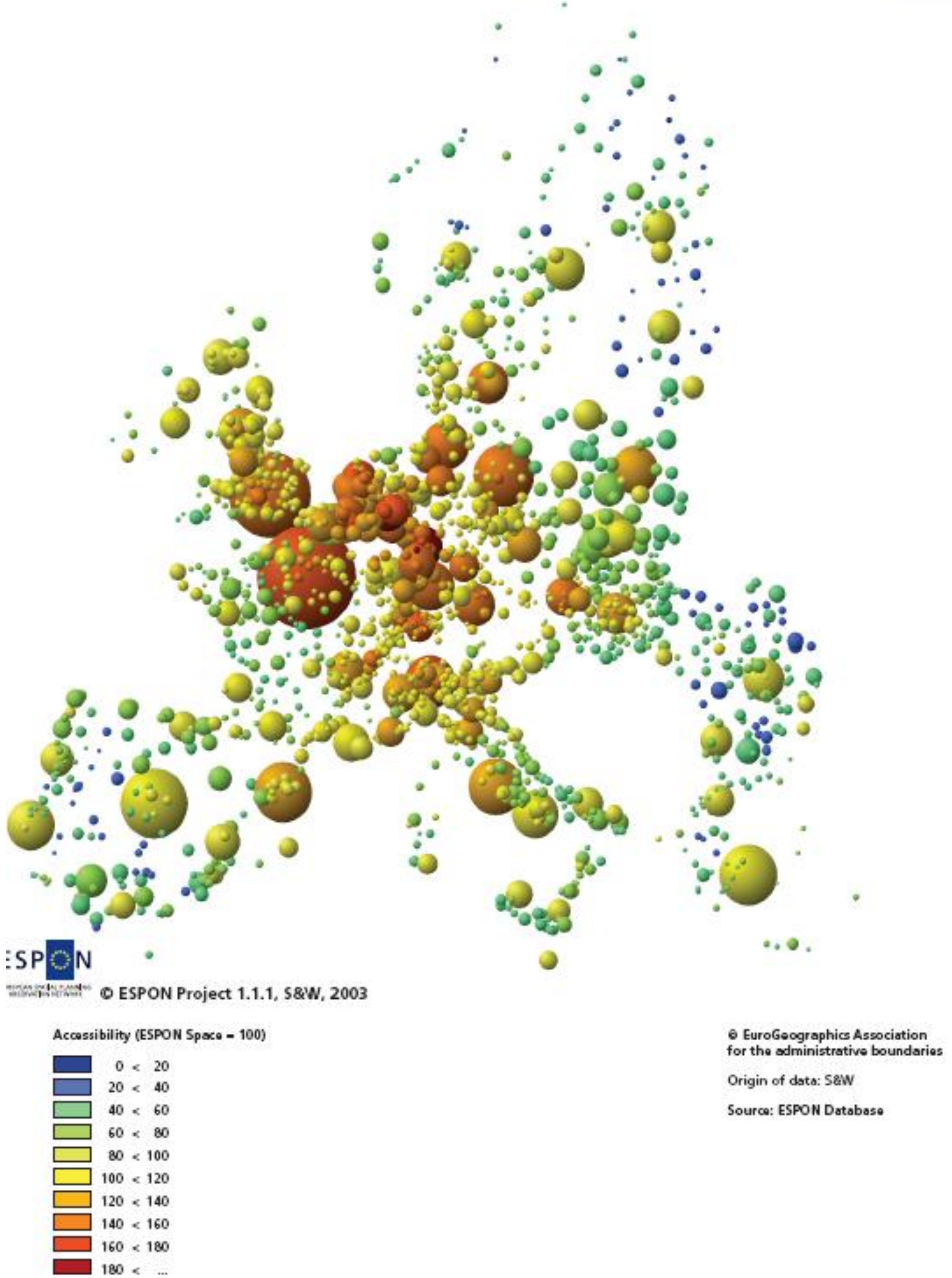


Figure 20 – Potential accessibility by air, 2001 (source, Espon, 2006, p. 17)

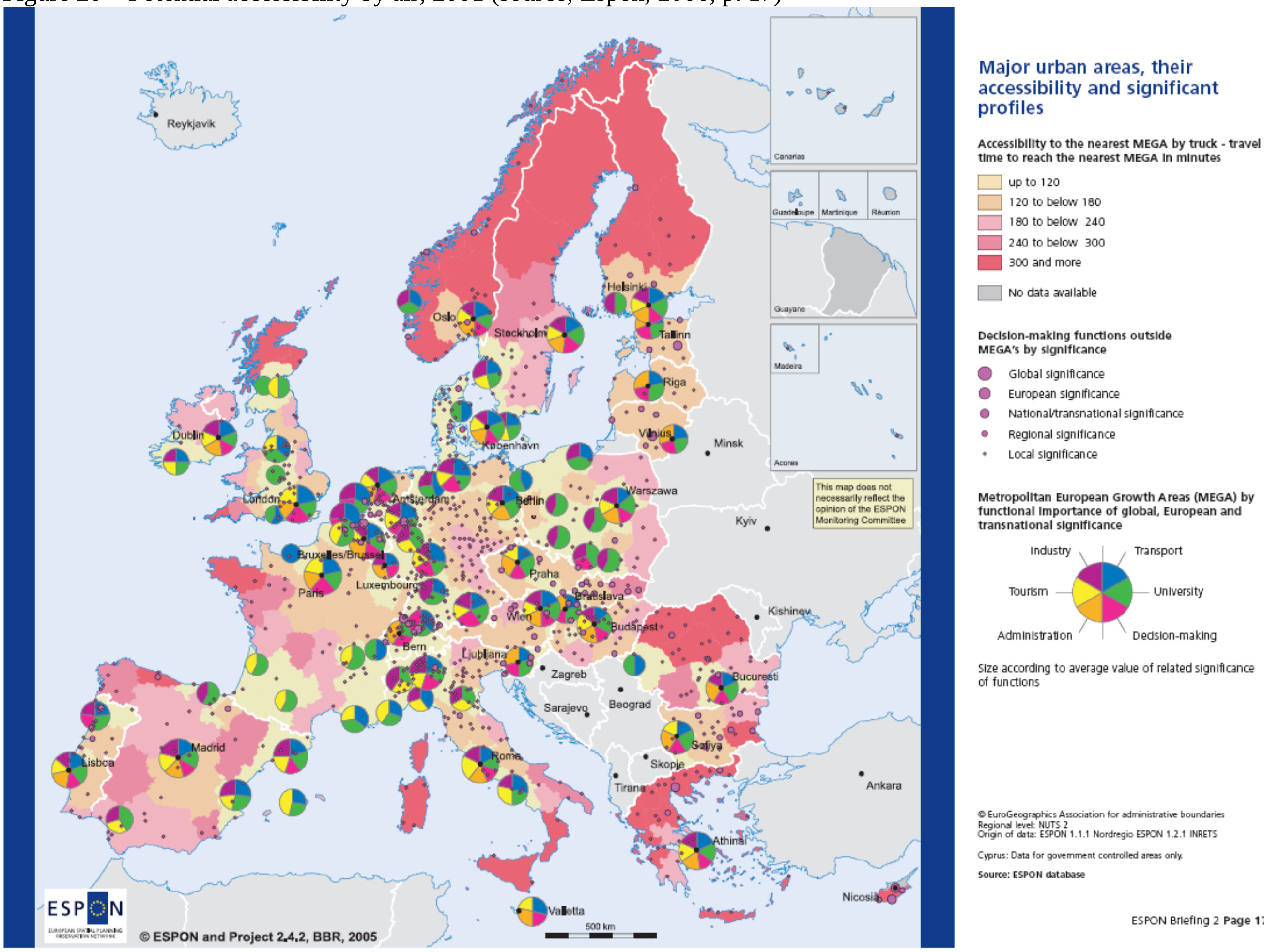


Figure 21 – Potential Integration Zone, their accessibility and profiles, 2005 (source, Espon, 2006, p. 7)

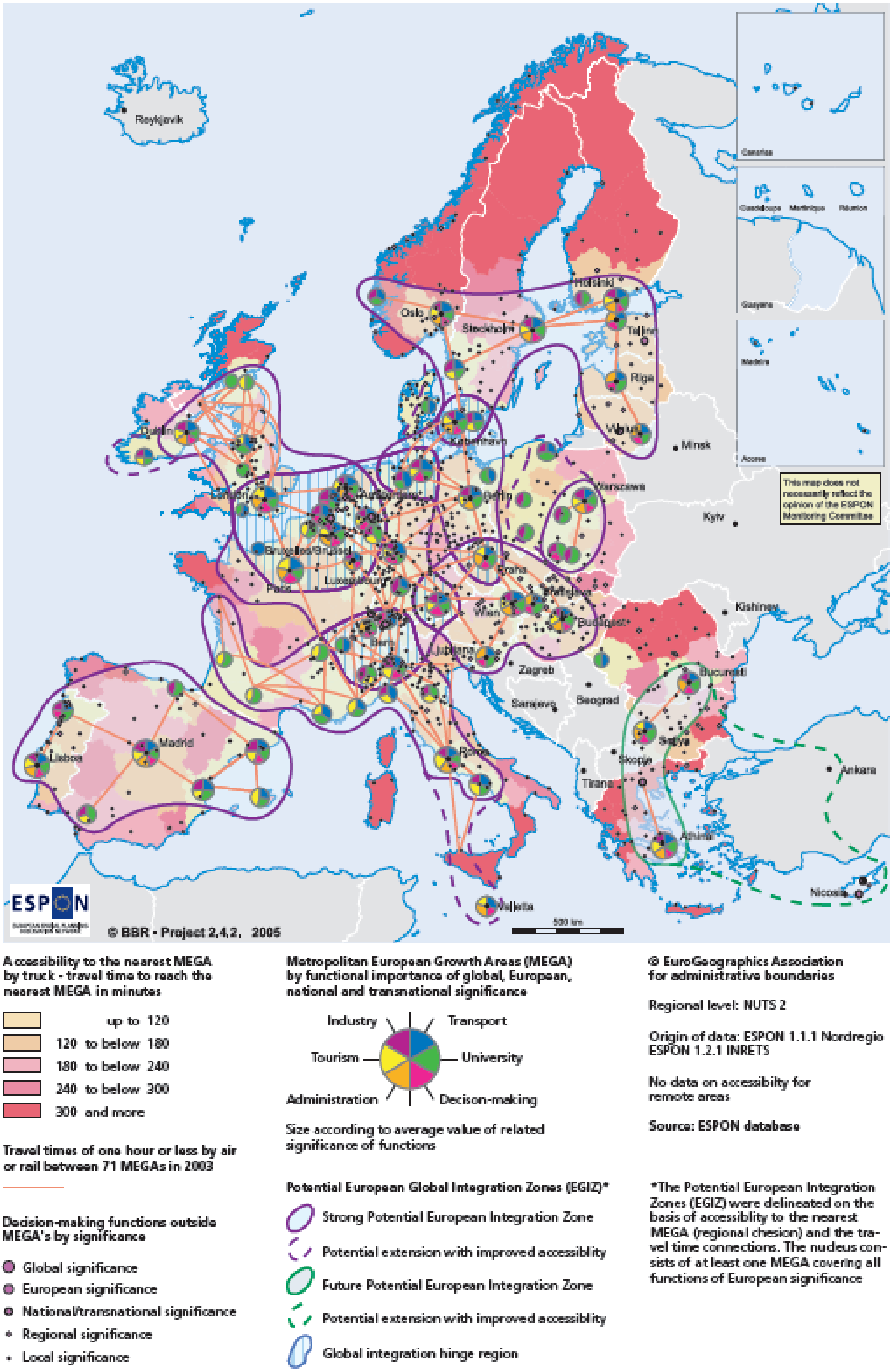


Figure 22 – Scenario for change in transportation flows, 2000-2020 (source, Espon, 2005, p. 239)

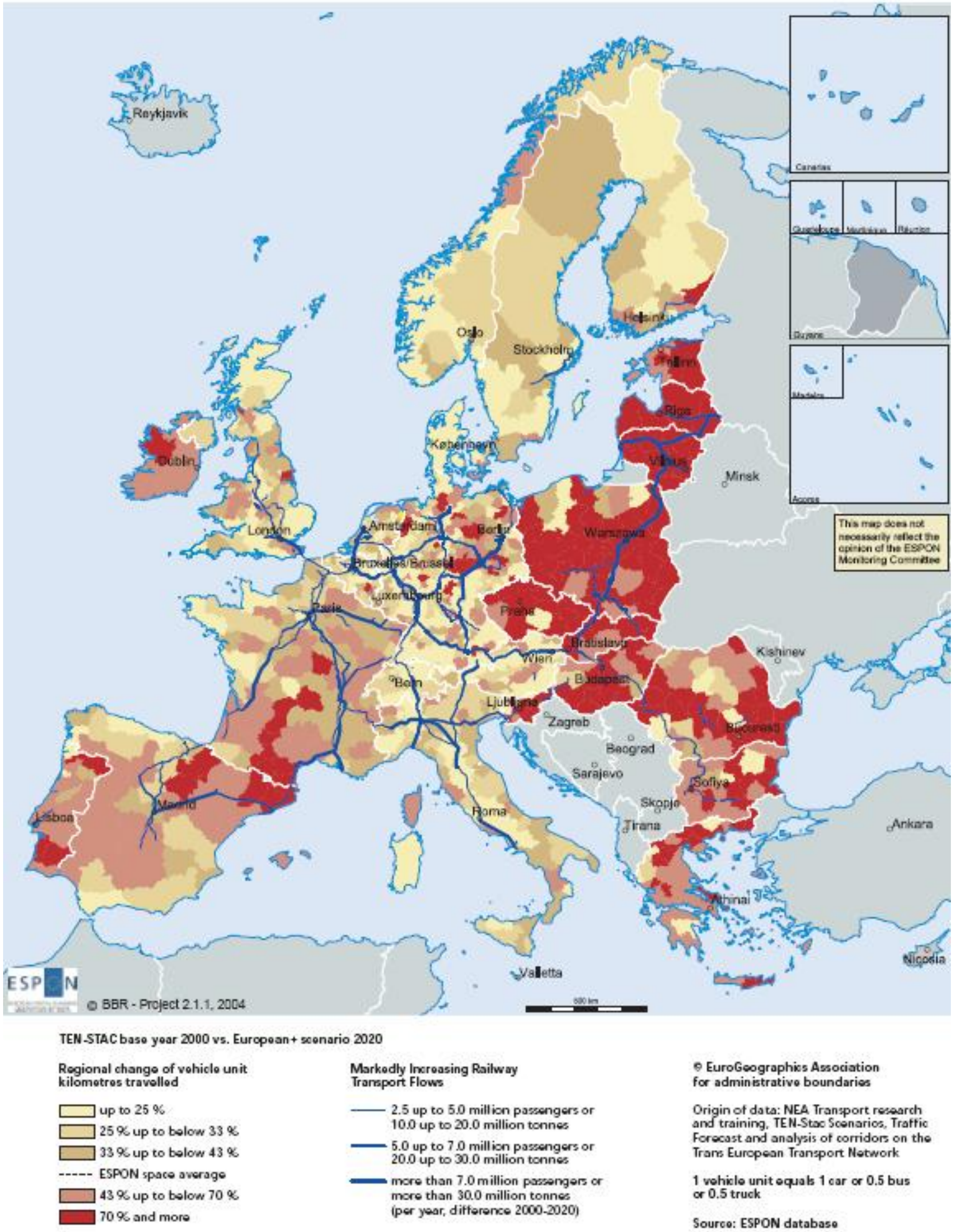


Figure 23 – Change in GDP per capita when implementing TEN\TINA and higher transport costs, 2001-2021 (source, Espon, 2004, p. 15)

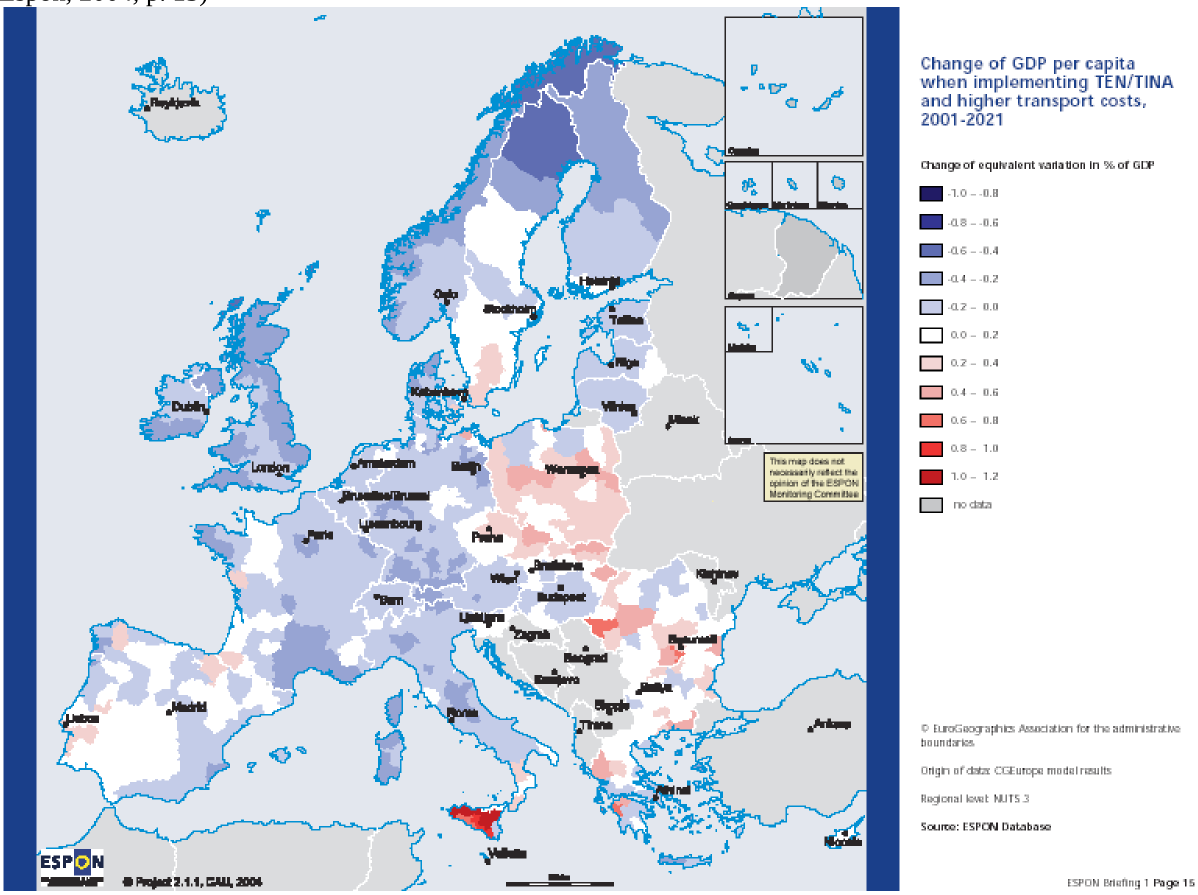


Figure 24 – Estimation of changes in transport on main corridors, 2000-2020 (source, Espon, 2004, p. 15)

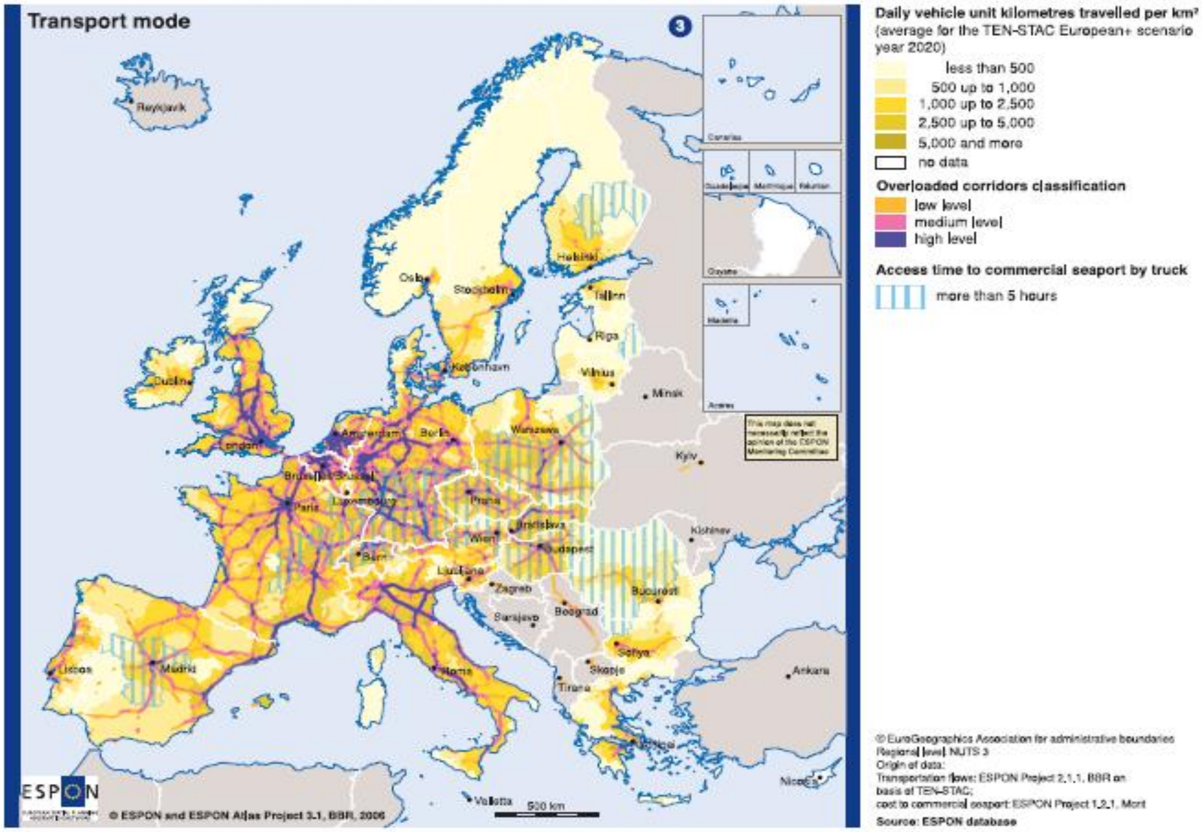


Figure 25 – Potential Integration Zone, their accessibility and profiles, 2005 (source, Espon, 2006d, p. 37)

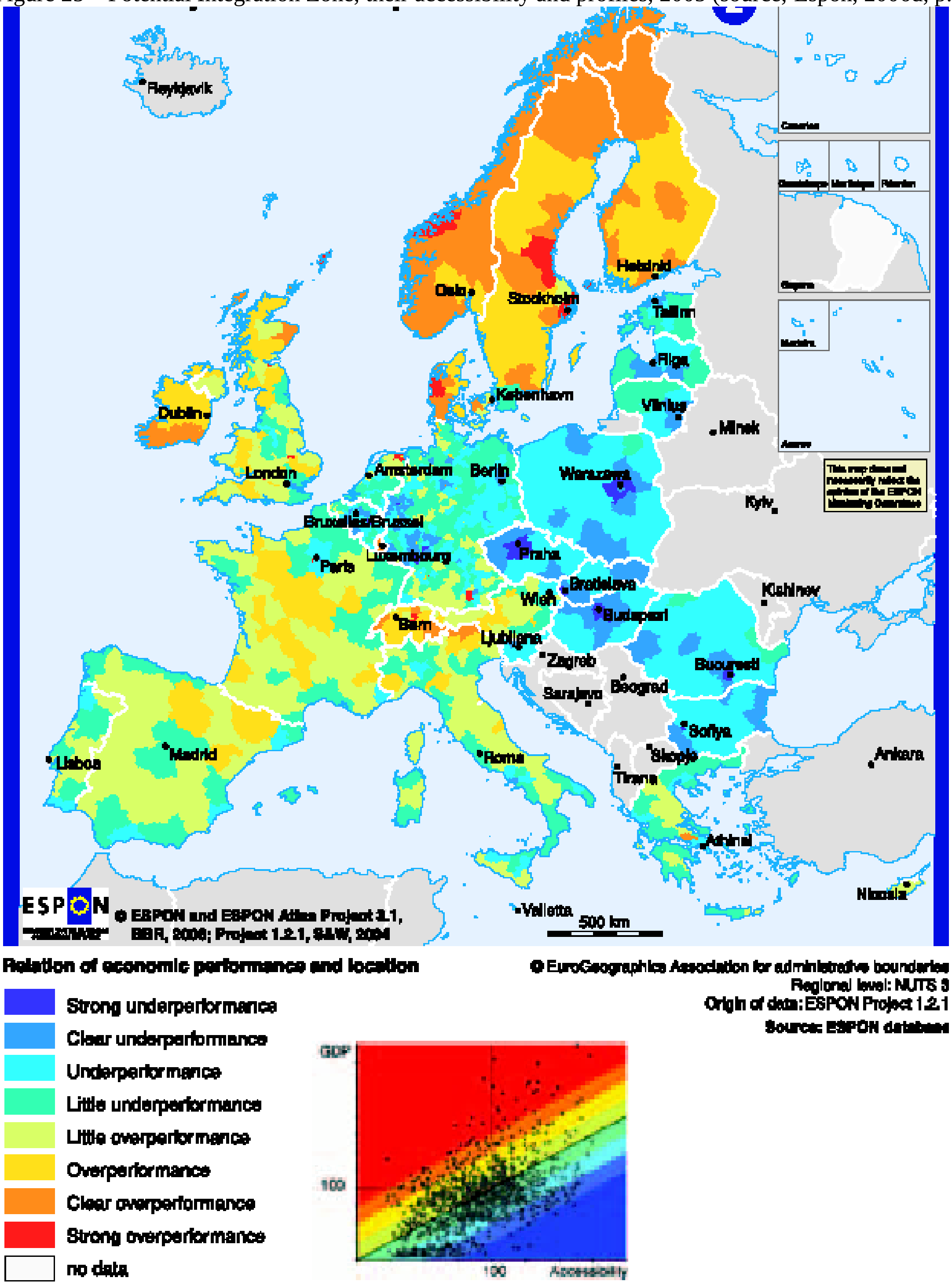


Figure 26 (a) *Trends in transport energy consumtion* and Figure 26 (b) *Modal split in 1995 and 1999*

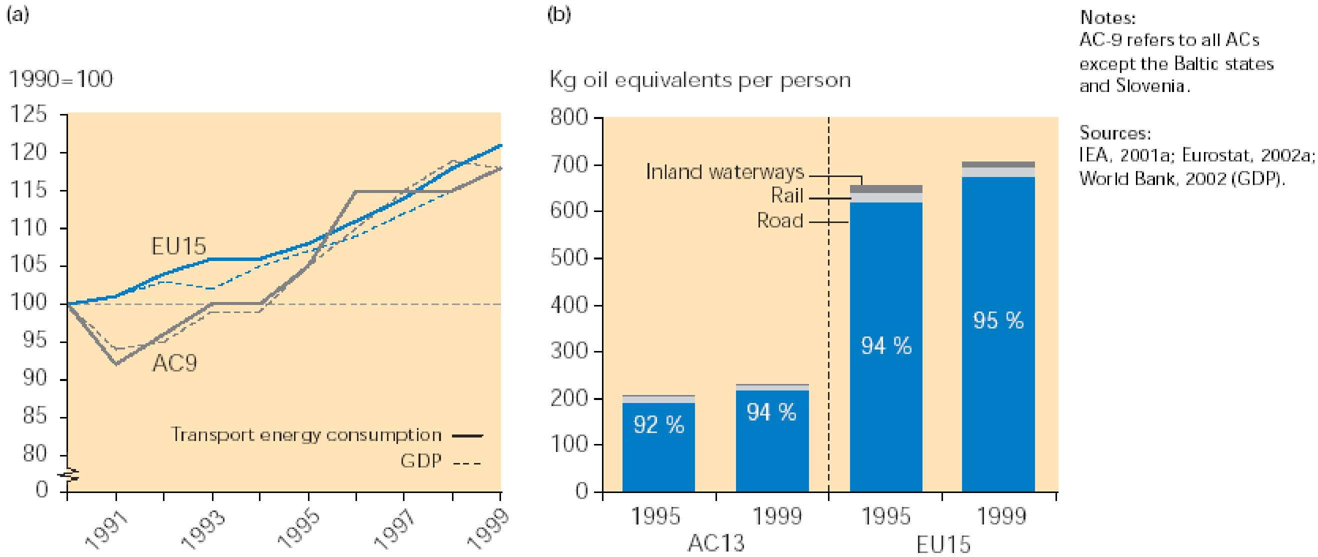


Figure 27 - Greenhouse gas emissions rise as transport volume increases (source, European Environment Agency, 2008, 17)

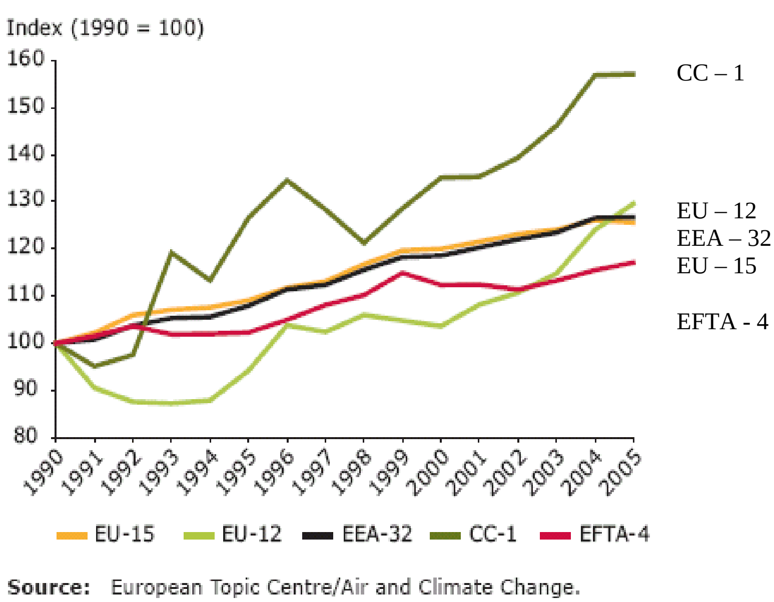
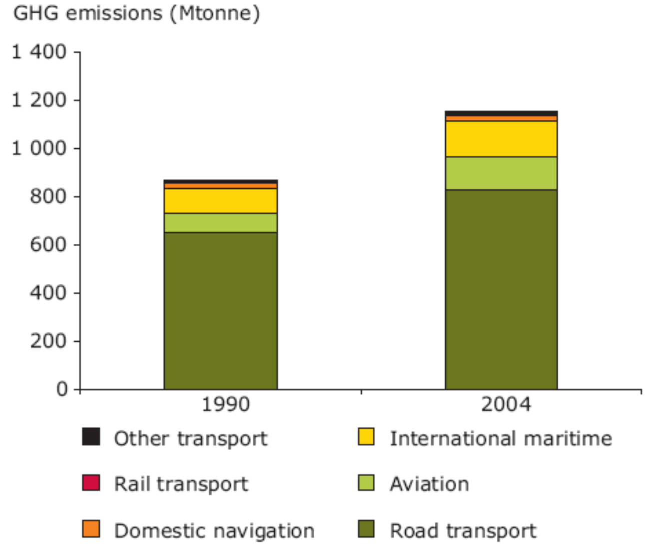


Figure 28 - Emissions per Mode of Transport 1999, 2004



Source: EEA, see also the metadata section.

Figure 29 - Average carbon dioxide emissions per km from new cars

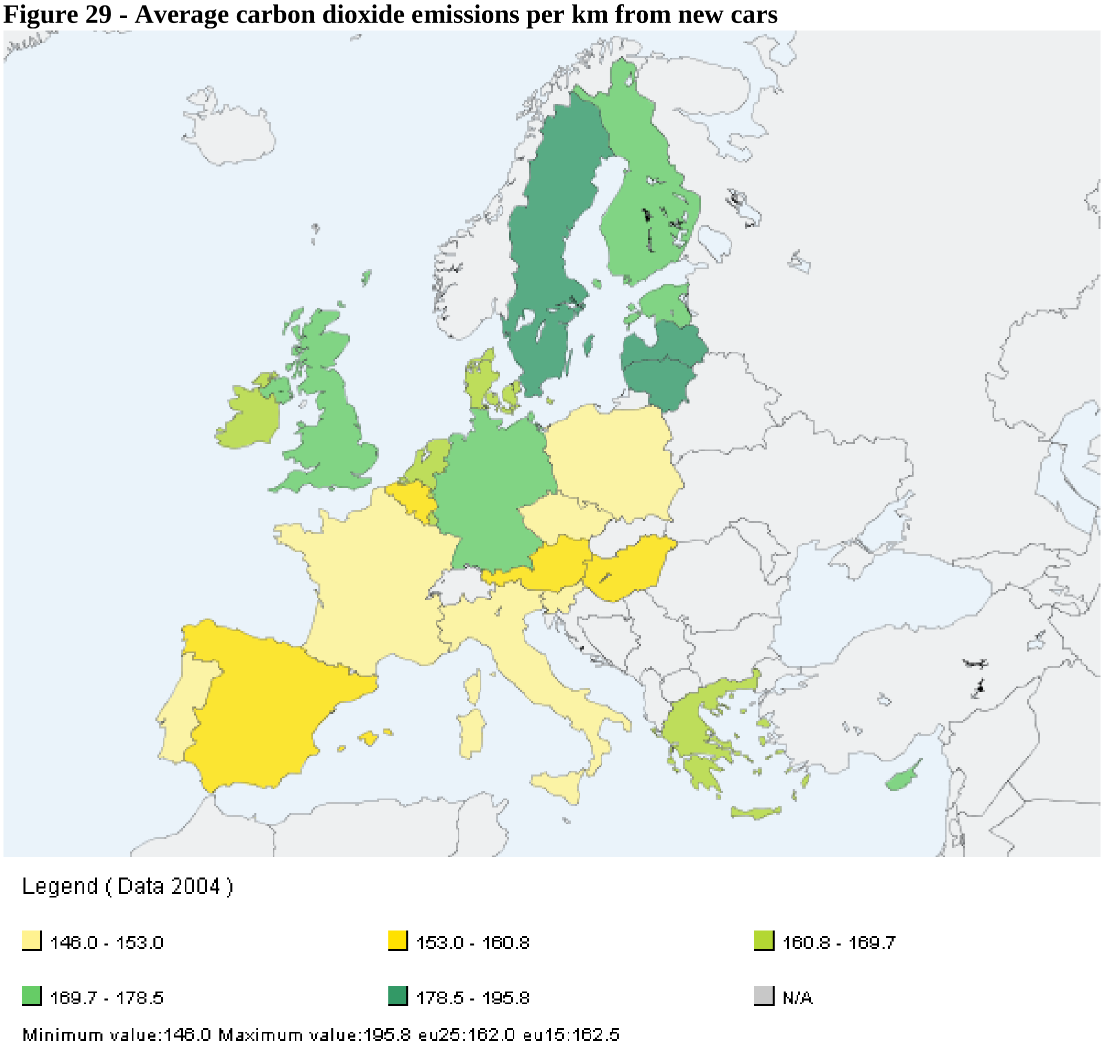


Table 7 - Car Ownership 1995, 2005 (Unit: Cars per 1 000 inhabitants)

	1995	*2005*	*Increase %*
EU15	**430**	**495**	**15,10%**
Belgium	422	467	10,70%
Denmark	321	354	10,30%
Germany	495	546	10,30%
Ireland	274	385	40,50%
Greece	207	348	68,10%
Spain	362	454	25,40%
France	434	491	13,10%
Italy	529	581	9,80%
Luxembourg	568	659	16,00%
Netherlands	366	429	17,20%
Austria	452	501	10,80%
Portugal	374	572	52,90%
Finland	372	448	20,40%
Sweden	411	456	10,90%
U.K.	374	463	23,80%
EU10	**218**	**320**	**47,10%**
Czech Rep.	295	373	26,40%
Estonia	267	350	31,10%
Cyprus	338	448	32,50%
Latria	134	297	121,60%
Lithuania	198	384	93,90%
Hungary	217	280	29,00%
Malta	488	525	7,60%
Poland	195	314	61,00%
Slovenia	357	456	27,70%
Slovakia	189	222	17,50%
EU25	**394**	**463**	**17,50%**

Table 8 Freight transport volume and indices by country (source: EEA, 2008, p. 41)

	2005 (Unit: 10 million tonne km)	*1995 (1990=100)*	*2000 (1990=100)*	*2005 (1990=100)*
EU15	**1,875.25**	**116**	**136**	**151**
Austria	58.2	154	199	214
Belgium	60.54	114	128	117
Cyprus	1.39	107	122	138
Denmark	25.28	122	131	127
Finland	41.64	97	122	120
France	254.89	109	125	119
Germany	469.62	123	140	155
Greece	24.02	116	154	206
Ireland	18.21	107	223	318
Italy	234.62	122	137	155
Luxembourg	9.54	151	204	225
Netherlands	138.21	110	131	144
Portugal	45.3	154	215	336
Spain	244.87	114	163	248
Sweden	60.25	112	122	132
U.K.	190.06	107	113	116
EU10	**378.15**	**92**	**98**	**125**
Czech Rep.	58.38	114	115	123
Estonia	16.46	47	112	143
Hungary	36.35	73	86	112
Latvia	28.17	45	70	109
Lithuania	28.37	46	62	106
Malta	0.5	100	100	100
Poland	162.13	98	104	132
Slovakia	32.12	165	107	127
Slovenia	14.28	96	104	157
EU25	**2,253.40**	**111**	**128**	**146**

Data include freight moved by road, rail and inland motorways. Source: Eurostat, 2007

Table 9 Total passenger transport demand in EEA member countries (1990–2005)

geo\time	*2004*	*1995*	*2000*	*2004*
EU15*	**5,560.60**	**114**	**129**	**137**
Austria	123.5	114	130	139
Belgium	142	110	128	124
Denmark	73.3	106	113	117
Finland	83	103	110	122
France	972.1	108	124	131
Germany	1,180.20	121	129	140
Greece	100.5	118	153	178
Ireland	67.7	126	191	306
Italy	904.7	115	135	134
Netherlands	243.7	109	123	126
Portugal	97.6	129	168	194
Spain	492.8	136	171	199
Sweden	126.5	101	109	115
U.K.	953.00	109	116	123
EU10**	**471.4**	**101**	**117**	**125**
Czech Rep.	94.3	101	120	125
Hungary	79.2	92	99	100
Poland	235.9	104	125	140
Slovakia	35.3	104	110	110
Slovenia	26.70	100	118	125
EU25	**6,032.00**	**113**	**128**	**136**

*EU15 does not include Lichtenstein
**EU10: because of lack of data it includes only: Czech Republic, Hungary, Poland, Slovakia, Slovenia
Year 2005 only include 'Rail', 'Bus' and 'Car' passenger transport.; Source: EEA, 2007. TERM fact sheet 12a (based on Eurostat, 2008).

Table 10 - Number of killed people in road accidents

geo\time	1995 N°	2000 N°	2006 N°	2000 (1995=100)	2006 (1995=100)
EU15	**46,098**	**41,009**	**29,516**	**89**	**64**
Belgium	1,449	1,470	1,069	101	74
Denmark	582	498	306	86	53
Germany	9,454	7,503	5,091	79	54
Ireland	437	418	368	96	84
Greece	2,412	2,037	1,657	84	69
Spain	5,749	5,777	4,104	100	71
France	8,892	8,079	4,709	91	53
Italy	7,020	6,649	5,669	95	81
Luxembourg	70	76	36	109	51
Netherlands	1,334	1,082	730	81	55
Austria	1,210	976	730	81	60
Portugal	2,711	1,877	969	69	36
Finland	441	396	336	90	76
Sweden	572	591	445	103	78
U.K.	3,765	3,580	3,297	95	88
EU10	**12,899**	**11,480**	**9,918**	**89**	**77**
Czech Rep.	1,588	1,486	1,063	94	67
Estonia	332	204	204	61	61
Cyprus	118	111	86	94	73
Latvia	611	588	407	96	67
Lithuania	672	641	759	95	113
Hungary	1,589	1,200	1,305	76	82
Malta	14	15	10	107	71
Poland	6,900	6,294	5,243	91	76
Slovenia	415	313	262	75	63
Slovakia	660	628	579	95	88
EU25	**58,997**	**52,489**	**39,434**	**89**	**67**

Eurostat: Fatalities caused by road accidents include drivers and passengers of motorized vehicles and pedal cycles as well as pedestrians, killed within 30 days from the day of the accident. For Member States not using this definition, corrective factors were applied.

Table 11 - Emissions of particulate matter from transport; Road Transport -1 000 tonnes. (1993=100)

geo\time	*2004*	*1993*	*2000*	*2004*
EU15	**3,853.81**	**100**	**76**	**62**
Belgium	128.52	100	87	76
Denmark	58.57	100	76	62
Germany	693.74	100	80	59
Ireland	43.9	100	111	99
Greece	105.32	100	95	84
Spain	530.17	100	97	94
France	594.26	100	65	53
Italy	600.14	100	69	60
Luxembourg	8.50	100	72	75
Netherlands	146.69	100	73	62
Austria	123.76	100	104	122
Portugal	99.98	100	116	107
Finland	65.37	100	77	50
Sweden	87	100	72	57
U.K.	567.89	100	68	50
EU10	**577.18**	**100**	**85**	**76**
Czech Rep.	89.35	100	140	79
Estonia	12.01	100	117	76
Cyprus	8.80	100	114	65
Latvia	18.31	100	97	112
Lithuania	31.72	100	111	144
Hungary	108.63	100	115	122
Malta	2.95	100	102	97
Poland	237.02	100	57	57
Slovenia	32.28	100	94	86
Slovakia	36.11	100	92	101
EU25	**4,431**	**100**	**77**	**64**

Eurostat: This indicator is defined as the aggregated particulate-forming potential of emissions of particulate matter (PM10), nitrogen oxides, sulphur dioxide and ammonia from transport.

Table 12 - Emissions of ozone precursors from transport. 1000 tonnes of ozone-forming potential (1994=100)

geo\time	*2004*	*1995*	*2000*	*2004*
EU15	**7,626.53**	**95**	**70**	**52**
Belgium	233.74	93	77	62
Denmark	134.72	98	71	57
Germany	1,249.07	96	70	50
Ireland	93.58	100	89	67
Greece	323.39	100	97	73
Spain	987.49	94	83	71
France	1,219.12	92	62	45
Italy	1,347.12	98	67	48
Luxembourg	14.04	104	73	58
Netherlands	272.81	94	74	60
Austria	197.87	96	90	97
Portugal	213.71	98	93	80
Finland	141.49	97	77	53
Sweden	175.63	95	67	50
U.K.	1,022.75	94	61	40
EU10	**1,188.36**	**90**	**71**	**63**
Czech Rep.	181.63	97	93	58
Estonia	25.92	85	73	56
Cyprus	20.60	100	100	67
Latvia	36.54	92	97	99
Lithuania	56.91	116	99	80
Hungary	230.32	102	105	105
Malta	4.63	100	100	91
Poland	493.48	80	51	50
Slovenia	57.35	103	83	69
Slovakia	80.98	102	82	85
EU25	**8,814.90**	**95**	**70**	**53**

Eurostat. This indicator is defined as the aggregated ozone-forming potential of emissions of nitrogen oxides, volatile organic compounds, carbon monoxide and methane from transport.

Appendix B. Discussion of the accessibility indices

Modal accessibility. The simplest way to measure accessibility is to measure the cost and time af accessing a location or an area by a certain mode, for instance:

- Road accessibility describes the potential accessibility of an area only considering road transport.
- Rail accessibility describes the potential accessibility of an area only considering rail transport.
- Air accessibility describes the potential accessibility of an area only considering air transport.
- Time to market meso-scale: it is based on the accessibility at the meso level by rail and road, weighted by population.
- Time to market macro-scale: it is based on the accessibility at the macro level by rail and road, weighted by population.

Multimodal accessibility. It is calculated as the combined effect of alternative transport modes, i.e. an aggregated picture of road, rail and air accessibility (including waterways to some extent) for a certain location.

Hub (airport or seaport) accessibility: The connectivity indicator (ICON) measures the minimum access time needed, by car or truck, to travel from one region to the closest transportation hub (e.g. the closest motorway entrance, railway station, commercial port, commercial airport etc.). This indicator also takes into account the utility of the hub, in terms of the services it provides.
Measuring the connectivity of a region to the nearest commercial seaport provides key information on the connections between ports and their hinterlands. Strong port-hinterland connections have obvious potentials for economic development. Commercial seaports (for roll-on-roll-off and containers traffic) of a capacity between 0.5 to 100 million tons per year are considered and their hinterland is demarcated by using accessibility by car, up to a journey time of 3 hours. In addition, the capacity of the port, which gives an indication of the level of maritime services it can provide, are integrated into the connectivity calculation (i.e. the less services, the lower the connectivity). The combination of these two aspects implies that areas with good access to small ports are perceived as having a lower connectivity.

Network accessibility. The European space can be conceived as a network. A location has a specific place and role in a network . Network analysis models can be used to calculate indicators based on graph theory. The indicators can refer to nodes or links of the network, such as accessibility or flows. The ESPON Project calculated a great variety of accessibility measures based on network analysis models such as:

- an ICON index measuring the time or cost to reach the nearest node of a transport network, such as motorway exits, railway stations, logistics terminals, airports or seaports providing a minimum level of service, such as travel speed or number of trains.
- Accessibility indices measureìing the average transport time or cost of goods transport to all regions in Europe taking account of the maximum driving hours of lorry drivers.
- Daily accessibility indices measuring the number of customers or suppliers that can be visited in a round trip during a business day.
- Potential accessibility indices applying an implicit transport model to calculate the number of destination in all regions weighted by a negative function of travel time or cost. The multimodal potential accessibility is calculated by an implicit modal split model as the logsum of modal impedances.

City accessibility. Cities as nodes in networks and centres of regions are an important objects of investigation. Achieving balanced polycentric urban systems is one of the major objectives of the European Spatial Development Perspective (ESDP), which as well is mentioned in the Community Strategic Guidelines on cohesion adopted by the Council in October 2006.The ESPON (European Spatial Planning Observation Network) Project formulated a hierarchy of cities expressed by the classification into Functional Urban Areas (FUA) and Metropolitan European Growth Areas (MEGA).
An indicator of polycentricity was developed combining three dimensions: size, location and connectivity:

- The size indicator measures the distribution of population and GDP based on the notion that a flat rank-size distribution is more polycentric than an urban system dominated by one large city.
- The location indicator measures the spatial distribution of cities assuming that a uniform distribution of cities across a territory is better for a polycentric urban system than one where all cities are clustered in one part of the territory.
- The connectivity indicator measures the distribution of accessibility across cities assuming that an urban system with good connections between lower-level cities is more polycentric than one in which all connections are concentrated on the largest city.

In addition, a GIS-based method is developed to delimit the catchment area of Functional Urban Areas (FUA) as the sum of the areas of municipalities within 45 minute car travel time from the centre of the FUA called Potential Urban Strategic Horizons (PUSH). Based on the overlap of adjacent PUSH areas, Potential Polycentric Integration Areas (PIA) are identified based on the hypothesis that FUA which share a significant proportion of their commuter catchment area could solve planning and spatial development challenges through integrated polycentric development policies.

ICT accessibility. As the economy moves towards more and more intangible activities supported by the information society and the rapid development of telecommunication facilities, accessibility is no longer limited to physical mobility of goods and people. In the new context, even remote territories are connected in real time to a variety of information sources and flows, making innovative activities possible.