High Speed for Europe

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Abstract

High-speed traffic is a central market segment of European railways and is therefore of great importance for their future.Consequently, all Europe's railways are working together within the High-Speed Task Force of the International Union of Railways (UIC). The past 2 years in particular have seen the opening of more new lines. The network will be developed substantially over the next few years, with the emphasis on line projects connecting with national networks.

High Speed for Europe

The transport market in Europe is growing at a fast rate, with passenger services doubling over the past 20 years. Increasing environmental awareness and modern telecommunications have not so far stemmed the rising mobility, so transport operators are increasingly reaching their capacity limits. The debate in the public arena concerning transport infrastructure development is taking on correspondingly-large dimensions. The situation of railways is characterized by the fact that they are missing out on the growth in transport; maintaining or increasing their market share is dependent on consistent improvement of services. High-speed traffic in the passenger sector stands a very good chance of reversing the current trend.

This explains the ever-growing importance of "high speed" on railways and discussion of transport policy, particularly since railways are extending their services rapidly in this sector and can offer market-oriented and environment-friendly alternatives to congested road and air traffic. High-speed rail services have seen great expansion over the past 2 years with the introduction of High-speed traffic on a further series of new lines.

The term "high-speed traffic" encompasses all trains running at speeds over 200 km/h but also trains running at 200 km/h if the terrain, population density or economic reasons do not justify higher speeds. The introduction of corresponding market products generally coincides with the opening of new lines to commercial operations. In addition to new lines, the European high-speed network consists of upgraded lines (200-250 km/h) and connecting lines (<200 km/h).

Soon after the first 210-km/h section went into operation in Japan between Tokyo and Osaka in 1964, the idea of high-speed transport began taking shape in Italy, France and Germany. Initially, priority was given to projects along important national corridors like the Rome-Florence Direttissima or the new line between Paris and Lyons. However, attention very soon turned to international traffic, a move commensurate with the technical opportunities offered by high speed. Products can be successfully marketed for distances of up to 1200 km in daytime traffic and up to 2500 km for overnight traffic. Many international routes in Europe lie within these limits.

High-Speed Task Force

The increasingly international dimension of high-speed rail led the railways to set up the High-Speed Task Force within the International Union of Railways in 1990. As a result of the new political climate in Central and Eastern Europe, the scope for high-speed applications has broadened considerably, and is now in a position to encompass all Europe. Consequently, the elements of the problem have become more complex and more than 30 railways currently work together within the Task Force.

The group is headed by Michel Walrave, with the assistance of the UIC High-Speed Division, which is responsible for the general supervision of work. As a body of the Task Force, the Steering Committee determines its objectives, tasks and a special working programme, which was set up to cover the specific needs of high speed on an international basis. This programme covers, for instance, the development of a long-term master plan, creation and maintenance of databases, socio-economic evaluations, technical harmonization and communications. The Executive Committee is responsible for implementing the work programme and for monitoring the work of six geographical groups covering the whole of Europe.

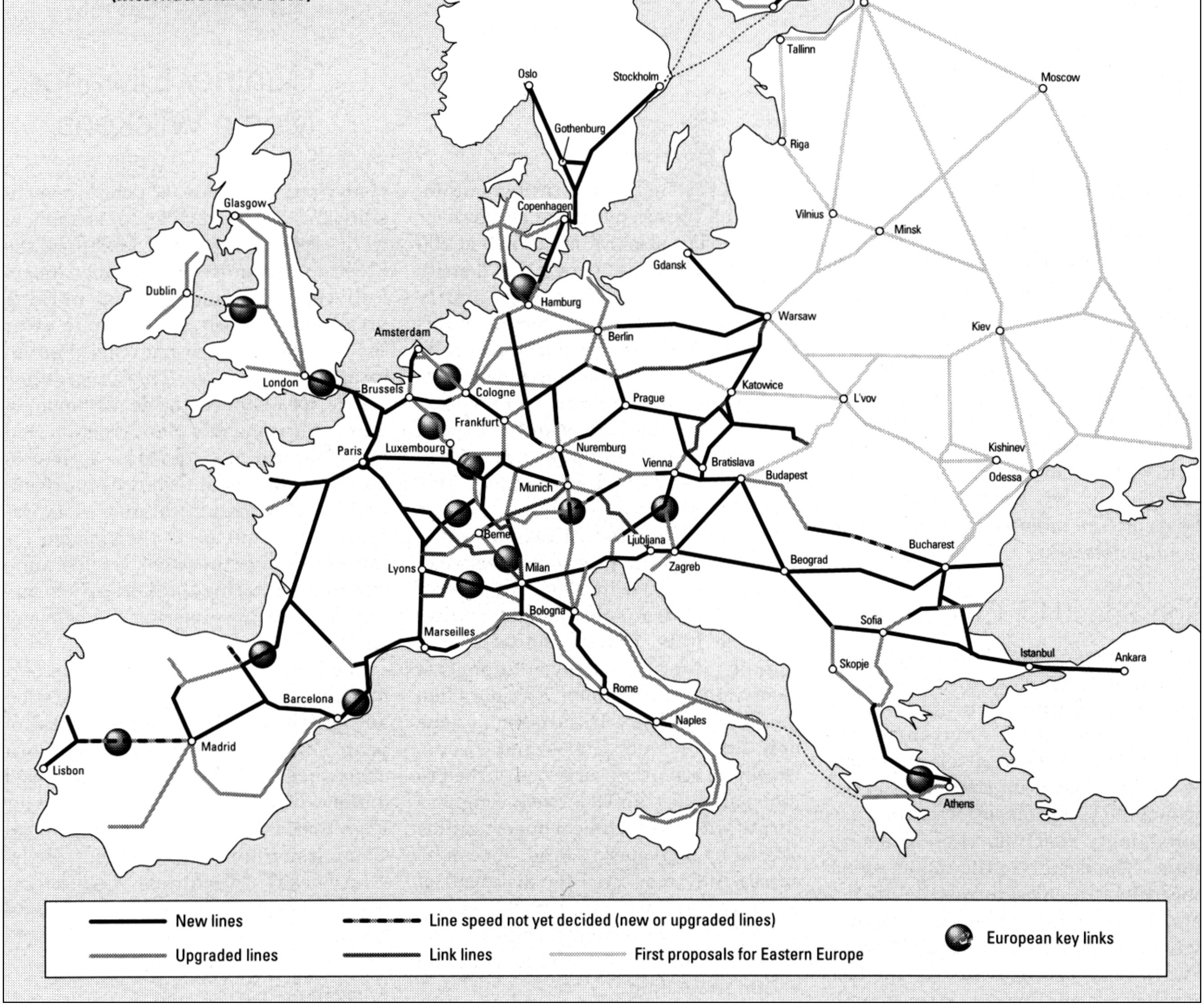
The High-Speed Task Force is in permanent contact with the Commission authorities and the bodies of the European Union with a view to network achievement. Therefore, it is involved in the work of the "High-level Group for High Speeds" chaired by the European Commission and the activities of the "Networks", "Technical harmonization", "Train command/control" and "Funding" Sub-Groups.

Master Plans

Preparation for the first truly European network, drawing the national systems together into an integrated whole, is taking place over a number of stages and has yet to reach full completion. In the first phase between 1985 and 1988, a "Proposal for a European high-speed network" was drawn up by the SNCF and the DB, and was subsequently published in 1989 by the Community of European Railways (CER) [1].

A "High-level Working Party" was then set up under the aegis of the EC Commission and given the task, amongst other things, of producing a master plan for a European High-speed Rail Network. The Working Party pub-

Figure 1 Long-term European Master Plan (International Routes)



lished its report in 1990, under the title "The European High-speed Rail Network" [2]. It was approved by the EC Council on 17 December 1990, together with the "Master Plan for the European High-speed Rail Network (2010)".

This master plan includes 9,000 km of new lines, 15,000 km of upgraded lines and 1,200 km of connecting lines. Fifteen "key links" are of particular importance to the European network. These are, for the most part, international projects in geographically-difficult areas (e.g. mountains, straits), calling for costly engineering works and posing funding problems. The investment required to implement the master plan was set at about ECU100 billion for infrastructure and ECU50 billion for rolling stock.

The updating and extension of this EC master plan has since been continued within the High-Speed Task Force [3]. The major objective has been extension of the proposed area of the network to cover all Europe and to come up with a comprehensive proposal since the opening up of Eastern Europe. At the EURAILSPEED '92 Congress in April 1992 in Brussels [4], the "Long-term Master Plan for a European High-Speed Network" was made public after drafting in agreement with the EC [5]. This current master plan is an extension of the two previous proposals. For example, the 15 key links propounded by the EC are also found in the UIC plan. For the EC plus Switzerland and Austria, it covers a network 23,000-km long, including 12,000 km of new lines. The funding to pay for the infrastructure of this network is estimated at ECU200 billion, including projects that have already been implemented. A 35,000-km network is planned on a Pan-European scale (excluding the former USSR), to include 20,000 km of new lines. The plans for Central and Eastern Europe are currently being defined in greater detail and extended towards Russia and the Ukraine. A first proposal has been included in the newest map (Fig. 1) [6].

Extended Services

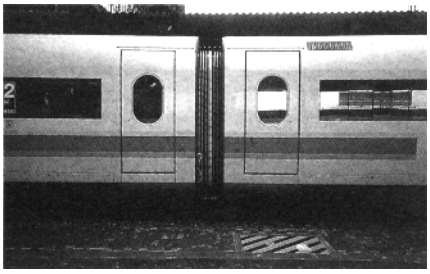
In France, commercial operation of high-speed trains began in 1981 with the opening of the southern section of the newly-built South-East line. French National Railways (SNCF) started revenue service on the Atlantic TGV line designed for 300 km/h in two stages (1989/1990). The Paris-Arras section of the new North TGV line was opened on 23 May 1993, followed in September 1993 by the extension to Lille and Fréthun/Calais at the entrance to the Channel Tunnel, adding 333 km of new line to SNCF's high-speed network. From 1994, this route will be used by the "Eurostar" trains linking London with Paris and Brussels, although the 71 km of new line in Belgium between Lille and Brussels is not scheduled to open until 1997. This is due to special political circumstances preventing the railway starting construction of the new line over the full length.

■ London Waterloo International Station waiting for Inauguration of Cross-Channel Service (M. MIURA)

■ Eurostar Train atTrial on North TGV Line (M. MIURA)

On 29 May 1994, the 70-km link between the North TGV and the South-East TGV was opened, with stations at Charles de Gaulle Airport and the Eurodisney theme park. On 3 July 1994, the South-East TGV was extended to Valence (83 km), bringing the journey time from Paris to Marseilles (around 770km) down to 4 hours. As France forges ahead with development of its high-speed network, the TGV share (passenger kilometers) of long-haul passenger traffic is expected to rise further, from 31% in 1990 to 56% in 1996.

High-speed revenue service began in Germany in June 1991 with the market launch of the InterCity Express (ICE) and the full opening of the new Mannheim-Stuttgart (100 km) and Hanover-W?rzburg (327 km) lines. With the conventional InterCity trains, the ICE's form a network with clockface services and stations where trains stop systematically. From 23 May 1993, the service has been restructured and expanded, with a major factor being the integration of Berlin. Services are provided by 60 ICE trainsets, accounting for 25% of the German Railways long-haul services. Berlin is also the focal point of the opening of the new Wolfsburg-Berlin line in 1997, the next major extension of the ICE service.



■ ICE Train at Frankfurt Central Station (T. SUGA)

Comparisons are frequently drawn between German and French high-speed traffic. However, the influence of the very different geographical structure on infrastructure projects and service planning is often understated. The SNCF timetables, which are geared to demand, and the large distances between TGV stops (up to 800 km) associated with this policy, must be seen against the background that a large number of journeys either begin or end in the Paris area (10 million inhabitants). To respond to the very broad range of customer needs, it is more advantageous in Germany to have a network in the true sense of the term because of the polycentric structure of the country. However, the two concepts are beginning to converge because the DB, with its Sprinter-ICE, network of branch lines and individual timetable slots outside the clockface system is structuring its service more flexibly, whereas the SNCF, by increasing the frequency of trains on important routes,is coming closer to clockface service planning. For example, 10 TGVs currently leave Paris for Rennes at 20 minutes past the hour on weekdays. This is a welcome development given the project to link the high-speed networks in France and Germany by means of the new lines between Paris-Brussels-Cologne and Paris-Saarbrücken/Karlsruhe.

■ Train Stewardess welcoming Passengers to AVE (T. SUGA)

High speeds began in Spain on April 1992 with the first traffic on the 471-km Madrid-Seville line. Unlike the rest of the rail network, this line was built to the standard 1,435 mm gauge, so all European high-speed lines have the same gauge. The next scheduled project is the new line between Madrid, Barcelona and the Spanish-French border. This will connect with the new French line from the border via Perpignan to Montpelier and thence with the South-East TGV, creating a link between Spain's high-speed services and the European high-speed rail network.

High-speed traffic in Italy is provided by 15 ETR450 trainsets at a speed of 250 km/h. These trains have been operating since 29 May 1988 on the Direttissima line from Rome to Flo-

■ ETR450 at Rome Termini Station (T. SUGA) rence and beyond, to Genoa, Milan, Venice, Turin, Bari and Naples. By 2000, it is planned to open the new Turin-Milan-Bologna-Florence and Rome-Naples lines to traffic, making a major corridor with a total length of 900 km including the section already in use. Planning, funding and execution of these high-speed projects is the task of a specially-created company, Treno Alta Velocit?(TAV) S.p.A. In an interesting and innovatory form of public-private partnership, 40% is capitalized by Italian railways with the remaining 60% made up of private capital.

Network Development

Tables 1 and 2 show the development of the European high-speed rail network up to the year 2000. The increasing links between high-speed systems will create a network effect. At the same time, the participating European railways will have a top-rank European product at their disposal.

To realize its full potential, the network linking Paris, London, Brussels and Amsterdam will require construction of a new line from London to the Channel Tunnel and upgrading of the Brussels-Amsterdam link. The very high population density in southeast England makes it very complex to determine a definite layout for the London-Channel Tunnel link. Nevertheless, the line should be open before 2000. The Brussels-Cologne line is of specific importance as a link to the German high-speed network and as an element in the main West-East route (Paris/London-Brussels-Cologne-Berlin-Warsaw). It is also hoped that the new line between Cologne and the Rhine/Main region (to Frankfurt and Wiesbaden) can be opened by the year 2000. Future travel times are shown in Figure 2.

Integration of the individual networks hinges on projects in France. The extension of the South-East TGV as far as the French-Spanish border will bring Spain into the network, whereas the planned Alpine crossing between Lyons and Turin will connect the French and Italian networks. The combination of new and upgraded lines on the Strasbourg-Dijon-Lyons route is a major element in the Berlin-Frankfurt-Lyons-Barcelona route. Southern Germany will be linked to France by the East TGV.

In addition to the Lyons-Turin line, the requisite capacity on transalpine corridors will be provided by the Basle-Milan, Munich-Milan and Vienna-Tarvisio routes. The positive result of the referendum of 27 September 1992 means that the projects have been given the go-ahead in Switzerland.

Extending the network to Scandinavia will require building complex tunnels and bridges. An essential element is upgrading the Hamburg-Copenhagen line with a fixed link across the Femer Belt. The decision in favour of a fixed link between Copenhagen and Malmö means the high-speed network can be extended to Stockholm and Oslo.

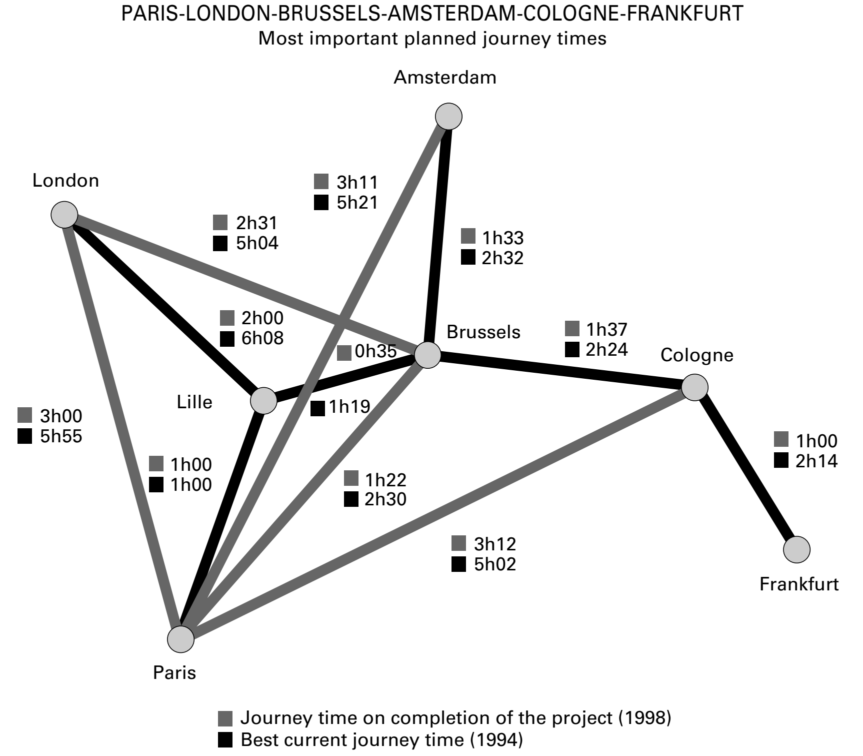
Table 1 Development of European High-Speed Network from 1981 to 1998

			length in km (new lines)
1981	France	TGV South-East (1st part)	301 km
	Italy	Direttissima (1st part)	150 km
1983	France	TGV South-East (2nd part)	116 km
1984	Italy	Direttissima (2nd part)	74 km
1988	Germany	NBS Würzburg-Hannover (1st part)	90 km
1989	France	TGV Atlantic (1st part)	176 km
1990	France	TGV Atlantic (2nd part)	106 km
1991	Germany	NBS Würzburg-Hannover (2nd part)	237 km
	Germany	NBS Mannheim-Stuttgart	100 km
1992	Spain	Madrid-Seville	471 km
	Italy	Direttissima (3rd part)	24 km
	France	TGV Rhône-Alpes (1st part)	38 km
1993	France	TGV North (without Lille-Belgium frontier)	320 km
1994	France/GB	Channel Tunnel	50 km
	France	North/South-East Connection	70 km
	France	TGV Rhône-Alpes (2nd part)	83 km
Lines in service summer 1994			2406 km
1996	France	Atlantic Connection	32 km
1997	France / Belgium	Lille-Brussels	84 km
	Germany	(Hannover)-Wolfsburg-Berlin	158 km
	Germany	Wolfsburg-Braunschweig-(Göttingen)	12 km
	Germany	(Hamburg)-Uelzen-Stendal-(Berlin)	15 km
1998	Belgium	Brussels-(Aachen)	89 km
Lines in service up to 1998			2796 km

Table 2 Development of European High-Speed Network Likely Opening Up to 2000/2002

		estimated length in km (new lines)
Germany	Cologne-Rhine/Main	186 km
	Leipzig-Lichtenfels-(Nuremburg)	190 km
	Nuremburg-Ingolsradt-(Munich)	90 km
	Karlsruhe-Offenburg	70 km
Austria	Vienna-Bruck an der Mur	35 km
GB	London-Channel Tunnel	110 km
France	TGV Mediterranean	303 km
	TGV East (1st part)	338 km
	Lyons-Montmélian (1st part of Lyons-Turin)	107 km
Spain	Madrid-Barcelona	606 km
Italy	Turin-Milan	150 km
	Milan-Florence	264 km
	Rome-Naples	222 km
Fra/Spain	Perpignan-Barcelona	174 km
Netherlands	(Brussels-Antwerp)-Amesterdam	86 km
DK/Sweden	Copenhagen-Malmö	46 km
		2977 km
Lines in service up to 2002 (Total)		5773 km

Figure 2 High-Speed Network



High Speed is a Success

The results of the railways already in the high-speed rail sector are spectacular. Through vast improvements in quality, the railways have acquired substantial numbers of additional customers. Train load factors are reaching remarkable levels such as 51% in Germany, 65% in France and 66% in Spain. This demonstrates the attractiveness for customers of this unique combination of speed, comfort, safety and convenience. Overall, in western Europe, high-speed traffic already represents over 10% of total rail traffic, expressed in passenger-kilometres. The detailed development is shown in Figure 3, which clearly illustrates the pace at which the system has progressed in the early 1990s.

Even more impressive are the results per corridor. For example, on the South-East TGV network as a whole, an increase of over 90% was recorded in the number of passengers carried between 1981 and 1992. During the first year of operation of the North-European TGV, French Railways gained more than 20% of new passengers. Results on the Madrid-Seville line in Spain are striking; a total of 2.8 million passengers was recorded in 1993, 86% of whom were new customers! On InterCity routes, German Railways' market share between Frankfurt and Hamburg rose by 11%, from 28% to 39%, after inauguration of the ICE trainsets. This tremendous success will be repeated on international lines when they come into service [7].

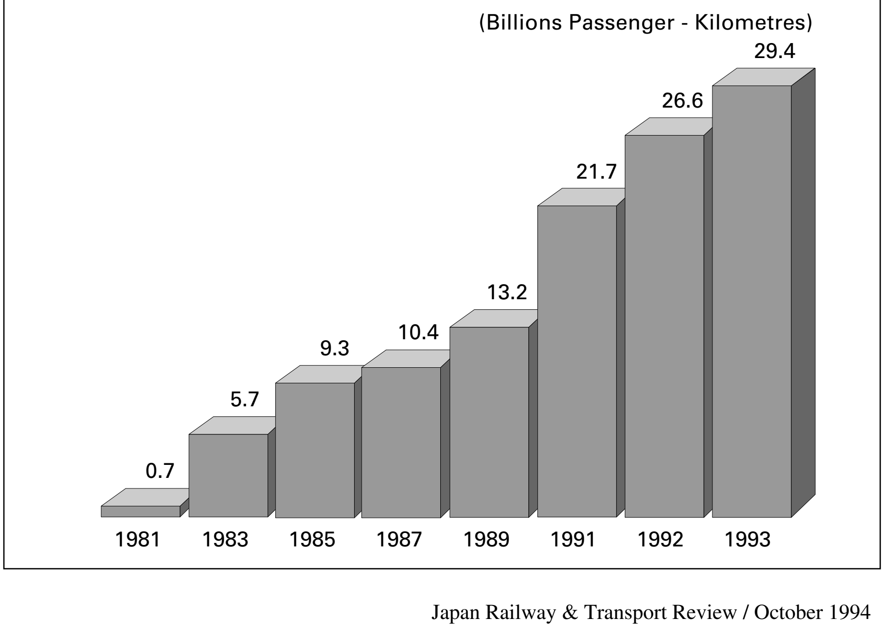
Interoperability

The establishment of a European high-speed rail network will mean overcoming technical obstacles. The following aspects are of relevance: track gauge, power supplies, rolling-stock technology and signalling techniques [8].

Spain, Portugal and the successor states of the former USSR do not have the standard European track gauge (1,435 mm). Spain's decision to build the high-speed Madrid-Seville line using the standard gauge may point the way ahead. According to initial information from eastern Europe, there is interest in building new lines to the standard gauge. On the other hand, there are indications that the new Moscow-St. Petersburg line will be broad gauge. Given the specific conditions and the continuation of the broad-gauge line to Helsinki, this would not pose problems.

In all probability, Europe will continue to have a range of different power-supply systems, because the rolling stock can be designed to work with several systems. With modifications, it can be used on several different railway networks. Future generations of vehicles will also be equipped for the particular area where they will be used.

Figure 3 Development of High-Speed Rail Traffic in Europe



Since these areas are becoming increasingly international, covering more than one railway network, solutions will probably tend more-and-more to favour wide-scale use.

Problems are posed by signalling and communication systems, because safety has to be guaranteed at the system interfaces. The experience gained from the "Eurostar" service on the Channel-Tunnel route will be very useful, because there are numerous problems to be resolved. The UIC is promoting development of the European train control system (ETCS), which may lead to harmonization in the longer term.

Independently of this, the railways and railway industry are currently working together on developing technical specifications for interoperability in high-speed traffic, in the context of implementation of the EU Directive on interoperability, the purpose of which is to lay down technical standards. Once defined, these standards will apply to all new projects; probably, there will be a limited selection of sub-systems. Therefore, more than one current system will be allowed, since there would be no way of avoiding isolated technical solutions otherwise.

Vehicles

The vehicles used in high-speed traffic are top-of-the-range products tailor-made by railway industry to suit operators' requirements. Table 3 shows the rolling stock used in Europe at present and additional projects still at the planning stage. It is clear from the table that France already has an entire family of TGVs in revenue service and that projects to extend this fleet over the next few years are moving ahead very rapidly. The first impression that all TGVs are the same is deceptive. The different series of TGV are all geared specifically for use in particular areas and for meeting the corresponding requirements in terms of capacity and quality. The length of TGV units is fixed, but when required, two units can be coupled to form a single unit. In this way, it is possible to split a train at a stop along the journey and serve different end stations.

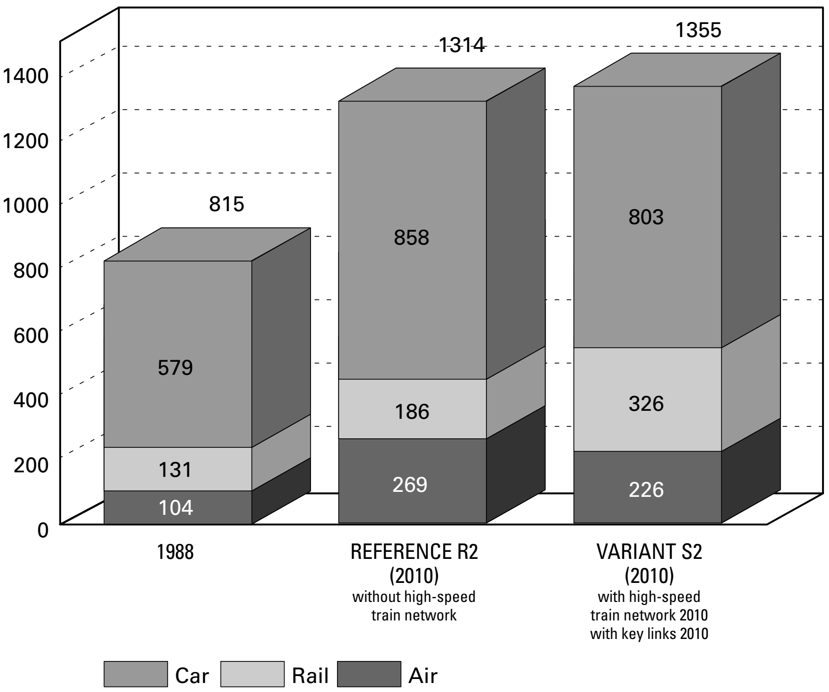
For example, there are three types of South-East TGV: a standard version with first and second class seating, a version with only first class accommodation, and units with a third current supply system for traffic between France and Switzerland. The Atlantic TGV has ten intermediate coaches, two more than the South-East TGV, and has more modern technology. The R?seau (Network) TGV will be able to circulate freely on all SNCF new lines and is also equipped for journeys travelling at high speed over several hours. The PBKA TGV will be flexible at the international level, since it will have the current supply systems and safety equipment used in France, Belgium, Germany and the Netherlands. It will run between Paris, Brussels, Cologne (Köln) and Amsterdam.

The first series of ICEs operated by German Railways is substantially longer than the TGV, generally comprising between 11 and 13 intermediate coaches. However, the number of coaches can be varied to suit requirements, not on a daily basis but according to sections of the timetable. In line with market requirements, the ICE offers passengers a high degree of comfort compared with foreign trains. Nineteen ICE units are fitted with additional pantographs so that they can be operated in Switzerland. Orders have recently been placed for a new ICE series which will differ from its predecessors, particularly in length. Here, the German railways have adopted the idea used on the TGVs and

Table 3 Rolling Stock for 250 km/h in Europe
– Present Situation and Planned Extensions –

Operating railway	Rolling stock	Current supply systems	N°	Comments
SNCF	South-East TGV	≈ 25 kV 50 Hz = 1.5kV	99	in service, 7 units only 1st class
SNCF, (SBB/CFF)	South-East TGV	≈ 25 kV 50 Hz = 1.5 kV ≈1.5 kV 16 2/3 Hz	9	in service, for traffic into Switzerland
SNCF	Atlantic TGV	≈ 25 kV 50 Hz = 1.5 kV	105	in service
SNCF	Réseau TGV	≈ 25 kV 50 Hz = 1.5 kV	50	in service
SNCF	Réseau TGV	≈ 25 kV 50 Hz = 1.5 kV = 3 kV	40	trial runs, intended for traffic to Belgium
SNCF	Double-decker TGV	≈ 25 kV 50 Hz = 1.5 kV	1st series prob. 45 units	under development
French postal service	Postal TGV	≈ 25 kV 50 Hz = 1.5 kV	3	postal service on Paris-Lyons
SNCF, SNCB, BR	Eurostar	≈ 25 kV 50 Hz = 3 kV = 0.675 kV	38	about to enter into service; 7 units for traffic North of London
SNCF, SNCB, NS, (DB)	PBKA TGV	≈ 25 kV 50 Hz = 1.5 kV = 3 kV ≈ 15 kV 16 2/3 Hz	37	orders placed, DB to lease 3 units from SNCB, in service 1996
RENFE	AVE	≈ 25 kV 50 Hz = 3 kV	16	in service, 8 further units ordered
DB	ICE	≈ 15 kV 16 2/3 Hz	60	in service, including 19 units for traffic into Switzerland
DB	ICE-2	≈ 15 kV 16 2/3 Hz	44	ordered, in service 1997
DB	ICE-2/2	≈ 15 kV 16 2/3 Hz ≈ 25 kV 50 Hz = 1.5 kV	4	ordered, for traffic to NL from 1998 on
DB	ICE-2/2	≈ 15 kV 16 2/3 Hz ≈ 25 kV 50 Hz = 1.5 kV = 3 kV	9	ordered, in service 1998
DB	ICE-2/2	≈ 15 kV 16 2/3 Hz	37	ordered, in service 1999
FS	ETR 450	= 3 kV	15	in service
FS	ETR 460	= 3 kV	10	ordered, in service 1994
FS	ETR 500	= 3 kV ≈ 25 kV 50 Hz	30	ordered, in service 1995

Figure 4 Traffic in Billion Passenger Kilometres (SCENARIO B)
(Trips 80 km only, without former East Germany, air traffic without intercontinental flights)



have built shorter units that can be operated either on their own or joined together depending on requirements. German industry, in association with German railways, is developing an ICE for international traffic, equipped with different signalling and power supply systems. Plans are also made for an ICE with tilting technology.

The Spanish high-speed train, the "AVE", is based on the TGV, although some of the technical equipment came from Germany. RENFE has incorporated three classes of coaches in all AVE trains. The Italian railways, for their part, have put another idea into practice; their high-speed train, the ETR450, runs on the new line at 250 km/h. On other lines, its tilting body enables it to negotiate curves at higher speeds by "leaning into" the curve eliminating the need for upgraded infrastructure. More thought could be given to use of tilting-body techniques in high-speed trains in other countries with a view to reducing journey times on upgraded and connecting lines.

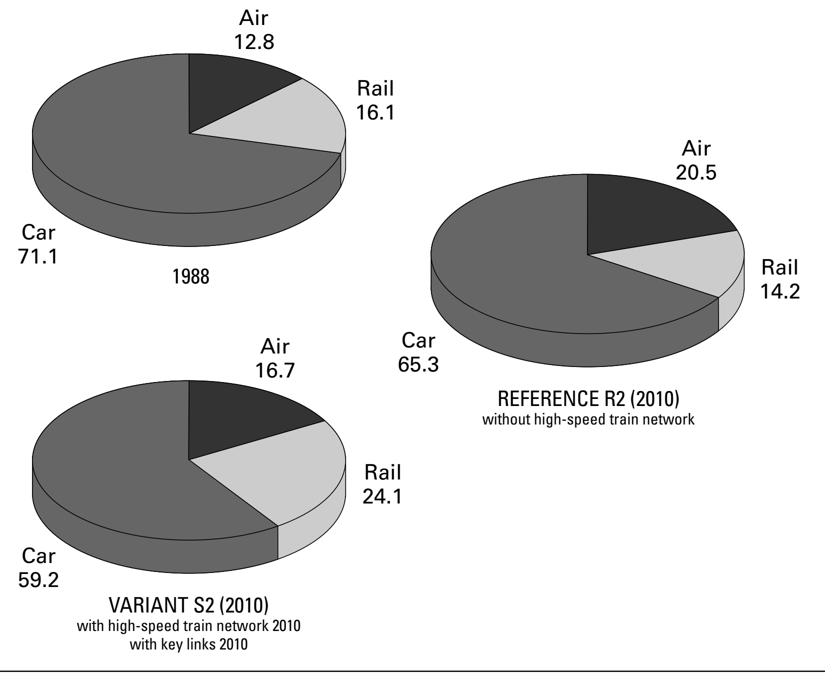
Particular attention is currently focused on "Eurostar", the new high-speed train due to enter revenue service through the Channel Tunnel from mid-1994, linking London with Brussels and Paris. Technically speaking, "Eurostar" belongs to the TGV family, but differs from the other versions in terms of its special conditions of use and safety regulations. "Eurostar" comprises 18 intermediate coaches and has an overall length of 394 meters. It is built in a strictly symmetrically fashion from the center of the train out.

Looking to the future, there is the planned development of a double-decker TGV, the same length as the Réseau TGV but with 45% more seating. It will offer precious capacity-enhancing opportunities without the need to upgrade infrastructure, while at the same time substantially reducing operating costs per seat-kilometer. The operating speed will probably rise above 300 km/h, although no definite decision has been taken yet. In view of these new opportunities and the important associated research, it would be preferable if European industry could cooperate closely to develop economic solutions for high-speed trains in Europe [9].

Traffic Forecasts

The study commissioned by the UIC/CER and the EC on "Traffic forecasts and evaluation of a high-speed network

Figure 5 Modal-Split of Long Distance Traffic (SCENARIO B)
(Travel Distance 80 km, without former East Germany, air traffic without intercontinental flights)



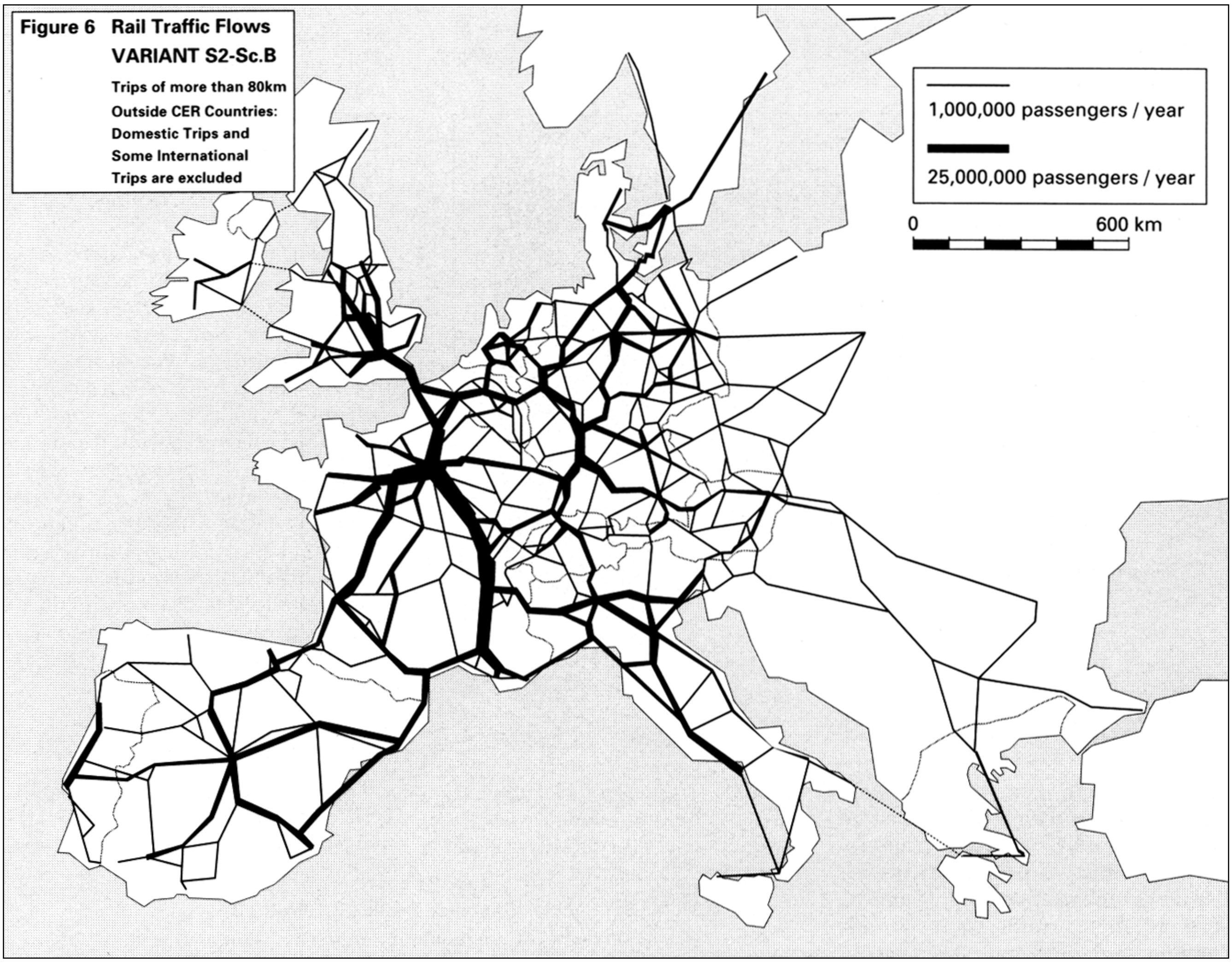


Figure 6 Rail Traffic Flows
VARIANT S2-Sc.B
Trips of more than 80km
Outside CER Countries:
Domestic Trips and
Some International
Trips are excluded

in western Europe" was completed in early 1994. It was conducted by two companies: INTRAPLAN and INRETS [10]. It is the first study comprising traffic forecasts based on consistent data for all national and international passenger traffic (distances over 80 km) and for all transport modes except coaches. The geographical sub-division made in the study is very precise and takes in the whole area of the EU plus the Alpine countries (183 traffic centres, plus a further 14 larger traffic centres covering neighbouring countries).

The principal aim of the study was to carry out traffic forecasts and cost-benefit analyses for the railways operating the high-speed network. Distinctions are made between the differing degrees of development in the high-speed network. The study assumes moderate economic growth and a lower relative increase in mobility than in the past, since slightly restrictive hypotheses for quality and costs were taken as the basis of journeys by private car. Developments in rival modes of transport were simulated, particularly to take account of the foreseeable expansion of the motorway network and improvements in flight connections.

The following development scenarios were at the forefront of the forecasts and evaluations relating to the high-speed network.

- Reference case (R2), i.e. status quo (in relation to 1988), with no further development of rail infrastructure.
- Basic alternative (V23), i.e. completion of high-speed network without key links
- Full alternative (S2), i.e. completion of high-speed network including key links

A comparison of these alternatives shows that in 2010, railways operating high-speed rail services stand to gain, when taken together, 142 billion passenger km per year. This represents a 72% increase, 40% of which can be traced to traffic transferred to the railways from the roads, and 31% to traffic transferred from the airlines, with the remainder being newly-created traffic (Figure 4). The market share of the railways in relation to total passenger traffic in western Europe over distances of more than 80 km should rise from 14% to 24% for the S2 full alternative, in terms of passenger km (Figure 5). On this basis, high-speed trains would generate 65% of passenger km in passenger rail traffic, compared with only 7% for the R2 reference case without further developments to infrastructure. Future rail traffic flows are shown in Figure 6.

The share of total revenue generated by high-speed trains is less than 10% with the R2 reference case, but rises to 72% for the S2 full alternative. With regard to investment, with the S2 full alternative, the internal rate of return is 6.4% where only the costs attributed to passenger traffic are taken into account, and 4.3% where all investment is set against passenger traffic, which is clearly an extreme hypothesis.

Sensitivity calculations with respect to competitors' service conditions (particularly air tariffs or car running costs) show relatively stable cost-effectiveness of the high-speed network, on the assumption of less-favorable competitive conditions for the railways.

Conclusion

These results demonstrate the urgent need to develop the high-speed network and the new vistas that will open up as a result. The new situation throughout Europe calls for a transport system suited to the size of the continent. Through the development of high-speed rail services, the European railways are improving their product range radically and are increasing their market share substantially, to the greater benefit of their economic results. Alongside such corporate objectives, there is also the political determination to promote development of rail transport as one way of providing Europe's population with sustainable mobility compatible with the constraints of environmental conservation. ■

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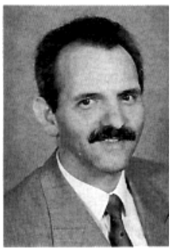

Gunther Ellwanger

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