High-speed **Europe**

A SUSTAINABLE LINK BETWEEN CITIZENS

Directorate-General for Mobility and Transport

EUROPEAN COMMISSION

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PREFACE

The European Union is committed to making the transport of goods and the mobility of people more secure, more efficient and more environmentally friendly, with priority given to social and territorial cohesion, as well as to economic dynamism. Looking ahead to the near future, I envisage a transport system that closely meets the needs of its users, that is fast and intelligent but that minimises its environmental impact. The use of high-speed trains shows how this vision for the future can be made a reality today, thanks to the combined efforts of the Member States, partners from the industry and the financial support from the Union.

Several economic and cultural centres in Europe can already be reached by trains travelling at speeds of 300 km/h and sometimes more. This includes cities such as London, Paris, Brussels, Frankfurt, Amsterdam, Barcelona, Madrid, Rome and Milan. The development of further connections remains a key priority of several European programmes, such as the trans-European transport network (TEN-T). Completion of these projects will soon give the Union and its citizens a true high-speed rail network that will allow its users to travel in conditions of improved comfort and safety while at the same time reducing their impact on the environment.

This success also demonstrates our extraordinary capacity for innovation, which allows us to create competitive and inter-operable systems of real technological excellence that support the development of our economy. European competitiveness is built on strengths such as know-how, expertise and innovation and I look forward to the new export possibilities that will open up for our companies. The fact that European standards are being used for high-speed railways in China, in Latin America, in the United States and in Morocco is recognition of the level of excellence in Europe and signals a new era for sustainable transport and mobility.

Siim Kallas
Vice-President of the European Commission,
Commissioner in charge of mobility and transport

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1. INTRODUCTION

High-speed lines (HSLs) offer European citizens a safe, fast, comfortable and ecological mode of transport. A high-speed train is a train capable of reaching speeds of over 200 km/h on upgraded conventional lines and of over 250 km/h on new lines designed specifically for high speeds. Today, trains running on the most recently installed lines can reach speeds of 360 km/h, while trains running on upgraded conventional lines can reach speeds of up to 250 km/h.

HSLs have truly revolutionised sustainable mobility, by allowing a significant increase in the speed and frequency of journeys between the major European cities. This cutting-edge infrastructure illustrates the Union's immense capacity for technological innovation and the vitality of European industry, which is constantly developing new systems, especially in terms of rolling stock. The reduced travelling times, higher levels of passenger comfort and low environmental impact enable HSLs to compete with and complement road and air travel, thereby helping to implement viable mobility at European level.

The development of high-speed rail travel took off after the 1974 petrol crisis. Faced with Europe's energy dependency and concomitant threats in terms of mobility, several European countries decided to develop a new, fast mode of transport which would not guzzle fossil fuels. Italy was the first European country to inaugurate an HSL (on the Direttissima line between Florence and Rome) in 1977, but it was France that led the technological boom, introducing the first high-speed train (HST) (nicknamed Rail Concorde) between Paris and Lyon in September 1981. Germany joined the venture at the beginning of the 1990s, with the Intercity Express (ICE), followed shortly by Spain, which introduced the Alta Velocidad Española (AVE) in 1992. At the end of 2009, Europe had 6 214 km of high-speed lines on which trains could run at speeds in excess of 250 km/h.

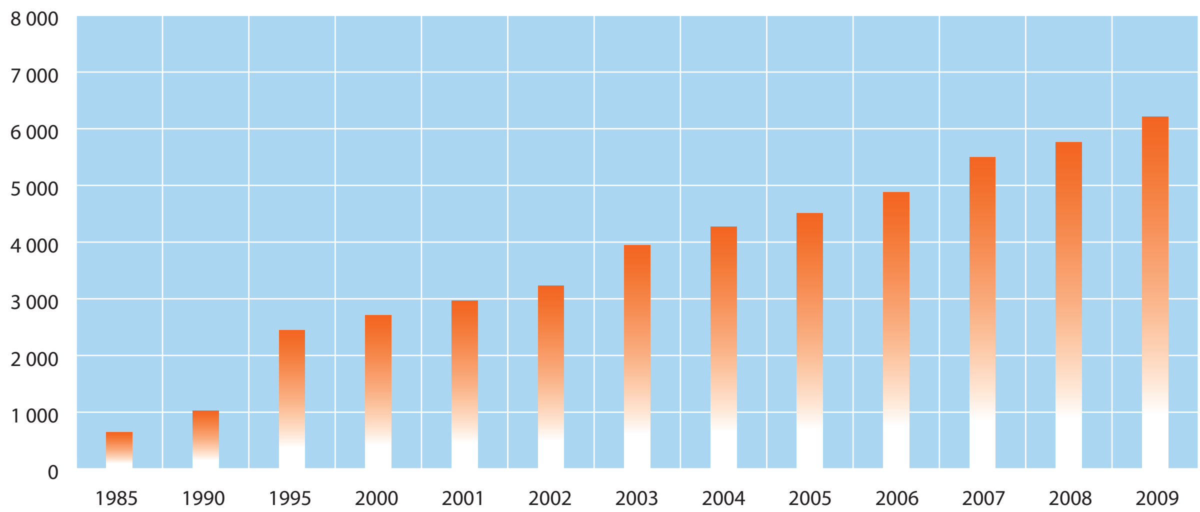
There are currently different technical standards on the HSL European network and this generates significant extra costs. The huge potential of HSLs in terms of mobility throughout the continent has still not been fully exploited. That is why the European Union is promoting a pan-European HSL network. In order to do so, it is issuing common technical and quality standards for all Member States. It is also establishing a framework for the development and implementation of standardised tools, such as the European rail traffic management system (ERTMS). It is being assisted in this by the European Railway Agency (ERA), the body responsible for helping to integrate the European rail networks by improving rail safety and allowing trains to cross borders within the EU without having to stop.

2. THE HIGH-SPEED NETWORK AND CITIZENS

2.1. Development of a truly European network

The European HSL network is expanding constantly. The United Kingdom, Sweden and Germany have upgraded large sections of their conventional network so that they can be used by high-speed trains. The opening in November 2007 of the second section of the Channel Tunnel to St Pancras line is just one of many examples. HSL construction projects are proliferating elsewhere in Europe. The Belgian HSL network has plans to expand, with the 'Diabolo' line to improve rail access to Brussels National Airport, and France has plans to double the HS lines between Paris and Lyon. Spain has plans to lay some 10 000 km of HSLs between now and 2020, so as to ensure that 90 % of its inhabitants have an HST station within 50 km of their home. With its network saturated in the south of the country, Sweden plans to construct a completely new HS line between Stockholm and Gothenburg. This line, which will be restricted to passenger trains, will provide better services to numerous towns between the two principal Swedish cities. This project forms part of a global project, which is designed to improve rail capacity in Sweden by constructing new lines and renovating existing lines. This action is being taken in spite of the climate and terrain in Scandinavia, which make it very difficult to set up railway infrastructure.

Increase in HSLs in km (1985–2009)

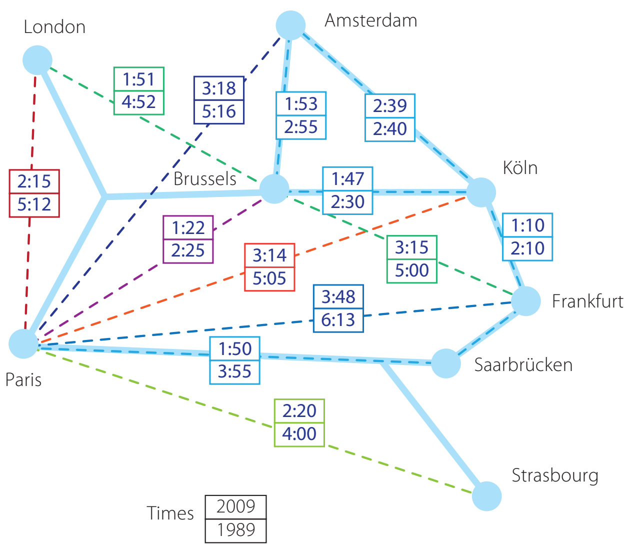


NB: Only lines or sections of lines on which trains can exceed speeds of 250 km/h are included.
Sources: International Union of Railways (UIC), High-Speed Department; national sources.

Europe aims to use the trans-European transport network (TEN-T) to link all HSLs on the continent into a proper integrated European high-speed network. The liberalisation of the mainline international passenger railway market on 1 January 2010 will also allow operators to compete and offer users a wider range of transport options.

The first trans-European HSL, between Paris, Brussels, Cologne, Amsterdam and London, is already close to completion. This network, which is used by several rail operators (Thalys, Eurostar, Deutsche Bahn, NS Highspeed) will significantly cut journey times between major German, Belgian, French, Dutch and British cities. The ERTMS will guarantee that the system is fully interoperable. In January 2008, the International Union of Railways (UIC) had registered 1 050 HS carriages in service in Europe.

Journey times between stations 1989–2009



2.2. Advantages for passengers

High-speed trains provide unsurpassed passenger comfort. The layout of the compartments, the interior fittings of the carriages and even the lighting have been designed to create a comfortable and pleasant space suitable both for work and relaxation. Passengers have a great deal of personal space, with access to more and more services, such as Internet, power sockets for their electronic equipment, headrests and folding tables. They can also walk around on board and there are restaurant cars serving food and drinks. Unlike on aircraft, the use of mobile telephones is not prohibited; however, it is confined to dedicated spaces between carriages in order to avoid disturbance to other passengers. Particular attention has also been paid to access to compartments, by reducing the gap in height between the train and the platform.

European standards are gradually being established, both to ensure greater compatibility between trains and lines and to ensure that carriages comply with important quality standards, especially in terms of safety and environmental impact.

Multimodal railway stations in city centres provide quick, easy access to the rail network. The development of HSLs has consistently cut journey times between various urban and economic centres in the Union. At present, London is 2 hours 15 minutes from Paris and 1 hour 51 minutes from Brussels and Brussels is 3 hours 15 minutes from Frankfurt. This compares with 5 hours 12 minutes from London to Paris, 4 hours 52 minutes from London to Brussels and 5 hours from Brussels to Frankfurt in 1989.

The advantages of HSLs, in terms of frequent connections (which can easily be modified depending on demand) and flexibility for passengers, have allowed the railways to compete more effectively against other modes of transport. Since 1997, over 6 million passengers a year have been using the Brussels–Paris HSL. As a result, flights have been cut back on this route ([1]).

([1]) Trans-European Transport Network Executive Agency, Priority Project 2 'High-speed railway axis Paris–Bruxelles/Brussel–Köln–Amsterdam–London: PBKAL (http://tentea.ec.europa.eu/en/ten-t_projects/30_priority_projects/priority_project_2/).

2.3. Link with trans-European transport network (TEN-T) policy

The programme for the trans-European transport network (TEN-T), as introduced under the Treaty of Maastricht and defined in Decision 1692/96/EC in 1996 (2), is designed to guarantee optimum mobility and coherence between the various modes of transport in the Union. The main priorities of this policy, which accounts for a large part of the White Paper on transport policy in the EU (3), are to establish the key links needed to facilitate transport, optimise the capacity of existing infrastructure, produce specifications for network interoperability and integrate the environmental dimension.

The TEN-T focuses very closely on the development of high-speed transport. Of the 30 priority projects put forward under this programme, no fewer than 14 concern high-speed lines. The new Lyon–Trieste–Divača/Koper–Ljubljana–Budapest–Ukrainian border railway axis, the new high-speed railway axis in south-west Europe and the integration of the high-speed rail network on the Iberian peninsula into the European network are just a few examples of TEN-T projects supported by the European Union. The development of the European Rail Traffic Management System (ERTMS) is also one of the projects that receives serious funding as part of the implementation of the TEN-T.

TEN-T axes and priority projects relating wholly or partly to HSLs

Axis/ Project No	Title
1	Railway axis Berlin–Verona/Milan–Bologna–Naples–Messina–Palermo
2	High-speed railway axis Paris–Brussels–Cologne–Amsterdam–London
3	High-speed railway axis of south-west Europe
4	High-speed railway axis east
6	Railway axis Lyon–Trieste–Divača/Koper–Divača–Ljubljana–Budapest–Ukrainian border
12	Nordic Triangle railway/road axis
14	West coast main line
16	Freight railway axis Sines/Algeciras–Madrid–Paris
17	Railway axis Paris–Strasbourg–Stuttgart–Vienna–Bratislava
19	High-speed rail interoperability in the Iberian peninsula
20	Railway axis Fehmarn belt
22	Railway axis Athens–Sofia–Budapest–Vienna–Prague–Nuremberg/Dresden
24	Railway axis Lyon/Genoa–Basel–Duisburg–Rotterdam/Antwerp
28	Eurocaprail on the Brussels–Luxembourg–Strasbourg railway axis

(2) Decision 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network (OJ L 228, 9.9.1996).

(3) *White Paper — European transport policy for 2010: time to decide* (http://ec.europa.eu/transport/white_paper/documents/doc/lb_texte_complet_fr.pdf).

2.4. Growing demand

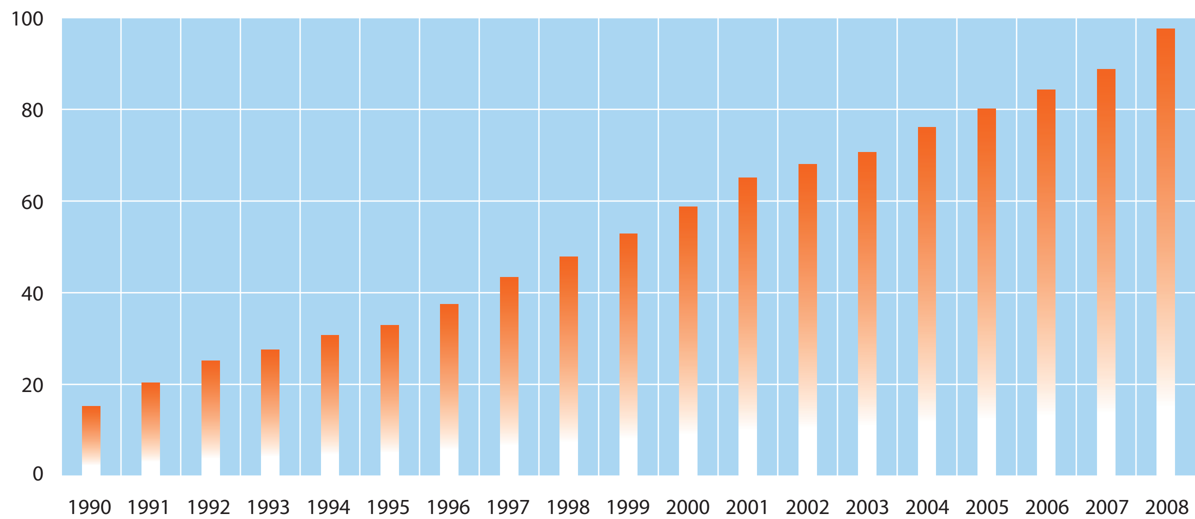
Since high-speed lines were introduced, the number of passengers opting for this mode of transport has constantly increased. The number of passengers on all German, Belgian, Spanish, French, Italian and British lines increased from 15.2 billion passenger-kilometres in 1990 to 92.33 billion in 2008.

The continuous development of efficient, interoperable control/management tools allows infrastructure capacity to be increased, while guaranteeing high safety standards. It is possible today to route a train on an HSL every four to five minutes.

2.5. Competitiveness with other modes of transport

Expansion of the HSL network has breathed new life into rail transport in terms of competing with other modes of transport. Today, high-speed trains account for approximately 40 % of traffic over medium distances and even more on certain routes, such as London–Paris, Paris–Brussels and Madrid–Seville. It is, in fact, on journeys which take under three hours that HS trains are most competitive: access time is much shorter than by air and journey times are shorter than by car.

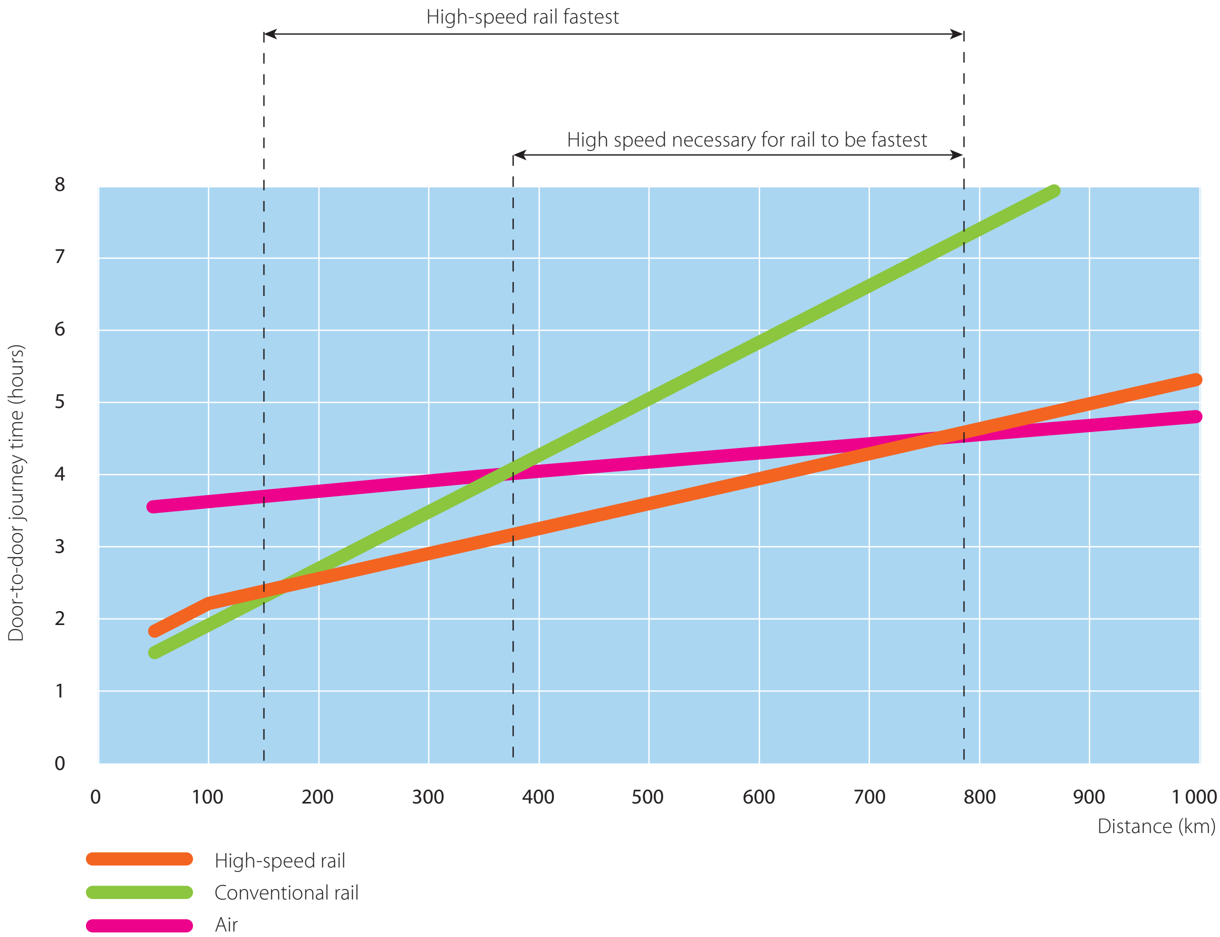
Increase in number of HS passenger-kilometres (pkm) in Europe (1990–2008), in billion pkm



NB: Figures refer to all traffic using high-speed rolling stock.
Sources: International Union of Railways (UIC), national statistics, estimates.

In 2007, passengers on all European rail networks travelled an average of 372 km on high-speed lines. HSLs are preferred over air and road travel for journeys of between 400 and 800 km. At below 150 km, they offer a limited bonus compared with road or conventional rail travel. Between 150 and 400 km, travel by rail (on both HS and conventional lines) is quickest. Above 900 km, air travel gains the upper hand, except for journeys on which rail offers specific advantages (HS snow train, overnight services, car trains, etc.). The European Union is using the TEN-T programme to encourage cooperation between rail companies, airlines and road transport operators, in order to foster synergies between these different sectors and optimise the integration of transport at European level. This approach will improve transport energy use, which in turn will generate environmental advantages.

Journey times v. distance for rail (HS and conventional lines) and air transport



Source: High-speed rails: international comparisons, Steer Davies Gleave, Commission for Integrated Transport, London, 2004.

Paris–Lille: at the heart of the European HSL network

The 333 km North HSL, which opened in 1993, links Paris to the Belgian border and to the Channel Tunnel via Lille. Trains in commercial service are capable of speeds of up to 300 km/h, which has considerably improved rail journey times between Paris and Lille. The extension of this line northwards to Belgium and the United Kingdom and southwards, via the HSL Interconnexion Est, makes it a key link in the European high-speed rail network. Lille is one of the main winners from this project as it now sits at the crossroads of Europe, in the centre of the Brussels–London–Paris triangle. Euralille has become the third biggest business centre in France in just over a decade.

Frankfurt–Cologne: an HSL restricted to passenger services

As of 2002, the 177 km Cologne–Frankfurt HSL has set the journey time between these two cities at 1 hour 10 minutes. It now takes no more than an hour to reach Frankfurt International Airport from Cologne. This is a unique case in a network basically designed for mixed passenger/freight traffic; it is restricted to passenger traffic, due to its steep gradient (4 %). It links Rhine-Ruhr and Rhine-Main, two of the most urbanised regions of Germany, which are home to some 15 million people. The engineers applied important technical innovations in order to build this line. For example, the tracks were laid on concrete slabs, rather than on ballast, and the trains use magnetic (eddy current) brakes.

Turin–Milan–Naples: linking north and south

The Italian HSL network, which was inaugurated in 1977 with the Direttissima line between Florence and Rome, was extended in 2005–06 with the Rome–Naples and Turin–Novara lines. The opening of the Milan–Bologna and Naples–Salerno lines in 2008 increased the AV/AC (Alta velocità/Alta capacità) network to over 900 km. With motorway interconnections at numerous points, the Italian HSL is the backbone of the transport network linking the north and south of Italy. It also forms part of the north-south rail corridor linking Berlin and Palermo and is a top priority project under the trans-European transport network programme.

Madrid–Barcelona: journey time 2 hours 38 minutes

The Madrid–Barcelona HSL was opened in February 2008. This new 621 km line reduced the journey time between the two cities from 7 hours on a Talgo train in 1996 to 2 hours 38 minutes. In time, this line will be extended towards France via the Perpignan–Figueras cross-border tunnel, linking Spain to the trans-European HSL network. The Madrid–Barcelona line will also help to relieve pressure on the saturated air route between the two cities. After a year in service, Renfe (Red Nacional de Ferrocarriles Españoles) has captured 40 % of the traffic between Madrid and Barcelona.

EU high-speed railways (categories I, II and III) in 2010

0 300 600 km

Completed	*Under construction*	*Planned*
Category I	*Category I*	*Category I*
Category II	*Category II*	*Category II*
Category III	*Category III*	*Category III*

Administrative land accounting units
(GISCO Database, Eurostat)
Cartography: European Commission, 20 November 2008.

3. A TOOL AT THE SERVICE OF EUROPEAN TRANSPORT POLICY

3.1. Trans-European transport network policy and investments

According to recent forecasts by the European Commission, European demand for transport is expected to increase by 25 % for passenger transport and by 29 % for freight transport between now and 2020 (reference year: 2000). This highlights the importance of the Community trans-European transport network (TEN-T) programme. Facilitating passenger and freight mobility by developing and upgrading an integrated transport infrastructure throughout Europe and complying with strict safety and quality standards is a key objective in safeguarding the competitiveness of the Union. That is why the TEN-T programme also plays a key role in the Europe 2020 strategy for smart, sustainable and inclusive growth.

The cost of implementing the entire TEN-T is estimated at around EUR 900 billion between 1996 and 2020 ([4]). As far as high-speed rail is concerned, 14 priority projects ([5]) have been launched to develop new lines and/or upgrade existing ones at a cost of some EUR 269 billion between 1996 and 2020. The European Union is giving financial support to these projects via the TEN-T budget, the Structural Fund, the Cohesion Fund and the European Investment Bank (EIB).

In the past, a large number of European HSLs were financed by the public sector. This was true of France (for the South-East, Mediterranean, European East and Rhine–Rhône HSLs), Belgium, Germany, Spain and Italy. These projects were supported at national level, with help from the European Union via the budget allocated to the TEN-T and/or via the Structural Fund and the Cohesion Fund. The EIB also contributed towards the development of the network by granting loans.

3.2. Territorial cohesion and regional planning

HSLs help not only to increase mobility between major urban economic centres in the EU, but also to improve services to the intermediate towns crossed by high-speed trains. The speed of high-speed rail transport therefore helps to increase the mobility of passengers and freight and to create a feeling of proximity within the Union.

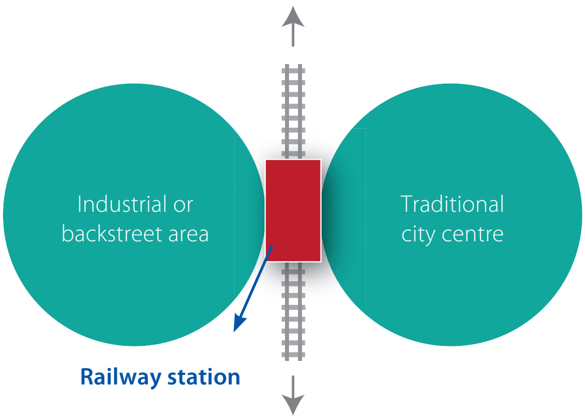
The positive impact of the HSL network on certain sectors, such as the high-tech or upscale tertiary service sectors, helps to boost economic specialisation in the regions concerned and to improve complementarity between the various economic centres in Europe. This is without doubt of benefit to Europe's competitiveness at international level.

Connecting a station to the HSL network may influence the entire urban development of the surrounding district. The district of King's Cross in London will certainly experience far-reaching changes following the inauguration of the international station at St Pancras. Planning permission covering a 75 hectare site was granted in 2006 for the restoration of 20 historic buildings and the construction of 25 office blocks, 20 access roads and 10 public spaces. In France, this has also applied to HST stations opened on the outskirts of cities. They have fostered the creation of satellite cities, such as at the Avignon HST station in Courtine, where a HST business centre is to be developed.

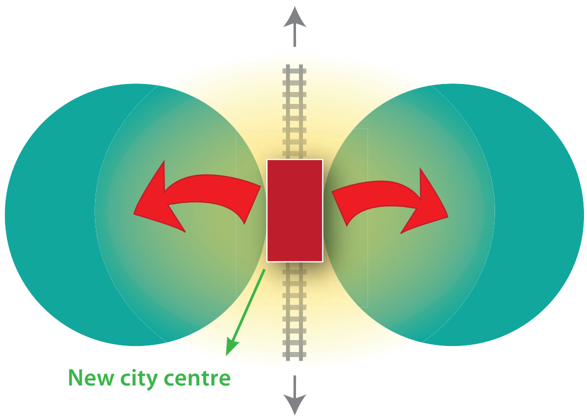
([4]) European Commission, Mobility and Transport DG, 'Transport infrastructure' (http://ec.europa.eu/transport/infrastructure/index_en.htm).
([5]) TEN-T policy includes a total of 30 priority projects at an overall cost of some EUR 415 billion between 1996 and 2020.

Changes in passenger stations

Railway and station act as a barrier



Railway station interconnects and becomes the new centre



Source: Presentation to the sixth UIC High-Speed Rail Congress, 'The high-speed railway station of the future – How to achieve it?', Ir. Rudolf Mulder – DHV, presentation date: 17 to 19 March 2008.

3.3. Security and interoperability

High-speed trains are one of the safest means of transport. Various systems are used to guarantee optimum safety. There are systems to transmit speed limits to the driver (at very high speeds, the driver can no longer read trackside signals correctly). However, in the past, these systems were developed at national level by specific manufacturers and are not compatible with one another.

Therefore, trains need to be fitted with several systems if they are to cross borders. For example, Thalys trains operating between France, Benelux and Germany need to be fitted with seven different signalling systems. As France, Germany and Belgium have sections of conventional lines and sections of high-speed lines in succession, two control systems are needed for each country.

These multiple train control systems underline the importance of the interoperability of the HS network being promoted and implemented by the European Railway Agency (ERA). Directive 2008/57/EC ([6]) defines interoperability as the ability of the trans-European high-speed rail system to allow the safe and uninterrupted movement of high-speed trains which accomplish the specified levels of performance. This ability rests on all the regulatory, technical and operational conditions which must be met in order to satisfy essential requirements in terms of safety, reliability and availability, health, environmental protection and technical compatibility ([7]). In other words, interoperability does not only concern management and signalling systems. All aspects of rail transport are concerned, from infrastructure (e.g. bridge headroom, standardised gauge), through energy (e.g. electrification system) to passenger services (e.g. information systems, reservation methods), maintenance (e.g. system to cut maintenance costs) and rolling stock (e.g. engines).

ERTMS

The ERTMS rail traffic management system is one of the tools co-financed by the European Union to meet the demand for interoperability. The ERTMS comprises the wireless global system for mobile communications — railways (GSM-R) and the European train control system (ETCS) and has been designed and implemented under the aegis of the European Railway Agency (ERA, see box on page 14). This unique system helps to make European HSLs interoperable and optimise rail traffic management along international corridors. Rollout of the ERTMS started in 2005 on various HSLs (Rome–Naples, followed by Madrid–Lerida). In time, the ERTMS will be deployed over the entire European network, thereby reducing significantly the costs generated by multiple management and signalling systems.

([6]) Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (recast) (OJ L 191, 18.7.2008).
([7]) Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system (OJ L 235, 17.9.1996).

The key role of the European Railway Agency

The European Railway Agency (ERA) was set up in 2004 in order to support the development of a safe European rail network, the competitiveness of which would no longer be hampered by technical obstacles. The ERA is mainly concerned with improving network safety and interoperability. It plays a key role because, in a railway area without barriers, a decision taken unilaterally by one country might potentially prevent foreign trains from operating in it. The existence of a European coordination body is, by definition, a key element in guaranteeing the efficiency of the European rail network of tomorrow.

Interoperability also concerns the synergy between HSLs and conventional networks. European rolling stock manufacturers have had to call on all their know-how and technical expertise in order to design high-speed trains that can run on conventional tracks. Some Spanish HSTs (Alaria, Alvia, Talgo) and all French HSTs are able to operate on conventional lines. In Germany and Italy, the network is totally compatible. All categories of trains are able to use HSLs and conventional lines indiscriminately.

3.4. Intermodality and co-modality

Intermodality means the use of several means of transport during a single journey. This concept applies to both passenger and freight transport and includes rail, road, air and urban transport.

The environmental impact of aircraft and saturation of the major European airports is leading towards limitations on air traffic within the Union. This creates a favourable situation for fostering synergies between the rail and air networks. Airlines can therefore make use of HSL networks to channel passengers from various regions to a central airport. The Thalys trains have already created this sort of synergy between Brussels and Paris Charles-de-Gaulle Airport.

Co-modality means the use of each mode of transport for the most suitable purpose and, where appropriate, the use of a combination of modes of transport. Applied to the railway sector, this principle infers that the capacity freed up by HSLs can be used for long-distance goods traffic, which is the preferred means of transporting rail freight. The gain in capacity translates into infrastructure availability, be it virtual (free train paths) or physical (dedicated infrastructure). However, where train paths are simply freed up, this gives rise to a number of technical and operational challenges. The difference in speed between a (slower) goods train and a high-speed train impacts on rail traffic management for the simple reason that freight trains spend longer on the track and therefore use up more traffic capacity (train paths). This difference in speed may also cause safety problems when these two types of train pass. This makes safeguarding infrastructure availability, while guaranteeing optimum capacity and security, an extremely difficult task. Physically freeing train paths simply means dedicating HSLs solely to passenger traffic and giving freight a higher priority on conventional lines. This is an option being explored by Sweden in particular.

HSLs and airports: intermodality in action

There are some particularly remarkable examples of HS stations operating along intermodal lines with airports. Frankfurt International Airport is a pioneer in this. Opened in 1972, traffic increased considerably following the introduction of the Frankfurt–Cologne HSL in 2002. According to Deutsche Bahn, two thirds of train passengers are either leaving or have arrived by plane.

In France, the station at Paris Charles-de-Gaulle Airport is located at the interconnection between the North HSL and the South-East HSL. It is served by 52 HSTs a day, linking the main towns in France, and by five HSTs serving northern Europe (Brussels and Amsterdam).

In Belgium, Brussels National Airport will be linked to all the main Belgian cities and to several European cities, such as Paris, Amsterdam, Cologne and Frankfurt, by 2012.

3.5. Making transport more ecological

At a time when climate change is high on the political and social agenda, the attraction of rail transport is even greater, due to its low environmental impact. Out of 25.1 % of CO_2 emissions attributable to transport in the EU-27 in 2007, only 0.6 % were from rail, which carried over 6 % of all passengers and nearly 11 % of freight ([8]).

High-speed trains are powered by electricity and their carbon footprint is therefore almost zero in their operating zones, although the CO_2 emitted during electricity generation does need to be taken into account. This rate varies depending on the primary energy used to generate the electricity consumed by HSLs. If it is generated from solid fossil fuels (coal), as in Poland or Germany, HSLs obviously have a bigger carbon footprint. However, the development of renewable and/or nuclear energy will allow this impact to be reduced in future.

Although the environmental impact of HSLs can also be reduced by improving the energy efficiency of trains and working on other elements of the vehicle, the carbon footprint of rail travel is still much smaller than that of air or road travel. In the case of a journey from Paris to Marseilles, CO_2 emissions in grams per passenger-kilometre (g/pkm) are just 2.7 g/pkm by HS train, compared with 153.0 g/pkm by air and 115.7 g/pkm by car ([9]). From the point of view of energy efficiency, HSTs also perform better, using 12.1 grams of petrol per passenger-kilometre, compared with 17.6 for conventional trains, 18.3 for a coach, 29.9 for a car and 51.5 for an aircraft ([10]).

Breakdown by origin of electricity used by the railways in 2005

Member State	Solid fuels	Oil	Gas	Nuclear	Renewable	Total
BELGIUM	11.8 %	1.9 %	25.3 %	58.1 %	2.9 %	100 %
GERMANY	54.0 %	0.1 %	8.3 %	26.7 %	10.9 %	100 %
SPAIN	38.0 %	3.8 %	18.3 %	21.5 %	18.4 %	100 %
FRANCE	4.5 %	1.8 %	3.2 %	85.8 %	4.7 %	100 %
ITALY	33.8 %	10.0 %	41.5 %	0.0 %	14.7 %	100 %
UNITED KINGDOM	37.0 %	1.0 %	37.0 %	20.0 %	5.0 %	100 %

Sources: EcoPassenger, Environmental methodology and data — Final report, Institut für Energie und Umweltforschung Heidelberg GmbH, Heidelberg, June 2008.
Rail transport and environment — Facts and figures, UIC-CER, June 2008.

([8]) *EU energy and transport in figures — Statistical pocketbook 2010;* the figure for rail does not take account of CO_2 emissions during generation of the electricity used in rail transport.
([9]) European Commission, European high-speed train — An easy way to connect (http://ec.europa.eu/transport/wcm/infrastructure/studies/2009_03_06_eu_high_speed_rail.pdf).
([10]) Alstom, 'Ecoconception: Designing responsible products' (http://www.transport.alstom.com).

3.6. Competitiveness and standard of service

HSL passengers enjoy numerous advantages in terms of speed, frequency, accessibility, reliability, price and safety. Rail companies now pitch their prices on the basis of the model used in air transport, by applying 'yield management' techniques designed to maximise income for the carrier and improve available capacity management.

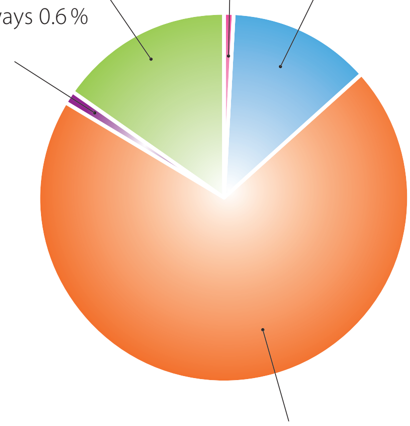
This means that passengers can take advantage of promotional offers for certain times and journeys. The most loyal customers are also offered additional services, such as the facility to cancel, change or fast-track their reservation. New promotions similar to 'low-cost' alternatives, such as iDTGV in France, also offer different packages, depending on the passenger's specific requirements.

If the HSL network is deployed as planned, it will allow savings of the equivalent of 22 million tonnes of CO_2 between now and 2020 and 34 million tonnes per annum once the network has been fully deployed in 2030 ([11]).

Research is already under way with a view to minimising the environmental impact of high-speed trains by reducing their dependency on fossil fuels. Numerous projects funded by the EU framework research programme have also focused on reducing noise pollution from HSLs. Mention should also be made of the European Noemie campaign, the aim of which was to evaluate the noise impact of high-speed trains.

For its part, the European Commission issued a communication in July 2008 on rail noise abatement, which made provision for measures to be adopted to halve the noise from freight trains. Thus, by 2014, the noise caused by the rail fleet should be reduced significantly for 16 million citizens ([12]).

CO_2 emissions by mode of transport in the EU-27



Source: EU energy and transport in figures — Statistical pocketbook 2010.

([11]) European Commission, 'European high speed rail — An easy way to connect' (http://ec.europa.eu/transport/wcm/infrastructure/studies/2009_03_06_eu_high_speed_rail.pdf).

([12]) Communication from the Commission to the European Parliament and the Council 'Rail noise abatement measures addressing the existing fleet' (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0432:FIN:EN:PDF).

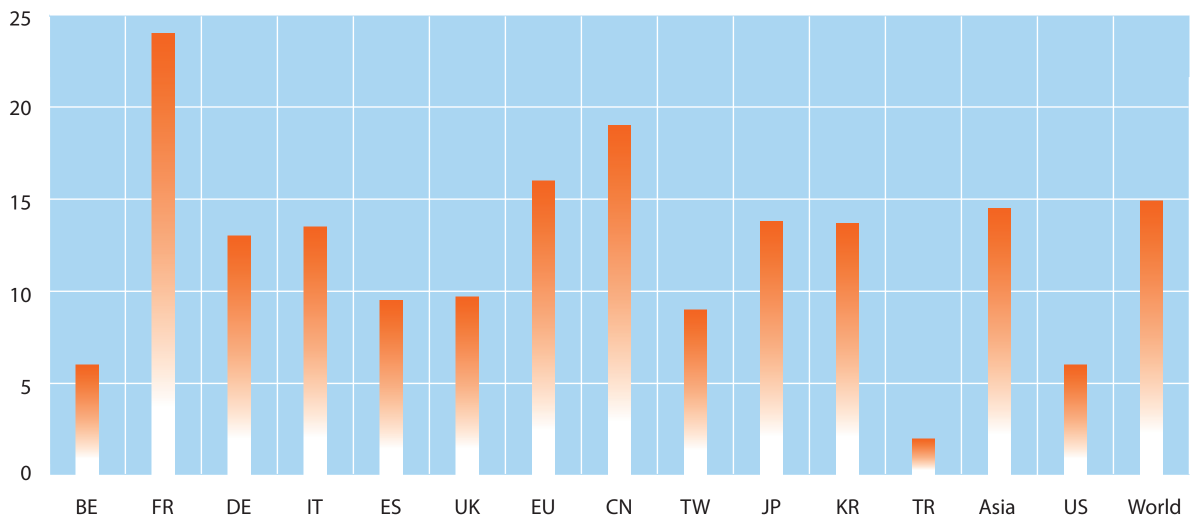
4. A TECHNOLOGICAL AND COMMERCIAL SUCCESS

4.1. Speed records and technology applied

In April 2007, TGV-POS 4402 beat the rail speed record, reaching 574.8 km/h on a section of the East HSL. Even though speeds in commercial operation are around 60 % of this, European prowess in this area is helping to develop the whole range of HSL-related technologies.

This European record is the result of highly advanced research. The engines of the V150 are far more powerful than the standard models. The total output of the V150 has been increased to 19.6 MW, compared with 9.6 MW for a conventional HST. The strain on the catenary power transmission cables has been increased to 4 tonnes, in order to make them as rigid as possible, reduce the size of the wave caused by passing trains and prevent any power cuts. The track cant has been increased in the curves, enabling commercial trains to operate at 320 km/h, rather than the usual 300 km/h on this line.

Number of trains per 100 km on new HSLs in the world (2009)



Source: International Union of Railways (UIC), High-Speed Department.

In its strategic agenda for 2020, the European Rail Research Advisory Group (ERRAC) identifies seven priority research areas for the future development of the European rail sector ([14]):

- intelligent mobility: implementing a passenger information system which is harmonised at European level;
- environment and energy: increasing the energy efficiency of trains, reducing environmental impacts (CO_2 emissions, noise) and researching alternative fuels, in order to minimise the dependency on fossil fuels during electricity generation;
- safety: improving safety for passengers and staff;
- homologation, testing and safety: speeding up product approval procedures and minimising risks through better safety management;
- competitiveness and technology: improving the interoperability and attractiveness of products for customers;
- economy and strategy: developing new network infrastructure-related cost management and forecast models;
- infrastructure: developing less costly maintenance methods and maintenance-free interoperable infrastructure systems.

Researchers are already devoting all their attention to these improvements, which give a glimpse of the numerous new efficient European technologies which are likely to emerge in future.

4.2. Research and development at the service of HSLs

High-speed trains are a remarkable technological success, the outcome of government-funded research and development (R & D) and the innovation of European industry, working closely with the railway companies, equipment manufacturers and civil engineers.

As Claude Soulié and Jean Tricoiret write in their *Grand livre du TGV*, 'The HST evokes the image of a train, of stock, coupled not just with high speed, but also with the innovation of the articulated rake. The HST is a "system" made possible by formidable progress in all rail techniques, especially track and power capture' ([13]).

Technological innovation encompasses all elements of the system: platforms, bridges and tunnels, track and power supply, as well as management and signalling systems. The ERTMS standard has propelled Europe to the cutting edge of rail management and signalling systems.

The EU framework research and development programmes have contributed enormously to this development, thanks to the remarkable partnership between research centres and industry.

The success of European technology

The European rail traffic management system (ERTMS) is gradually being installed on high-speed and conventional lines. There are currently six railway equipment suppliers in Europe. The vitality of the European market has put EU industry at an advantage when it comes to exporting this type of product and the ERTMS is now the global industry standard. This system is also in use in non-European countries, such as Taiwan, South Korea, India and Mexico. These countries have chosen this system for its cost, its excellent performance and its important advantages in terms of reliability, enhanced line capacity and increased speeds ([15]).

([13]) Claude Soulié and Jean Tricoiret, *Le grand livre du TGV*, La vie du rail, 2003.
([14]) European Rail Research Advisory Council, 'Strategic rail research agenda 2020', May 2007 (www.errac.org).
([15]) UNIFE-ERTMS factsheets, 'ERTMS deployment outside Europe' (http://www.ertms.com).

4.3. Commercial expansion

Numerous improvements and new technologies have been conceived in order to allow commercial exploitation of high-speed rail transport. These innovations are highly visible in the infrastructure, which has been modified considerably in order to cope with the constraints of high speeds. For example, ballast (the bed of stones used to support the rails) has been improved or, in some cases, replaced altogether by concrete, as in Germany. In order to guarantee better running, which is essential at high speeds, and slash maintenance costs, long welded rails were introduced as far back as the 1960s, thanks to the development of a system of elastic rail clips. These have also limited wheel wear from passing over fragile weld zones and lowered noise levels (the familiar 'di-dum' on conventional tracks), which increase as the speed increases. The points used to branch from one line or track to another have also been totally modified. For example, movable-point diamonds have been developed to stop the train 'jumping' as it passes from one track to another and the points have been elongated to limit braking during rerouting or when entering a station.

As far as rolling stock is concerned, the introduction of high speeds has basically been possible thanks to improvements to a plethora of tiny details, rather than to the introduction of radically different technologies. European engineers have improved the aerodynamics of vehicles, for example by modifying the front of the locomotives or linking carriages in order to limit friction and resultant speed losses. A great deal of work has also been done to the bogies, the running device beneath the train which contains the wheels, the axles, the transmissions and the braking devices. All this has provided more stable carriages at high speed and allowed their vibration and noise dampening properties to be improved. Finally, the additional braking systems needed at high speed, be they electric (disc brakes) as in France, or magnetic (eddy current brakes) as in Germany, have been improved considerably.

Obviously all these technical advances made by European engineers have ensured and will continue to ensure that HSLs are deployed on the continent. They also place the European rail industry at an advantage on the world market. Numerous countries are planning to develop HSLs on their territory, thereby generating a great deal of opportunity to export European expertise in this sector (cf. next paragraph). This leading position now needs to be maintained. New operators, such as China and Korea, are now breaking into this market of the future, meaning that R & D efforts in Europe will need to be stepped up if Europe wants to maintain the leading position it currently enjoys in this sector.

4.4. A world market

Numerous countries are developing or plan to develop HSLs and European industry is well placed to succeed in these markets. China has just ordered 100 HS trains from a European manufacturer for the 1 300 km line between Beijing and Shanghai ([16]). In Taiwan, HS trains have linked the north and south of the island (Taipei–Kaohsiung) since November 1996 and, according to estimates by the Taiwan High Speed Rail Corporation (THSRC), it is used by some 187 000 passengers a day ([17]). In South Korea, the KTX (Korean Train Express) celebrated its fifth anniversary in 2009. Based on European technology, it has already transported 170 million passengers (105 000 persons per day) ([18]).

Although Asia is without doubt the continent with the most dynamic HSL sector, initiatives are also being taken on the other side of the Pacific. Brazil plans to install an HSL between the cities of Campinas, São Paulo and Rio de Janeiro.This project will cost an estimated EUR 13 billion and is expected to enter into service in 2014 ([19]). In the United States, HSLs are expected to gain new momentum under the combined effect of the economic recovery plan and environmental policies. California has just released USD 4.7 billion under the economic recovery plan in order to develop a 1 280 km HSL network. This project will cost an estimated EUR 50 billion ([20]) and should enable California to save 5.5 million tonnes of CO_2 per annum ([21]).

In Africa, the first HSL is to be built in Morocco, linking Tangiers and Kenitra. The works, which are being funded with support from the EIB, are due to start in 2010 and reach completion in 2013.

([16]) 'Siemens sells 100 HST in China', *Le Figaro*, 20.3.2009 (http://www.lefigaro.fr).
([17]) Systra, 'Taipei–Kaohsiung (Taiwan) high-speed line' (http://www.systra.com).
([18]) 'Positive result from five years of KTX', Ville. Rail et Transports. 20.5.2009 (http://www.ville-transports.com).
([19]) Rio–São paulo: the Paris–London of the tropics', Ville. Rail et Transports. 23.9.2009 (http://www.ville-transports.com).
([20]) 'Californian HST finally on track', *Le Moniteur*, 18.2.2009 (http://www.ville-transports.com).
([21]) 'The Californian project finally on track', Ville. Rail et Transports. 6.5.2009 (http://www.ville-transports.com).

5. THE FUTURE

5.1. Market developments

Historic operators, such as Deutsche Bahn in Germany, Renfe in Spain, SNCF in France, Trenitalia in Italy and SJ in Sweden, play a decisive role in preserving European excellence in the HSL sector. These companies often work together through subsidiaries in order to operate international lines. Examples are:

- Thalys, set up in 1996 by the French, Belgian, German and Dutch railways to operate the HSLs between Paris, Brussels, Cologne and Amsterdam;
- Lyria, set up in 2002 by SNCF and CFF to operate high-speed links between France and Switzerland;
- Eurostar, set up in 1994 by SNCF, SNCB and British Rail (now replaced by Eurostar UK Ltd) to link Paris and Brussels to London;
- Artesia, a subsidiary of SNCF and Trenitalia, set up to operate trains between France and Italy;
- Alleo, a subsidiary of SNCF and Deutsche Bahn, set up in 2007 to operate the international trains on the East European HSL;
- Cisalpino, a company affiliated with Trenitalia and CFF, which operates all international rail links between Italy and Switzerland.

These subsidiaries, which aim to develop a European HSL network to facilitate travel within the Union, form a basic hub for the development of a European HSL network.

A European directive set 1 January 2010 as the date for the liberalisation of the international passenger rail transport market ([22]). This liberalisation will invigorate the sector by enabling existing operators to offer their services abroad and by fostering the emergence of new operators on the market. Thus airlines will be able to start operating HS trains to and from the airports which they serve. Increased competition and a diversified supply will reduce HS transport costs to passengers and help to promote more considered mobility choices.

There has already been a strong upswing in the demand for high-speed rail services and this is expected to rise even faster between now and 2020. In fact, if the supply of services remains constant, long-distance rail traffic will increase by two thirds in Europe, from 189 billion passenger-kilometres (pkm) in 1999, to 315 billion pkm in 2020. If environmental policies are tightened up, the figures should be higher (416 billion pkm in 2020, an increase of 120 % compared with 1999) ([23]).

([22]) Directive 2007/58/EC of the European Parliament and of the Council of 23 October 2007 amending Council Directive 91/440/EEC on the development of the Community's railways and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure (OJ L 315, 3.12.2007).

([23]) 'Passenger traffic study 2010/2020, Conclusions', Intraplan-IMTrans-Inrets for the UIC, February 2003.

5.2. Network expansion

According to forecasts in the TEN-T programme, the trans-European HS network (category I and II lines) should be 22 140 km long overall by 2020, compared with 9 693 km in 2008. By 2030, once the high-speed TEN-T has been completed, the network will comprise 30 750 km and traffic will have risen to 535 billion passengers per kilometre per annum (24).

In order to fully develop a trans-European HSL hub, several priority projects are devoted to the north-south link between networks. The south-west Europe high-speed rail axis will link the Iberian peninsula to the rest of Europe in a fully interoperable network. The vital north-south corridor through the Alps (Berlin–Verona–Milan–Bologna–Naples–Messina–Palermo axis) will link major German and Italian cities. The Lyon-Trieste–Divača/Koper–Divača–Ljubljana–Budapest–Ukrainian border axis, which crosses this corridor at right angles, will be able to absorb some of the constantly increasing traffic between the south-east, the centre and the south-west of Europe (25). Network extension projects are also being planned in Poland, Sweden and the United Kingdom. Poland has already announced a new HSL, linked to the European network, between Warsaw, Wrocław and Poznan.

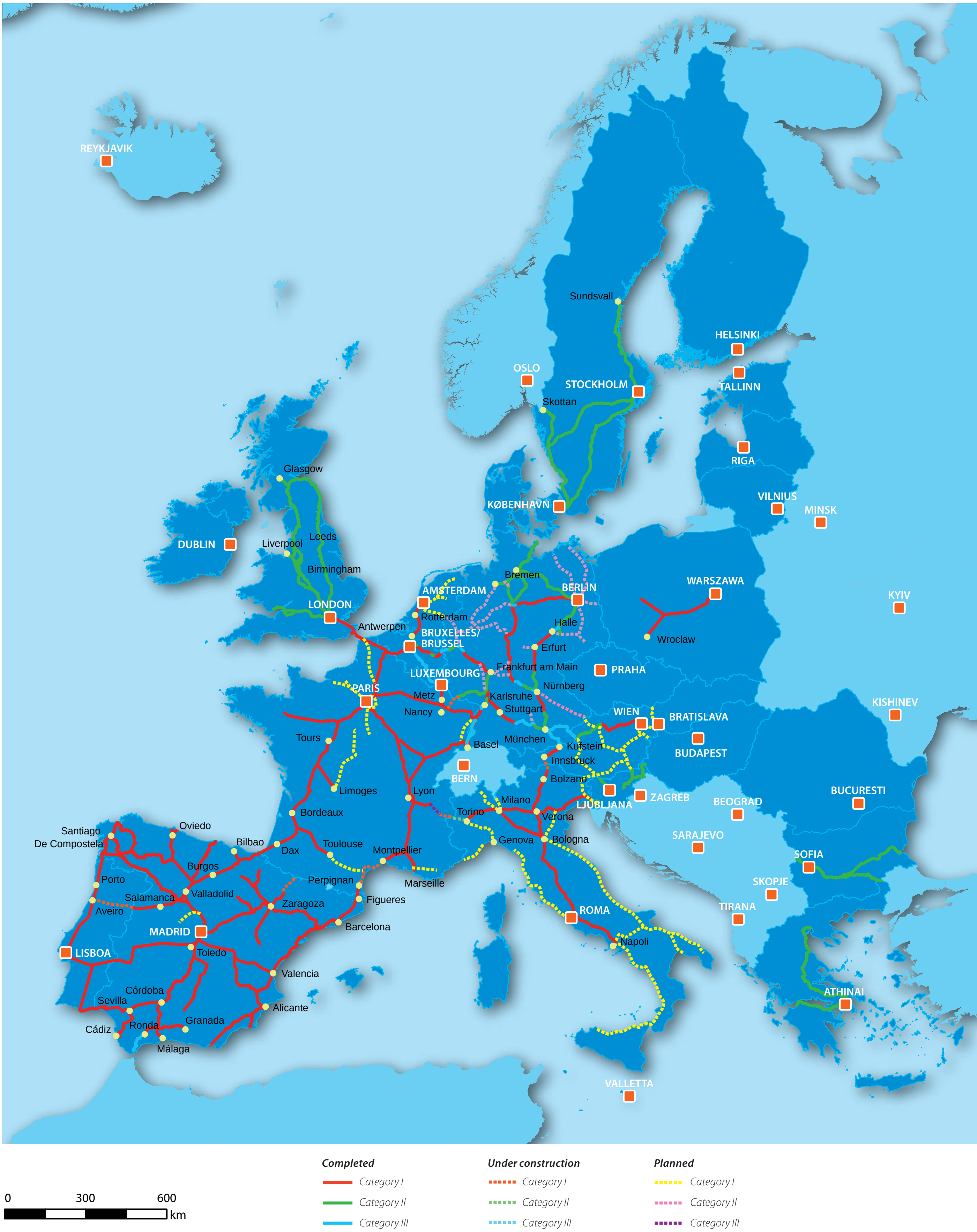
The network will also need to be extended to third countries, in order to cope with the increase in passenger and freight volumes forecast for between now and 2020. Thus, Russia will be linked to Finland by a 415 km upgraded line, which will provide the first fast rail link between Russia and the EU. The number of passengers between Helsinki and St Petersburg is expected to reach 481 200 in 2014, compared with 229 600 in 2007, while speeds will increase from 160 km/h to 220 km/h. This will reduce the journey time between the two cities from 5 hours 30 minutes to 3 hours 30 minutes.

To the south-east, Turkish State Railways are receiving EU support to develop their own high-speed network. The first 200 km section linking Ankara to Eskisehir was opened in March 2009, reducing the journey time between the two cities from 3 hours to 1 hour 20 minutes. In time, this line will extend as far as Istanbul (533 km), cutting the journey time from Ankara to Istanbul from 6 hours 30 minutes to 3 hours. Another three lines are already being planned: Ankara–Konya, Ankara–Sivas and Istanbul–Bulgarian frontier. The first phase cost EUR 628 million. It is planned to invest USD 20 billion in the Turkish railways over the next 15 years (26).

Fighting climate change, by developing a trans-European HSL network, is one of the European Union's main objectives. High-speed passenger transport will allow high levels of mobility to be maintained, while guaranteeing the sustainability of the European transport system.

(24) European Commission, 'European high-speed rail — An easy way to connect' (http://ec.europa.eu/transport/wcm/infrastructure/studies/2009_03_06_eu_high_speed_rail.pdf).
(25) TEN-T — Progress report 2009, September 2009.
(26) 'High speed launched in Turkey', Ville. Rail et Transports. 19.3.2009 (http://www.ville-transports.com).

EU high-speed railways (categories I, II and III) in 2020



Administrative land accounting units
(GISCO Database, Eurostat)
Cartography: European Commission, 20 November 2008.

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