ET2050 Draft Final Report

Scientific Report

VOLUME 4

TRANSPORT TRENDS AND SCENARIOS

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February 28th 2014

ET2050

DRAFT FINAL REPORT

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1 BACKGROUND TO THE COMMON TRANSPORT POLICY

1.1 BACKGROUND

The *Common Transport Policy* (CTP) is an essential component of the EU policy since the Maastricht Treaty of 1992, when the concept of Trans-European transport Networks (TEN) was introduced for the first time, with a special emphasis on interconnection and interoperability of the diverse national networks. The main policy instruments of the CTP are the White Paper on Transport and the TEN-T programme. The *TEN-T programme* is intended to increase the co-ordination in the planning of infrastructure projects by the member states. Progress in the TEN-T implementation has been relatively slow due to the scale, complexity and cost of the proposed projects in the past. A new proposal of TEN-T guidelines was presented in October 2011, intended to focus the efforts of the program on key network elements of European relevance. The *White Paper on Transport* is the document of strategic reflection providing the conceptual framework for the CTP, having had substantial influence on EU, national and regional policies since 1992 (e.g. liberalisation of transport markets and modal change from road to rail). The 2009 EC Communication on the Future of Transport[1] triggered the debate for the 2011 White Book revision, proposing that focus should now turn on improving efficiency of the transport system through co-modality, technology development, and prioritise infrastructure investment on links with highest returns. The new transport White Paper[2] was presented in late March 2011.

According to the 2011 Transport White Paper, one of the major challenges in the field of transport is to break the system's dependence on oil without sacrificing its efficiency and compromising mobility, in line with the flagship initiative "Resource efficient Europe" set up in the EU2020 Strategy[3] and the new Energy Efficiency Plan 2011[4]. Curbing mobility is not an option. The EU and Governments need to provide clarity on the future policy frameworks (relying to the greatest extent possible on market based mechanisms) for manufacturers and industry so that they are able to plan investments.

The concept of co-modality introduced by the White Paper back in 2006 implies that greater numbers of travellers are carried jointly to their destination by the most efficient (combination of) modes. Individual transport is preferably used for the final miles of the journey and performed with clean vehicles. In the intermediate distances, new technologies are less mature and modal choices are fewer than in the city. However, this is where EU action can have the most immediate impact. Better modal choices will result from greater integration of the modal networks: airports, ports, railway, metro and bus stations, should increasingly be linked and transformed into multi-modal connection platforms for passengers.

There is an objective of full operativity by 2030 of the EU-wide multi-modal TEN-T 'core network' presented by the TEN-T guidelines in October 2011. The core network is aimed at ensuring efficient multi-modal links between the EU capitals and other main cities, ports, airports and key land border crossing, as well as other main economic centres. It is to be focused on the completion of missing links – mainly cross-border sections and bottlenecks/bypasses – on the upgrading of existing infrastructure. Better rail/airport connections would be devised for long distance travel. Among other targets, the White Paper establishes the objective of having trippled the length of the existing high-speed rail network by 2030, and maintaining a dense railway network in all Member States. By 2050, a European high-speed rail network should be completed. The goal of these targets is to allow by 2050 a majority of medium-distance passenger transport going by rail, and by 2050, all core network airports becoming connected to the rail network, preferably high-speed. The quality, accessibility and reliability of transport services is to be increasingly important, requiring attractive frequencies, comfort, easy access, reliability of services, and inter-modal integration.

Other key elements in relation to passenger transport are according to the transport White Paper the improving the energy efficiency performance of vehicles across all modes and using transport and infrastructure more efficiently through use of improved traffic management and information systems. The gradual phasing out of 'conventionally-fuelled' vehicles is a major contribution to significant

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1 COM(2009)279
2 COM(2011)144
3 COM(2010)2020.
4 COM(2011)109.

reduction of oil dependence, greenhouse gas emissions and local air and noise pollution. The use of smaller, lighter and more specialised road passenger vehicles must be encouraged. By 2030, the use of 'conventionally-fuelled' cars in urban transport should be halved, and by almost eliminated in cities by 2050. Low-carbon sustainable fuels in aviation would have to reach 40% by 2050; at the same time it should be reduced EU CO2 emissions from maritime bunker fuels by 40% (if feasible 50%). Road pricing and the removal of distortions in taxation can also assist in encouraging the use of public transport and the gradual introduction of alternative propulsion.

According to the CTP Evaluation report[5] (EC 2009), substantial progress has been made in the last 20 years towards meeting the objectives of the CTP of creation of a competitive internal market for transport services, by liberalising the transport market. Market opening has been very successful in the air sector and there would be signs that market opening in the rail sector is starting to bring success (but it is too early to assess the full results of this as still some nations hamper the access to their national network). In all sectors, further reforms are required in order to fully implement liberalisation. Whilst there has been progress towards the objective of introducing a system of transport infrastructure pricing and taxation which better reflects marginal costs, and most of the specific measures proposed in the 2001 White Paper have been implemented, overall progress towards meeting this objective has been limited, largely because most decisions about pricing and taxation are still taken by Member States, and in some cases face strong public opposition.

In order to ensure that the limited TEN-T funds are used most efficiently to address infrastructure bottlenecks, decision-making about the allocation of funding should tend to be, according to the same source, increasingly based on cost benefit analysis of different schemes, using consistent criteria and parameters, not favouring specific modes of transport. The different environmental and other social costs of different modes should be taken into account in this cost benefit analysis. In fact, the EC provides unified criteria for project appraisals, as embodied in the regulations of the Structural Funds, the Cohesion Fund, and Instrument for Pre-Accession Assistance, through its Cost-Benefit guidelines[6]. However many methodological issues remain unsolved (e.g. appraisal of the so called intangible effects, both positive and negative) and even worse, the very paradigms of e.g. time savings in cost-benefit analysis are still being debated intensely.

But emphases on different type of policy aims and instruments may change over time, also in the CTP. The Commission has identified seven transport policy areas in which specific policy measures could have a key role in stimulating the expected shift of the transport system to another paradigm. These policy areas are: pricing, taxation, research and innovation, efficiency standards and flanking measures, internal market, infrastructure and transport planning. Only a long-term and overarching strategy established for all identified policy areas has a reasonable chance of achieving the EU objectives. It should combine policy initiatives targeted at enhancing the efficiency of the system through better organisation, infrastructure and pricing with those that are more focused on technology development and deployment. It should also provide a framework for action at all levels of government.

The table below gives a mapping between the drivers identified and the policy areas. It also provides in the second column an indication of possible policy measures in each of the specified policy areas that would be referred to in the White Paper on Transport Policy as component of the overall strategy.

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[5] *Evaluation study analysing the performance of the Common Transport Policy in reaching the objectives laid down in the 2001 transport White Paper and in its 2006 mid-term review*, EC2009 http://ec.europa.eu/transport/strategies/studies/doc/future_of_transport/20090908_common_transport_policy_final_report.pdf

[6] *Guide to Cost-Benefit Analysis of Investment Projects,* DG Regio 2008

Table 1: Mapping drivers, policy areas, possible policy measures envisaged in the White Paper and modelling hypothesis

Policy Areas	Possible policy measures envisaged in the White Paper	Modelling hypothesis
Driver 1: Cheap for users, expensive to society: prices do not reflect true costs		
Pricing	Strategy for the gradual phasing in of a coherent internalisation system for local externalities in all transport modes on the whole network	Internalisation of local externalities for all modes of transport according to the values specified in the handbook on internalisation[75]
Taxation	Establish a link between vehicle fuel taxation and the environmental performance and full internalisation of the cost of GHG emissions for all modes of transport in a co-ordinated and stepwise manner Establish a link between vehicle taxation and the environmental performance Assess the possibility of introducing VAT on all international passenger transport services inside the EU Promote a revision of company car taxation to eliminate distortions or, as a second best, to provide incentives for clean vehicles.	Elimination of distortions in energy taxation by establishing an energy and CO_2 component in excise duties and abolition of exemptions[76,77] Introduce a CO_2-related element in the registration and annual circulation taxes[78] Introduction of VAT on all international passenger transport services inside the EU[79] Elimination of favourable taxation regime for company cars[80]
Driver 2: Innovation: transport technologies do not achieve low carbon mobility		
Research and Innovation	Conduct a screening to identify key innovative technologies, with a view to better target existing resources, define a governance structure for organising their development and enhance coordination of European and national (private and public) efforts and funding Bring together all relevant actors within the transport system, to develop research and deployment agendas, to design standards and to build demonstration projects, including bilateral cooperation frameworks in research and innovation with the main transport partners	Improvement of the cost of batteries and of other critical technological components Deployment of supporting infrastructure (charging points, refuelling stations)
Efficiency standards and flanking measures	Use standards for controlling energy efficiency as well as air pollution for all vehicles which have proven to be an effective way of providing the industry with certainty concerning long-term objectives Encourage deployment of clean energy carriers by establishing the necessary supporting infrastructures Improve the effectiveness of fuel efficiency labelling, promote eco-driving and support eco-driving dissemination	Implementation of CO_2 standards for all vehicles (cars, vans, trucks, locomotives, vessels, barges, aircrafts)
Driver 3: Supply of transport services: not sufficiently efficient		
Internal market	Railways: develop corridors, strengthen the European Railway Agency and ensure convergence of technical standards, reinforce the network of rail regulators and further pursue the opening of markets (domestic passengers). Aviation: effective implementation of the Single European Sky project - from the designation of a network manager, via the integration of national air traffic control to the deployment of the next generation of air traffic management system (SESAR). Maritime transport: simplification of the formalities for ships travelling between EU ports; a single electronic environment for all port/maritime transport related information exchanges and management; and a review of restrictions on provision of port services. Road transport: phase out of restrictions in the internal market like *cabotage* and of non-harmonised enforcement of social legislation. Promote quality jobs and uniform working conditions	Increase in the efficiency of all transport modes as a result of the removal of regulatory, administrative and technical barriers Wide deployment of Intelligent Transport Systems
Infrastructure	Propose a core network consisting of nodes and links relying primarily on the efficient use of existing infrastructure via ITS/smart mobility solutions and aiming at bridging missing links, facilitating multimodality and creating links to third countries. Establish a firm long-term infrastructure plan for the completion of the core network together with EU Member States detailing the projects to be completed as well as the modalities.	Increase in the capacity and performance of the network resulting from the elimination of bottlenecks and addition of missing links
Driver 4: Transport planning: not sufficiently integrated from the first to the last mile		
Transport planning	Encourage the establishment of urban mobility plans and implementation of related measures to manage demand in non-collective motorised transport modes	Shadow carbon pricing[81] as a proxy for locally determined policies (pricing, support to public transport and non-motorised modes, integrated land planning)

Mapping drivers, policy areas, possible policy measures envisaged in the White Paper and modelling hypothesis (Impact Assessment report of 2011 transport White Paper)

1.2 TERRITORIAL DIMENSION OF TRANSPORT

A central element of the Community Strategic Guidelines on Cohesion 2007-2013[7] (2005) is the assumption that transport infrastructure and accessibility are necessary conditions for economic growth in the Union, having a direct impact on the attractiveness of regions for businesses and people.

[7] http://ec.europa.eu/regional_policy/sources/docoffic/2007/osc/index_en.htm

This is supported by the Reports on economic and social cohesion[8] (2007, 2010), which reiterate how improved accessibility tends to create new job opportunities for rural and urban areas, but warns that potentialities from improving accessibility depend on the previous competitiveness of the regions concerned, being some regions liable to lose out as they become more open to competition from elsewhere. The reports claim the importance of combining investment in transport infrastructure with support for businesses and human capital development to achieve sustainable economic and social development. The Territorial Agenda of the EU[9] (2007) claims the need to support to the extension of the TEN-T for economic development in all regions of the EU, especially in the EU12 countries, while the Green Paper on Territorial Cohesion[10] (2008) later puts the accent on regional and local accessibility as key elements for granting balanced access to services and European transport terminals and networks.

The two dominant themes of spatial planning in Europe, as reflected already in the *Europe 2000* study programme, are the urban and regional dichotomy, and the centre and periphery dichotomy. The "integration" between urban-rural, as well as between centre-periphery has always been the European narrative to overcome territorial unbalances. The necessary links to integrated urban and rural zones were included into the wider concept of "partnership", later on by the ESDP. On the other hand, solving "missing links" in the networks of transport and communication was an important issue in the definition of the Trans-European Transport Networks, and the creation of "integration zones", "polycentric and cross-border development areas", between central and more peripheral regions.

The European Spatial Development Perspective (ESDP) of 1999 (European Commission,1999) lists the trans-European transport networks as major policy field of importance for European spatial development, only second to EU economic policy, because of their effect on both the functioning of the Single Market and economic and social cohesion. In line with its spatial vision of polycentric and balanced system of metropolitan regions, city clusters and city networks, the ESDP called for improvement of the links between international/national and regional/local networks and strengthening secondary transport networks and their links with TENs, including efficient regional public transport systems, improvement of transport links of peripheral and ultra-peripheral regions, both within the EU and with their neighbouring third countries and promoting the interconnection of inter-modal junctions for freight transport, in particular on the European corridors.

Following the European Spatial Development Programme (ESDP), the Study Program on European Spatial Planning (SPESP), carried out a number of specific researches territorial structures and typologies, and the opposition between urban and rural areas. Urban-rural partnerships as defined by the ESDP required among others, a balanced settlement structure and improvement of accessibility (concerning land use and development of public transportation networks). Improved infrastructure and accessibility bring new kinds of rural-urban linkages.

The first Territorial Agenda of the European Union: Towards a More Competitive and Sustainable Europe of Diverse Regions of 2007 (European Commission, 2007) took up the vision of polycentric territorial development of the EU of the ESDP, highlighted the territorial dimension of cohesion and emphasised the importance of integrated and sustainable multi-model transport systems but failed to set priorities.

The new Territorial Agenda of the European Union 2020: Towards an Inclusive, Smart and Sustainable Europe of Diverse Regions of 2011 (European Commission, 2011d) puts spatial development into the framework of the Europe 2020 Strategy and the 5th Cohesion Report and takes up the proposals of the ESDP for inter-modal transport solutions, further development of the trans-European networks between main European centres and improvement of linkages between primary and secondary systems and accessibility of urban centres in peripheries.

The Europe 2020, the growth strategy of the EU for the coming decade, aims at five targets in the fields of employment, research and development, greenhouse gases, renewable energy, energy efficiency, education and social inclusion. European Commission, 2010). The Commission emphasises that essential elements of the transport policy are better integration of transport networks,

8 http://ec.europa.eu/regional_policy/sources/docoffic/official/reports/cohesion5/index_en.cfm

9 http http://www.eu-territorial-agenda.eu/Reference%20Documents/Territorial-Agenda-of-the-European-Union-Agreed-on-25-May-2007.pdf

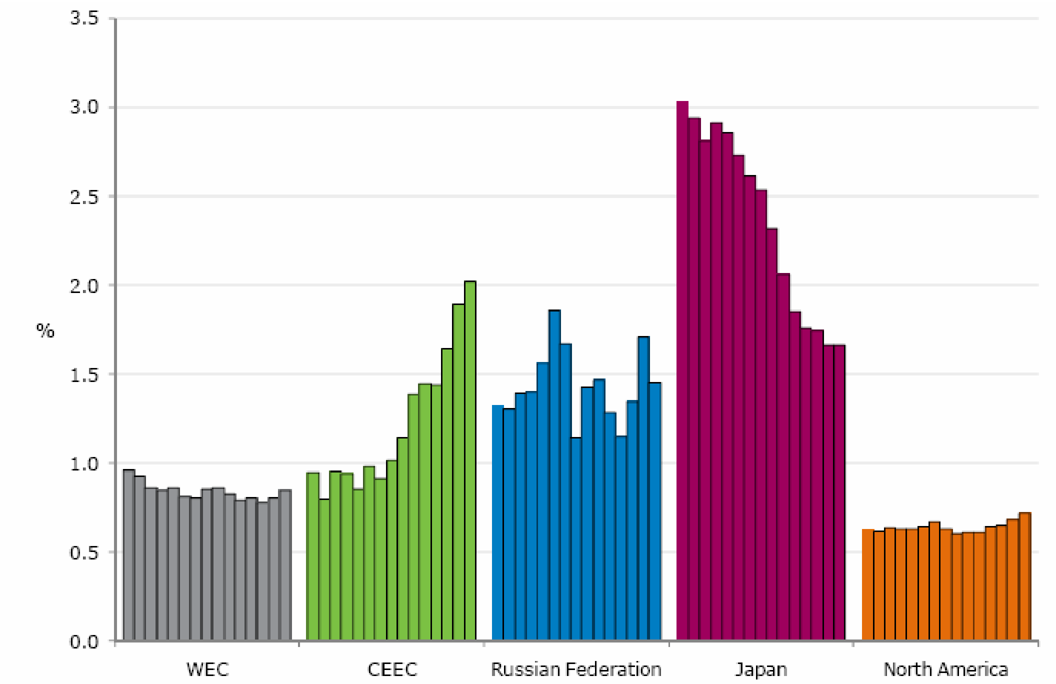
10 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0616:FIN:EN:PDF

promoting clean technologies, and upgrading infrastructure. Among the obstacles to be overcome, insufficiently interconnected networks are listed. Transport is listed among the policy tools to be applied only in very general terms as "smart transport and energy infrastructure".

A further example of the current debate on cohesion aspects is the changes in the understanding of the “urban-rural narrative” as put forward through the Spanish Presidency (2010)[11]. Its contribution highlights the need for a thorough investigation of urban-rural relationships and spatial trends in conceptualizing the new pattern of spatial relations, becoming visible through increased flows and implying analysis beyond core and periphery paradigms. New territorial paradigms emerge today thanks to ICTs and to faster and cheaper transport, increased accessibility and connectivity. These changes result on severe reductions of distance or cost to reach core areas of Europe from the peripheries (“cost of being peripheral”) and making remote places more accessible when well connected to the networks. Even when distance still matters, impacts on spatial development become today more complex, ubiquitous centres and peripheries can suddenly emerge almost anywhere, even in remote rural areas, and the challenge is to face increasing development opportunities but also to manage exposure to threats.

1.3 Transport Investment in Europe 1995-2012

The total investment in infrastructure in Europe between 1995 and 2012 has been on average between 0.9% and 1.2% of total European GDP. The level of investment in Western European Countries has been substantially lower than in the Eastern European countries, but overall levels are well above mean values in other regions of the World such as North America. Investment levels in Europe before the 1990’s were even higher, around 2% of GDP. Between 2007 and 2011, investment in the EU Member States dropped between around 20%, in some countries even 30% (EC Ameco DB).

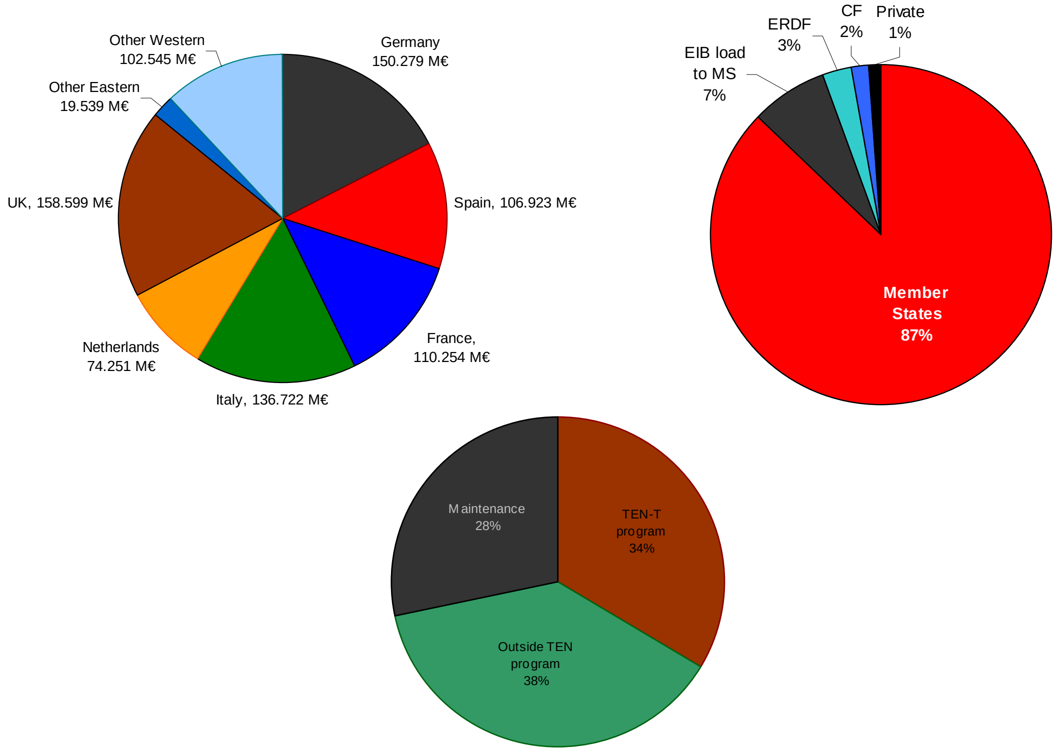


Note: WECs include Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Spain, Sweden and the United Kingdom. CEECs include Albania, Croatia, Czech Republic, Estonia, FYROM, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia and Slovenia. North America: United States data 2003-2009 estimated. Public road investment based on Bureau of Economic Analysis data on Investment in Government Fixed Assets (highways and streets). Private road and private rail investment based on U.S. Census Bureau data on Construction Spending. Public rail investment estimated based on Bureau of Economic Analysis data on Investment in Government Fixed Assets (transportation) using fixed share for rail investment based on 2003 data. Inland waterways investment estimated based on data from U.S. Census Bureau data on Construction Spending (from 2003 level annual change). Japan: not including private investments.

[11] Spanish Presidency (2010). *Urban-rural narratives and spatial trends in Europe: the State of the Question*, Report prepared by, Mcrit Sl, Barcelona, July 2010

Investment in transport infrastructure 1995-2009 as % of GDP at current prices. (OECD 2011)[12]

In particular, for the programming period 2000-2006, the total investment in the transport sector is estimated in € 859 billion (EC 2008), approximately € 120 billion per year or 1,07% of the total GDP. About 1/3 of all invested funds in transport were spent on infrastructure maintenance, and approximately 60% were specifically dedicated to providing new infrastructure. The funding of new infrastructure proceeded mostly from National budgets of Member States (almost 90%), and only 5% of total expenditure was assumed by European funds (Cohesion Fund and ERDF). Six countries accounted for 85% of the total investment (UK, Germany, Italy, France, Spain and the Netherlands).



Structure of Infrastructure investment and financing 2000-2006 (EEA, TEN-T EA, EC)

[12] International Transport Forum, *Trends in transport infrastructure investment 1995-2009,* OECD Statistics Brief, July 2011

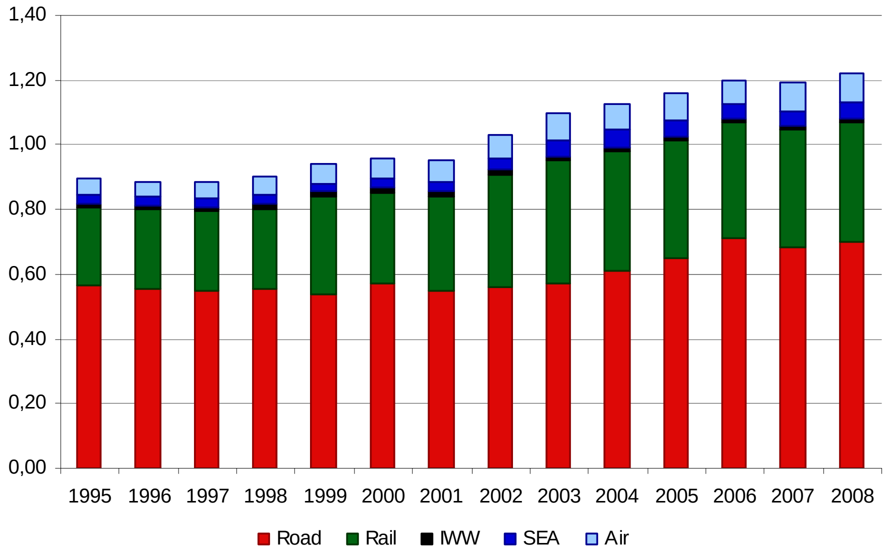
TABLE 3.5 TOTAL TRANSPORT INVESTMENT ACROSS EUROPE: 2000-2006 (€ M)

	MS Public Funding	ERDF	CF	Private	Total	EIB
Austria	13,894	3		n.a.	13,897	871
Belgium	4,699	27		n.a.	4,726	516
Czech Republic	9,371	95	546	n.a.	10,012	2,039
Cyprus	1,073	-	25	1,255	2,355	84
Germany	147,326	2,953		n.a.	150,279	4,080
Denmark	8,271	3		n.a.	8,274	1,705
Estonia	414	20	213	n.a	647.6	8
Spain	83,968	9,523	4,814	8,618	106,923	15,403
Finland	15,422	23		n.a.	15,445	410
France	109,481	774		n.a.	110,254	5,934
Greece	n.a.	4,185	1,490		5,676	4,286
Hungary	63	145	724	n.a.	976	1,516
Ireland	15,335	1,096	294	n.a.	16,725	681
Italy	134,071	2,652		n.a.	136,722	7,638
Lithuania	727	82	126	n.a.	935	75
Luxembourg	1,024	2		n.a.	1,026	386
Latvia	439	56	353	n.a.	848	52
Malta	229	4	9	n.a.	243	
Netherlands	74,155	96		n.a.	74,251	624
Poland	11,046	539	2,694	n.a.	14,279	2,389
Portugal	4,903	2,592	1,635	n.a.	9,130	5,987
Sweden	13,304	63		n.a.	13,367	1,277
Slovakia	3,036	100	381	n.a.	3,523	275
Slovenia	n.a.	4	122	n.a	n.a.	829
UK	158,182	416		n.a.	158,599	4,259
Total EU25	**810,433**	**25,454**	**13,426**	**9,873**	**859,113**	**61,324**

Source: Country reports. Notes: Shaded rows are Member States where information where poor or incomplete: no data for Slovenia; the Belgian figure covers only one region; Hungary and Lithuania data available only since 2004, Greece no public sector figures. Current prices

Total Transport Investment Across Europe 2000-2006 (EC 2009)

For the 1995-2008, the analysis per modes reveals that around 60% of total transport investment (in TENs and in National and Regional infrastructure) has been devoted to Road mode, 20% to Rail and 10% equally split between Air and Water modes (including maintenance).



Total Infrastructure Investment as a share of GDP (per modes) 1995-2008 (EEA 2010)

If focus is placed onto TEN-T only, based on the study TEN-INVEST (EC 2003), the programming period 2000-2006 was expected to allocate around € 290 billion in investments on the TENs (34% of the total for the period).

The analysis reveals that almost half of investments were allocated in rail and around 35% to road. This was especially important in Western European countries, where the development of High Speed Rail networks required large investments (around € 20 million per kilometre of HSR, against € 5 million per kilometre for motorways, on average). In Eastern European countries, investment on roads was still dominant.

Figure 6-1: Share of investments by mode, Member States

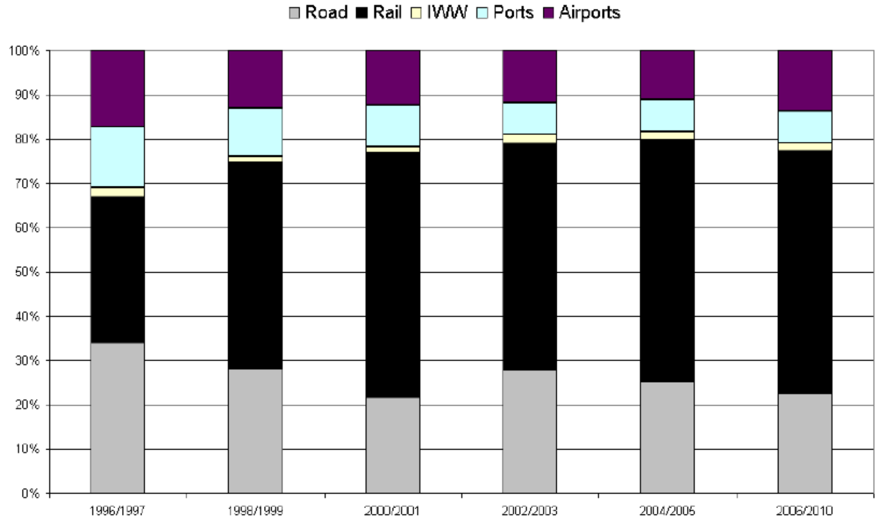


Figure Total Infrastructure Investment in TEN-T per modes in Western Europe 1995-2010[13] (EC 2002)

Figure 6-2: Share of investments by mode, Candidate Countries

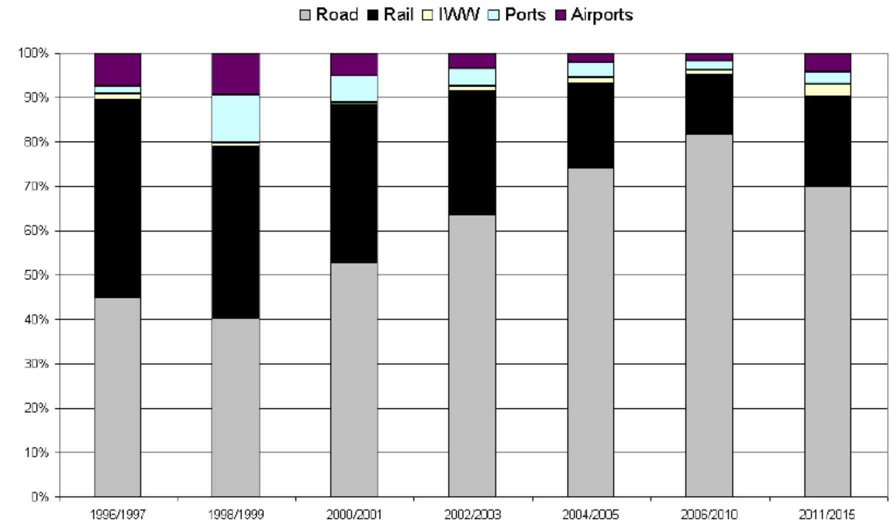


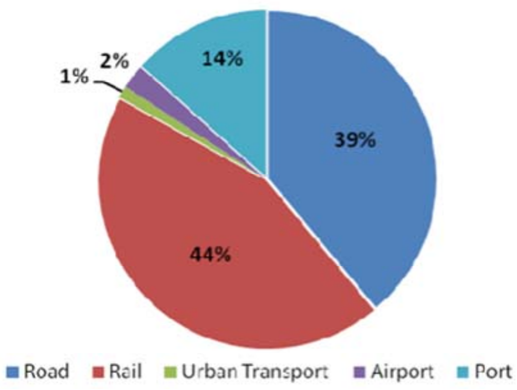
Figure Total Infrastructure Investment in TEN-T per modes in Eastern Europe 1995-2010[14] (EC 2002)

More detailed data is available for beneficiary countries of the ISPA and CF budgets plus Malta and Cyprus (EC 2012). The EU-16 Member States are Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, Spain, Portugal, Ireland, Greece, Malta and Cyprus. During the period 2000-2006, a total of € 200 billion was invested in the TENs (34% of the total transport investment). During that period, rail projects represented a 44% of the total investment (2.000 km of new rail and 6.700 km of refurbished lines), 39% in road (4.200 km of motorways and

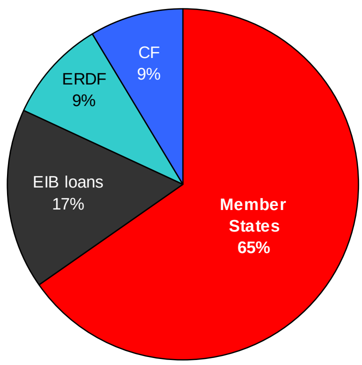
[13] PLANCO (2002); *TEN-Invest Transport Infrastructure costs and Investments between 1994 and 2010 on the Trans-European,* for the EC DG Transport. Estimations in function of budget projections.
[14] PLANCO (2002); *TEN-Invest Transport Infrastructure costs and Investments between 1994 and 2010 on the Trans-European,* for the EC DG Transport. Estimations in function of budget projections.

upgraded roads), and 14% in ports. Funding came on a 65% for Member States, while the other 35% was obtained from EIB loans and grants, the ERDF and the CF.

Budget allocation per mode

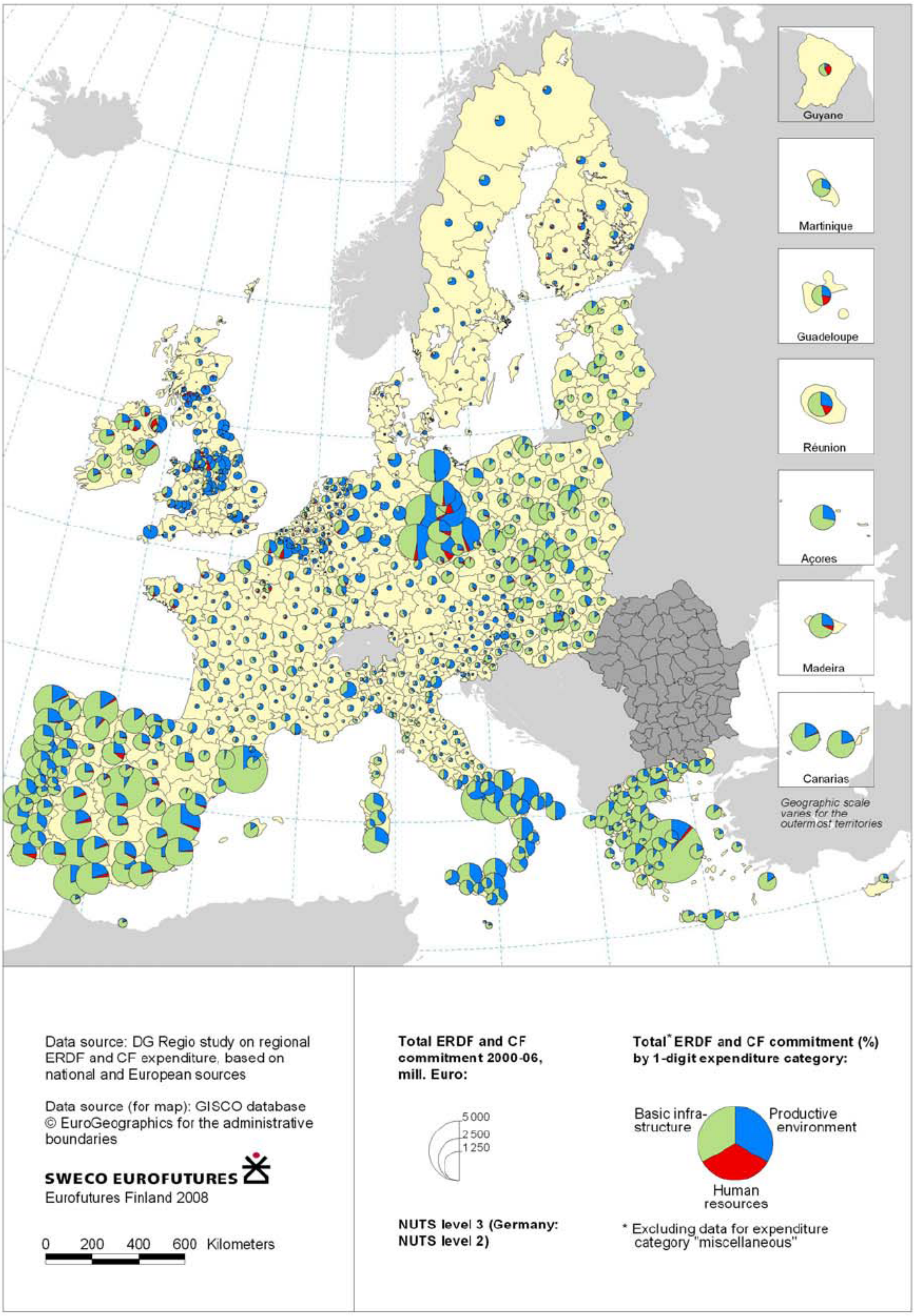


Budget allocation per contributor



Structure of Infrastructure investment in TENs and financing 2000-2006 in the ISPA and CF Beneficiaries plus Malta and Cyrpus (EC 2012)

Map 1: Total ERDF and CF commitment, 2000-2006, mill. Euro



Total ERDF and CF commitment, 2000-2006, in million euros. (DG Regio 2008)[15]

[15] SWECO et al (2008), *ERDF and CF Regional Expenditure,* for EC DG Regio, July 2008

Table 2.8 – Investment in Transport in the EU-16 Member States 2000-2006 (€m)

Country	Member State Funding	ERDF	ISPA/CF Commitments	EIB	**Total**	Total Excluding ERDF	Total Excluding ISPA/CF	**% of ERDF to Total**	**% of ISPA/CF to Total**
Bulgaria	-	-	444	n/a	**444**	444	-	-	100%
Cyprus	1,073	-	51	84	**1208**	1208	1,157	0%	4%
Czech Rep	9,371	95	604	2,039	**12,109**	12014	11,505	1%	5%
Estonia	414	20	213	8	**655**	635	442	3%	48%
Greece	n/a	4,185	1,367	4,286	**9,838**	5653	8,471	74%	16%
Hungary	63	145	1,057	1,516	**2,781**	2636	1,724	6%	61%
Ireland	15,335	1,096	312	681	**17,424**	16328	17,112	7%	2%
Latvia	439	56	352	52	**899**	843	547	7%	64%
Lithuania	727	82	412	75	**1,296**	1214	884	7%	47%
Malta	229	4	9	n/a	**242**	238	233	2%	4%
Poland	11,046	539	2,965	2,389	**16,939**	16400	13,974	3%	21%
Portugal	4,903	2,592	1,633	5,987	**15,115**	12523	13,482	21%	12%
Romania	-	-	1,077	n/a	**1,077**	1077	0	0%	100%
Slovakia	3,036	100	381	275	**3,792**	3692	3,411	3%	11%
Slovenia	n/a	4	132	829	**965**	961	833	0%	16%
Spain	83,968	9,523	6,423	15,504	**115418**	105895	108,995	9%	6%
TOTAL	**130604**	**18,441**	**17,432**	**33,725**	**200202**	**181761**	**182770**	**10%**	**10%**

Source: Based upon Table 4.1 of the Ex Post Evaluation of Cohesion Policy Programmes 2000-2006 Co-financed by the ERDF. Note: some of the financial information for Member States is poor or incomplete. No information for Bulgaria and Romania is available, other than ISPA/CF.

Investment in TENs 2000-2006 in the ISPA and CF Beneficiaries plus Malta and Cyrpus (EC 2012)

In synthesis, the analysis of past trends allows to take the following conclusions. Between 1995 and 2012:

- The EU has spent on average between 0.9% and 1.2% of EU GDP in infrastructure investment.
- About 1/3 of available funds have been spent on infrastructure maintenance and the rest on construction of new infrastructure.
- More than 85% of investment is financed with Member States national budgets. EU funds represent 5% of investment, and almost 10% is constituted by EIB loans and private investments.
- Around 60% of total investment has been devoted to Road mode. 20% to Rail and 10% equally split between Air and Water modes.
- 50% of investment devoted to new infrastructure is targeted at TEN-T networks, and the other half to national networks.
- Almost half of investment on TEN-T has been devoted over the last 10 years to rail, and around 35% to road. In the ISPA and CF beneficiary countries, the proportion of road investments is slightly higher, approaching 40%.

1.4 INVESTMENT PLANS IN THE TENS

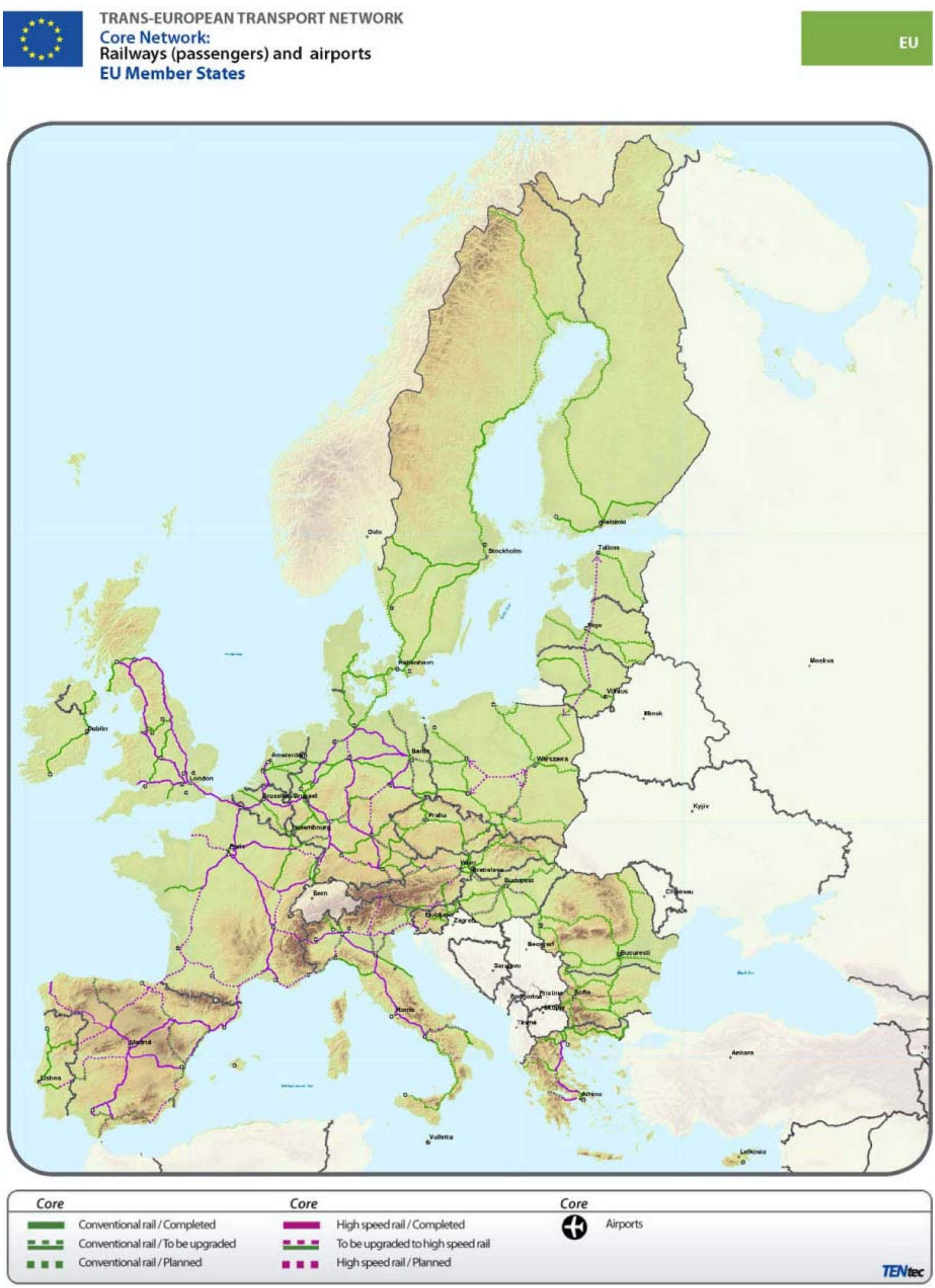
The cost of EU infrastructure development to match the demand for transport has been estimated by the 2011 EC Transport White Paper in € 1.5 trillion for 2010-2030. In fact, the completion of the TEN-T network would require about € 550 billion, which some € 215 billion could be referred to the removal of the main bottlenecks. This does not include investment in vehicles as well as guidance and information systems.

Approximately 50% of these investments are planned to be allocated to rail infrastructure, almost 30% to road, and the rest would be evenly distributed between the air mode and the maritime. For the land-based infrastructure, this would imply acting over approximately 21.500km of roads, 8.500km of high speed rail and 5.000km of conventional rail.

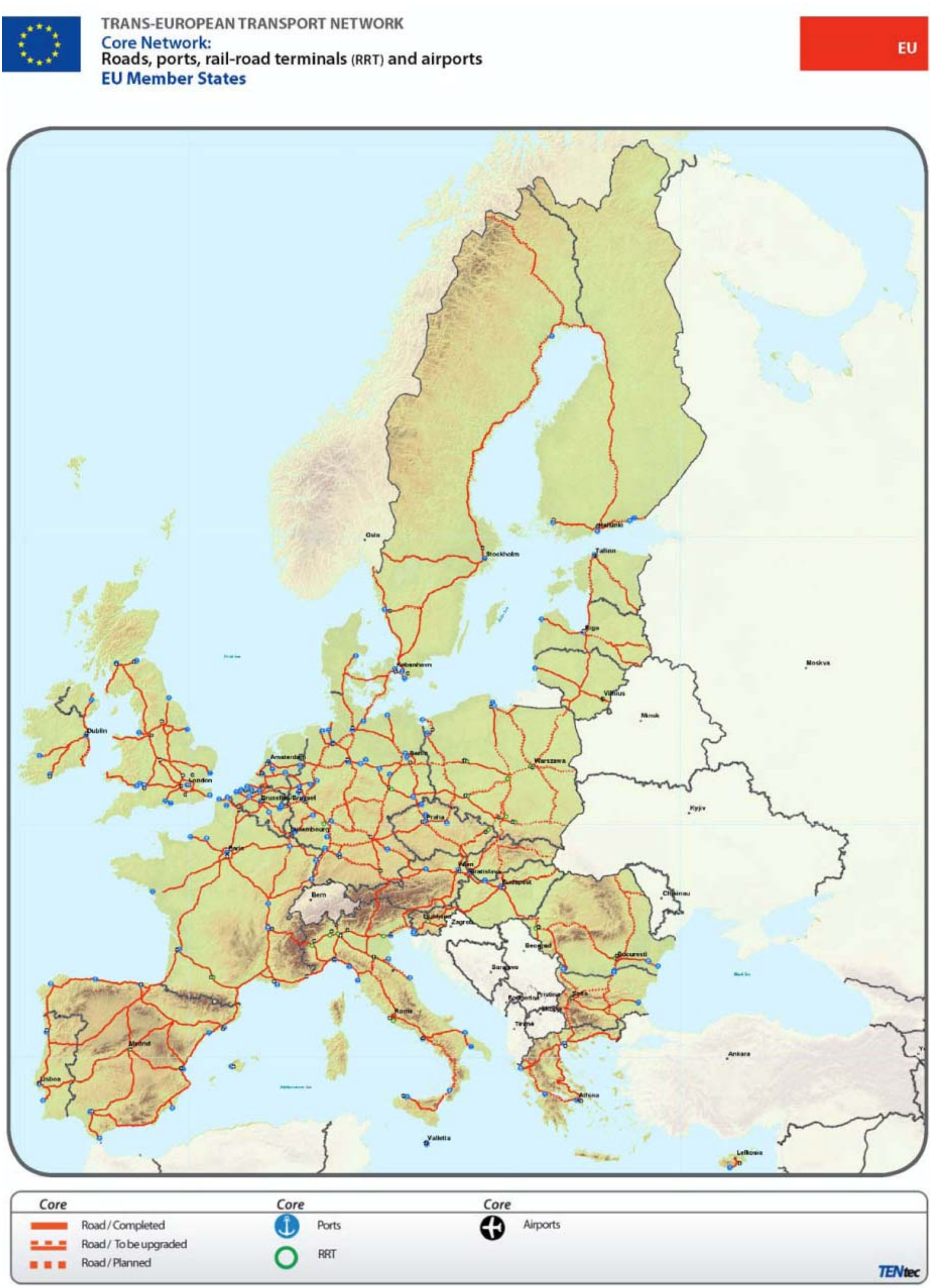
Mode	Investment required to complete TEN-T	Network considered
Road	150.000 M€	21.400 km
Rail	275.000 M€	13.400 km (65% in HSR)
Air	65.000 M€	
Ports	60.000 M€	
Total TEN-T	550.000 M€	

Estimated infrastructure needs to complete TENs[16]

[16] Modal allocation estimations are based on planned TEN-T core network, White Paper qualitative assessments and TransTools network previsions for 2030 and 2050.



TEN-T Rail Core Network. Guidelines Revision (proposal) (EC, December 2011)



TEN-T Road Core Network. Guidelines Revision (proposal) (EC, December 2011)

1.5 CTP: 2011 TRANSPORT WHITE PAPER[17]

The key policy goals of the 2011 Transport White Paper are synthesized below.

- **Single European Transport Area**. Elimination of remaining barriers between different modes and different national transport systems (less unnecessary regulation and bureaucracy, and more technical compatibilities). Increasing the cohesion of transport network by establishing binding commitments of Member States towards implementation of TEN-T core network projects.
- **More diversified funding for transport**. Increased use of PPP schemes; better coordination of funding sources to meet Common Transport Policy objectives and targets: ERDF, Cohesion Fund, TEN-T budget, EIB loans; bond issuing initiatives to fund major infrastructures; "user-pays" principle.
- **Increased efficiency of investment**. Ex-ante project appraisal with cost benefit guidelines; competitive tendering, even when services of public interest may not operate under competition; clarification and uniform treatment of public funding; efficient corridor planning approach rather than project approach.
- **Environment welfare**. Internalisation of external costs of transport; EURO standards to seek further vehicle efficiency; visible links between the "polluter-pays" and "user-pays" principles and use of issued revenues.
- **Technology intensive**. More technology development more focussed on key thematic elements (alternative fuels, smart vehicles, efficient traffic and infrastructure management); European industry's leader in the global market.
- **Infrastructure priorities**. To address bottlenecks, cross-border links and network interconnections; to complete HSR network by 2050 to replace air transport below 1000km; to connect all airports to rail, preferentially to HSR, to promote air-rail intermodal travel. **Core Network**. Dual transport network composed of a high efficient multi-modal core network, and EU-wide cohesive network; increasingly segregated freight and passenger (enhanced flows and safer transport); increasingly balanced network between EU15 states and New Member States
- **Transport management**. Technology, pricing and scheduling to enhance infrastructure management and increase effective capacity (ATM, ERTMS, ICT…); *European Integrated Multimodal Information and Management Plan*, providing real-time network information all over Europe, efficient multi-modal planners and centralised ticketing.

The table below provides more details on the development of the above policy objectives.

Synthesis of major concepts included in the 2011 Transport White Paper

Market regulation	Pricing & funding	Technology	Infrastructure	Management
Single European Transport Area eliminating all residual barriers between modes and national systems (technical and bureaucratic).	**Increasing difficulty in funding of transport infrastructure** -due to ageing society (social budgets), financial crisis, and alternative fuel vehicles reducing fuel taxation incomes.	**More focused R&D efforts required in Europe**. China's R&D spending grows at double digit rate (already 2nd largest R&D world power) and is focussed in most promising areas, while European research efforts remain diffused.	**Cost of EU missing infrastructure to match demand for transport** is estimated € 1.5 trillion for 2010-2030 (€215 billion for bottlenecks). Investment in vehicles and equipment required additional €1.0 trillion.	**Co-modality implies use of each mode where especially competitive**: - urban mobility → PT & electric vehicles (EV) - travel below 300km → conventional car - travel up to 1000km → high speed rail - long distance travel → aviation

[17] EC DG Move (2011): Transport White Paper "Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system" COM(2011) 144 final

Market regulation	Pricing & funding	Technology	Infrastructure	Management
Single European Railway Area - award of public service contracts under competition, - strengthening role of the European Rail Agency, - enhancing separation between IMs and operators	**“User pays” principle** Socioeconomic benefits and positive externalities may justify some level of public funding of transport but users are to pay for higher proportion implementation and operation costs.	**More efficient vehicles**, smaller and lighter. Vehicles in all transport modes need to become cleaner, safer and more silent.	**Balanced infrastructure endowment** between EU12 (New Member States) and EU15 countries.	**HSR in competition with aviation** and to provide alternatives to short haul- and feeding flights (+176 billion passenger kilometres for HSR by 2050 relative to 2005; +67 billion pax·km for air).
Single European Sky Modernised ATM infrastructure by 2020 (SESAR) and legislation changes to allow tripling airspace capacity, reduce 50% ATM costs, reduce 10% environmental impact.	**Road user charges to all vehicles on the whole network based on distance**, to reflect at least the marginal cost of infrastructure (wear and tear), congestion, air and noise pollution. Eurovignette extended to passenger transport	**Alternative fuels** - ROAD → urban EV, hydrogen & methane for mid distance), biofuels, LNG and LPG for long distance. - RAIL → electricity - AIR → biomass - WATER → biofuel, hydrogen (IWW), LPG and LNG (SSS), LNG & nuclear (deep sea)	**Dual TEN-T layer:** Multimodal TEN-T ‘core network’ by 2030 (selected corridors to carry large volumes of traffic with high efficiency and low emissions). EU-wide comprehensive network’ underneath the core network .	**Attractive frequencies, reliability and intermodal integration** for enhanced quality service.
Binding commitments by MS to implementation of TEN-T core network projects (granting accomplishment of agreed time frames).	**Rail ticket fees set to stand for at least full operating costs of services** (2001 Directive on infrastructure charges).	**Galileo** (European Global Navigation Satellite System) to support existing ITS solutions once operational	**Core network constituted mostly of existing infrastructure.** Missing cross-border links and links connecting modes to be a priority under the Core Network.	**Infrastructure capacity to be adjusted to real traffic needs**. To make available high capacity links on the entire core network is not an objective.
Liberalisation of rail domestic passenger transport by 2012.	**European airports to be operated as businesses** in a competitive environment	**Ubiquitous communication in Road Transport** Infrastructure to vehicles to reach zero accident targets and tackle congestion	**Transport terminals conceived as multimodal connection platforms** - All core network airports linked to HSR by 2050, and efficiently connected to closest urban centres with PT	**Increasing separation between passenger and freight traffic** to optimise traffic flows (traffics with different needs) and increase safety
Rail infrastructure is a natural monopoly IMs under scrutiny to ensure that pricing and investment decisions are consistent with the goal of fostering railway	**Internalisation of externalities** The principle for charging should be that of marginal social cost pricing. Congestion pricing should be introduced to pay for local road externalities	**Advanced driver assistance systems** lane departure warning, anti collision, pedestrian recognition, eCall, in-vehicle speed limit regulator	**Corridor approach to infrastructure investment**, (e.g. Brenner Corridor Platform; ERTMS Rotterdam-Genoa freight corridor)	**Road management with ICT** to optimise transport and routes -10% reduction in fatalities per year (3,500 lives) -10% reduction in congestion costs (€ 12.3 billion)
Pan-European rail IMs In the long term to ensure co-ordinated development along key corridors, but allowing competition or benchmarking between different route managers. The EC will keep	**Noise-differentiated infrastructure access charges for rail** (proposed in 2010 by EC).	**Levitation rail**. Implanted in Shanghai airport, Japan plans to build Megalev between Tokyo and Osaka, EU has some trial tracks.	**Complete high-speed rail network by 2050**. Triple the length of existing HSR network by 2030 and maintain a dense rail network in all MS. By 2050 the majority of mid distance passenger transport will go by rail.	**More efficient rail management with ERTMS** (European Rail Traffic Management System). New signalling systems allow more trains to operate safely on a given section of track
EURO Standards Technological standards are effective to accelerate the introduction of cleaner vehicles by providing fixed targets for the industry.	**Airport charges** do not take into account the cost of congestion, or local externalities (noise, NOx)	**Unconventional technologies for aviation unlikely** before 2050, even if development of alternative fuels is accelerating	**Freight dedicated rail corridors**, with exclusive lines or preferential.	**More efficient Air Traffic Management (SESAR).** To reduce between 6% and 13% air trip lengths by 2020 (less air space fragmentation). Currently, Intra-EU routes are 15% less efficient than domestic.

Market regulation	Pricing & funding	Technology	Infrastructure	Management
Competitive tendering for public service contracts, and services of general interest. –competition for the market instead of competition in the market.	**Elimination of distortionary subsidies** to infrastructure financing and to service operation. Better modal choices will also have to be guided by prices that reflect all costs associated to transport	**Wind-based concepts** for waterborne transport, and LNG and Nuclear powered shipping	**Airport capacity between 2007 and 2030 will not be met** (between 11% and 25% of demand) despite a 40% capacity increase (Eurocontrol 2008).	**Better management of EU airports** - enhanced landing / take-off slot allocation - "One Stop Security**"** (no further control at transfer points if security control passed already at EU airport) - better ground-handling services
Ex-ante project appraisal. *Guide on Cost-Benefit Analysis in 2002 (updated in 2008)* to be used.	**Integrated funding framework for transport required** European Regional Development Fund (ERDF) and Cohesion Fund (13% of total) and loans from EIB (16% of total) to better focus CTP targets	**Interoperability of electronic technologies** - Electronic ticketing - Electronic tolling - Airport management systems (CUPPs).	**A corridor approach**. Transport corridors will need to be analysed within 2 years from the publication of the future EC *Corridor guidelines*, under the aegis of the European Coordinator and a multi-annual corridor development Plan	**River Information Services (RIS).** Establishment of an interoperable, intelligent traffic and transport system to optimise the existing capacity and safety of IWW and improve interoperability with other transport modes
Clear treatment of public funding to transport infrastructure and services.	**Diversification of funding sources** both public (EU, National and regional governments) and private (financial institutions and corporate). PPPs increasingly important.	**Electronic ticketing** on mobile devices (smart cards, cell phones…) can provide public transport operators and authorities with real time statistical data on users' behaviour.		**European Integrated Multimodal Information and Management Plan** (EIMIP). Real-time transport information throughout Europe and multimodal integrated ticketing all over EU.
	Europe 2020 Project Bond Initiative to provide support to companies issuing bonds to finance large-scale infrastructure projects. The EC would be risk-sharing with the EIB.			

Source: ORIGAMI FP7, 2012

In particular, a number of transport targets are set up by the 2011 Transport White Paper. These targets are presented below:

Synthesis of transport targets included in the 2011 Transport White Paper

Sector	Year	Target	Source
Transport emissions and energy consumption	2020	10% of transport energy from renewables in 2020	Renewable Energy Roadmap Communication by the EC, 2007
	2020	fuel suppliers reduce greenhouse gas emissions from fuel across its life-cycle by 10% by 2020	Energy Policy, 2007
	2020	10% of transport energy from biofuels in 2020	Energy Policy, 2007
	2050	Phasing out fuel powered cars by 2050	Transport White Paper 2011
	2030	Transport emissions (including CO_2 aviation, excl. maritime), 20% lower in 2030 in relation 2008	Transport White Paper 2011

Sector	Year	Target	Source
	2050	Transport emissions (including CO2 aviation, excl. maritime), 60% lower in 2050 in relation 1990's	Transport White Paper 2011
Trans European Networks TEN-T	2030	Multi-modal TEN-T core network by 2030	Transport White Paper 2011
	2050	All core network airports connected to rail network by 2050, preferably by high-speed rail	Transport White Paper 2011
	2050	All core seaports sufficiently connected to the rail freight and, where possible, inland waterway system.	Transport White Paper 2011
Urban transport	2030	Lower 50% the use of "conventionally-fueled" cars in urban transport	Transport White Paper 2011
	2050	0% use of "conventionally-fueled" cars in urban transport	Transport White Paper 2011
	2030	CO2 free logistics in cities by 2030	Transport White Paper 2011
Road transport	2010	Reduction 50% the number of road fatalities by 2010 compared with 2001 levels	
	2030// 2050	By 2020, 50% fatalities in road transport. Close to zero fatalities in road transport by 2050.	Transport White Paper 2011
	2020	Car emissions: 95 g CO2/km target for 2020	Regulation 443/2009 h
	2030 // 2050	30% of road freight over 300km should shift to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050 (facilitated by efficient and green freight corridors)..	Transport White Paper 2011
Rail transport	2030	To triple the length of high-speed rail network by 2030.	Transport White Paper 2011
	2050	To complete a European high-speed rail network by 2050.	Transport White Paper 2011
	2050	By 2050, the majority of medium-distance passenger transport should go by rail.	Transport White Paper 2011
Aviation	2050	Low-carbon sustainable fuels in aviation to reach 40% by 2050	Transport White Paper 2011
	2020 // 2050	Stabilisation of air emissions by 2020 (carbon neutral growth) and 50% reduction in 2050 compared to 2005	IATA
Maritime	2050	CO2 emissions from maritime transport should be cut by 40% (if feasible 50%) by 2050, compared to 2005 levels	Transport White Paper 2011
Freight Transport	2030	In freight transport, (rail + IWW) modal share of 30%	Transport White Paper 2011
	2050	In freight transport, (rail + IWW) modal share of 50%	Transport White Paper 2011
Transport management	2020	SESAR, Modernised air traffic management infrastructure.	Transport White Paper 2011

Sector	Year	Target	Source
	2020	To establish the framework for a European multi-modal transport information, management and payment system	Transport White Paper 2011
	2050	Move towards full application of “user pays” and “polluter pays” principles	Transport White Paper 2011

2 DEFINITION OF SCENARIOS 2030

2.1 INFRASTRUCTURE ASSUMPTIONS

2.1.1 Assumptions on budget for new infrastructure

Based on available GDP each year, for each scenario, and on alternative hypothesis of transport investment evolution as a % of GDP, the different scenarios come up with an overall 2013-2030 budget to be invested in the TENs, at National and Regional levels, in transport management and maintenance, and in implementation of smart transport infrastructure.

Budgets are then used to build transport infrastructure in Europe in the TENs (core and comprehensive), and the national and regional networks.

- The MOSAIC model implements investments in the TENs network (core and comprehensive), selecting specific links of the transport network to be upgraded. Links to which investments are dedicated are chosen with criteria of efficiency (links with highest levels of traffic) and cohesion (links in lagging regions). (see following chapter)

- National and regional infrastructure budgets are distributed on a NUTS2 level, according to alternative criteria in each scenario.

All scenarios consider a reduction of transport investment budgets in Europe between 2007 and 2014, in line with trends observed for the Gross Capital Formation in Europe between 2007 and 2011 (AMECO DB, civil engineering and transport equipment categories).

Overall investments for the 2013-2030 period are in all cases lower than in the 1995-2012 period. The TENs are not completed in any of the scenarios.

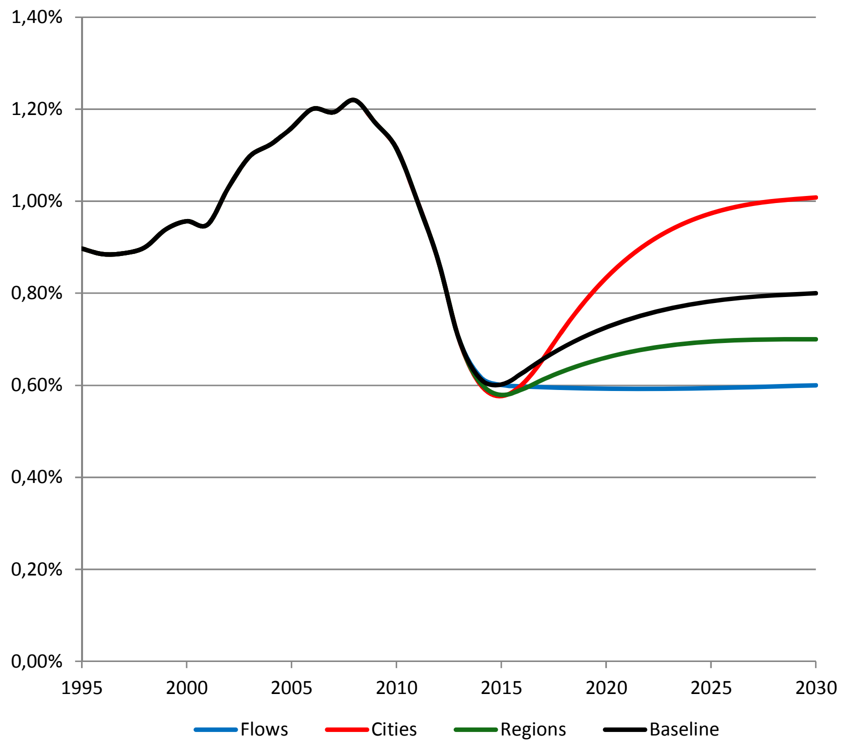
The main scenario orientations are as follows:

- The **BASELINE** is a propagation of observed trends since 1995, taking into account the financial crisis.

- The **A Scenario** considers relatively low levels of infrastructure investment, allocated in where in those projects were investments provide more return (mostly in the busiest links of the networks). Airports and ports are a priority in the flows scenario. Within each country, available regional investments are allocated in those areas more open to the global economy.

- The **B Scenario** considers higher levels of infrastructure investment than all other scenarios, with high stress in rail infrastructure. European investments are allocated based on balanced criteria of efficiency and cohesion. Within each country, available regional investments are allocated in those areas being more populated.

- The **C Scenario** has lower investment than CITIES but higher than FLOWS. It gives more attention to local and regional infrastructure than to TENs. Management and infrastructure maintenance is increasingly important compared to other scenarios. European scale investments follow more territorially balanced patterns, tending to benefit Eastern Europe. Within each country, available regional investments are allocated according to landscape and environmental conservation criteria.



Total transport expenditure per scenario (% of GDP)

Below, the basic hypotheses are detailed below for each scenario.

BASELINE

- € 1.970 billion (2013-2030) in transport investment, 0’73% of cumulated GDP. Infrastructure investment rate in 2030 converging to Western European Countries (WECs) levels (0,8%).
- 2% of budget on ITS implementation
- 1,0% yearly maintenance budget maintained
- € 330 billion in TENs and € 700 billion in National and Regional networks (32% in the TENs)
- 60% of required investments to complete the TENs engaged up to 2030
- € 166 billion in the CORE network and € 161 billion in Comprehensive network. Projects evenly allocated between core and comprehensive networks (50% // 50%).
- Modal allocation of investment in TENs, in line with overall 1995-2012 period.

A Scenario “FLOWS”

- € 1.610 billion (2013-2030) in transport investment, 0’60% of cumulated GDP. Infrastructure investment rate in 2030 converging to typical North America levels (0,6%).
- 10% of budget on ITS implementation

- Yearly maintenance budget reduced to 0,6% in 2030

- € 330 billion in TENs and € 500 billion in National and Regional networks (40% in the TENs)

- 60% of required investments to complete the TENs engaged up to 2030

- € 290 billion in the CORE network and € 35 billion in Comprehensive network. Projects mostly allocated in the Core (85% // 15%).

- Modal allocation of investment in TENs, substantially increased for air and ports, substantially decreased for rail.

B Scenario "CITIES"

- € 2.290 billion (2013-2030) in transport investment, 0'85% of cumulated GDP. Infrastructure investment rate in 2030 converging to typical EU level in the 1990s (1,0%).

- 2% of budget on ITS implementation, like in Baseline

- 1% yearly maintenance budget maintained

- € 470 billion in TENs and € 865 billion in National and Regional networks (35% in the TENs)

- 85% of required investments to complete the TENs engaged up to 2030

- € 231 billion in the CORE network and € 235 billion in Comprehensive network. Projects evenly allocated between core and comprehensive networks (50% // 50%).

- Modal allocation of investment in TENs, increasingly rail based.

C Scenario "REGIONS"

- € 1.790 billion (2013-2030) in transport investment, 0'67% of cumulated GDP. Infrastructure investment rate in 2030 converging to 0,7%.

- 5% of budget on ITS implementation

- Yearly maintenance budget increased to 1,2% in 2030

- € 220 billion in TENs and € 540 billion in National and Regional networks (29% in the TENs)

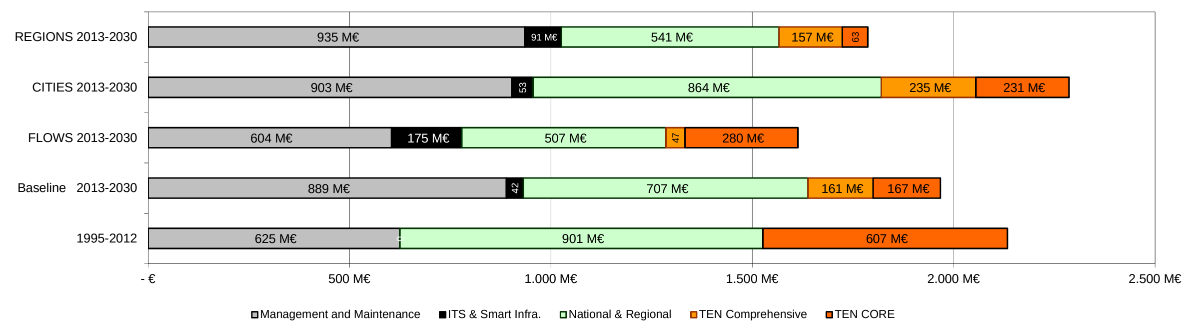
- 40% of required investments to complete the TENs engaged up to 2030

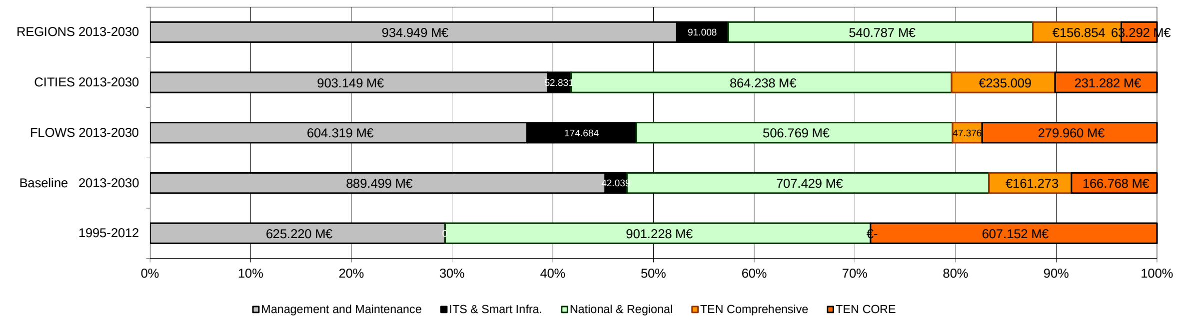
- € 65 billion in the CORE network and € 160 billion in Comprehensive network. Projects mostly allocated in the Comprehensive network (30% core // 70% comprehensive).

- Balanced modal allocation of investment in TENs, as in Baseline

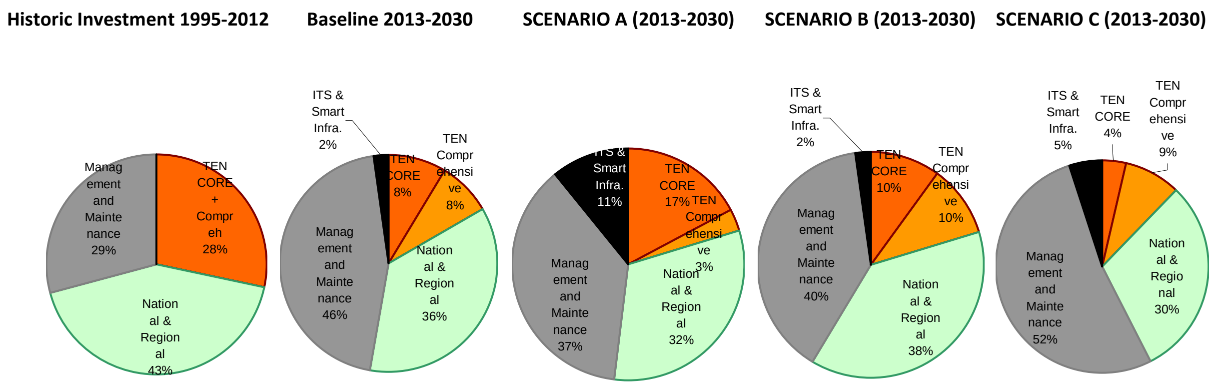
Transport Investment in Europe	1995-2012		Baseline 2013-2030		SCENARIO A (2013-2030)		SCENARIO B (2013-2030)		SCENARIO C (2013-2030)	
Average anual GDP growth	1,55%		1,88%		2,22%		2,31%		1,82%	
% GDP spent in transport investment	**1,04%**		**0,73%**		**0,60%**		**0,85%**		**0,67%**	
in TEN CORE infrastructure	28,5%	*607.152 M€*	8,5%	*166.768 M€*	17,3%	*282.920 M€*	10,1%	*234.319 M€*	3,5%	*63.171 M€*
in TEN COMPREHENSIVE infrastructur	0,0%	*- €*	8,2%	*161.273 M€*	2,9%	*47.874 M€*	10,3%	*238.106 M€*	8,8%	*156.554 M€*
in National & Regional infrastructure	42,2%	*901.228 M€*	36,0%	*707.429 M€*	31,8%	*518.214 M€*	38,2%	*885.714 M€*	30,2%	*538.287 M€*
in management and maintenance	29,3%	*625.220 M€*	45,2%	*889.499 M€*	37,1%	*605.360 M€*	39,1%	*905.629 M€*	52,4%	*934.622 M€*
in ITS and smart infrastructure	0,0%	*- €*	2,1%	*42.039 M€*	10,8%	*176.577 M€*	2,3%	*53.481 M€*	5,1%	*90.844 M€*
TOTAL	100,0%	2.133.600 M€	100,0%	1.967.008 M€	100,0%	1.630.946 M€	100,0%	2.317.248 M€	100,0%	1.783.478 M€
Modal split of infrastructure investment in TENs (CORE + COMPREHENSIVE)										
% road	29,9%	*181.727 M€*	29,5%	*96.636 M€*	36,2%	*119.685 M€*	26,3%	*124.124 M€*	30,3%	*66.577 M€*
% rail	44,6%	*270.835 M€*	42,1%	*138.256 M€*	24,6%	*81.491 M€*	49,6%	*234.240 M€*	43,3%	*95.180 M€*
% air	9,9%	*60.303 M€*	10,6%	*34.849 M€*	17,8%	*58.741 M€*	8,5%	*40.272 M€*	10,9%	*24.002 M€*
% ports	8,0%	*48.751 M€*	10,3%	*33.697 M€*	16,4%	*54.337 M€*	8,1%	*38.358 M€*	10,5%	*22.979 M€*
% intermodal	7,5%	*45.536 M€*	7,5%	*24.603 M€*	5,0%	*16.540 M€*	7,5%	*35.432 M€*	5,0%	*10.986 M€*
Provision of new infrastructure in the TENs										
New or upgraded roads (km)	21.400 km		11.400 km		14.100 km		14.600 km		7.800 km	
New HSR lines	8.500 km		4.300 km		3.100 km		8.900 km		3.000 km	
Upgraded rail lines	4.900 km		2.500 km		300 km		1.000 km		1.700 km	
In the CORE network										
Roads			5.130 km		8.460 km		4.088 km		1.950 km	
HSR lines			2.430 km		3.100 km		5.340 km		750 km	
Conventional rail			1.413 km		300 km		600 km		425 km	

Synthesis of key indicators of transport investment in ET2050

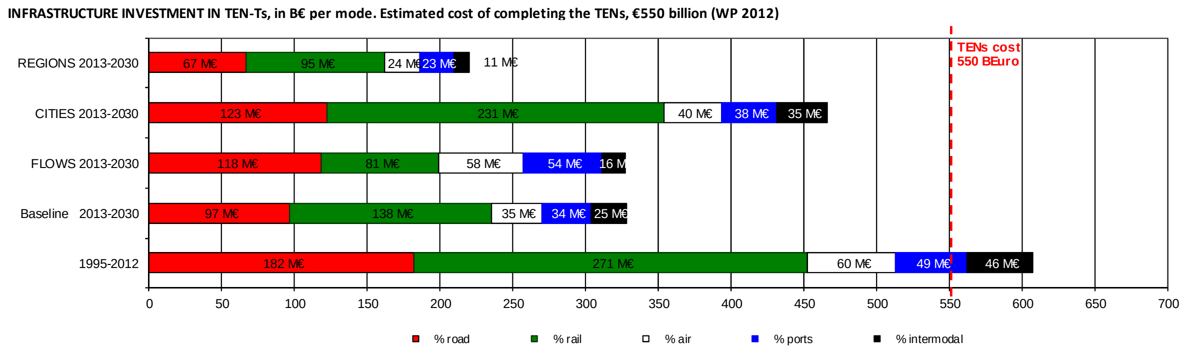


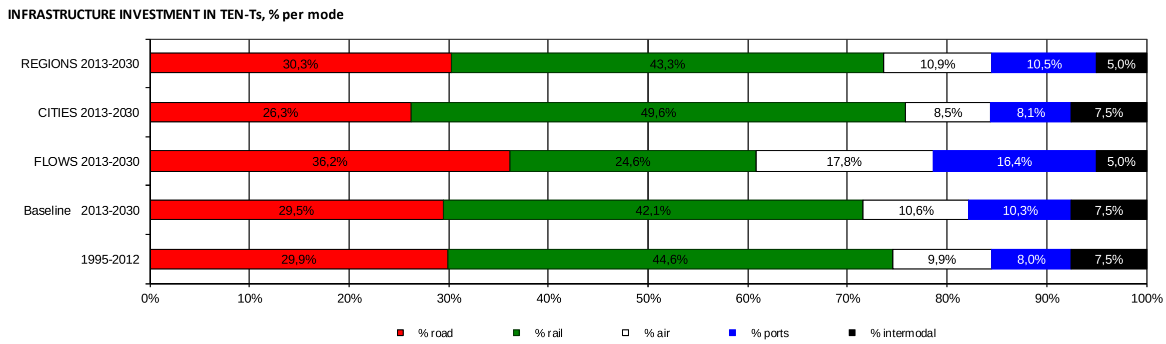


Total transport investment 2013-2030 for different scenarios, compared to 1995-2012 observations. Absolute values on top, relative at the bottom

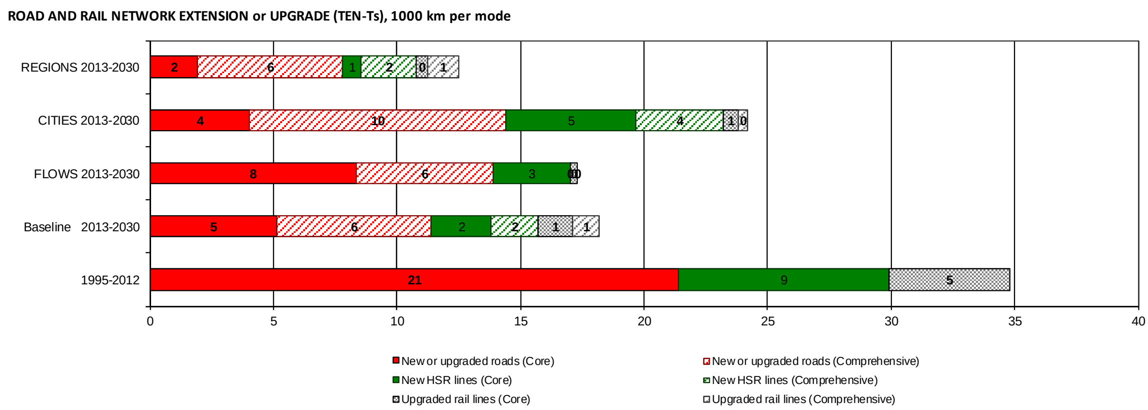


Total transport investment abatement by major chapters. 2013-2030 for different scenarios, compared to 1995-2012 observations.





TENs transport investment per modes. 2013-2030 for different scenarios, compared to 1995-2012 observations. Absolute values on top, relative at the bottom



TENs network development per modes. 2013-2030 for different scenarios, compared to 1995-2012 observations (in kilometres)

2.1.2 Allocation of transport investments in the road and rail TENs

Trans-European Transport Networks

The following figures synthesise the proposal for alternative hypothesis in relation to infrastructure endowment in ET2050. This proposal is based on variations upon the baseline.

MOSAIC implements sets of new transport infrastructure specifically for each scenario and the Baseline. The new links implemented will correspond to investments in the TEN-T core network based on investment budgets determined in previous chapters. The size of the new infrastructure to be provided is synthesised in the following table:

	Baseline	FLOWS	CITIES	REGIONS
Construction of TEN-T core roads (km)	11.400	13.900	14.400	7.800
Construction of TEN-T core HSR (km)	4.300	3.100	8.800	3.000
Construction of TEN-T core conventional rail (km)	2.500	300	1.000	1.700

Synthesis of new infrastructure provide in MOSAIC

The selection of specific links in MOSAIC graph (rail and road) is based both on "cohesion" principles (eastern European links are more likely to be selected) and on "competitiveness" principles (links with highest levels of traffic are more likely to be selected).

$$P_i = \left(\frac{Traffic_i}{MaxTraffic_{EU}} \right)^{\alpha} \left(\frac{MaxGDPcapita_{EU}}{GDPcapita_j} \right)^{\beta}$$

With

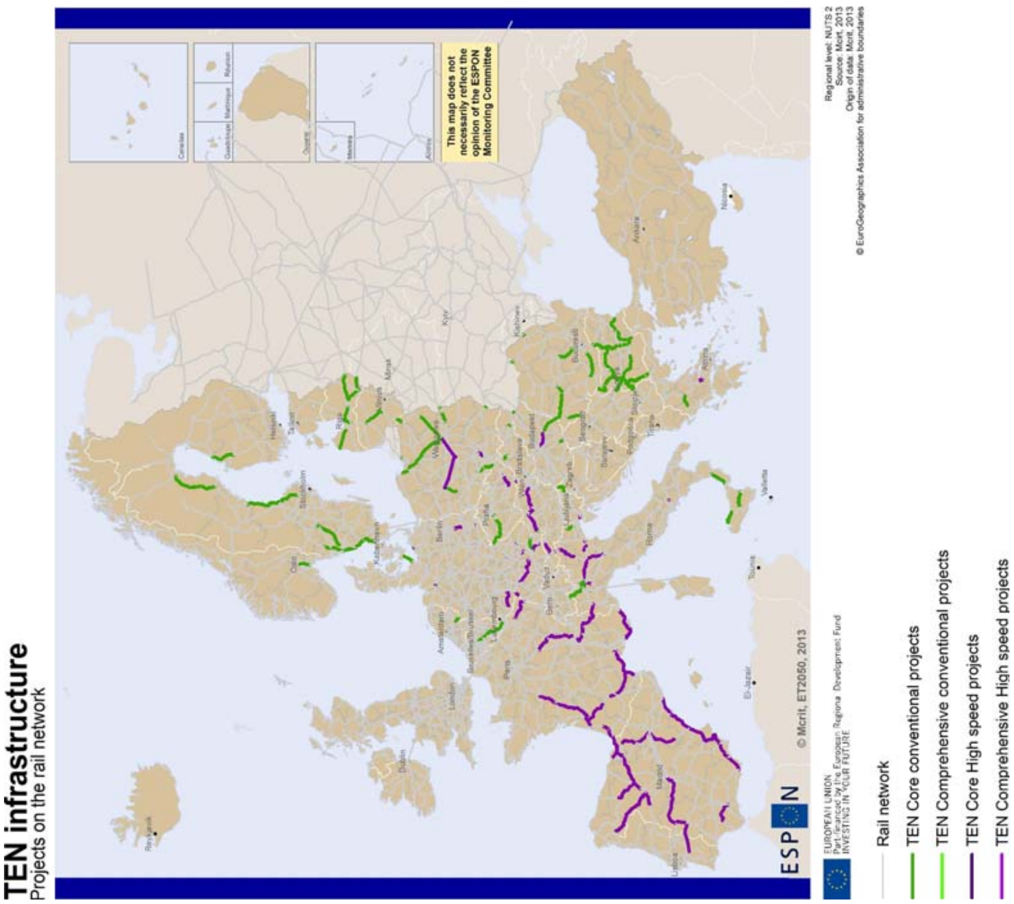
P_i . probability of link i being chosen to be upgraded
$Traffic_i$. traffic through link i
$MaxTraffic_{EU}$. maximum traffic of all links on the model
$GDPcapita_j$. income per capita of NUTS3 j were link i is located
$MaxGDPcapita_{EU}$. maximum income per capita of all NUTS3
$\alpha, \beta \in [0,1]$ constants

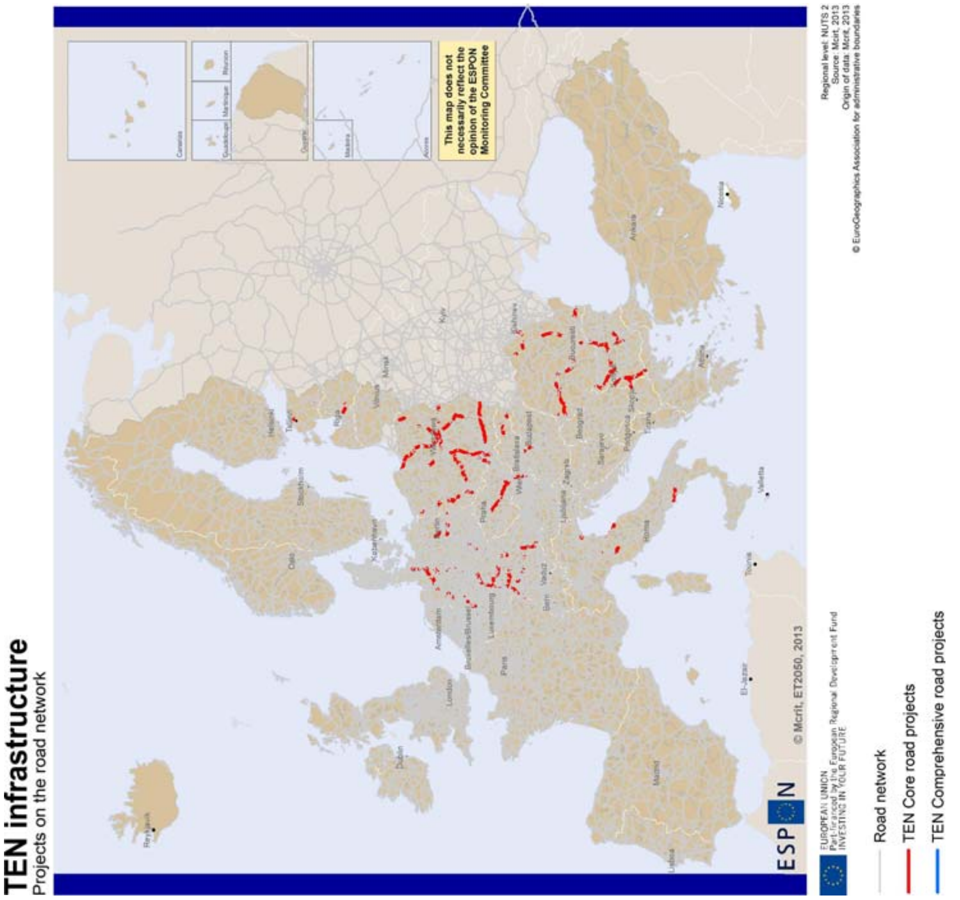
The selection of links for each ET2050 scenario responds to the following α, β parameters, presented in the following table.

	Baseline	FLOWS	CITIES	REGIONS
α	0.60	0.90	0.40	0.10
β	0.40	0.10	0.60	0.90

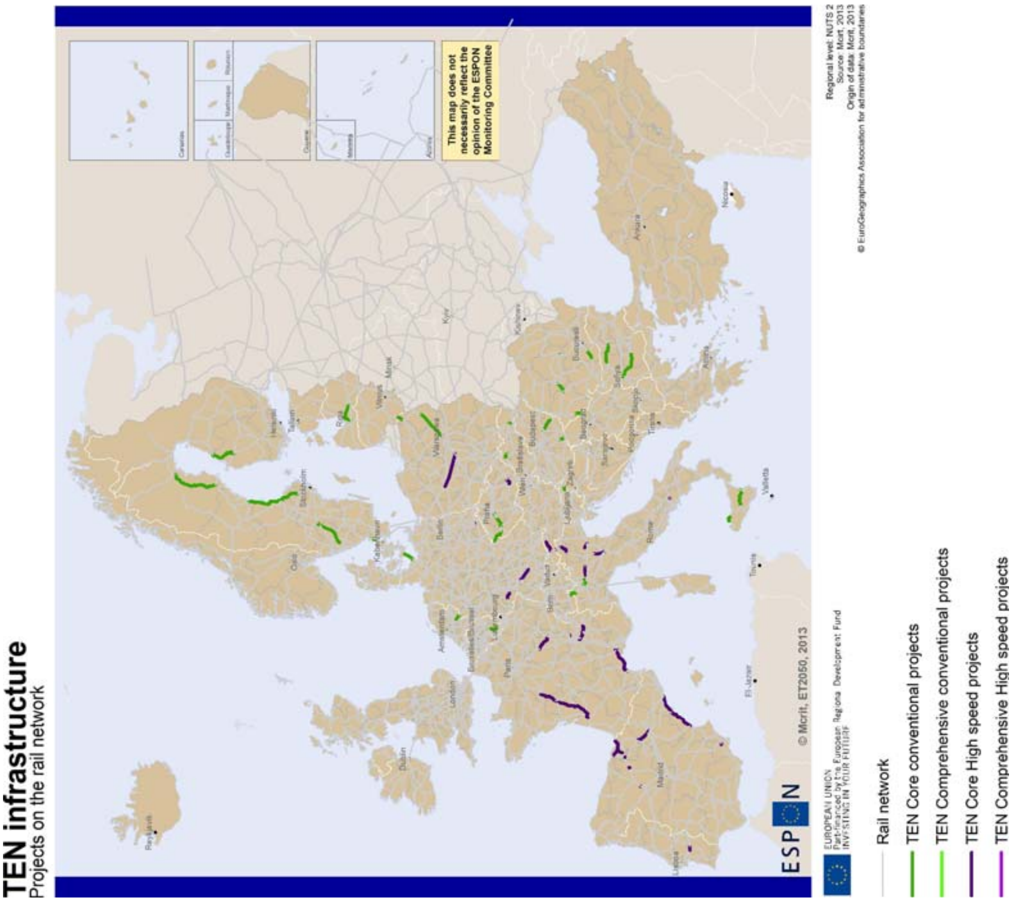
Competitiveness (α) and Cohesion (β) parametres for scenarios

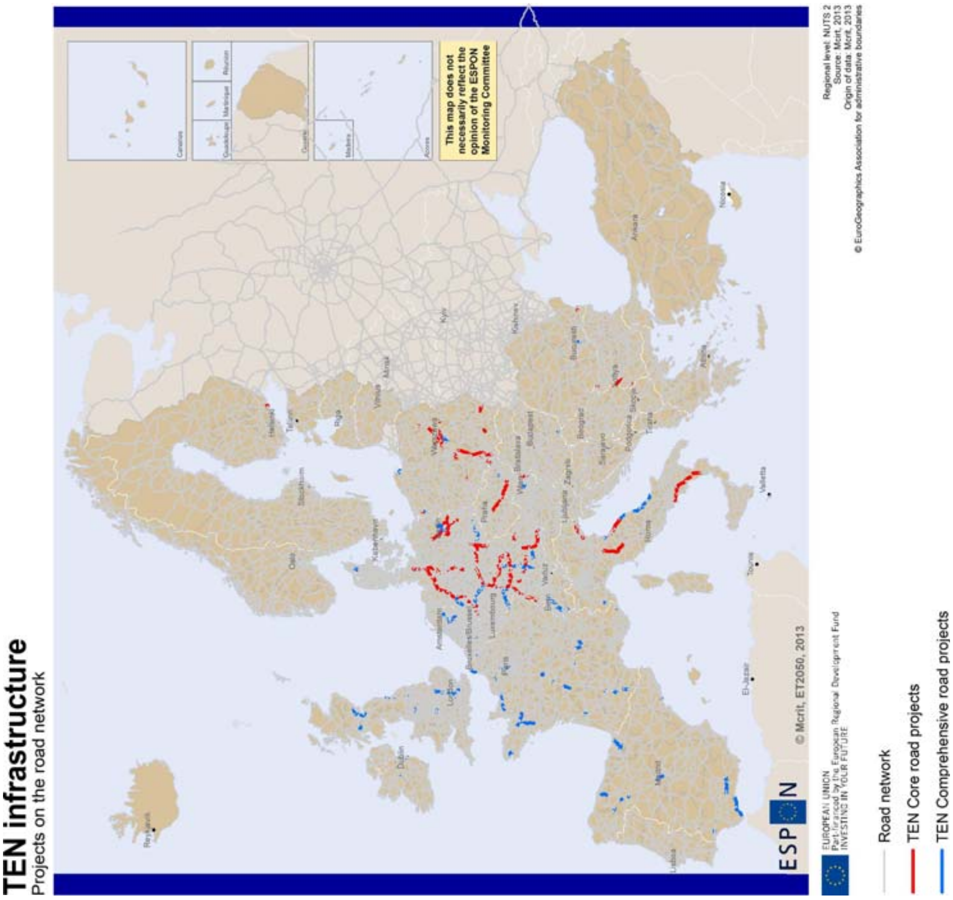
The following two maps show the implemented rail and road networks for the **Baseline** up 2030



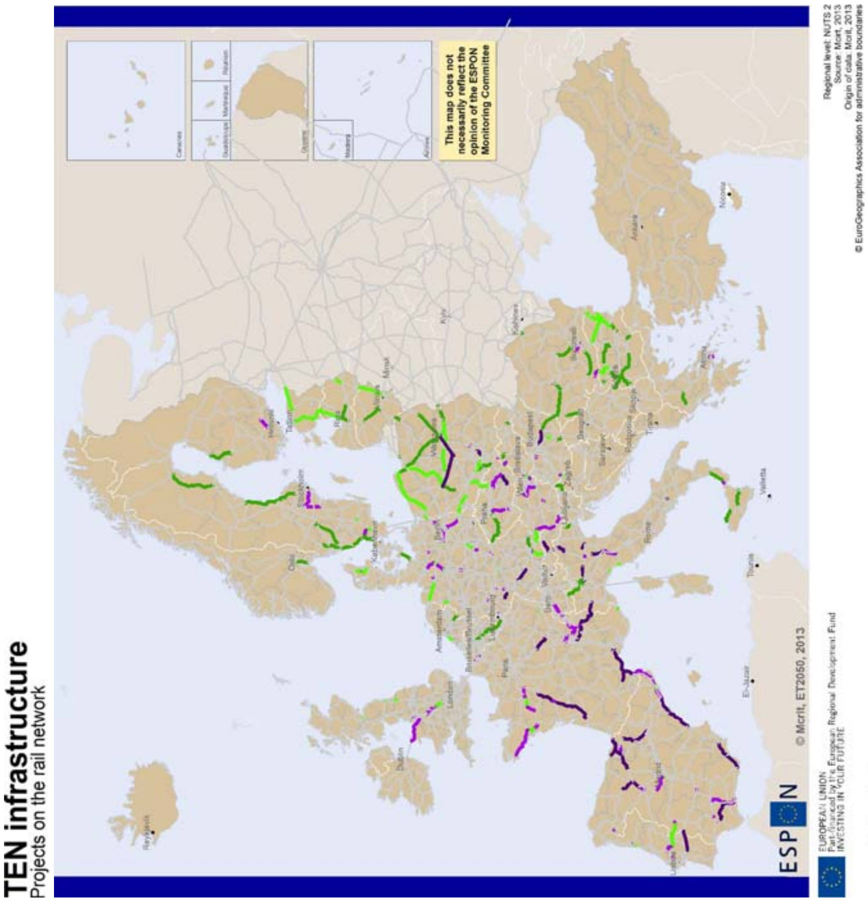


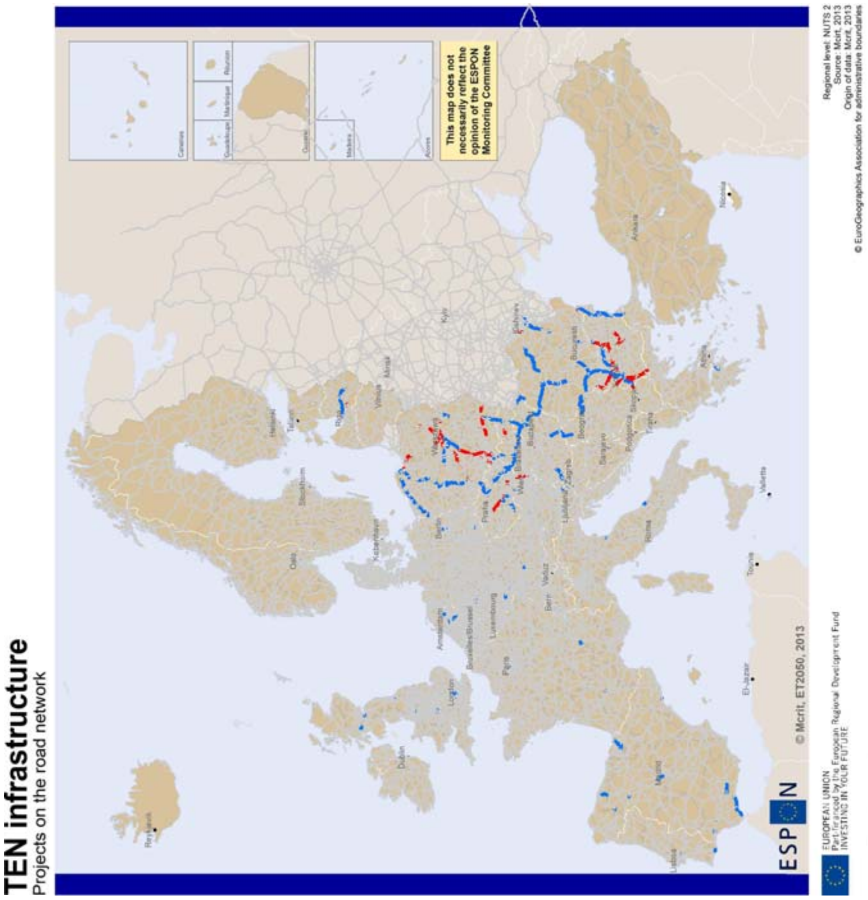
The following two maps show the implemented rail and road networks for the **A Scenario** up 2030



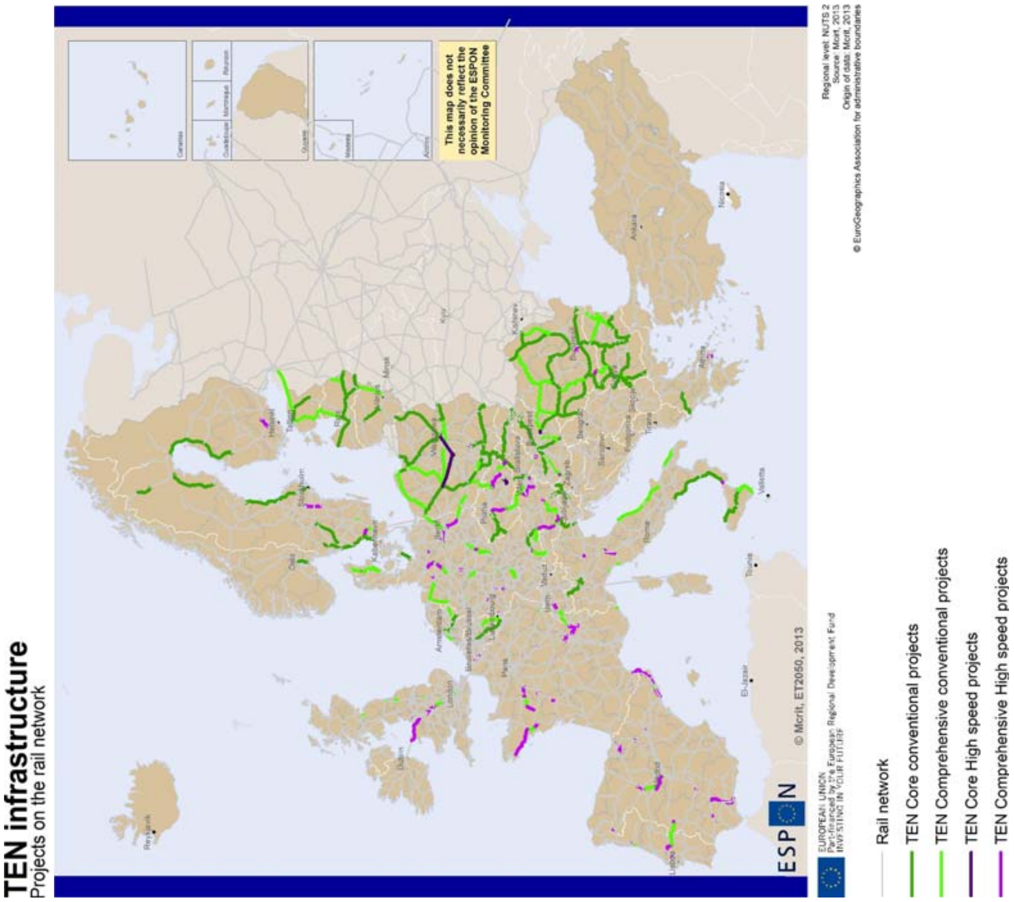


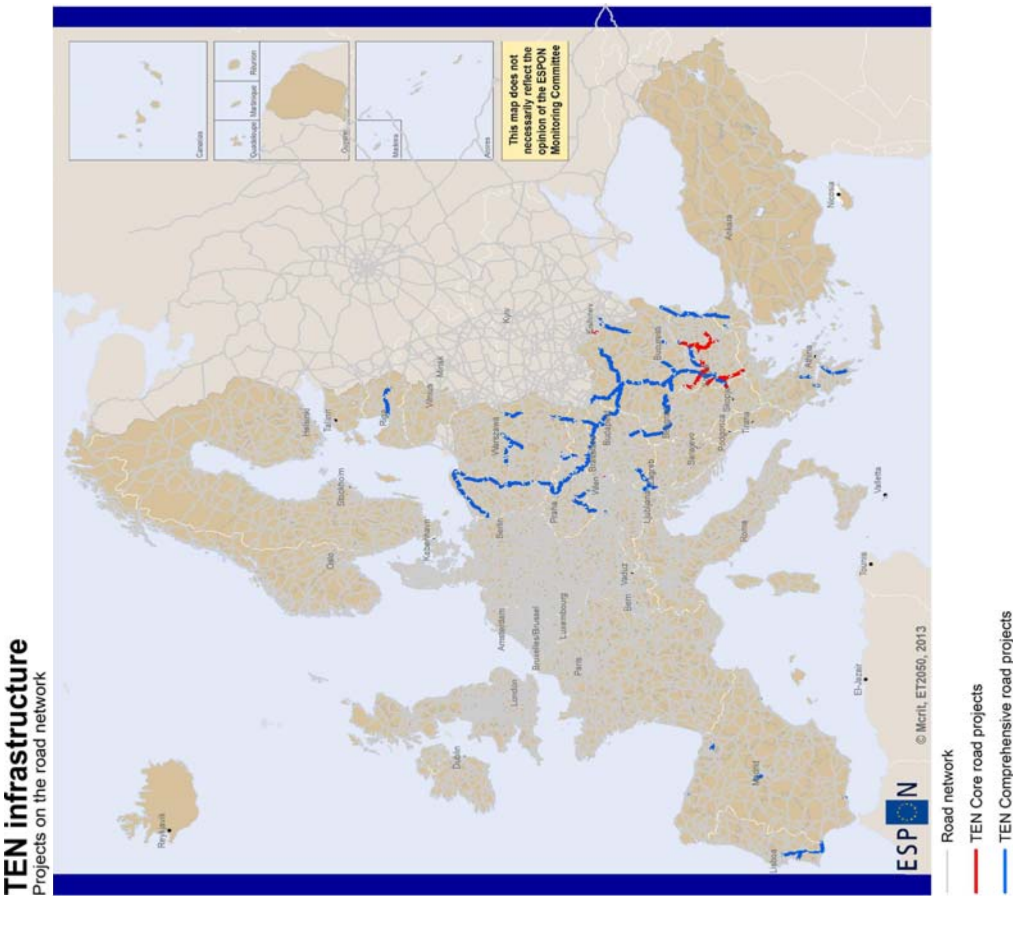
The following two maps show the implemented rail and road networks for the **B Scenario** up 2030





The following two maps show the implemented rail and road networks for the **C Scenario** up 2030

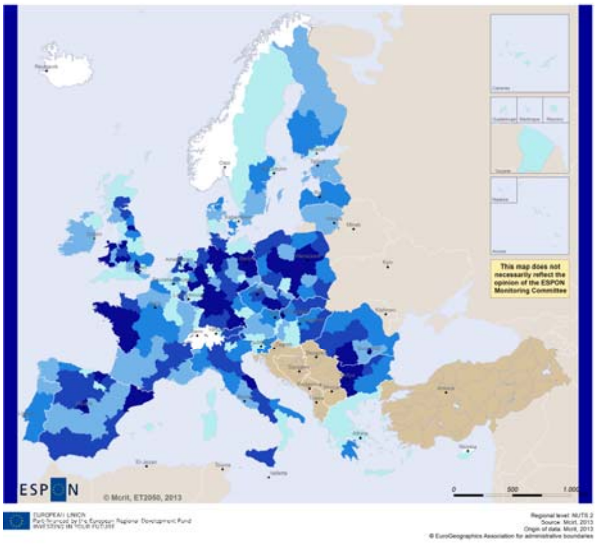




European Transport Investments 2013 - 2030

Measured as Investment per area (millions €/km2)

Baseline 2030

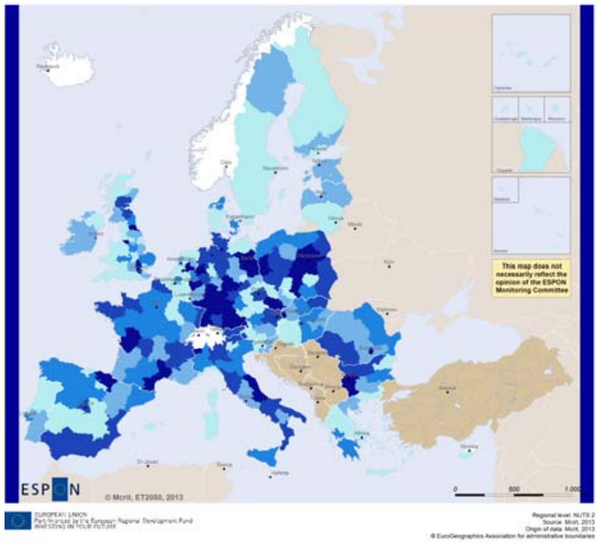


BASELINE 2030. Transport Investments in TENs (maintenance excluded)

Budget allocated to each NUTS2 represented in Million Euros per km2. Accumulated 2013-2030

- 0,00
- 0,01 - 0,03
- 0,04 - 0,08
- 0,09 - 0,17
- 0,18 - 4,73

Scenario A 2030

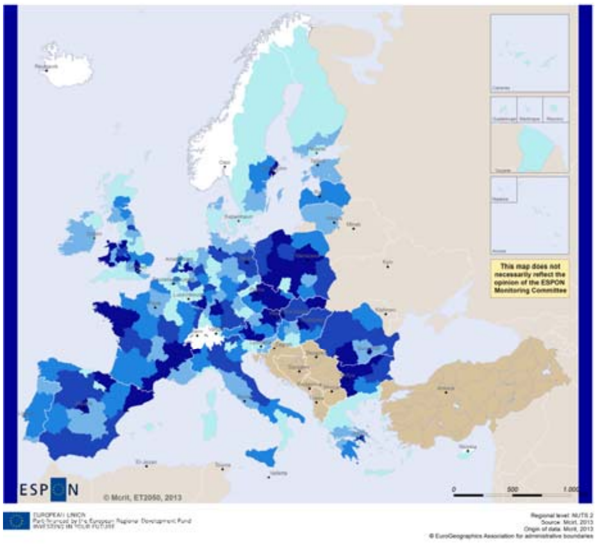


SCENARIO A 2030. Transport Investments in TENs (maintenance excluded)

Budget allocated to each NUTS2 represented in Million Euros per km2. Accumulated 2013-2030

- 0,00
- 0,01 - 0,05
- 0,06 - 0,09
- 0,10 - 0,19
- 0,20 - 4,57

Scenario B 2030

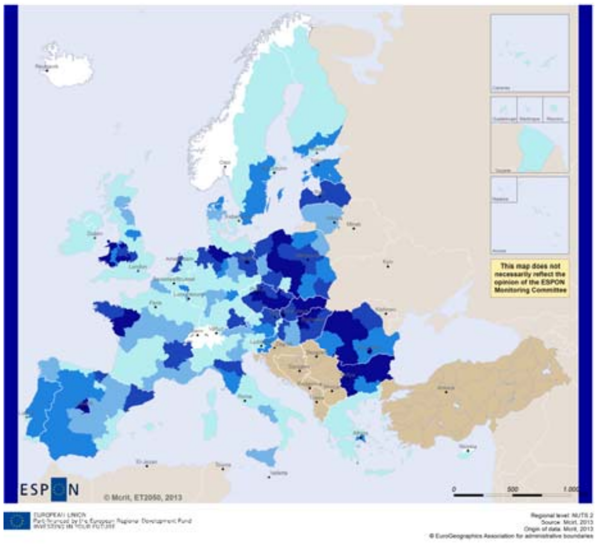


SCENARIO B 2030. Transport Investments in TENs (maintenance excluded)

Budget allocated to each NUTS2 represented in Million Euros per km2. Accumulated 2013-2030

- 0,00
- 0,01 - 0,05
- 0,06 - 0,11
- 0,12 - 0,21
- 0,22 - 6,17

Scenario C 2030



SCENARIO C 2030. Transport Investments in TENs (maintenance excluded)

Budget allocated to each NUTS2 represented in Million Euros per km2. Accumulated 2013-2030

- 0,00
- 0,01 - 0,02
- 0,03 - 0,09
- 0,10 - 0,23
- 0,24 - 2,95

Budget allocated in the TENs at NUTS2 level, 2013-2030

Allocation of transport investment at National level

The methodology to allocate transport investment budgets at regional and national in ET2050 scenarios is as follows.

- European-wide regional and national budgets are determined in each scenario based on the overall transport budget available (dependant on GDP growth and the % GDP spent in transport), and the share of this budget spent in regional and national infrastructure. The insides of this process are presented in previous chapters.

- The European-wide regional and national budget for transport infrastructure is distributed among countries proportionally to their GDP. This assumption takes into account that the budget for regional and national transport infrastructure is provided by the capacity of each national economy.

- National budgets are distributed among NUTS3 in each scenario according to the following criteria:

    - BASELINE: National and regional investments allocated based on regional GDP, population and surface

    - FLOWS: National and regional investments allocated based on regional GDP

    - CITIES: National and regional investments allocated based on regional population

    - REGIONS: National and regional investments allocated based on regional surface

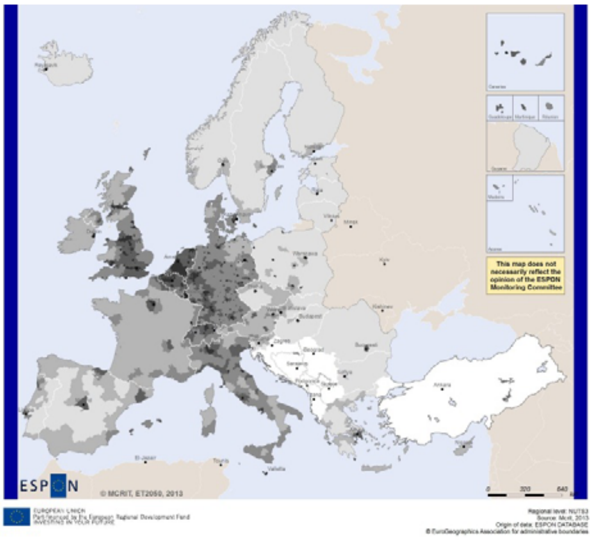
Country	BASELINE	FLOWS	CITIES	REGIONS
Austria	15,3	11,0	18,7	11,7
Belgium	18,7	13,4	22,8	14,3
Bulgaria	1,9	1,4	2,3	1,5
Switzerland	18,5	13,3	22,6	14,2
Cyprus	0,9	0,7	1,1	0,7
Czech Republic	8,0	5,7	9,8	6,1
Denmark	12,6	9,0	15,4	9,7
Germany	134,2	96,1	163,9	102,6
Estonia	0,9	0,6	1,1	0,7
Spain	58,8	42,2	71,9	45,0
Finland	10,0	7,2	12,2	7,6
France	105,4	75,5	128,7	80,6
Greece	12,8	9,2	15,7	9,8
Hungary	5,8	4,1	7,0	4,4
Ireland	9,7	7,0	11,9	7,4
Iceland	0,6	0,4	0,7	0,4
Italy	84,8	60,7	103,6	64,8
Liechtenstein	0,2	0,1	0,2	0,1
Lithuania	1,7	1,3	2,1	1,3
Luxembourg	2,1	1,5	2,6	1,6
Latvia	1,2	0,9	1,5	1,0
Malta	0,3	0,2	0,4	0,2
Netherlands	32,2	23,1	39,4	24,6
Norway	12,5	8,9	15,2	9,5
Poland	19,6	14,1	24,0	15,0
Portugal	9,3	6,7	11,4	7,1
Romania	7,6	5,4	9,2	5,8
Sweden	18,0	12,9	22,0	13,8
Slovenia	2,0	1,4	2,5	1,5
Slovak Republic	3,5	2,5	4,3	2,7
United Kingdom	98,2	70,3	119,9	75,0
ESPON	707,4	506,8	864,2	540,8

National and regional transport investment, per countries (in € 1000 million)

National Transport Investments 2013 - 2030

Measured as Investment per area (millions €/km2)

Baseline 2030

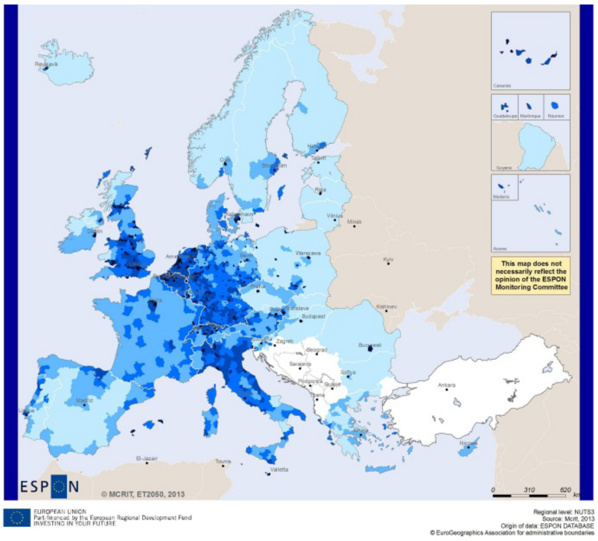


National Transport Investments (TENs and maintenance excluded)

Budget allocated to each NUTS3 represented in Million Euros per km2. Accumulated 2013 - 2030

- < 0,08
- 0,08 - 0,20
- 0,20 - 0,35
- 0,35 - 0,70
- > 0,70

Scenario A 2030

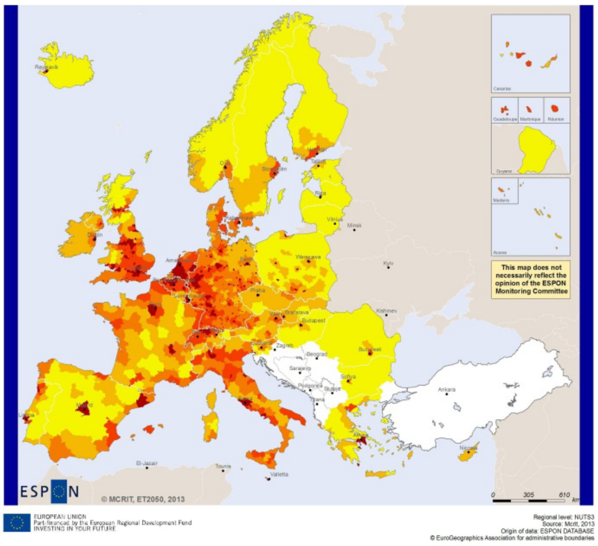


National Transport Investments (TENs and maintenance excluded)

Budget allocated to each NUTS3 represented in Million Euros per km2. Accumulated 2013 - 2030

- < 0,06
- 0,06 - 0,12
- 0,12 - 0,22
- 0,22 - 0,62
- > 0,62

Scenario B 2030

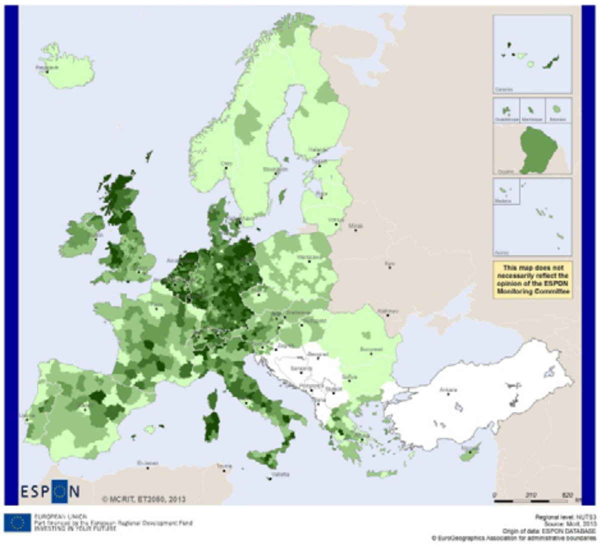


National Transport Investments (TENs and maintenance excluded)

Budget allocated to each NUTS3 represented in Million Euros per km2. Accumulated 2013 - 2030

- < 0,07
- 0,07 - 0,18
- 0,18 - 0,34
- 0,34 - 0,98
- > 0,98

Scenario C 2030



National Transport Investments (TENs and maintenance excluded)

Budget allocated to each NUTS3 represented in Million Euros per km2. Accumulated 2013 - 2030

- < 0,04
- 0,04 - 0,10
- 0,10 - 0,20
- 0,20 - 0,35
- > 0,35

Budget allocated in National transport networks at NUTS3 level, 2013-2030

2.2 TRANSPORT POLICY ASSUMPTIONS

The general transport policy orientations of the A, B and C scenarios are assumed as follows:

Policy Area	A Scenario	B Scenario	C Scenario
Liberalisation of the transport market	High	Medium	Low
Pricing and taxation	Low	Medium	High pricing
Infrastructure provision	Low	High	Medium
Service management	High	Low	Medium
Bans and regulations	Medium	Medium	High

Following these general orientations, different transport policies have been considered when defining each scenario.

The **A Scenario** considers intensively increasing performance of existing infrastructure through better management and higher technological implementation. Satellite guidance allows optimal routing in road transport; revised airport procedures reduce check-in / security times to 15 minutes for short haul and 30 minutes to long haul flights; integrated EU air space management to accommodate three times more air movements and better management of landing and take off manoeuvres at airports optimises air transport so that 99% of flights arrive and depart within 15 minutes of their scheduled time in all weather conditions[18]; A substantial reduction of subsidies to infrastructure investment (public funding) and service operation, forces each mode to become more economically self-sufficient, sometimes requiring increases of transport fees in currently more subsidised modes. A diversification of funding sources involves the private sector to a higher level (e.g. PPPs, MACs, project bonds).

Example: IATA Check Point of the Future

The Checkpoint of the Future ends the one-size-fits-all concept for security. Passengers approaching the checkpoint will be directed to one of three lanes: ‘known traveller’. ‘normal’. and ‘enhanced security’. The determination will be based on a biometric identifier in the passport or other travel document that triggers the results of a risk assessment conducted by government before the passenger arrives at the airport. The three security lanes will have technology to check passengers according to risk. “Known travelers” who have registered and completed background checks with government authorities will have expedited access. “Normal screening” would be for the majority of travellers. And those passengers for whom less information is available. who are randomly selected or who are deemed to be an “Elevated risk” would have an additional level of screening. Screening technology is being developed that will allow passengers to walk through the checkpoint without having to remove clothes or unpack their belongings. Moreover. it is envisioned that the security process could be combined with outbound customs and immigration procedures. further streamlining the passenger experience.

Near term concept for airport checkpoint of the future by IATA. aimed at drastically reducing check-in and security times at airports (allowing for access to airports up to 15 minutes only before a flight departure)

[18] As reflected in ACARE Vision 2020 (and Flightpath to 2050, Targets on Levels of Service

The **B Scenario** considers a rising level of transport infrastructure investment, especially focused on rail programs aimed to enlarging current HSR network in Europe in line with White Paper targets and mostly financed from public funds. The Single European Transport Area is reinforced to facilitate seamless mobility across Europe, but competition from outside Europe (e.g. aviation companies from third countries) is not opened. Road pricing is extended to motorways today not having tolls. ICTs in large urban areas result on less congested road traffic allowing for greater speeds in city access and egress. The wide-spread application of ERTMS systems allow for 10% faster operating rail.

Example: Motorway Control System in Stockholm and France

The Motorway Control System (MCS) installed on the E4 motorway through Stockholm is aimed at better managing the flow of traffic in Stockholm's motorways through ICTs. The system has been in operation since the late nineties and is currently being expanded. It includes a dynamic speed limiting system based on real-time speed detection in the motorway. Studies by the KTH in Stockholm (K.Bang. A.Nissan et al) seem to point that MCS decreases the deviation of speeds in the motorway. which would indicate an improvement in homogeneity and traffic safety. MCS also reduced the frequency of very short headways as well as the frequency of lane changes between the middle and the left lane. In France. in the Rhone Valley motorway network (A7-A9 motorways from Lyon to the Spanish border) ITS are being implemented in the same direction. This motorway corridor is particularly busy during the summer time and recurring congestion deeply lowers the level of service. ASF. the motorway manger. designed and implemented a variable speed limit system in order to increase the corridor capacity. the infrastructure safety and driver comfort. Following the very positive results of the 2004 experiment. ASF decided to extend the variable speed limits service to 330 km of the A7/A9 motorway network. Among others. the system reduced accidents by 20 to 30%. congestion by about 20% and increased capacity in the corridor by 3 to 5%.

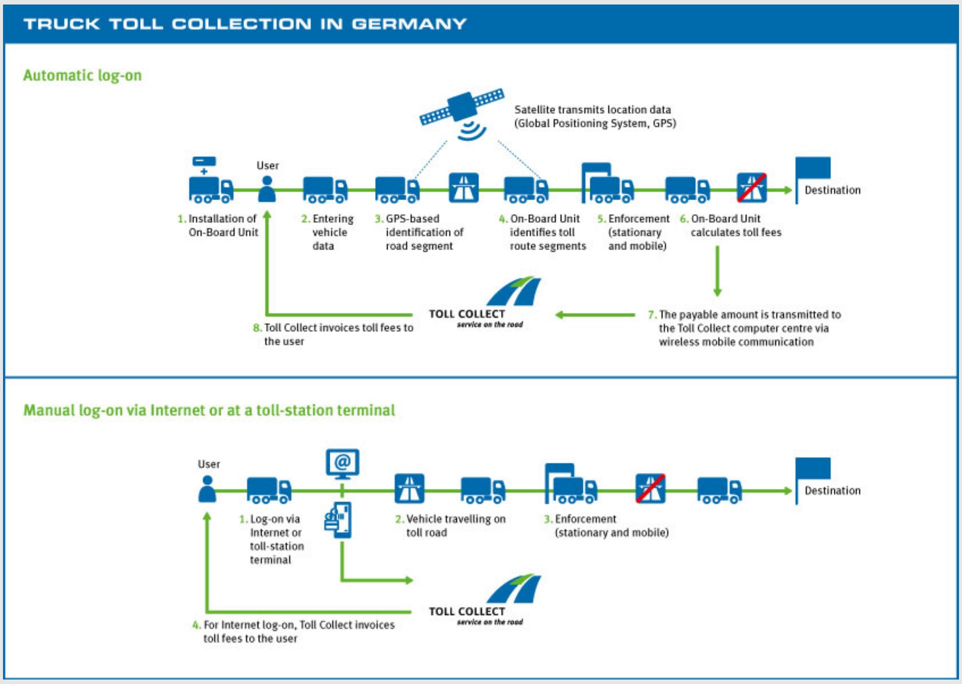
Motorway Control System in Stockholm improves homogeneity and traffic safety. reduces the frequency of very short headways as well as the frequency of lane changes between the middle and the left lane.

The **C Scenario** considers a regulation framework is set up to encourage the use of more environmentally friendly modes, and this includes increased road pricing as an extension of Eurovignette to cars, extended air taxation, limited maximum speeds in motorways to disencourage the use of private cars for passenger transport. Subsidies are dedicated to greener transport services or aiming at territorial cohesion. Increased vehicle research and Euro Standard regulations over the private sector bring down vehicle emissions from new vehicles, lowering average emission factors of the vehicle fleet. Favourable taxation and technological developments promote expansion of alternative fuelled cars fleet. The technological promotion will as well foster the development of vehicles with less weight than traditional engines leading to much lower fuel consumption. More efficient driving regimes are favoured with enhanced vehicle technologies and user training.

Example: Vehicle Miles Travelled taxation; Mobimiles in Netherlands and LKW-MAUT in Germany

A vehicle miles travelled (VMT) tax based on GPS technologies for passenger vehicles has been proved feasible in several pilot trials in the past (e.g. USA Oregon State. 2007). but has yet not been implemented anywhere. In Europe. the Netherlands is willing to transition to a VMT by 2018 and while Denmark and several USA states are considering this system as well. Distance based taxation is already implemented for freight in Europe in certain areas. as a consequence of the Eurovignette directive. Member states may apply an "external cost charge" on trucks. complementing already existing infrastructure charging. They may also modulate the infrastructure charge to take account of road congestion. with a maximum variation rate of 175 %

during peak periods limited to five hours per day. The level of tolls can vary depending on the emissions of the vehicle. the distance travelled. and the location and the time of road use. Such differentiated charging is intended to encourage the move to transport patterns which are more respectful of the environment. Based on GPS technology and relying on transponders installed inside vehicles. Germany applies since 2005 the LKW-MAUT tax for trucks based on the distance driven in kilometres. time of the trip. number of axles and the emission category of the truck. The tax is levied for all trucks using German autobahns. whether they are full or empty. foreign or domestic. and rises €2.4 billion per year mostly dedicated to road investment.



LKW-MAUT tax collecting and enforcement system in Germany

Next table presents a synthesis of main hypothesis:

	A Scenario	B Scenario	C Scenario	BASELINE
Market liberalisation	-5% road and air transport costs due to liberalisation +5% rail cost increases due to decreased public subsidies	Like Baseline	-5% rail cost decrease due to increased subsidies	Limited liberalisation to procedures of public tendering of services
Transport taxation and pricing	Like today	Pricing in those motorways where there are no tolls today	+ 5% road and air transport costs due to taxation	Like today
Infrastructure provision	0,60% of EU GDP in infrastructure provision by 2030 (€1630Bn)	1,00% of EU GDP in infrastructure provision by 2030 (€2320Bn)	0,70% of EU GDP in infrastructure provision by 2030 (€1780Bn)	0,80% of EU GDP in infrastructure provision by 2030 (€1970Bn)
Optimised service management	0,07% of EU GDP yearly in smart ITS infrastructure equipment +10% average air speed due to enhanced management (mostly airport take-off / land optimisation)	0,02% of EU GDP yearly in smart ITS infrastructure equipment +10% average rail speed due to enhanced management	0,04% of EU GDP yearly in smart ITS infrastructure equipment +5% average rail speed due to enhanced management	0,02% of EU GDP yearly in smart ITS infrastructure equipment
Bans and regulations	-10% vehicle emission factors respect to Baseline, due to environmental regulation	-10% vehicle emission factors respect to Baseline, due to environmental regulation	- 5% average road speeds due to regulation -20% vehicle emission factors respect to Baseline, due to environmental regulation	Car emission factors in 2030 a 30% lower than in 2010, with development of new technologies and driven by Euro Standard regulations

Transport and energy assumptions for A, B and C Scenarios

3 MAIN RESULTS

3.1 Impacts on Accessibility

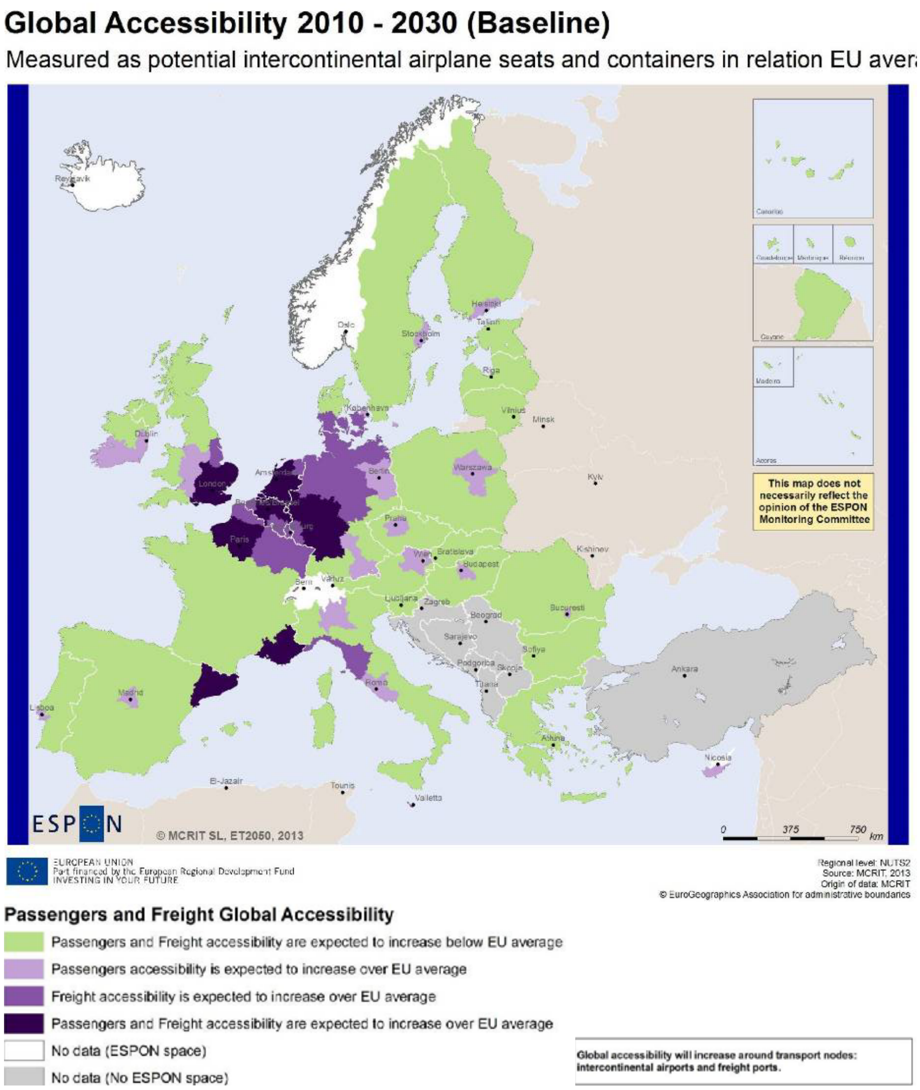
3.1.1 Global Accessibility: Towards Increasing Polarisation in the Baseline

More relevant accessibility differences across European regions will be related to global connectivity.

Accessibility to intercontinental flights becomes mostly available around core airports in Europe (London, Paris, Amsterdam and Frankfurt). Madrid also emerges as a global hub. Several European capitals (Rome, Warsaw, Praha, Wien, Copenhagen, Stockholm, Berlin), and large metropolitan areas (Milano, Nice/Marseille, Barcelona) will play a complementary role, while small regional airports will grow because of specific purposes (e.g. low-cost, tourism, corporative…).

Freight accessibility to extra-EU markets dominated, still as today, by Northern European ports, mostly by Rotterdam, Hamburg, Antwerp and Bremen, with the significant contribution of Felixtowe, the Hague and Zeebrugge. Limited growth of Mediterranean ports, especially Barcelona, Valencia and Genoa, not much other ports like Algeciras, Gioia-Tauro, Marsaxlock (Malta), Athens.

The connexion between Second-Tier Cities and regions to main global hubs become a critical development condition. While more networked-like structures may emerge at European scale, increase hub-spoke hierarchical configurations emerge at global scale.



Baseline – Global Accessibility increase 2010-2030

At regional level:

- ***Baltic Sea – Artic Region***. The hub strategies implemented by Nordic airline provides consolidate the position of the capital regions of Helsinki, Stockholm and Copenhagen as main the Nordic countries' main global gateways. However, in those countries, the active policy strategy of developing secondary airports gives the opportunity for local businesses and persons in other parts of these countries to benefit from this improved global accessibility. In the Baltic States, the lack of modern airport infrastructure and the limited extent of international-oriented services in their economic base limits their incentive and capacity to develop more global reach. In the latest years especially Helsinki but partly also Stockholm have started to profile their airports as getaways to Asia, especially to China and Japan.
- ***North-west Europe.*** The global accessibility of the North Western Europe is polarized in already highly accessible regions linking Frankfurt, London, Paris and Amsterdam, regions with high densities of transport infrastructures for airplane passengers and containers. The global accessibility of peripheral regions such as the Provence-Alpes-Côtes d'Azur in France and the Leinster / Munster regions in Ireland benefits of their harbours infrastructures combined to good airplane connections.
- ***Central and Alpine region.*** The Baseline map of global accessibility conforms to expectation.
- ***Central European region.*** Accessibility in the region mostly increases along TEN networks and in major aviation hubs; the South-Eastern transport connection plays a tertiary role in transport compared to the North-Eastern German–Russian corridor and the global integration of Core Europe. The weakness of urban counter-poles (with the potential exceptions of Poland and Romania) diminishes their individual transport roles, particularly with the assumption of a Europe of MEGAs. Under the absolutisation of global integration, the region will remain a backwater.
- ***South-Central Mediterranean Region.*** The relative peripherality of both EU Countries encompassed in this macro-region implies a relatively weak growth of accessibility in both of them. Lombardy, with Milan's airport system, and Lazio, with Rome's, are expected to experience a higher than average growth of passenger accessibility. Surprisingly, Tuscany and Liguria, that are usually less well-connected areas, present remarkable growth of both passenger as well as freight accessibility. All other regions in this macro-region present low growth of both indicators.
- ***Western Mediterranean Region.*** Consolidation of Madrid as the European getaway to South America, and a like increase in Europe-Africa traffics (e.g. Maghreb). Secondary role for Lisbon, Barcelona and Nice/Marseille airports. Intercontinental traffics in these airports far from leading airports in Europe. The development of these airports can be driven by a further development of intercontinental leisure tourism resulting from expanding middle classes in BRIC and other developing countries, and by global business tourism (e.g. fairs and congresses).

  Valencia, Balearic Islands and Canary Islands remain attractive only at European level, with relatively low intercontinental connections despite high levels of overall aerial traffics in airports such as Palma de Mallorca, Tenerife and Alicante, mostly linked to summer tourism. Andalusia far from these levels despite the importance of tourism in the region. Castilla-la-Mancha performing better than other regions due to the influence of Madrid.

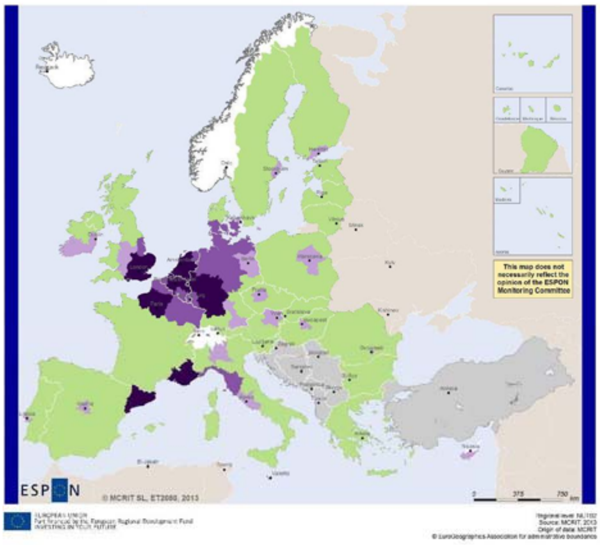
  Mediterranean ports will not be able to effectively increase their hinterlands into Europe, despite recent important investments to increase capacity in several ports. Leading role of the tandem Barcelona-Valencia in the Western Mediterranean region, driven by relatively high role of manufacturing (exports) and the importance of the inland hinterland (imports), which comprises Madrid. Gibraltar, Marsaxlock (Malta), Gioia Tauro maintain a clear transhipment role in the future, by 2030. A greater role of Marseille could be expected in the future, taking into consideration the strength of the Europe / Asia traffics, and the good geographical location of this port in the head of the Rhone/Rhine axis.

3.1.2 Global Accessibility: Rebalance of European Hubs may be possible according to scenario analysis

Global accessibility tends to remain concentrated in the core of Europe for the Baseline scenario and the A Scenario, indicating that key global hubs (ports and airports) mostly remain inside the Pentagon. Scenario B explores the possibility of a strong development of the Mediterranean ports for the commerce with Asia, whereas Scenario C tends to distribute activities to a higher extent all over the continent.

Global Accessibility 2010 - 2030 (Baseline)

Measured as potential intercontinental airplane seats and containers in relation EU aver

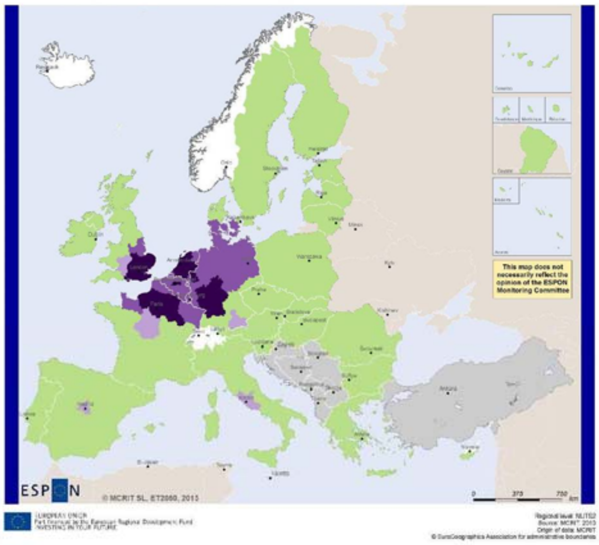


Passengers and Freight Global Accessibility

- Passengers and Freight accessibility are expected to increase below EU average
- Passengers accessibility is expected to increase over EU average
- Freight accessibility is expected to increase over EU average
- Passengers and Freight accessibility are expected to increase over EU average
- No data (ESPON space)
- No data (No ESPON space)

Global Accessibility 2010 - 2030 (Scenario A)

Measured as potential intercontinental airplane seats and containers in relation EU aver

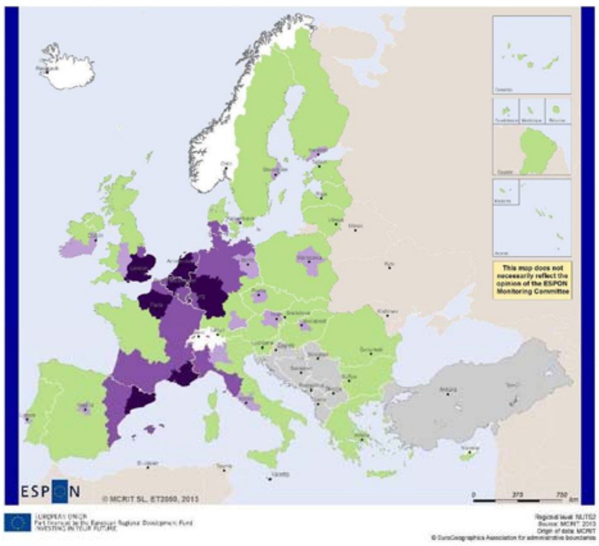


Passengers and Freight Global Accessibility

- Passengers and Freight accessibility are expected to increase below EU average
- Passengers accessibility is expected to increase over EU average
- Freight accessibility is expected to increase over EU average
- Passengers and Freight accessibility are expected to increase over EU average
- No data (ESPON space)
- No data (No ESPON space)

Global Accessibility 2010 - 2030 (Scenario B)

Measured as potential intercontinental airplane seats and containers in relation EU aver

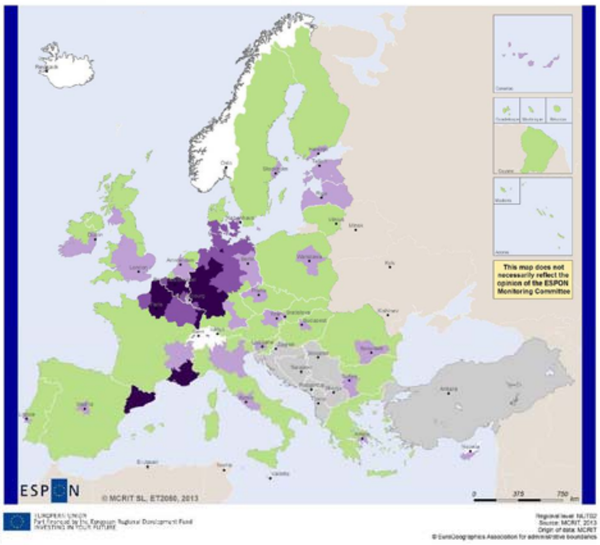


Passengers and Freight Global Accessibility

- Passengers and Freight accessibility are expected to increase below EU average
- Passengers accessibility is expected to increase over EU average
- Freight accessibility is expected to increase over EU average
- Passengers and Freight accessibility are expected to increase over EU average
- No data (ESPON space)
- No data (No ESPON space)

Global Accessibility 2010 - 2030 (Scenario C)

Measured as potential intercontinental airplane seats and containers in relation EU aver

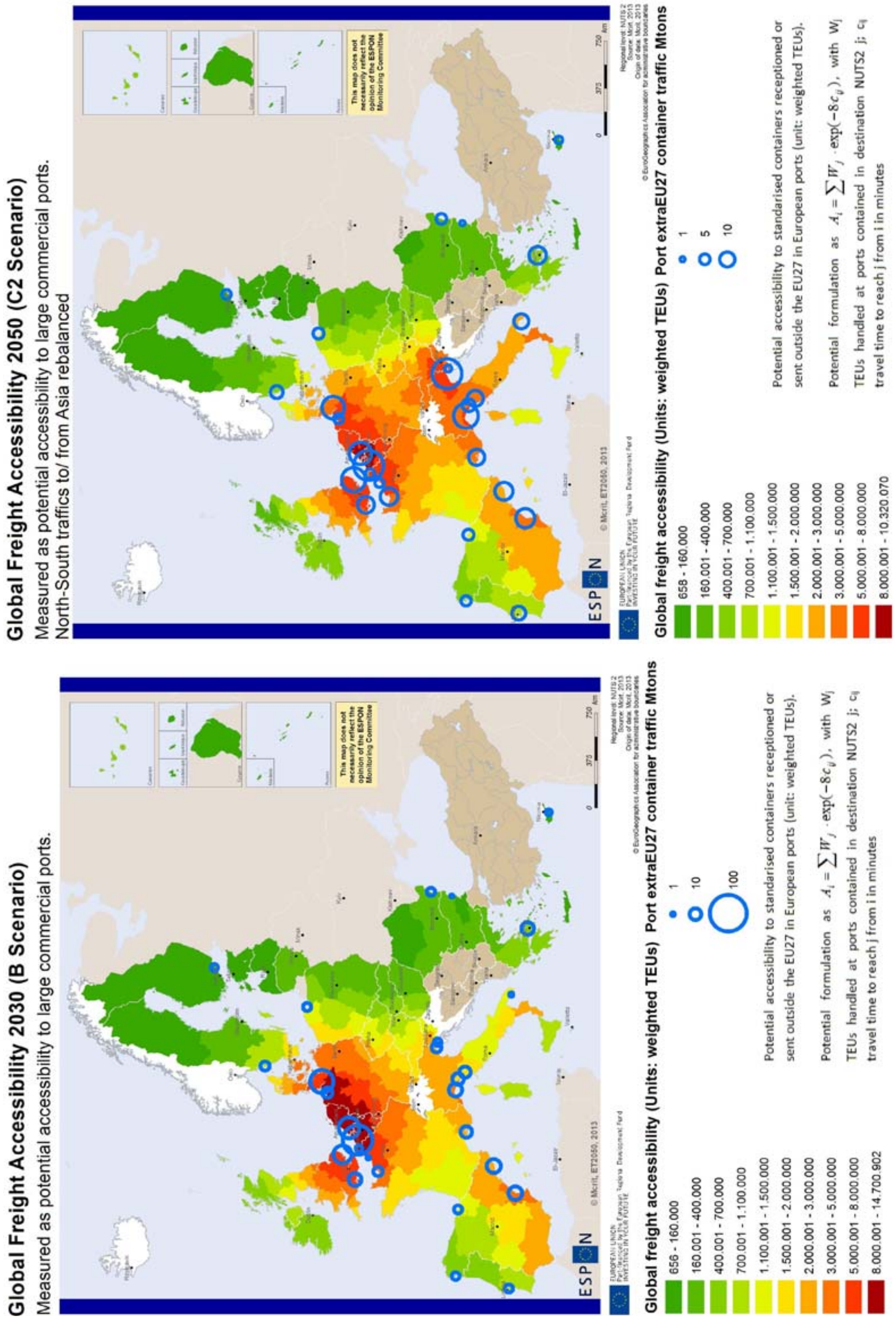


Passengers and Freight Global Accessibility

- Passengers and Freight accessibility are expected to increase below EU average
- Passengers accessibility is expected to increase over EU average
- Freight accessibility is expected to increase over EU average
- Passengers and Freight accessibility are expected to increase over EU average
- No data (ESPON space)
- No data (No ESPON space)

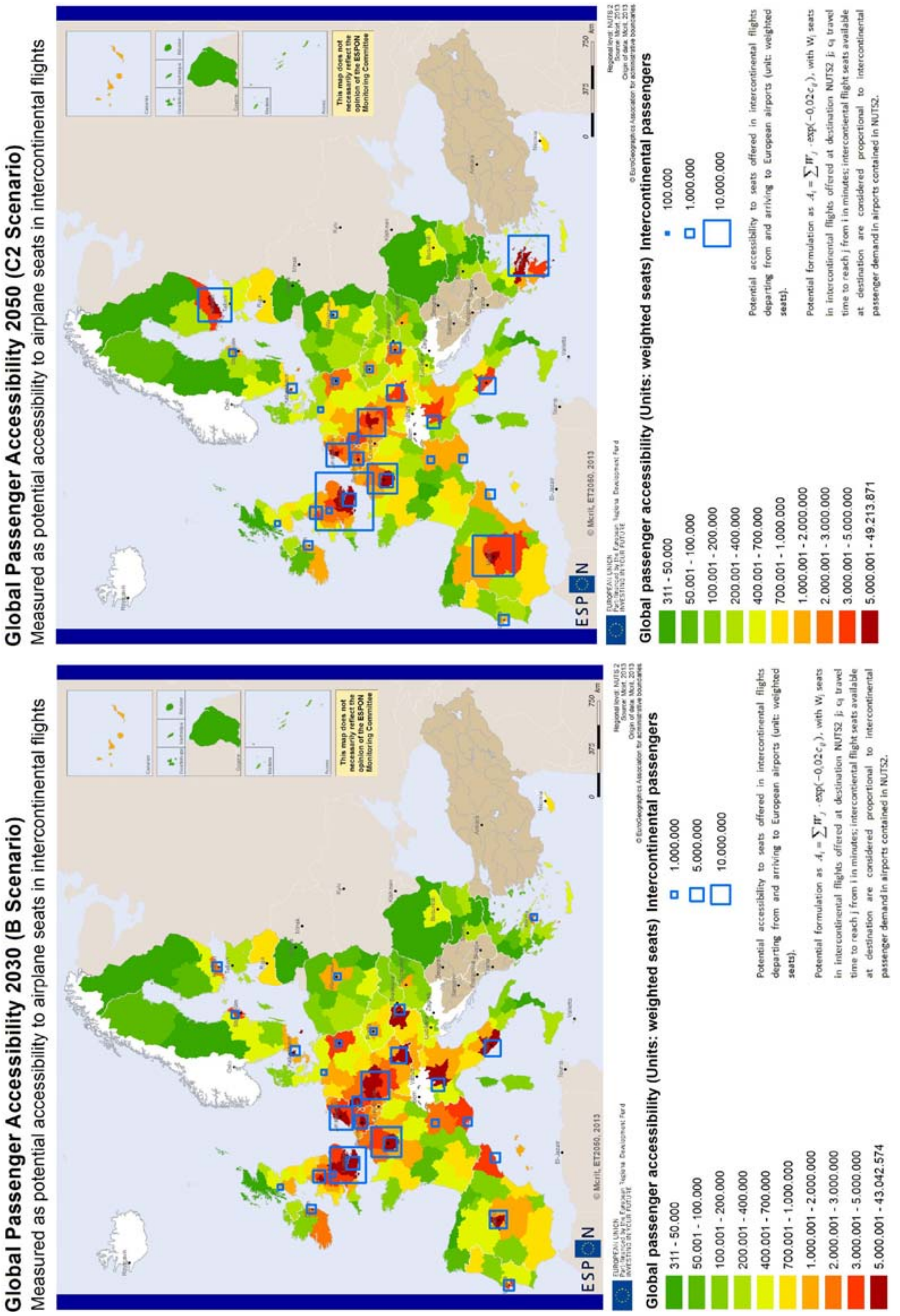
Exploratory Scenarios – Global Accessibility Increase 2010-2030

For accessibility to global ports, if a more polycentric system of global ports in Europe was promoted, as considered by the Scenarios B and C, economic savings could be of great importance. Today, the maritime transport flows between Europe and Asia represent approximately 3 times in magnitude the size of flows between Europe and the Americas (18MTEU vs 6MTEU, Drewry 2008). 75% of the traffics through the Mediterranean and bound for Europe are handled in the Northern European ports (mainly Rotterdam, Hamburg, Antwerp and Bremen). If these container traffics were handled already in the Mediterranean, this would save time, euros, emissions of GHG and contaminants, and alleviate congestion in areas such as the English Channel.



Rebalance of European Port Network. Scenarios B and C

The 70% of the intercontinental air European transport is generated at 4 airports, corresponding to the bases of national flag carriers up front of the different air alliances: British Airways–One World handle 25% of EU intercontinental traffic at Heathrow, Lufthansa–Star Alliance 15% at Frankfurt, Air France-Skyteam 17% at Paris CdG and KLM–Skyteam.(13%) at Amsterdam Schiphol. However, the economic, environmental and time saving could be large if the European getaways were more distributed (e.g. Madrid / Lisbon for flights to latin America, Helsinki for flights to China, Athens or Istambut for flights to the middle east and southeast Asia).



Rebalance of European Airport Network. Scenarios B and C

3.1.3 European Accessibility: More infrastructure does not lead to more accessibility

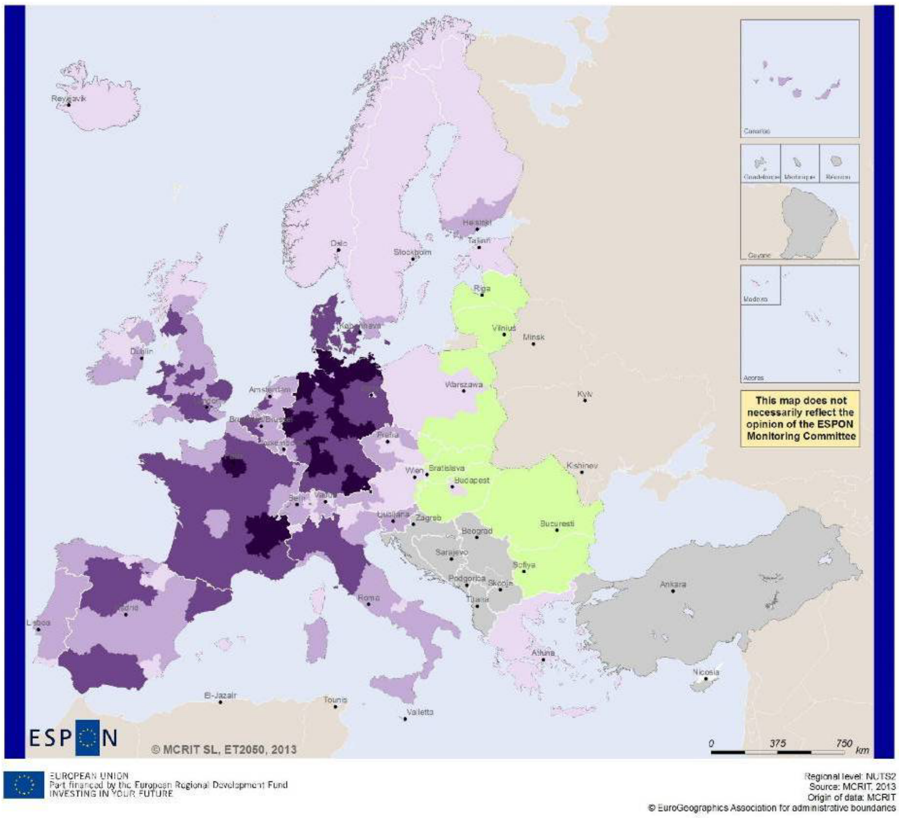
Increase in transport endowment mostly concentrated in Eastern European, and still in Southern European, regions

Even if investments on infrastructure are reduced in the coming years, accessibility patterns will tend to become more homogeneous across European regions, if measured in terms of endowment (but no if measured in terms of people or GDP accessible in a given time or generalised cost).

Accessibility measured as the accessible population weighted by the time of reaching this population always improves when new infrastructure is built, excepts in regions where population declines. When considering the cost of using infrastructure, accessibility measured as accessible population within a limited travel budget does not increase everywhere. When higher travel costs associated to new transport infrastructure are not compensated by travel time savings, this may lower the accessibility in certain regions. This is especially relevant for passenger with lower values of time, e.g. private and holyday trips, and less for business travellers (e.g. infrastructure development in the Iberian Peninsula has almost no impact in accessibility for non-business trips.

European Accessibility 2010 - 2030 (Baseline)

Measured as change in accessible population weighed by shortest access time



Absolute variation in accessibility 2010-2030 (Units: Millions Equivalent population)

- < - 0
- 1 - 5
- 5 - 25
- 25 - 50
- > 50
- No data (ESPON space)
- No data (No ESPON space)

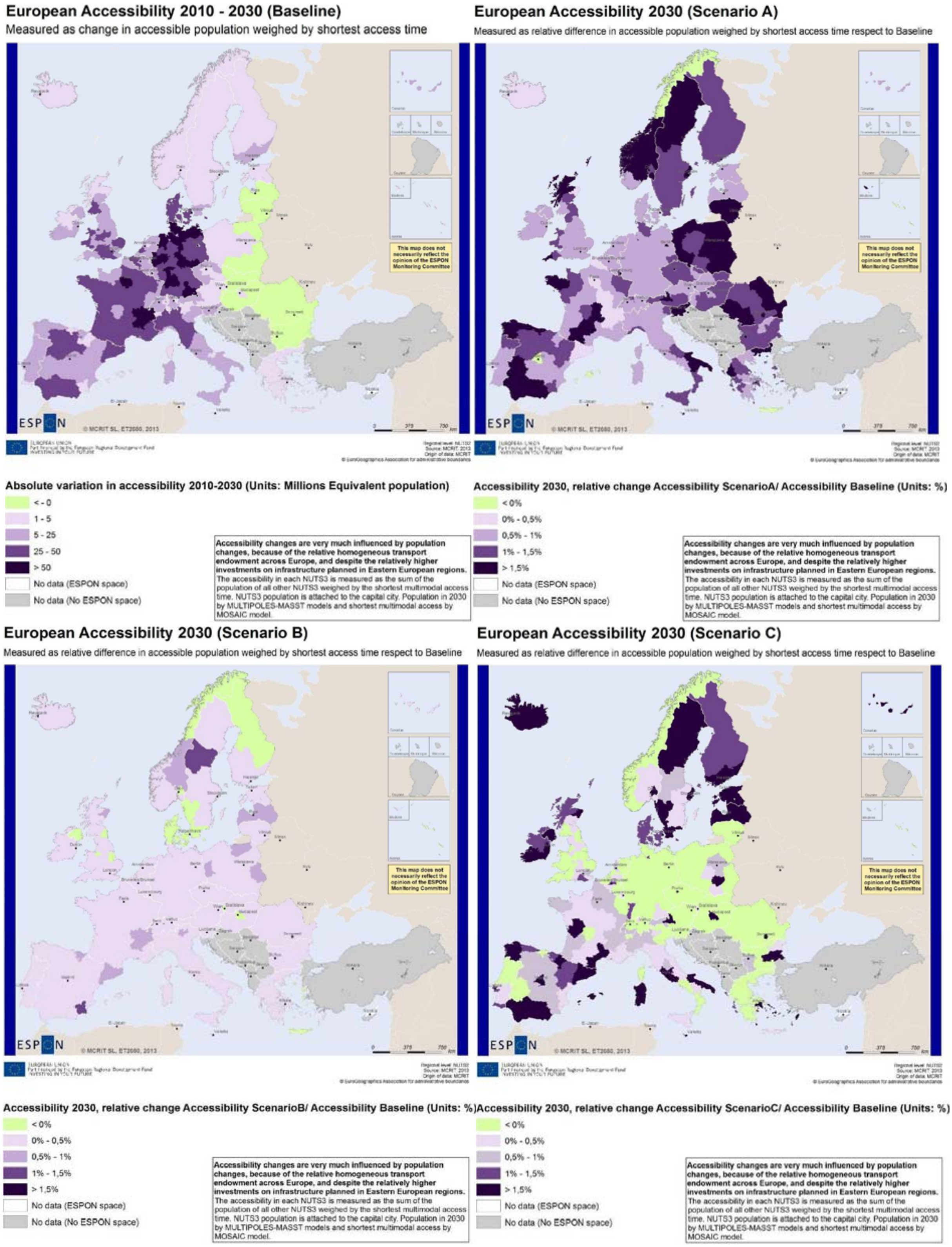
Accessibility changes are very much influenced by population changes, because of the relative homogeneous transport endowment across Europe, and despite the relatively higher investments on infrastructure planned in Eastern European regions. The accessibility in each NUTS3 is measured as the sum of the population of all other NUTS3 weighed by the shortest multimodal access time. NUTS3 population is attached to the capital city. Population in 2030 by MULTIPOLES-MASST models and shortest multimodal access by MOSAIC model.

Baseline – Global Accessibility increase 2010-2030

At Regional level:

- ***Baltic Sea –* Artic Region.** The relative small-size of the national economies and populations in the Baltic Sea and Arctic regions is a 'natural' limit for them to gain substantially in terms of European acces-sibility. Capital regions are the ones that gain most in terms of accessibility, even if other re-gions witness a slight improvement of their position with regards to accessibility. In the BSR, only Lithuania will witness a reduction of its relative accessibility.
- ***North-west Europe.*** Reinforcement of already highly positive dynamics in many North Western European Regions except in the South of Belgium, the North of Scotland and the North of The Netherlands which remain peripheral less accessible regions.
- ***Central and Alpine region.*** The Baseline map appears to be influenced by the choice of population as destination activity and the presentation of absolute rather than relative growth in accessibility between 2010 and 2030, otherwise the position of Germany would not be as dominant as shown in the map.
- ***Central European region.*** Improvement in absolute accessibility and transport infrastructure, but the increase of relative differences with respect to Core Europe. Highway investment projects may enjoy priority until the completion of adequate national networks; high-speed railways being restricted to a few select lines of European significance, connecting capital cities.
- ***South-Central Mediterranean Region.*** Accessibility as measured with millions of equivalent population experiences a very high increase in the traditionally industrialised areas in North-Western Italy, in line with rates to be found in Western Germany, Southern France, and South-Western England. Elsewhere in the macro-area, and in particular in Slovenia, only weak accessibility growth can be identified
- ***Western Mediterranean Region.*** Results confirms that accessibility in Southern regions is relatively high, at the level of the rest of Europe. Infrastructure in Spain, even if nowadays presents excess of capacity and high maintenance costs, is one of the key assets to help the future development of the country, together with land availability (in the interior regions). The infrastructure sector have grown during the latest decade to a very high level and begins to internationalise their activities.

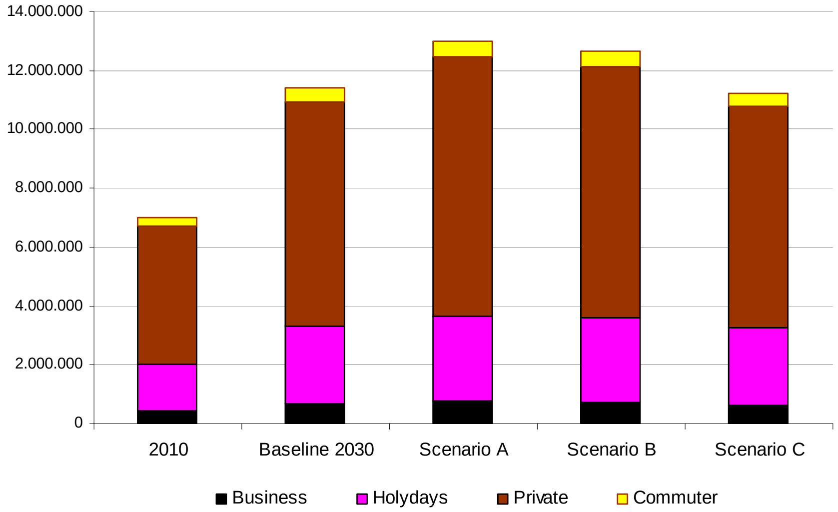
The results of scenarios in terms of accessibility are as follows: whereas the B Scenario and the Baseline are mostly coincident in terms of European accessibility (showing a general increase of core and western accessibility in Europe in relation to 2010), the Scenario C provides only with marginal accessibility increases but mostly concentrated in the Northern and Southern peripheries, while Scenario A provides greater accessibility to Eastern Europe, mostly due to new motorway projects.



Exploratory Scenarios – European Accessibility Increase 2010-2030

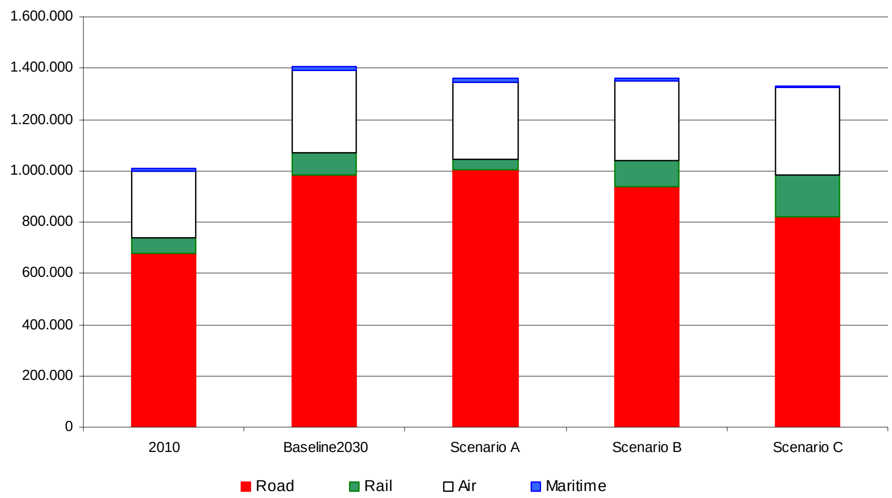
3.2 IMPACTS ON TRAFFICS

The number of trips between NUTS3 in Europe increases in all scenarios between 2010 and 2030, between 61% in Scenario C and 86% in Scenario A. The largest body of inter-NUTS3 trips remains the trips due to personal affairs (private trips), followed holydays.



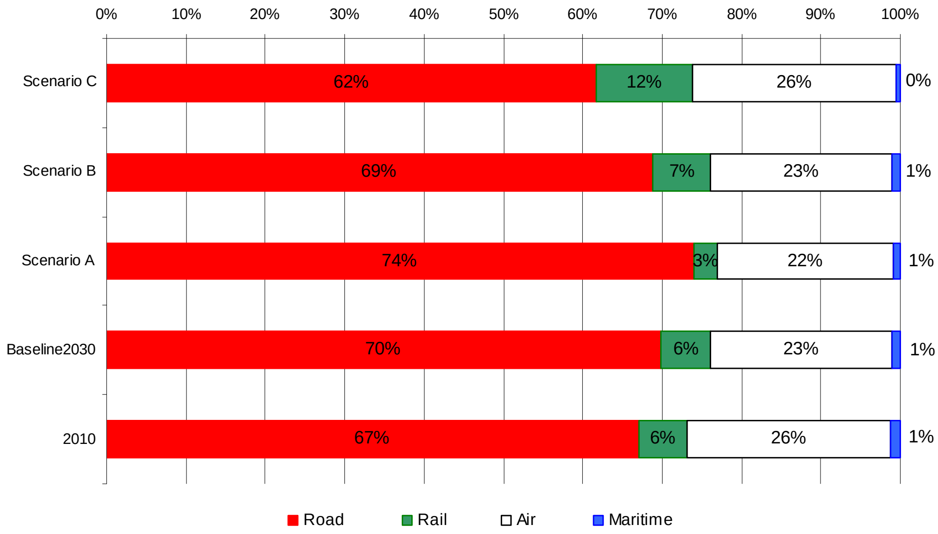
Total number of trips travelled yearly in Europe 2010 and 2030 (Baseline+Scenarios) by trip purpose

Long distance mobility in Europe is expected to grow from 2010 to 2030 in all scenarios, between 32% (Scenario C) and 39% (Baseline 2030). All scenarios result in less overall passenger·kilometres than the Baseline in 2030. The fact that the total number of trips inter NUTS3 increase much faster than the total passenger·kilometres indicates that trips tend to be shorter for all scenarios in 2030 than in 2010.



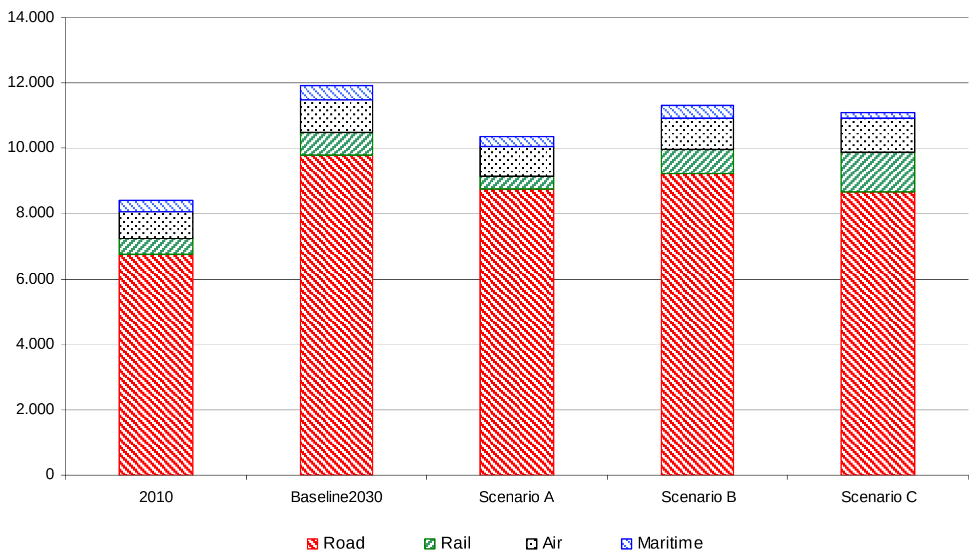
Total trip·kilometres travelled yearly in Europe 2010 and 2030 (Baseline+Scenarios) by mode of transport

Road will remain the main mode for passenger transport in Europe (between 62% and 70% in 2030 compared to 67% in 2010), but some degree of modal shift can be achieved depending on the policies applied. Rail has the highest growth potential in the Scenario C "Regions", up to 12% in 2030 compared to 6% in 2010, but also the Scenario B "Cities" provides for moderate rail modal share increases, whereas Scenario A causes rail share to decrease by one half.



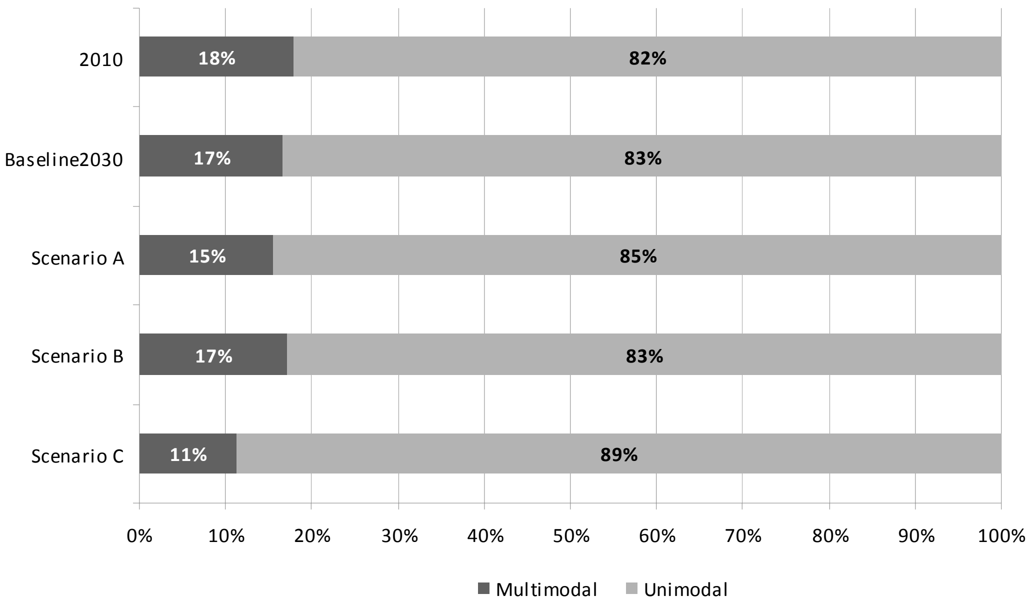
Modal Split based on Total trip·kilometres travelled yearly in Europe 2010 and 2030 (Baseline+Scenarios) by mode of transport

Total travel time increases in Baseline 2030 by 41.7% against Baseline 2010, about +7% more than the increase of total trip kilometres (39.0%). This implies that the overall transport system is slower in 2030 than in 2010, for the Baseline. Scenarios B and C maintain approximately the same speeds as Baseline 2010, meaning that the total number of hours spent in travelling in Europe increases just at the same rhythm as the number of passenger·kilometres travelled (0.7% speed increase in Scenario B, and 1.8% speed decrease in Scenario C). Only Scenario A shows a 32% average speed increase.



Total time spent travelling yearly in Europe 2010 and 2030 (Baseline+Scenarios) by mode of transport

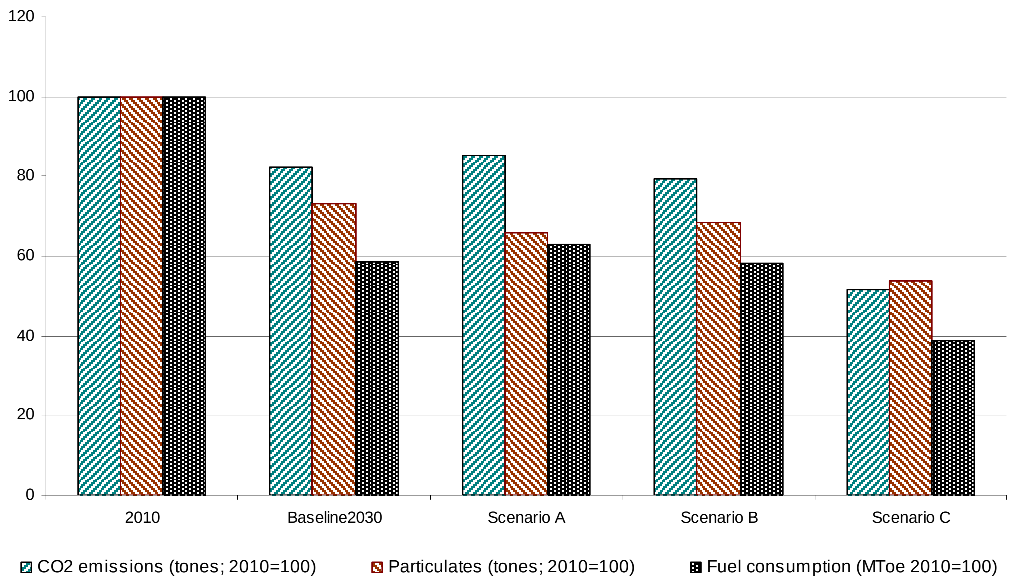
Scenario C shows a lower share of multimodal trips, implying that trips in Scenario C require less changes between modes than in other scenarios (11% of trips in 2030 in Scenario C require using more than one mode, whereas 18% require so in the 2010).



Share of trips in Europe requiring the use of only 1 mode of transport (unimodal) and requiring more than 1 (multimodal), 2010 and 2030 (Baseline + Scenarios)

3.3 IMPACT ON TRANSPORT EXTERNALITIES

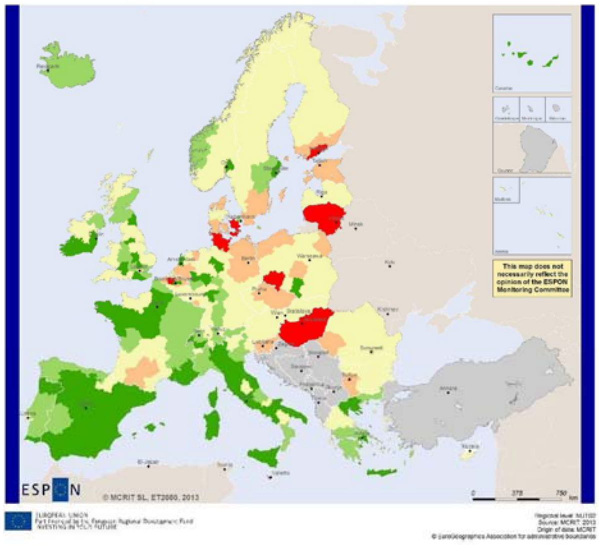
All Scenarios show a relative decline of transport emissions and fuel consumption in relation to 2010. This is mostly due to the increase in vehicle efficiency (reduced emission factors in 2030 in relation to 2010), and larger shares of non-conventionally fuelled vehicles in the future. Scenario C shows the largest gains in environment, and the fact that the scenario is successful in increasing the rail share translates onto a relative factor decline of the CO2 emissions in relation to the total fuel consumption.



Environmental and Energy indicators of transport in 2030, relative to 2010 (2010=100)

CO2 Transport Emissions 2010 - 2030 (Baseline)

Measured as saving potential emissions due to transport



CO2 Transport emissions (Units: Millions of CO2 tonnes saved)

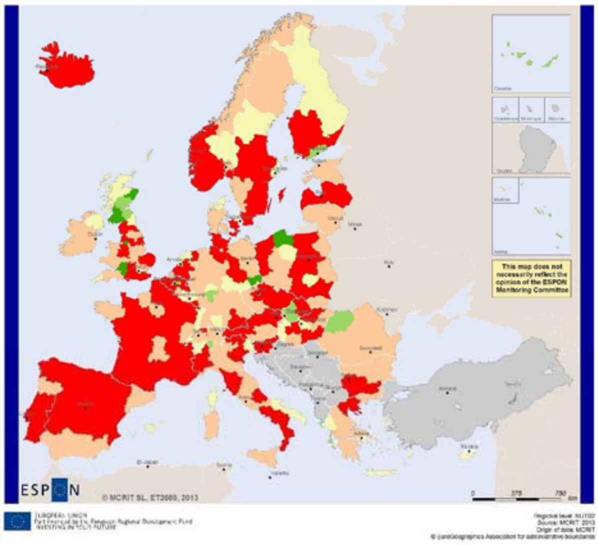
Results obtained by MOSAIC Model

- < -100
- -100 - -50
- -50 - 0
- 0 - 50
- > 50
- No data (ESPON space)
- No data (No ESPON space)

Reduction of 16% of Transport CO2 emissions. The combined impact of economic crisis with reduced GDP growth, and the use of more environmentally friendly energy sources leads to a net reduction of CO2 emissions specially in more industrialised and populated regions.
Results are based on assumptions based on transport traffics forecasted by MOSAIC as well as in other economic sectors.

CO2 Transport Emissions 2030 (Scenario A)

Measured as relative change in saving potential emissions due to transport respect to Baseline



CO2 emissions, relative change Emissions Scenario A / Emissions Baseline (Units: %)

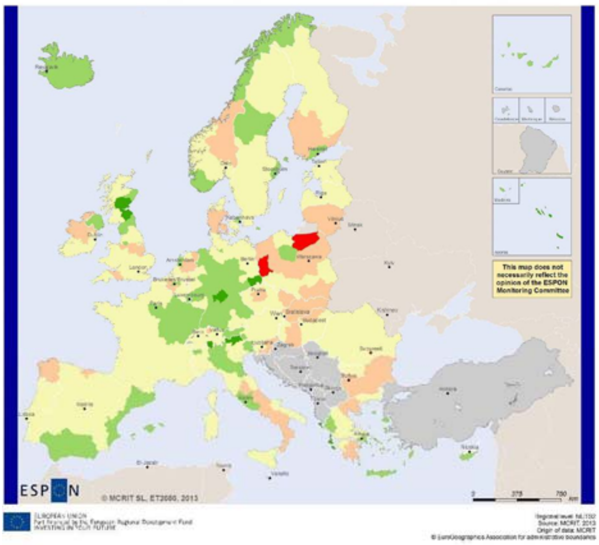
Results obtained by MOSAIC Model

- < -10%
- -10% - -5%
- -5% - 0%
- 0% - 5%
- > 5%
- No data (ESPON space)
- No data (No ESPON space)

Results are based on assumptions based on transport traffics forecasted by MOSAIC as well as in other economic sectors.

CO2 Transport Emissions 2030 (Scenario B)

Measured as relative change in saving potential emissions due to transport respect to Baseline



CO2 emissions, relative change Emissions Scenario B / Emissions Baseline (Units: %)

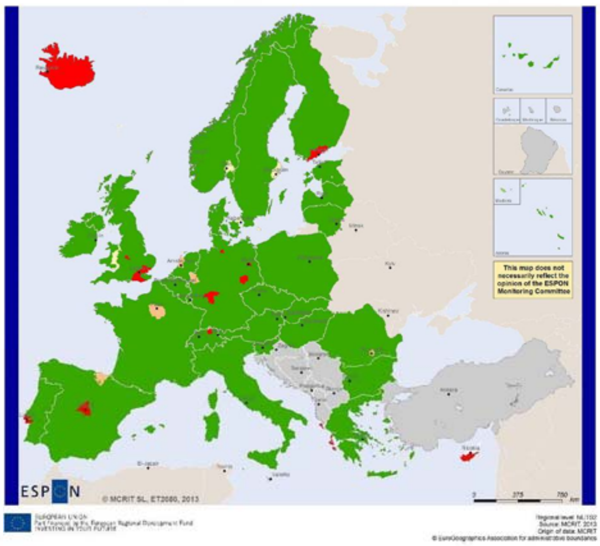
Results obtained by MOSAIC Model

- < -10%
- -10% - -5%
- -5% - 0%
- 0% - 5%
- > 5%
- No data (ESPON space)
- No data (No ESPON space)

Results are based on assumptions based on transport traffics forecasted by MOSAIC as well as in other economic sectors.

CO2 Transport Emissions 2030 (Scenario C)

Measured as relative change in saving potential emissions due to transport respect to Baseline



CO2 emissions, relative change Emissions Scenario C / Emissions Baseline (Units: %)

Results obtained by MOSAIC Model

- < -10%
- -10% - -5%
- -5% - 0%
- 0% - 5%
- > 5%
- No data (ESPON space)
- No data (No ESPON space)

Results are based on assumptions based on transport traffics forecasted by MOSAIC as well as in other economic sectors.

Exploratory Scenarios – Co2 Emission Savings from transport 2010-2030 compared to Baseline

4 REFERENCE TO THE MOSAIC MODEL

4.1 MODEL DESCRIPTION

The provision of transport scenarios in ET2050 is based on quantitative modelling using MOSAIC, the European-wide model developed in the INTERCONNECT FP7 research project.

MOSAIC is a modal choice and assignment module originally programmed to investigate how interconnection facilities and services influence the costs of transport, and therefore, how the upgrading of interconnections in Europe may impact on the European transport system.

MOSAIC has been developed in C++ on top of BridgesNIS. BRIDGES/NIS is a suit of C++ routines developed in the Bridges 4th EU Research Framework by MCRIT (1999), and continuously upgraded since (www.mcrit.com/bridges). The outputs produced (16Gb, 450 million registers) are processed by ad-hoc routines programmed to compute specific indicators measuring transport performance and interconnection, as well as to carry on sensitivity analyses.

State-of-the-practice forecast models are based on a conventional modular structure with trip generation, distribution, modal split and network assignment, having two major draw-backs:

- The separation between mode choice and traffic assignment means that intermodal chains can be hardly included and analysed in these kinds of model.
- Interconnections between local and regional networks are neglected.

MOSAIC is intended to overcome the weaknesses of state-of-the-practice forecast models at continental level in relation to the integration of interconnections into their modal choice and assignment procedures.

MOSAIC is fed with trip matrices, originally originated by TRANS-TOOLS, and works as stand-alone software to perform multi-modal network assignments. A meta-model approach is later adopted to process the large data outputs of MOSAIC and produce sets of indicators.

MOSAIC network graph is based on the so-called *supernetwork approach*. In this approach, the different modal sub-networks (uni-modal networks) are completely integrated, and the combined modes and the interactions among the vehicular modes on the roads might be explicitly taken into account. The multi-modal graph was constructed using the road, rail and air graphs from TRANS-TOOLS, identifying intermodal terminals and establishing connectors between networks at these points.

The multi-modal graph includes the TEN-T core and comprehensive networks, and major national infrastructures. All in all, it considers 37,000 road links; 12,000 rail links; 3,200 air connections; and several ferry connections (linking road and rail networks).

Connectors between networks were initially created automatically using the following criteria: all cities are connected to closest roads, but only to closest rail stations when these are located nearer than 15 kilometres. Airports are connected to the closest rail stations when these were located nearer than 10 kilometres, and to the closest roads when located nearer than 5 kilometres. Rail stations are always connected to roads. Needless to say, this procedure implies a substantial simplification of local and regional networks and was refined manually on a case by case basis.

Basic average values of time by trip purpose are based on TRANS-TOOLS, ranging from € 7.5 per hour for holiday travellers to € 25.0 per hour for business travellers. As the value of travel time for each traveller also depends on the personal income, average European values have been refined using dispersion coefficients to consider the effect of GDP per capita disparities on travellers depending on their NUTS3 of origin. Average travel fees are also based on TRANS-TOOLS services and refined to consider the effect of GDP per capita disparities in different areas of Europe

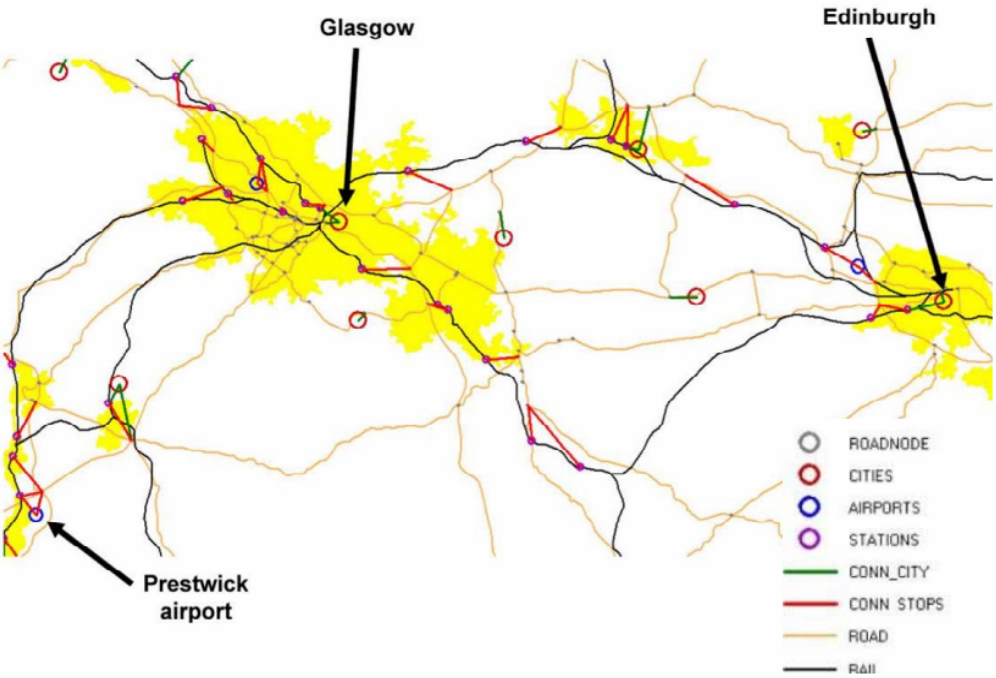


Figure 4-1 Multi-modal transport graph in MOSAIC Model

Each transport network has a different travel cost per kilometre ranging for € 0.09 per kilometre for local rail services and € 0.20 per kilometre for long-distance rail services, with € 0.15 per kilometre for road mode. The air mode costs are estimated in function of the size of the airport of departure – directly proportionally- and the relative length of the trip.

The costs of interconnections are calculated based on the costs attached to the intermodal connectors, in euros per kilometre -as a fee ranging € 0.1 per kilometre in city to rail connections, to € 0.25 per kilometre in city to road and road to rail connections-, and the cost of facing increased travel times due to the speed attached to the connector, in euros per hour. Connector speeds aggregates in one parameter both access and waiting times. Additionally, 90 minutes average time is imposed between successive air services. No additional transfer time is considered in connections between long-distance rail networks (TEN-T) and regional or short-distance networks. Aviation is facing much higher interconnection costs than rail, all considered.

MOSAIC assigns TRANS-TOOLS Origin-Destination matrices between NUTS3, rearranged to be assigned all together onto the multi-modal graph. IntraNUTS3 are 90% of the trips in EU27, and 75% in pax-km. Therefore, MOSAIC models 25% of total EU27 mobility. For intraNUTS3 different modelling assumptions are needed.

Traffics on the networks - travel behaviour - depend on the topology of the integrated multi-modal graph and the impedance of its different elements. Interconnections are an additional element equivalent to other transport links, having a direct impact in the route choice processes. The variation of multi-modal parameters at connectors and transport terminals allow for analysis of the influence of interconnections in the behaviour of travellers.

All itineraries between centroids representing NUTS3 are finally computed based on lower cost paths by trip purpose. Trips are assigned following an AON multiclass algorithm. A total of 1,441 NUTS3 are considered, generating a total of 8.3 million possible minimum cost itineraries between NUTS3, considering the existence of four different trip purposes with different travel costs. On the other hand, the total number of long-distance trips in Europe is 5,800 million, according to TRANS-TOOLS second version, giving a total of 1,170,000 million trip-kilometres

The model does not take into account congestion in the networks, given that the analysed flows are long distance. Long distance traffic takes place during time periods usually much longer than the peak hours last; travellers tend to avoid these peak hours whenever possible to improve travelling times.

The hypothesis of not taking into account the congestion might lead to slightly incorrect results when the long distance traveller has to use networks running around big cities, as congestion might change the shortest path (in time) by using a longer (in distance) by-pass. However, the effect of these route changes has a very low impact on the costs in long distance trips.

Default cost and time impedance parameters in MOSAIC have been adjusted in a validation process against TRANS-TOOLS results aggregated at European level. The adjustment process was carried out by a process of successive simulations, instead of by an optimisation, given the number of parameters to be adjusted and the need to monitor the process step by step. The final difference in trip-kilometres obtained, after 20 simulations, was considered acceptable: below 0.5% for roads, below 2% for air and 6% for rail, resulting in a weighted error of 1% for all modes, as shown on the next graphic:

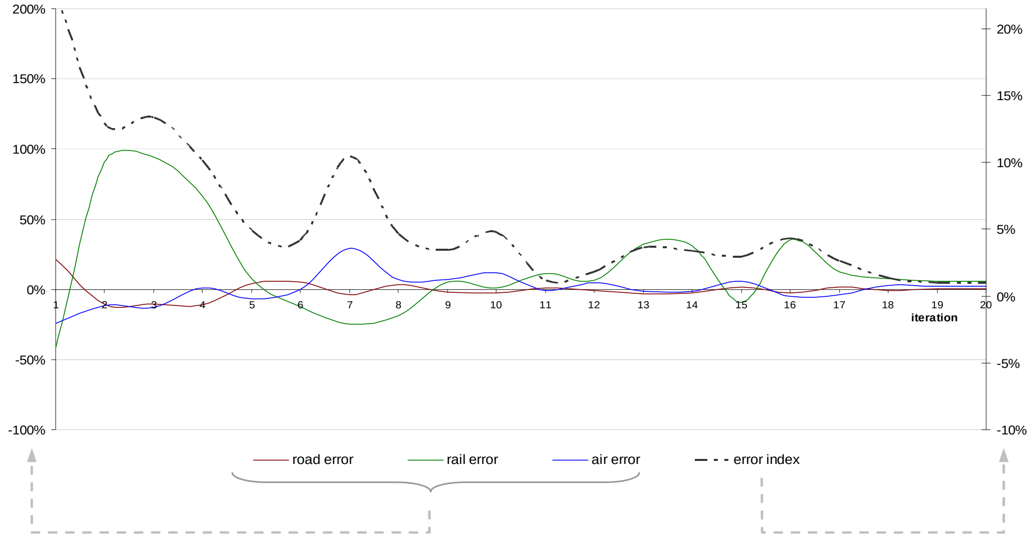


Figure 4-2 **Validation process of MOSAIC (validation consisted in adjusting the total trips-km of each mode at aggregated level to TRANS-TOOLS figures).**

The following facts may directly or indirectly influence the nature and magnitude of the results obtained by applying MOSAIC. First, the NUTS3 divisions differ between EU27 core regions, EU27 peripheral regions, and other neighbouring regions (Iceland is represented by one NUTS3, Belarus by 6 NUTS3, Spain by 52 NUTS3 and Germany by 439 NUTS3). In peripheral areas beyond the EU, traffic has fewer options to travel from one point to another, since networks are less dense, and this results in fewer transport options. Also, the definition of long-distance travelling by trips originated and bound onto different NUTS3 incorporates a number of relatively short inter NUTS3 trips (e.g. between German NUTS3). Because transport networks and modelling parameters were always defined, and validated, at European level, MOSAIC at this stage does not guarantee reliable absolute results at national or regional level, and always have to be analysed in relative terms. More than absolute values, it is always the comparison (e.g. between NUTS3, trip lengths and purposes, modes…) in the different scenarios studied, always at the European scale, that is relevant. Nor are trips from Europe to the rest of the World (not included in the reference area displayed in the following maps) considered.

4.2 MODEL UPGRADES FOR ET2050: GENERATION OF TRIP MATRICES

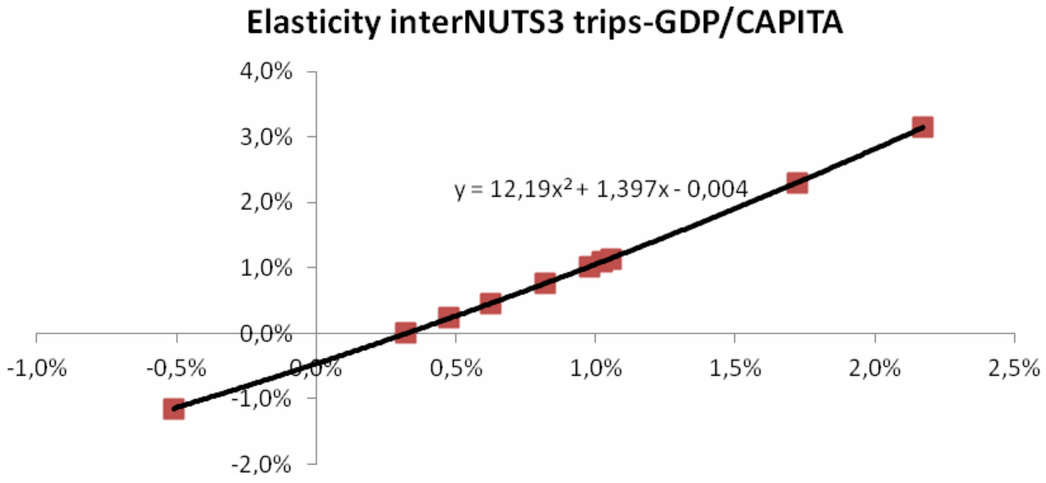
MOSAIC was upgraded during the development of the ET2050 project to consider how changes in demographics and economic growth could induce changes in mobility in Europe. This allowed estimating future travel demand between NUTS3 regions in Europe based on alternative hypothesis of population and GDP growth at regional level. In particular, inputs to Mosaic were taken from the results of the Multipoles and MASST models, allowing estimating coherent travel matrixes between European regions taking into consideration future socioeconomic conditions of each of these particular regions.

The applied methodology in brief consists of generating future travel demand by increasing today's travel generation at NUTS3 level (number of trips originated per year) based on the elasticity to economic growth, and considering increases in population. In general terms, it is considered that more wealth per capita induces more transport, i.e. increases travel rate. Distribution of trips across Europe is done via a uniform Growth Factor model with constraints to ensure that the resulting matrix is symmetrical (sum of trips at origin equals sum o trips at destination). No changes in current travel patterns are assumed per-se nor travel induction (behaviour changes in relation to origins and destinations are incorporated).

The specific steps of the methodology are exposed below:

1. Hypothesis of GDP and population growth at regional level are used to determine a future GDP/capita vector at NUTS3 level.

2. Elasticities of trip generation vs GDP/capita for interNUTS3 trips are derived from TransTools 2010/2030 matrices and TV+ metamodel[19]. Using the TV+ metamodel future traffic demand at aggregated European level is generated (total passenger and tonnes·kilometres per trip ranges). The TV+ metamodel is calibrated with complete TransTools forecasts generated during the TRANSvisions study (EC 2009), ensuring consistency with the EU reference scenario. A quadratic formulation is fitted between the variation rate of GDP/capita and the variation rate of trip generation from TV+ metamodel.



3. Elasticity is applied to the GDP/capita vector determined in step 1 to obtain the total future trip generation factors at NUTS3 level.

4. Trip generation factors yield growths per NUTS3 using the Transtools 2010 matrix as base. A doubly constrained Growth Factor model then used to distribute the trips, ensuring the sum of trips originated equals the sum of trips distributed.

5. Resulting trips per OD are divided in 4 trip purposes using the proportions of the Baseline 2010 matrix[20].

[19] See TRANSvisions study, EC 2009.
[20] Corresponding to the TENConnect TransTools OD Matrix (EC 2009)

4.3 SPQR PROTOCOL

The next table presents the structure of MOSAIC model, specifying the data (or samples), the formulation (or postulates), the queries the model can address, and the results it can produce. The inputs and outputs of the model are detailed thereafter.

MOSAIC Specification

NAME	**MOSAIC**
BACKGROUND	
Last update	2011
Developer	MCRIT based on TRANS-TOOLS (TT) previous developments.
Developed in the project	7th EU Framework Programme (INTERCONNECT)
Ownership	MCRIT co-financed by EC. No commercialised.
Main applications	TT is the best state-of-the-practice transport-oriented forecast model available at EU level. DGMOVE has required the application of TT model in all studies carried out during the last years in the process to redefine the Transeuropean transport networks and the new Transport White Book 2010-2020. TT model is being continuously improved in different projects of the 7th European Framework Programme. In the INTERCONNECT (2010) MCRIT developed the MOSAIC model, based on TT trip generation and distribution results, being also applied in ORIGAMI (2011-2012) to assess four different transport policy-scenarios for 2030.
Documents of reference	INTERCONNECT Final Report (www.interconnect-project.eu)
Scientific papers	TRA2012 "*Impacts of improving interconnectivity between local and long-distance transport networks in Europe: Conclusions from the modelling activities in the INTERCONNECT 7th EU Framework Programme project*"
Running time	12 hours
Size of total results	16 Gb
Data exchange format	Results can be provided in MDB format
Software platform	BridgesNIS (proprietary software programmed in C++ by MCRIT) linked to most GIS packages, especially Geomedia Intergraph. Tutorial and guide under development.
S A M P L E S	
Reference data from	2005
Data for calibration	MOSAIC internal parameters are calibrated with TT 2005 results.
Data inputs	Multimodal Transport Networks (50.000 links) including detailed intermodal exchanges and proxy to long-distance passenger services. Information restricted.
	TRANSVISIONS socioeconomic, trip generation and distribution databases 2005-2020-2030 produced by TRANSTOOLS for baseline scenarios at NUTS3 level. Publicly available information.
P O S T U L A T E S	
Forecast reliable up to	2030
Geographic coverage	EU27 and neighbouring countries
Adm. desegregation	NUTS3
Thematic scope	Passengers (freight not included)
Theory of TT-MSAIC	Integrated modal split and assignment for passengers applied to TT trip

	distribution matrices
Theory of TRANSTOOLS (TT)	4-steps passenger and freight transport model see: http://energy.jrc.ec.europa.eu/transtools/
Q U E R I E S	
Transport supply-oriented policies	How *infrastructure provision policies* (new infrastructure) may change traffics in the networks?, induce modal shifts?, change energy consumptions and emissions?, accidents?, increase accessibility?
Transport market regulatory policies	How *pricing and subsidy policies* may change traffics in the networks?, induce modal shifts?, change energy consumptions and emissions?
Technologic innovation	How changes on *vehicle technologies* may change traffics in the networks?,, induce modal shifts?, change energy consumptions and emissions?, accidents?
R E S U L T S (Main families of indicators)	
Transport endowment	Aggregated, by NUTS3, by mode
Infrastructure investment	Aggregated, by NUTS3, by mode
Costs of travelling	Between NUTS3 by trip purpose using optimal transport chains
Time of travelling	Between NUTS3 by trip purpose (business, visit, inter-NUTS3 commuting, holydays)
Accessibility	Surface, people or activities (GDP) at a given distance or time or cost from a given place
Trips	Between NUTS3 by trip purpose (business, visit, inter-NUTS3 commuting, holydays)
Modal shares	% trips between NUTS3 by trip purpose (business, visit, inter-NUTS3 commuting, holydays)
Modal chains	% length or time or cost between NUTS3 by trip purpose (business, visit, inter-NUTS3 commuting, holydays)
Emissions	CO2, PMx, NOx by network link, aggregated at NUTS3 or NUTS0
Typical graphic output (maps, diagrams)	Maps with traffics on transport links Accessibility maps displayed by 5x5 km2 cells Maps with patterns for NUTS3 Time lines for key indicators aggregated at different scales
DATA MANAGEMENT IN NON EU27 COUNTRIES	
ESPON space countries *(Iceland, Norway, Switzerland and Lichtenstein)*	Networks and travel data available, at a lower resolution than in EU27 countries. Data available for all ESPON partner countries
Accession countries *(Western Balkans and Turkey)*	Networks and travel data available, at a lower resolution than in EU27 countries. Data available for Western Balkans and Turkey
Neighbouring countries	Networks and travel data available, at a lower resolution than in EU27 countries. Data available for Ukraine, Belarus, Russia. No data available for Northern Africa nor Middle East.

5 REFERENCES

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