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HISPEEDMIX PROJECT

“High Speed Freight on the European High Speed Railway Network”

contract n. RA-97-AM-1127 R97 SIN 000762-B6716101

Project Co-ordinator: Ferrovie dello Stato spa (IT)

Partners: Ferrovie dello Stato - Società di Servizi e Trasporto per Azioni - “FS S.p.A.”
AEA Technology rail - formerly “BRR”
Deutsche Bahn AG - “DB AG”
Red Nacional de los Ferrocarriles Espanoles - “RENFE”
Societe National des Chemins de Fer Français - EPIC - “SNCF”
Foundation European Rail Research Institute - “ERRI”
Sciro Electra S.r.l. - “SCIRO”

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FINAL REPORT FOR PUBLICATION

High Speed Freight on the European High Speed Railway Network

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II. Partnership

The partners in the HISPEEDMIX project have been chosen in such a way to avoid overlaps and obtain synergy. The partnership structure has been set up focusing on two groups of complementary members.

Two Research and Development organisations specialised in the transport area which are involved at European and National level with projects linked to Hispeedmix:

1) the Research Institute of the English Railways AEA Technology Rail and
2) the Italian Consultant Company of the transport sector SCIRO.

Four of the most important rail freight operators and infrastructure managers in Europe: DB-Germany, FS-Italy, RENFE-Spain and SNCF-France.

In addition ERRI, the European Rail Research Institute, added its own expertise and established close links with all member railways, not directly participating in the project.

Four European Universities: Leeds (GB), Catalonia (ES), Madrid (ES) and Genoa (I), with the Centre for Transport Research, worked for the project development as well, as sub-contractors.

The future-orientated research and development work of the Deutsche Bahn AG is also integrated with the experimental activities in the Research and Technology Centre (RTC). The RTC has emerged from the unification and concentration of sections of the former central offices and testing facilities of the German Federal Railways and the German State Railways. With the creation of the research and technology sections at the DB AG 5 years ago, a process of change in the interplay between the railway and industry began simultaneously. Against the backdrop of the second stage of the railway reform, which gave rise of five large group subsidiaries in the form of limited companies under a management holding company at the beginning of 1999, the RTC took over the role of an innovative connecting link between the DB AG group as a mobility service provider and transportation company and between industry as a manufacturer. In doing so, the extensive wealth of knowledge has become increasingly directed at the core tasks of the RTC:

- System development of the railways with regard to the interplay between the technical subsystems and the individual group subsidiaries.
- Definition of the interaction of the sub-systems in their contact areas or interfaces.

- Services in the form of:
  - tests
  - technological advice
  - experts opinions
  - project management.

This includes extensive market monitoring, i.e. for both the railway customers and the RTC customers, of technological matters and of competitors. The RTC customers are essentially the group subsidiaries DB Reise & Touristik, DB Regio, DB Cargo, DB Netz and DB Station & Service. The manufacturers of railway technology and other construction companies also use the RTC facilities for testing and experimental purposes.
The DB AG through the RTC was responsible for the Hispeedmix project operational aspects.

The European Rail Research Institute (ERRI) is a foundation under Dutch law within the International Union of Railways (UIC) responsible for carrying out research, studies and tests to advance knowledge of railway technology in fields of common interest.
ERRI currently boasts 32 European Participants and 10 Affiliates from a total of 28 countries, including worldwide research organisations in the USA (AAR), Japan (RTRI), South Africa (Spoornet) and India (RDSO). This affiliation is in line with ERRI's objectives to stimulate international interchange of information and technology.
The Headquarters are based in Utrecht, the Netherlands.
ERRI carries out a policy of co-operating with various partners (users, railway operators and industry, technical research centres, universities, etc.) knowing that pooling resources will boost the effectiveness of projects and allow more flexibility and responsiveness to research requirements at a European level.
Its role includes co-ordinating long-term research programmes and ERRI is particularly active in:

- Management and execution of studies, research and tests
- Drafting of research and development programmes
- Development and testing of railway equipment
- Monitoring of emerging technologies and their application to the railways ERRI operates with professional in-house technical and management specialists and with contracted specialised resources allocated to each project.

ERRI can call on over 500 railway specialists, from a wide range of disciplines. The laboratories and testing facilities of the European railways are available to us for model/full-scale tests and demonstrations. The various resources needed to

manage and execute a specific research project are contracted according to open calls for tender.
In December 1997, a wholly-owned subsidiary was set up - European Rail Services B.V. (ERS). This reflects the way the Institute is developing and forms part of the structural changes taking place at ERRI. ERRI launched this subsidiary with two main objectives: to handle all of its commercial activities and to market ERRI's knowledge and expertise to a worldwide audience.
At the end of 1998, ERRI opened an office in the Community of European Railways' (CER) building in Brussels. Having a base at the heart of the European Union gives ERRI the opportunity to improve its contacts and communication with the European Commission, to advise on research initiatives and to obtain feedback on new policy developments.
With respect to the HISPEEDMIX project, ERRI was mainly responsible for the development of the project dissemination activities.

The story of the "Ferrovie dello Stato" began on the 3rd of October 1839, in what was then the Kingdom of the Two Sicilies, with the inauguration of the line connecting the two royal residences of Naples and Portici. The rulers of the other Italian states, not wishing to be outdone, quickly had other railway sections built in the Lombard-Venetian State (1840), in the Grand Duchy of Tuscany, in Piedmont and in the Papal State. These were still reserved for the Royal Families only. In Italy in 1850, there were 2,000 km of railway lines, 10,510 km in 1865 and 16,000 km in 1995.
In 1992: the "Ferrovie dello Stato" Body is converted into Ferrovie dello Stato S.p.A. (State Railways Inc.).
The changes, which the Company has undergone since 1992, have drawn strength and significance from the EU directives 91/440, 95/18 and 95/19. These have, in fact, revolutionised the railway sector, introducing the principle of free competition.
The Ferrovie dello Stato is today a Transport and Services Sole Corporation, the sole proprietor of which is, for the time being, the Ministry for the Treasury of the Italian Republic.
The overall length of the network amounted to 16,030.3 km at the close of 1997, a figure which does not differ significantly from that of the early nineties. Considerable, on the contrary, was the gradual technological improvement of the infrastructure during the last years, while the technical characteristics were notably strengthened. The electrified network at the end of 1997 equalled 10,358,3 km, or 64.6% of the total. The double-track network covered 6,106 km, 38.1% of the overall network. These percentages, referred to 1985, stood at 55.2% and 33.8% respectively. Lines equipped with the automatic blocking system reached 5,040 km in 1997, an increase of 205 km over the previous year and of 1,900 km (+61%) when compared with 1998.
Traffic concentration on the FS network continued at a high level during 1997. In this respect it is to be noted that 50% of the network absorbs 83% of the trains km covered and over 94% of the total Traffic Units. With reference solely to tons km, concentration was in the vicinity of 98%.

Infrastructure Division played a significant role in the Hispeedmix project development. In fact, not only had it co-ordinated the whole project being responsible for the project management, but it had also been responsible for the development of the project internal profitability, carried out by the Technical and Commercial Directions.

RENFE is the Spanish Rail Transport Company. It is organised in separate Business Units.
The *"Infraestructura Ave Y Coordinacion"* Business Unit is in charge of maintaining the Madrid-Sevilla high speed line and co-ordinating with the Spanish Ministry of Public Works, Transport and Environment the planning, design and construction of new lines as well as the improvement of existing ones.
In particular, one of the missions of that Business Unit is to give advice to the Ministry about the infrastructure and superstructure parameters to be considered for designing the new high speed lines, which is strongly related to the Task 1.c of the Hispeedmix project.
The *"Infraestructura Ave Y Coordinacion"* Business Unit of RENFE will work in the Hispeedmix project with the help of two major Sub-Contractors, both shared by RENFE:

- *Ingegneria Y Economia del Transporte, S.A.* (INECO)
- *Tecnologia E Investigacion Ferroviaria, S.A*. (TIFSA).

RENFE was responsible for the Hispeedmix project technological aspects.

Société Nationale de Chemins de Fer Français is a National Rail Transport company which realises RTD activity as a support to technical progress.
SNCF undertakes research in many field related to its activities in order to improve the service it provides to its customers and to optimise the specifications SNCF gives to manufacturers.
SNCF is the only railway company in the world which runs high speed freight trains operations, with a speed of 270 km/h. Since this service was launched in 1984, SNCF has now a great experience of business activities and logistics in this field.
In order to fulfil the demand and increase its service, SNCF must now develop a new way of maintaining tracks, since the maintenance is being done during the night on the SNCF high speed network and is therefore incompatible with freight operations which take place mainly at nights.

In this regard, SNCF participated actively in the Hispeedmix project development especially with the aim of developing new models concerning infrastructure maintenance and operation on the high speed network. Its participation included market studies and traffic forecast for high speed freight products on a European scale.

AEA Technology Rail brings together 30 years of railway expertise in Derby with one of the world’s largest independent international science and engineering businesses, to form a unique force in the railway industry.

- AEA Technology Rail inherits a unique pedigree from BRR, a company that has become acknowledged and respected as a world leader in many railway engineering and scientific disciplines
- AEA Technology Rail inherits an enhanced set of skills, experiences and resources from AEA Technology, which are now directly available to railway markets
- AEA Technology Rail understands the business needs of railway customers and focus on delivering them by reducing risk and improving performance
- AEA Technology Rail is a company that uses our wide technological capabilities to add value and to deliver innovative solutions Worldwide

AEA Technology Rail is a world leader in delivering innovative rail solutions to customers in the rail industry around the globe.

AEA Technology Rail's breadth of knowledge and experience across all areas of railway engineering and operation enables the wider implications of competing strategies to be rapidly evaluated in a true system-wide approach. Its capability covers all aspects of a railway system:

- Trains
- Rolling Stock
- Track
- Civil engineering
- Signalling
- Operational needs
- Safety

Its unique expertise enables the Company to assemble multi- disciplinary project teams containing the right balance and mix of skills to ensure that appropriate solutions are delivered.

Its independence and credibility within the industry further allows us to give impartial advice on both technical and commercial issues across traditional functional boundaries.

AEA Technology Rail applies its expertise to all stages of the product life cycle from concept identification through development, testing and application to maintenance and life extension. In delivering solutions in all these areas we are able to manage whole projects on behalf of customers, or provide products, advice, support, and guidance on specific issues to suit your demands at the time.
With regard to the Hispeedmix project, AEA was responsible for the market analysis carried out.

SCIRO s.r.l. was founded in 1987 by a group of researchers. The company operates in the field of advice, design and research for transportation technological systems, especially railway transportation, and industrial systems.
The following main Activity fields can be covered by SCIRO:

- Railway signalling systems
- Software
- RAMS
- Intermodal systems
- Transportation Economics
- Drives, power electronics and HW.

The staff consists only of graduates, mostly PhDs, of professors and managers with experience in private transport industry.
SCIRO's human resources and external consultant net have differentiated skills able to offer state-of-the-art solutions for complex, interdisciplinary projects: from SW to HW, from TLC systems to power supply, from transportation systems analysis to economic-financial studies. SCIRO is strictly linked with the International Scientific Community and is active in the field of R&D to follow its own vocation and to participate in the national and international projects with other partners.
SCIRO has always been active in the field of railway transportation, devoting particular interest to the development of innovative solutions, also in the European context, regarding Functional Specifications (e.g. ERTMS), Safety (e.g. risk analysis of ERTMS/ETCS), Design (e.g. time-table data base, traffic manager MMI, train graph), Implementation (e.g. diagnostics for the Strasbourg Eurotram), Validation (e.g. Verification & Validation of ATP/ATC, ACS Computer-based Interlocking and SCC Control/Command System for traffic control and operation).
SCIRO co-operates with both the FS Companies such as Italferr, Divisione Infrastruttura, Divisione Cargo as Engineering Qualified Vendor and National and International Companies active in the railway sector (Ansaldo Trasporti, Ansaldo Segnalamento Ferroviario, ABB Sae Sadelmi, ADTranz, etc.).
SCIRO operates in the development of customised solutions for intermodal systems.
SCIRO has co-operated with Transport Operators (terminal operators, rail/routes operators), with industries for goods handling (containerised and in bulk)

development and production, and with manufacturers of high-tech products (radio frequency tags, bar codes, GIS Geographical Information Systems, GPS satellite receivers).
In this respect, SCIRO offers management and technological advice aimed at the implementation of innovative solutions based on the integration of different elements).
SCIRO has developed solutions for logistic systems, such as containers localisation and identification on port and inland terminal yards, integrating different technologies such as sky-cam and satellite positioning, tracing and tracking of railway freight wagons at European level through intelligent systems for on-board communication and energy management, automatic logistic systems for container handling in ports, fleet management and tracing systems.
With reference to the Hispeedmix project, Sciro was responsible for the project system and safety aspect assessments.

University of Genoa

The Transport Research Centre operates within the University of Genoa - ITALY. The Centre aggregates know-how and expertise of all sectors of the University dealing with transport issues. Particularly, technologies, strategies, planning and economic aspects of transport are studied in the Centre.
Approximately fifty researchers with extensive experience in the different sectors of transport adhere to the Centre. The adherents come mainly from the Faculties of Engineering and Economics and carry out teaching activities in the context of the following:
The Centre collaborates with transport companies and public administrations on the basis of research conventions and contracts. The staff of the Centre is or has been involved in EC Funded projects (EURET- DG VII, MARCO - Telematics DG XIII, COMBINE enhanced COntrol centre for a Moving Block sIgNalling systEm) and National Research Council projects (2nd Transport Finalised Project, Optimum Energy Management in Railways and Electromagnetic analysis of railway systems).
In the Railway system area the Centre has specific expertise on power installations, electrical and mechanical aspects of rolling stock and track, traffic control and supervision, signalling, RAMS (Reliability, Availability, Maintainability and Safety).
In the Hispeedmix project the Centre was responsible for the Dependability Definition and the Technological aspects related to the power supply systems.

Founded in 1966 and taking its present name as an autonomous unit in 1971, the Institute for Transport Studies (ITS) at Leeds University is one of the leading inter-disciplinary groups involved in teaching and research in transport studies, with a staff of over 40 and typically some 80 postgraduate students at any one time. Its current emphases are on the planning, design, operation and use of land transport facilities in Europe and in developing countries.

ITS was awarded 5*A rating in the 1996 HEFC Research Assessment Exercise. The 5*A category is the highest, for "Research quality that equates to attainable levels of international excellence in a majority of sub-areas of activity and attainable levels of national excellence in all others." ITS staff contribute to the work of many high level committees, including the Department of the Environment, Transport and the Regions Standing Advisory Committee on Trunk Road Assessment, the Economics Expert Group of the International Railways Union and the Passenger Demand Research Forum of the British rail industry.

The Institute acts as a focus for transport teaching and research in Leeds. It provides an MA in Transport Economics an MBA in Transport Management, an M.Sc in Transport Planning and an M.Sc(Eng) in Transport Planning and Engineering, as well as research training leading to the degrees of M.Phil, and Ph.D. The Institute is the largest university-based transport research group in the UK. ITS has joined with the School of Geography to offer a BA (Hons) programme in Geography with Transport Planning, and with the Leeds University Business School, to offer BA (Hons) programmes in Economics with Transport Studies and in Management with Transport Studies.

The aim of ITS is to advance the understanding of transport systems throughout the world, by teaching and research activities which develop the necessary skills and best practice in the planning, design, operation, and use of transport systems.

The Institute is committed to achieving this aim in its research grants and contracts by meeting its sponsors' and clients' requirements as effectively, efficiently and closely as possible.

With regard to the Hispeedmix project, the Institute was responsible for the market study.

Universidad Politécnica de Madrid

The *Transport Department* is part of the largest Civil Engineering Faculty in Spain founded in 1802. Presently it has 3,800 students in four different branches: Transportation, Hydraulics, Structural and Urbanism/Regional Planning. The Transport Department is responsible for the teaching activities in Transportation at graduate and postgraduate level. It has 24 academics in charge of teaching activities in Transport and 40 Doctorate students dealing with different Transport activities. There are five sections within the Transport Department: Railway Engineering, Highway Engineering, Traffic Engineering, Ports Operation and Transport Economics and Planning.

The Transport Department has the following main fields of research: Transportation Planning; Economics of Transport; Transport Demand Management and Modelling; Traffic Theory; Environmental and Energy Analysis; Rail, Road and Ports Engineering, Intermodality and Interoperability, Private Finance of Transport Projects and Operation, Urban Transport and Logistics.

In the area of Transportation Planning and Economics of Transport, it is involved in a number of research projects financed by national and international institutions. It has taken part in the following projects of Transport and Telematics within the EU IV Framework Programme: SCENARIOS and SCENES (Transport-Strategic), HISPEEDMIX (Transport-Rail), TransPrice, AFFORD, ICARO (Transport-Urban) and EMMA (Telematics). It has also done research projects in the SAVE Programme as "Reduction of energy consumption and environmental pollutants through demand management policies based on HOV lanes and action on company motivation" and "Technologies and tactics to improve urban mobility in European cities (Thermie)". It has been responsible for a number of projects at national level as "mobility analysis in medium size cities in Spain", "Valuation of energy and environmental benefits of the urban ring roads: application to the M-40 motorway of Madrid Region", "Work-based trip reduction management in the N-VI corridor", "Congestion costs in the city of Madrid", etc.

The Technological University of Catalonia is a young university, though with a centenary tradition. Founded in 1971 under the name of Universidad Politécnica de Barcelona, it was initially composed of the technical schools of industrial engineers of Barcelona and Terrassa by the School of Architecture of Barcelona and some research institutes. These schools possessed a distinguished tradition and their origins date back, in some cases, to mid the 19th century.

Since its creation, the Universidad Politécnica de Barcelona has incorporated and created new schools and faculties. The statutes, revised and modified in 1995, provided the University with the matrix structure of centres, departments and institutes currently in place and it became known as Universidad Politécnica de Catalunya (UPC).

Studies leading to 42 degrees and a Doctorate can currently be studied. In addition to the official qualifications, the UPC offers 4 degrees of its own and a considerable variety of postgraduate studies: doctorate programs, masters, postgraduate programs and courses in the following areas:

Agricultural and Forestry, Architecture, Science, Health Sciences, Economics, Civil Engineering, Industrial Engineering, Photography and Multimedia, Computer Sciences, Nautical Studies and Telecommunications.

UPCINFO@INFO.UPC.ES

With regard to the Hispeedmix project, the University of Catalunya developed the Technological Constraints analysis.

III. Executive Summary

General presentation

Hispeedmix is a project initiated in 1997, under the aegis of the IV Framework Programme of Research and Development Technology of the European Union, in order to study the future potential of the European high speed Railway network with a view to providing a fast goods service. The first objective was to identify the conditions under which the use of the high-speed network for mixed traffic is technically possible and profitable. The first step was to identify those segments of the high speed European network which were potentially profitable and on which the Hispeedmix service could be launched.

The project, which took approximately 33 months, costed 2,000,000 €, of which 50% was financed by the European Commission and the rest by the Project Group.

The Project Group was made up of:

- four large railway networks: SNCF- France, DB- Germany, RENFE- Spain, FS- Italy;
- ERRI- the Netherlands (the European Rail Research Institute);
- AEA Technology Rail: the Research Institute of the English Railways;
- SCIRO, an Italian Consultant Company of the transport sector;
- four European Universities: Leeds, Catalunya, Madrid and Genoa with the Centre for Transport Research.

Objectives

Hispeedmix was proposed as a project to examine two different scenarios for offering freight services on the European High Speed Railway Network (EHSRN):

- to assess the market requirements for high speed freight traffic and the capability of the existing high speed lines to cope with such traffic;
- to study the utilisation of the high speed network for traditional freight traffic in mixed traffic conditions.

The objectives were to identify the strategic options for the mixed use of the EHSRN and to define the operational and technical parameters able to supply the identified potential demand.

The project was structured to achieve the following goals:

- To carry out detailed cost-benefit analysis with the development of financial models. This has provided us with the business case, which the investment necessary to offer new services will be based on.
- To define the economic and commercial reference parameters for offering European citizens a competitive freight and passenger service on the EHSRN.
- To examine the current freight transport market across Europe, and understand how the present market modal split arises. This has included the development of models to study how the rail market share can be

increased. It has involved a detailed examination of different commodity flows and detailed customer requirements.
- To examine how new freight services can be included with the existing EHSRN passenger timetable - that is, how freight can be pathed, or slotted, into the timetable. This will show us the journey times and number of trains which can be run on a network of key routes, for different combinations of operating parameters such as train speeds.
- To identify the figures expected for safety, availability and reliability of the system as a whole, in accordance with the indications developed during the economic and commercial study.
- To determine the reference parameters for the railway infrastructures and to determine the technical performances required for new high speed freight rolling stock, which lead to a reduction of Life-Cycle-Costs, without compromising quality and safety, in accordance with the objectives mentioned above.
- To define maintenance and operating models, which minimise costs, complying with the economic-commercial indications.

The strategy adopted

The market analysis clearly showed that the most promising sector, at least for the moment, is that of the integrators such as UPS, DHL and CERNAM. Also interesting were the results from the sectors of the market such as Post, Autotransportations and Airfreight. The integration of the different types of goods traffic between the largest European cities/airports will enable us to reach volumes sufficient to “fill” the Hispeedmix trains.
The punctuality is the critical/decisive factor for Hispeedmix success, much more so than cost and time.
In the typical goods delivery chain of the integrators – delivery within 24 hours – the railways can play a decisive role in the “direct night time connections” (9 hours) covering distances up to approximately 1500 – 1800 km, more than the hub/spoke connections where the journey time of approximately 3 hours would penalise the railway carrier when compared to other means of transport. In such direct connections single branches of differing hub/spoke systems could be used by different integrators offering a delivery more efficient than their competitors (air and road).
The initial Hispeedmix offer is aimed at the Premium Traffic of those sectors of the market studied (integrators, post, autotransports and air cargo).
It is likely that, as a result of offering such a service, it will be possible to develop a daytime service for short distances (3 hours), which would further increase the productivity of the network in general.

The potential offer

Due to the lack of up-to-date traffic data, which have been substantially withheld by the operators in the sector, a gravitational model for predicting traffic, calibrated on some better-known connections, enabled us to form a traffic matrix for 22 European cities with a total of 231 possible connections.

The following table refers to direct connections, estimated for the years 2005 to 2010, between two typical European cities chosen from among the 22 identified in the study.
The below data show that approximately 73 to 74% of the estimated demand could be satisfied with trains at 200 km/h. This is significant since such trains would cost far less to operate than very high speed trains. Furthermore, approximately 50% of the connections studied (117 out of 231) could be served by direct railway connections.

	2005	**2010**
Number of Trains per day, per direction	121	192
200 km/h	88	142
%	73	74
300 km/h	33	50
%	27	26

The impact on infrastructure maintenance
The Hispeedmix goods service will not affect the infrastructure more than any high-speed passenger service would do. In fact, the trains taken into consideration were specialised trains adapted from the high-speed passenger trains "loaded" with goods, which did not exceed 17 tons per axle. There will be no need for extra maintenance arrangements apart from those due to the increase in traffic, but the maintenance plans should be homogeneous throughout Europe and should, in addition, comply with "on condition" maintenance models assuring the running of the network 24 hours out of 24.

The high speed European Network for the 2005 is the scenario in which the "business" will be developed (see the illustration above).

Paris-Brussels-Cologne case-study
The Case-Study carried out on the Paris-Brussels-Cologne connection, by electro-mechanical simulations, showed that the power supply equipment, which exists on the network today, would allow fast goods trains to travel up to 300 km/h to fulfil their service.
The drawing-up of the potential "Hispeedmix offer", railway timetable based on the data included in the case-study, showed that the trains could be used on the existing high speed network with sufficient high quality and profitability.

Results and conclusions
The first analysis on the Return of Investment of a new Hispeedmix service was carried out by FS, in tight co-operation with the Partners. The methodolo- gical

basis of an overall Hispeedmix Business Plan was prepared, while an algorithm to analyse the service profitability was created and run. Results were quite encouraging, confirming the substantial feasibility of such an investment. A cash flow analysis was carried out, according to the methodology adopted. The annual estimated financial flows (based on sales, circulation and terminal costs) were compared; they arose from Hispeedmix service during the considered period, which corresponds to the investment economic life (30 years). The year of actualisation, which the changing value of money was referred to, was fixed to 1997. Three different hypothesis of actualisation rate, which were necessary in order to verify the profitability of the high speed train service for freight, were identified: 0%, 8% and 20%. The three different Net Present Values arising from the application of the actualisation rates were the following.
Actualisation rate 0%: 7,576,914,340 €
Actualisation rate 8%: 767,108,210 €
Actualisation rate 20 %: -586,776,267 €
The methodology adopted to evaluate the profitability of the whole network was to study the economical efficiency of each terminal on the network, considering all the connections starting from this point. Then, once the results were obtained for each terminal, the profitability ratios were calculated for the entire European network.
In order to estimate costs and revenues arising from the Hispeedmix service, different hypothesis concerning the terminal and the exploitation of the train set fleet were defined.
With regard to the number of train sets, a study was carried out in order to optimise their utilisation on each line and to determine a timetable. Its conclusions concerning the fleet needed were the base of the profitability study for the train sets investment. The train sets needed for each O/D pair was identified and the cost for one train set is about 12,200,000 €.
The number of trains run between each origin and destination, was used to determine the variable exploitation costs; another criteria concerning these costs was the number of kilometres between each origin-destination.
The terminal costs were linked to the number of train sets used on each line and to the general timetable of departures and arrivals in the terminal for every origin-destination pair. Actually, the number of train sets and the timetable determined the number of platforms that would be needed. So, the study concerning the timetable was also taken as an input to the profitability study in order to give the number of tracks and platforms needed in each terminal.
Finally, the amortisation of terminals and train sets was done over 30 years and the overhead costs were fixed at 15% of the whole costs. It was also considered that the land on which the terminals are built would be rented.
Concerning the revenues, the selling price used was 0.17 € per ton/km, which corresponds to what could be accepted by the market. It is above road prices, but also far under air prices: this means that the profitability of the service, which yet is very good, could even be improved.
In analysing profitability the following elements have been taken into consideration for each "terminal" of the network: loading and unloading platforms, the entire trains necessary to fulfil the service, the time slots, the cost of personnel and maintenance.

The Internal Profitability Rate, which makes the NPV equal to zero, corresponds to 11,75 %. It is possible to say that this ratio is good: effectively, a project is supposed to be reliable as long as its internal profitability ratio is above 8%, which is the case for Hispeedmix.
In particular the profitability calculated for the section of the network studied is equal to approximately 11.75%, taking a time span of 30 years for the amortisation of the acquisition of the terminals and the trains

<u>Exploitation and future work</u>
The results are encouraging for the European railway Companies which grasp the opportunity of starting a new business. It must be strongly emphasised that the success of the new service offered will be affected by organisational factors much more than by technical factors.
The Hispeedmix context is a potential new business area for railway companies, but it is necessary to verify the risk level for all interested partners, consisting of integrators, transport partners and airport companies as well. Therefore, the aim of a new Hispeedmix project is to carry out a complete analysis of the European high speed service for freight.
The challenge in this new area of business will call for the necessity of co-operation at an international level, which could be possibly done by forming a "Hispeedmix Company". This Company should be organised for quality service and should have a flexible approach to the market.
In this way the Railways could have the possibility of playing a fundamental role in this fast growing new sector of the market. The service could be extended to other sectors, step by step, requiring a fleet of fast goods trains, which could be used indifferently during the day and the night on the high speed European Railway network.
In order to realise the beginning of the Hispeedmix service a more detailed feasibility study will have to be undertaken on specific corridors followed by a business plan and integrated with a handbook specifying technical and managerial aspects of the service. Promising results would allow a pilot service to be launched

IV. Preface

For the last 25 years, the share of rail in freight transport in Europe has continuously been decreasing. This situation is mainly due to the improvement of the road competitiveness, even in long distance transportation owing to better infrastructure and vehicles and to efficient interoperability. In the same time, rail freight transportation has not achieved comparable results.

In fact, the cost of road transport in Europe has been cut by about 25% between 1970 and 1995. The quality of road services has been greatly improved by new infrastructure like fast motorways, reliable vehicles, tracking of freight with EDI systems and flexible management. The rail achievements have not been so significant, especially in terms of quality of service.

Nevertheless, the restructuring of American railroads demonstrates that the rail system is able to target and to reach such objectives, provided a relevant policy is defined and applied.

A. History of the project

1. State-of-the-art

The trans-European High Speed Railway Network (EHSRN) spanning the entire continent as far as the frontier of the former USSR consists of 35,000 km of high-speed lines, 20,000 km of which are new lines.

The European Council has realised the importance of this network not solely for the long-term development of the European Union, but also for short-term economic recovery and the EHSRN is one of its priorities.
Passenger and freight strategies for railway networks, in view of their highly integrated nature, both in terms of infrastructure and operation, are interdependent and connected.
Any increase in capacity due to the use of high speed trains can benefit other areas of activity, in particular freight. Therefore, the construction of new high speed lines for passenger traffic has released capacity for other activities, such as regional passenger services or the transport of freight.
That is why we have developed the “High Speed Freight on the European High Speed Railway Network” together with the planned passenger traffic.
The European High Speed Railway Network will comprise a system of railways with operating speeds in excess of 200 km/h and often up to 350 km/h, right across Europe. Much of it is very new, constructed in the last twenty years, and it includes important new links such as the Channel Tunnel, new Alpine crossings, Pirenee and links between Denmark and other Nordic countries.

The principal traffic carried at present on the high speed lines is passengers, although some of the system is already a mixed traffic railway. Already many of the systems have spare capacity, which can be made available to freight.
A scientific study of the parameters affecting the requirements for the high speed mixed - passenger and freight - railway system has not before been approached.

2. Degree of innovation

The solutions developed in this project are innovatory because there is no comparable high speed rail freight operation in existence anywhere in the world today.
The scientific methodology has been designed to develop, in an innovative way, a high level theoretical structure in order to obtain the technical specification and to implement the results obtained in a case-study.
The scientific process has taken into account all the technological and economic aspects and particularly aims:

- to fill the technological gap, that is to say the transfer knowledge between railways and other transport modes;
- to assess the return on investment (ROI), the pay back time and the internal rate of return (IRR) with regard to the European scenario.

The HISPEEDMIX project constitutes the basis for the further work programme of the European Commission "Trains and Railway Systems of the Future" and for an implementation phase in the V Framework Programme in the Thematic Network on Rail Freight Services.

B. The European integration

1. Co-operation between Hispeedmix, Eufranet and Intelfret

On the request of the European Commission, the EUFRANET project (to study the feasibility of a European dedicated freight transport network), the HISPEEDMIX project and the INTELFRET project (to implement an innovatory freight transport system, based on electronic process control), while maintaining their own objectives and characteristics, nevertheless have a common initial methodological and market analysis section, as well as common conclusions. The first three work packages are common, a fact which emerges from the project Technical Annexe.
Through the performance of these three projects, the European Commission aims to establish and assess a long-term, market oriented, technically strong and financially achievable strategy for the development of rail freight transport in Europe.
In order to achieve such a global objective, the three projects aim:

- to reduce the transport cost by allowing a better use of classical and high speed rail infrastructure and rolling stock;
- to suggest more efficient standards for rolling stock, operating methods and infrastructure and to optimise the balance between infrastructure and rolling stock costs;
- to improve the quality of transport in terms of transportation times, reliability and safety.

V. Scope of the project

A. Project baseline

The HISPEEDMIX project is consistent with others European projects and it has also taken into account several studies made at national level:

- HISPEEDMIX is consistent with EUFRANET and INTELFRET projects. It has three work packages in common with these two projects. The three projects have used the same hypothesis for the market requirements, a consistent evaluation methodology and have consistent conclusions. In that way, the DGVII will be able to define a global strategy for European Rail Freight development.

- As far as the interoperability and the system requirement definition are concerned, some aspects can be linked to the ERTMS control command project developed under the DGVII Rail Transport programme.

- The partners in the HISPEEDMIX project have been chosen in such a way to avoid overlaps and synergy can be obtained. The partnership structure is organised around two groups of complementary members: two Research and Development organisations specialised in the transport area which are involved at European or National level with projects linked to HISPEEDMIX, and four of the most important rail freight operators and infrastructure managers in Europe (DB, FS, RENFE and SNCF). In addition ERRI, the European Rail Research Institute, has added its own expertise and established close links with all member railways, not directly participating in the project.

B. Milestones

The HISPEEDMIX project has four milestones:

Milestone 1 is the first step of the project. The Customer needs and market segmentation, the Background and the Environment of the project and the evaluation methodology, to assess the European High Speed Railway Network, have been identified.

Milestone 2 is the second step of the project. The functional specifications have been completed.
The general architecture of the system has been defined, fully complying with the Interoperability technical specification and accordingly to safety of operation. Furthermore, the technological aspects related to the implementation of the mixed mode on infrastructure, nodes and rolling stock have been detailed the constraints have been pointed out and overcome.

Milestone 3 is the third step of the project.
This is the point when the operational methods have been identified, the maintenance plan has been described and the first part of the implemented case study has been developed.

Milestone 4. This milestone has allowed us to assess the final value of the HISPEEDMIX project.
The technical feasibility of the identified case study has been completed and the simulation results are presented and disseminated.

C. Objectives

HISPEEDMIX has been proposed as a project to examine two different scenarios for offering freight services on the EHSRN:

- to assess the market requirements for high speed freight traffic and the capability of the existing high speed lines to cope with such traffic;
- to study the utilisation of the high speed network for traditional freight traffic in mixed traffic conditions.

The objectives are to identify the strategic options for the mixed use of the EHSRN and to define the operational and technical parameters able to supply the identified potential demand.
The project has been structured to achieve the following goals:

- To carry out detailed cost-benefit analysis with the development of financial models. This has provided us with the business case, which the investment necessary to offer new services will be based on.

- To define the economic and commercial reference parameters for offering European citizens a competitive freight and passenger service on the EHSRN.

- To examine the current freight transport market across Europe, and understand how the present market modal split arises. This has included the development of models to study how the rail market share can be increased. It has involved a detailed examination of different commodity flows and detailed customer requirements.

- To examine how new freight services can be included with the existing EHSRN passenger timetable - that is, how freight can be pathed, or slotted, into the timetable. This has shown us the journey times and numbers of trains which can be run on a network of key routes, for different combinations of operating parameters such as train speeds.

- To identify the figures expected for safety, availability and reliability of the system as a whole, in accordance with the indications developed during the economic and commercial study.

- To determine the reference parameters for the railway infrastructures and superstructures, required for the mixed traffic; and to determine the technical performances required for new high speed freight rolling stock, which lead to a reduction of Life-Cycle-Costs, without compromising quality and safety, in accordance with the objectives mentioned above.

- To define maintenance and operating models, which minimise costs, complying with the economic-commercial indications.

D. Benefits

1. Community involvement is vital

The HISPEEDMIX project has strongly contributed to the European competitiveness, as it is based on a precise research methodology, and has produced results suitable for the scientific, technical and economic growth of the whole European Union. In fact, since the HISPEEDMIX partnership includes the main railway companies, the research benefits will influence the majority of the railway agencies involved in the Trans-European Network project. Furthermore, the HISPEEDMIX project results are mainly intended to improve the European rail transport service, considering the different aspects related to the different national rail networks, both in the contractors' states and in the rest of Europe. It is important to point out that the increase of competitiveness as a result of a good transportation system will not be limited to the area considered in the study but will be expanded to the regions on the European Union boundaries.

E. Economic and Social impacts

The HISPEEDMIX project is devoted to achieve a high speed for freight rail transport starting from the ambitious objective of making freight rail transport as fast as passenger in its High Speed operation service.

The increase in freight rail transport speed contributes to the transport time reduction on the EHSRN. This leads to the optimisation of freight railway network: the new modal split will be particularly useful to the rail transport.

In the evaluation of overall production costs of high speed rail transport, the know-how and capital investment dominate in the short term. At the same time, in medium and long term, the innovation introduced in the freight transport will improve the rail transport service both qualitatively and quantitatively.

VI. Means used to achieve the objectives

A literature review of the subject of mail, airmail and express freight was made. This work was written in the form of a background note as it contains information from magazines and meetings as well as published and unpublished reports. It covers work previously undertaken mainly in France and Germany, examines the premium freight market and notes costs and charges to the extent that these are available.

A survey was undertaken in order to determine the extent to which a high speed railway network might be used for the conveyance of premium freight traffic. A questionnaire was the chosen instrument.

The construction of a sample frame of over 455 company names and addresses was successfully undertaken. It included contacts at most European airlines and major airfreight forwarders, integrators, postal administrations, express parcels, courier operations and express road freight operators. A small initial pilot survey of 40 firms was undertaken, followed three weeks later by a full postal survey using the complete sample frame (total despatches were 455). The response rate was extremely low, and those questionnaires that have been returned, about 13, were generally incomplete, especially with regard to volumes. However, one purpose of the postal survey was to identify the people and companies to interview, and two recipients have volunteered to be interviewed in preference to returning the questionnaire.

The following step was to undertake some interviews. Interviews with four companies were undertaken (plus one by telephone), with provisional arrangements for others being made. The interview programme was placed on hold following the decision by the Management Committee in Munich on 25 Nov. 1997 to try to obtain customer requirements by means of a workshop of principal potential users. The workshop was to be held in Venice at the end of January 1998. The interviews were put on hold because most of the key players who we wished to interview would also be invited to the workshop. Over thirty key individuals were invited to attend the workshop. Unfortunately only a few were willing or able to attend, and the decision has had to be taken to cancel the workshop since it would not have been viable. The interviews were extended to as many key people as possible. A total of 29 companies were interviewed, two were interviewed by telephone. ITS was assisted by partners in France (SNCF) and Spain (UPM).

Difficulties were encountered in gaining interviews, most companies contacted were either reluctant to take part or refused. Those that did take part were unwilling to release detailed data on traffic volumes or costs.

However, interviews undertaken gave a good understanding of the circumstances under which firms will consider the use of HS rail and the limited volumes of traffic on which a high premium is likely to be paid.

To forecast the number of trains on the main origin-destination flows the methodology adopted was by modelling the offer on a European scale starting from the already known demand in France and on the international links between France, Belgium, Germany and Great-Britain.

The information collected in the interviews was unfortunately not sufficient for the purposes of this task: general statistical figures are not relevant for the high-speed niche market and the bottom up approach did not provide sufficient data due to the commercial confidentiality of the information required.
It became apparent, therefore, that a model was needed in order to evaluate the potential number of high-speed freight trains in Europe. The input to the model was the potential demand for high-speed freight trains so far declared to the railways operating on the existing high-speed passenger network in Europe. The output was a general train offer for the whole of Europe, the filter being the possibility for train operations to meet the time bands required by the market, and the competition from road transport.
The equation used was:

$$NT_{AB} = f(Pop_A, Pop_B)$$

$$with$$

$$NT_{AB} = \text{number of trains per day between A and B}$$

$$Pop_A = \text{Population of town A}$$

$$Pop_B = \text{Population of town B}$$

In absence of sufficient data to calibrate the equation, we supposed that we may define an equation derived from a gravitation model, but without taking into account the distance factor that we may assume may be much less significant than the international/national nature of the Origin – Destination for this kind of flows.
Therefore, we defined finally the function as follows:

$$NT_{AB} = \alpha * (Pop_A * Pop_B)$$

The parameter α depends on the nature of the flows
Based on the declared demands described in the work, α has been calculated as:

On a national basis, α =0.034015
On an international basis, α = 0.003707

(Populations being expressed in millions)
This takes into account the border effect, where, for the same link potential, international flows are approximately 11% of the national flows.

RAMS models were used to define the "Freight Dependability"
Delays and probability calculations were obtained using statistical models.

MOTORS (Modular Traffic Object Railway Simulator) is the software tool utilised to model the case study railway network and to perform electrical and mechanical simulations.
MOTORS is an integrated electromechanical simulator for railway and metro transit systems. The software is developed in C++, an object oriented language which makes it possible to manage large size software projects easily. The software is provided with a Windows graphic interface and runs on personal computer.
The simulator consists essentially of a mechanical module and two electrical modules (AC and DC), whose integration enables electromechanical simulations of electrified transport systems to be carried out. Both electrical and mechanical simulations may be performed in an integrated way or separately.
The mechanical module alone may be utilised to simulate whatever network layout, with no limitation to the number of lines, stations, junctions, trains. It's possible to verify the scheduled train timetable of each line and evaluate the capacity of lines and nodes. The simulation of different type of rolling stock (such as traction equipment, number of cars, max allowed speed, etc.) with different timetables is possible on the same network. The mechanical module provides both numeric and graphic outputs, including the train time-distance diagram and the train speed profile.
The electrical module alone may be utilised to evaluate short circuit equivalent impedance, short circuit currents and power distribution in static conditions.
Integrated use of electrical and mechanical modules makes it possible to study the electrified transport system under real conditions, taking into account the mutual interactions between the mechanical variables which characterise the convoys and the electrical variables which characterise the feeding network and the electrical traction drives. The tool takes into account available traction effort variations due to pantograph voltage and current value.
MOTORS solves an electromechanical load-flow at each integration step of the dynamic mechanical equations, assuming that the electrical transient of the feeding network is negligible if compared with the mechanical time constants of the train movement. The simulator solves the electromechanical load-flow equations at the steady state frequency, starting from the train requested power, as a function of the train speed, the available traction effort, the pantograph voltage and current, the efficiency and the power factor (for AC systems). Then the tool updates the mechanical state variables, such as train speeds and positions. The equations of the electrical feeding network are solved by rebuilding the admittance matrix at each simulation step. Current, voltage and power flows are supplied as output for each network node and branch.
Normal operation and fault condition analysis may be performed to evaluate pantograph voltage drop, electric substation requested power, energy consumption, rail contact voltage, etc.
Substation parameters and positioning, feeding conductor section may be optimised according to system requirements, such as the required headway or timetable, the rolling stock characteristics, total or partial fault conditions.
In AC network, the overhead contact line system is represented by the impedance matrix model. Carson Clem formulae are used to calculate the self and mutual impedance of wires, with ground return, taking into account geometrical and

physical parameters. This model does not take into account the capacitive effects existing among conductors and between conductors and ground, which are negligible at low frequency.

The final results were provided together with the tables and main references to the software tool developed to perform the profitability analysis. These were detailed in terms of costs and incomes derived by the realisation and operation of the Hispeedmix service by an operator. The major categories of cost were put into evidence, and the cash flow for a period of ten years was simulated with the tool in order to quantify the company revenues.

VII. Scientific and Technical description of the Project

A. Current Situation

1. Market and competition overview

The general economic conditions in Europe for the future are better now than in many years before. The European industry seems to have found the answer to the global challenge driven by service and information-technology. Therefore and because countries in Asia, South America and Eastern Europe are pushing into the markets, the freight business in Europe is changing rapidly. Old industry is substituted by providers overseas like steel and all related branches or at least restructured deeply by concentrating on finishing processes like chemical and automobile industry. New industries in the service and consumers´ branches are growing.

This development was initiated by the growing efficiency and concentration on logistics of the transportation industry. Liberalisation first in airline business, then in road and - at last - in railway business in combination with a revolution in information technology has promoted the deep restructuring of modern industry worldwide. Time-to-market and Just-in-time are quality criteria which nobody in the industry and in transportation can ever more neglect. The European transportation system grew into a function as the feeder between different and well-organised processes in factories, distribution centres and consumers.
According to the rapidly growing internet- and e-commerce-market, not only the industry but each consumer is getting used to short answering times: ordered yesterday, delivered today to any address.

That is why parcel service is maybe the most rapidly growing transportation market worldwide with new alliances between airlines and parcel companies as well as e-commerce-companies built every month. So far only trucking companies are included in these alliances – but no railway company.

2. Railway companies in Europe today

European railway companies are meant to develop into privatised companies operating in competition and – in future – even all over Europe. The speed of the restructuring process is very different and the variety of solutions for the so far mostly still national companies is big. This is not a really good situation but at least a good starting point for an answer to the challenge of the rapidly changing market in Europe, especially as the rail-freight-market has been decreasing continuously during the last decades down to 14% in average. The total freight market increased in this period by 90% to 1640 billion tkm in 1997.

Traditional goods for railways are still mass goods from the old industries which, in former times made railways freight transportation big. In all the other market segments railways are only minor players, specialised on long distances and block trains between factories and terminals. In other words: trucking companies got most of the freight in the growing markets as they can offer full service with frequent and fast transportation on a very high level of quality especially considering punctuality and reliability (see fig. 2 and 3).

Of course trucking companies have problems with congestion mainly in metropolitan areas and on some of the highways. They managed, however, to keep high standards much better than railway companies which are still concentrated on national and overnight transportation trying to improve international transportation by dealing with the many organisational and technical obstacles of their traditional operation modes.

The critical success factors for freight transportation are:

- Safety and reliability or punctuality including information services and alternative services in case of delay asking for:
  - monitoring and management systems for all subsystems as basic requirement for continuous optimisation of reliable operation;
  - quality management to keep up high standards in all areas from designing a market service to scheduling and managing it.
- Speed as a matter of time between manufacturing and sales processes binding capital asking for:
  - designing and scheduling all links as an integrated logistic chain to reduce transportation and transhipment time;
  - offering frequent service to reduce waiting time for freight at the forwarder and consignee;
  - harmonising speeds on railway lines to make traffic more fluent by increasing maximum and average speed of freight trains;
  - simplification and speeding up administration and planning processes as essential part of the time-to-market.
- Price for full service asking for:
  - integration of added value services as transportation itself is getting more and more a low value link in the logistic chain;
  - use of up-to-date marketing tools as yield-management.
- Full service including management for the whole logistic chain from ramp to ramp asking for:
  - integration of partners in the transportation chain and
  - offering logistic services as added value services managing the whole logistic chain for forwarders and consignees.

Considering these success factors, today most of them are dominated by the trucking business, some of them by the airline business, but non-really by railway business.
It must be the aim of the railway companies to become a serious competitor again by creating new market services and setting standards for at least some of

these factors. One of these new market services could be an express service using the high speed lines and technology known out of passenger business.

3. Infrastructure, Train Control and relevant technologies today

a) Train Control System – Current situation

Today many different train control systems exist based usually on block systems with all disadvantages concerning capacity and flexibility.
The different existing systems on high speed lines allow for a minimum headway between trains that varies from 3 up to 5 minutes (FS lines 5 minutes; TGV Paris-Sud Est 4 minutes; later TGV lines, including the belgian section of Paris-Brussels, 3 minutes; DB lines 3 minutes, Madrid-Sevilla line 3 minutes).
These headway values should be considered enough (from the line capacity viewpoint) to permit the introduction of Hispeedmix traffic on each national line. For international traffic the consideration of interoperability becomes necessary. On the Paris-Brussels line both national sections are equipped with the same cab signalling system, but this is not the case in other international relations that will be established in the future.
In a first step the train crossings over the borders are to be equipped with the different systems existing on each side.
In a second and more desirable step the gradual introduction of ERTMS will make the international traffic more and more easy.
ETCS and ERTMS designed a European solution for international traffic as an overlay system to the existing train control technology, the first piloting lines are in preparation and testing today.
So far plans are focused on introducing ETCS/ERTMS on trans-European high speed lines and their interconnections.
In order to permit this gradual introduction, two steps of interoperability are foreseen:
1) technical interoperability
2) operational interoperability.

The basic functions of the safe train operation in Europe ensure:

- **The train spacing functions by means of "block" systems**. These systems employ a large variety of technologic solutions, initially developed on a national basis. The "block" systems are mainly based on fixed block sections that realise a compromise between the train density, speed and line capacity. On line with mixed traffic (passengers and freight) the large difference between the train speeds is a serious problem for the fixed block system when aiming at a maximum "flow" (debit, transport capacity) of the line. The method of grouping trains with similar dynamic characteristics in "flow packages" is feasible for increasing the debit but is not effective if slot allocation on demand is asked (especially for coping with infrastructure access demands) or perturbations in schedule are frequent.

On high speed lines this system is only operational when homogenous traffic is only allowed (mainly the case of dedicated HSL in France).
The moving block spacing system (spacing of consecutive trains at distance depending on their instant dynamic characteristics - speed, braking distance - is only operational on lines with continuous train location and train-track communication, like the LZB (Linienzugbeeinflussung). This system enables the operation of mixed traffic in "decent" line debit parameters.
The existing systems are in general not compatible and not interoperable. Both the signalling system and the train-track communication are developed in different solutions in each European country.

- **The train routing systems (interlocking)** although present in the same large variety of particular solutions and diversity are less critical from an interoperability point of view. The signalling differences are problematic for "cross-border" operation. The different regulations in terms of access to station lines, speeds allowed on points, access to lines between stations are also developed on national basis.

- **The traffic control centres** are also developed on national basis, implementing national regulations and technical solutions for solving the main traffic control tasks: allocation of slots, supervision of traffic, regulation of traffic in case of disturbances, routing of trains.
  In general the traffic control centres operate via the train spacing and train routing (interlocking) systems. The direct train-centre radio-communication although not always mandatory for safe driving, is in practice an important tool for traffic regulation and, in some cases, an important fallback system for avoiding critical situations.
  The radio-communication systems, although normalised for interoperability in cross-border operation, are still not totally compatible and interoperable.

The ETCS (European Train Control System) employing EURO-RADIO and EURO-BALISE conceptions has been specified in order to reach a high degree of interoperability. This system, although only experimentally implemented on few lines, is generally intended for equipping major corridors.

b) Co-operation with the current systems

The hardware architecture of the mobile equipment, as required by the ETCS project, allows operating on existing systems infrastructure by receiving all present information from these systems infrastructure. For this purpose ETCS is able to integrate so called Specific Transmission Modules, STMs.
The STM functional design rules are made in order to guarantee that the Validation and Proof of Safety of the basic ETCS program structure need not to be redone each time a new STM is added to or removed from the system.
The trainborne hardware required for the existing systems can be reduced to the communications devices like antennas, transmitters and receivers. In addition, the STM shall have all the programs required to process the information received from the respective infrastructure into variables and formats understandable by the ETCS programs in the ETCS environment. These additional programs must

be designed in accordance with the same safety principles as the basic ETCS programs. In particular with regard to the handling of the time and odometer stamping procedures.
The information received from the existing system infrastructure must be “time and odometer stamped” directly upon reception. For all messages the same rules apply as well as to the information received by the ETCS transmission modules. The time and odometer information accompanies the received information all the way through the STM to all subscribers. Thus transmitted to the ETCS European Vital Computer or any other Module the validity of information can be checked easily.
The figure 4 below shows a general overview of the main functions for operation in STM Modes. As the transmission media and the data format of the existing systems are not known to the ETCS the real air gap is not longer in the direct scope of the ETCS. The conversion of primary data of existing systems into ETCS primary data can be interpreted as a "fictitious" air gap. It is then the task of the STM to convert external data into the ETCS format. The converted data will then be fed into the system processing that can be compared with an "injection" via the "fictitious air-gap".
The term "early injection" is used when the converted data from an STM passes the fictitious air gap in an early stage of the ETCS trainborne processing. This applies to the STM converting trackside characteristics or a static speed profile into the ETCS format, which is then "injected" as ETCS primary data for static speed profiles calculations.
The term "late injection" is used when the converted data from an STM passes the fictitious air gap in a later stage of processing. This applies to the STM converting existing signalling system information into dynamic speed profiles for supervision or just braking orders to be executed by the ETCS equipment.
If the existing system is based on two-way communication, the respective STM converts the ETCS data to be transmitted into the format of the respective system. Afterwards the STM communication devices are used for the transmission via the real air gap from the train to the track.

Fig. 4: Operation in STM – early injection procedure

c) Conclusion

For a transition period the ETCS trainborne equipment must be interoperable on the present national infrastructure. Therefore the ETCS must allow for Specific Transmission Modules (STM) to be added to the ETCS trainborne equipment.
The best way of combining the trainborne equipment of the ETCS with the trainborne equipment of existing systems is the way that requires the least total amount of software and hardware. It is the principle that shall also allow mixing of infrastructure from any existing system and the ETCS. A transition between these systems without loss of data is easily achievable.
Moreover these different strategies to interface the existing system to the ETCS trainborne equipment permit to maintain the same performances of the existing

systems or better they improve them. This can be realised simply by superimposing Eurobalises to the existing signalling system infrastructure, avoiding unnecessary duplication of the trainborne equipment or functions. Thus it is possible to avoid unnecessary costs for the railway administrations.

If a High Speed Freight or HISPEEDMIX-Traffic wanted to be successful, it should adopt ETCS/ERTMS as train control system for both lines and trains in order to reduce obstacles for changing railway networks to a minimum.
The first step into a HISPEEDMIX-Traffic should therefore concentrate on lines, which can be operated with multi-system trains.
Extension should concentrate on those lines which are to be equipped with ETCS/ERTMS for international traffic.
Freight operators who are interested in HISPEEDMIX-Traffic should work out a strategy to start and increase operation step by step and introduce their plans into the investment schedules of the European networks.

B. Business and service concept

1. Market Segments

HISPEEDMIX is aimed at providing high speed rail freight operations using the European High Speed Rail Network (EHSRN). Such high speed operations are relevant to the premium freight market, and the sectors within that market that were seen as providing potential traffic are:

- air freight
- integrator traffic
- mail
- express road services.

This study was carried out during 1997/98 and it must therefore be recognised that the results presented may not be totally representative of the current year 2000 situation. Traffic volumes are growing rapidly, e.g. integrator traffic had been growing at 20% per year, and was expected to increase at around 10% per year for the next five to ten years. In addition new markets are developing, which were not recognised at the time of the study. For example, the recent rapid growth of e-commerce looks set to generate a new and rapidly growing market for next day delivery of goods purchased via the internet.

a) AIR FREIGHT

Characteristics of Air Freight

Airfreight covers traffic moved by major airlines, whose main business tends to be the operation of scheduled passenger services. 'Air freight' consists not only of the freight carried in aircraft (either as belly hold freight in passenger aircraft, or in cargo or combi aircraft) but also of the freight carried to (and from) airport hubs by road vehicles, many of which have their own flight numbers: these are known as Road Feeder Services (RFS). The latter is the predominant method used for the intra-European sector of a service connecting with long-haul flights at major European airports. Typical major players in this area are Lufthansa, KLM and Alitalia.

In the case of intra-European airfreight, where the railways might offer a service, there are two ways in which the railways may be able to gain business, either by:

- competing directly with the airlines for the short haul traffic, or
- acting as a complementary mode to air for long haul inter-continental airfreight (in the form of a rail feeder), in this case mainly competing with road for distribution to and from major European airports.

Prospects of Moving Air Freight by Rail

Premium *short haul* freight traffic won from air is likely to form small volumes on any particular route. For example typical flows between Amsterdam Schipol and Paris Charles de Gaulle are 15 tonnes/day. These low volumes suggest that, rather than have dedicated freight trains, rail may be able to carry pallets or containers on certain scheduled passenger services in direct competition to scheduled air services, as is now the practice on some Eurostar trains between London and Paris or Brussels.

The situation regarding *long haul* international airfreight traffic is somewhat different. Significant RFS flows to and from the UK's main international airports (Heathrow, Gatwick and Manchester) are moved by road over long distances. Assuming such traffic patterns exist to international airports throughout Europe, substantial flows are potentially available for rail movement, by conventional as well as by High Speed trains, provided the required service criteria can be met. However, as little of this traffic is time critical, the demand for high speed rail will be small. In most cases this would require direct rail access to airports, allowing trans-shipment of through airfreight pallets directly to airport handling agents, thus minimising dwell time and transfer costs.

b) Integrator Traffic

Characteristics

Integrators move consignments of small parcels and documents, often using hub and spoke transport networks. Integrators are so called because they aim to offer a complete, fully-controlled transport system, as far as possible with their own land and air vehicles and handling facilities. They have been changing focus from their origins in domestic small package/overnight operations into major international operators with sophisticated communication and control systems, providing the basis for on-line booking and tracking systems for customers. Couriers are particularly strong in the market for extremely urgent traffic where

speed is more important than price. The five leaders in the market - UPS, FedEx, GDEW, TNT, DHL - have a total turnover of some 25.7 billion Euros and have over 1000 planes and some 200,000 road vehicles (1998 figures).
Most integrators and couriers have generally rationalised their use of transport by using air for inter-continental traffic and longer hauls across Europe, and road for short distances between hubs, however, they are prepared to consider whatever mode(s) might best suit the services they provide. The trade off between speed and distance (and cost) is illustrated in figure 5, which is from DHL's Network Planning Group.

Figure 5: DHL modal choice

In general, traffic collected in the country of origin up to late afternoon, 17.00 hours, must be dispatched from that country's gateway by 21.00 hours for next day delivery. The maximum time to a European central hub is about three hours, allowing two or three hours for sorting, then three hours for onward transport to the destination country. Pressure on the hub can be reduced by short distance trunk movements arriving early, and high volume routes having early and late departures.

A three-hour transit window gives each mode of transport a maximum operating radius around an integrator's hub. The radii are as follows:

- Heavy Goods Vehicle (truck) 250 km
- Light Goods Vehicle (van) 300 km
- Rail (conventional) 240 km
- Rail (high speed) 250-600 km (transfer time dependent)
- Air 300-1400 km (covering all Europe).

City pairs with sufficient volumes between them are often served directly by road, or in some cases air, to avoid the cost of movement via a hub. In this cases the transit time window between origin and destination can be some 9 hours. Depending upon the distances covered this may also allow the use of conventional rather than very high speed rail technology.

DHL have the largest volume and have changed to a multi-hub system. The original hub at Brussels was estimated to handle 1000 to 1300 tonnes per night. Other hubs (as well as those of other operators) are believed to handle between 400 tonnes and 700 tonnes per night (but the operators would not confirm these figures). However, depending on the degree of automation, investment in a hub can only be justified on a throughput of several hundred tonnes per night.

Prospects for Moving Courier and Integrator Traffic by Rail

There are prospects for rail for high volume flows from individual companies between airports, or between gateways and hubs, over distances of 300 km to 600 km. However, rail must be less costly than air.

Rail competitiveness is increased where there is a rail transfer station within an airport, especially if the airport is an integrator's hub, or a direct rail connection to a gateway.

The market for overnight documents and packets is expanding rapidly (estimated currently at 10% per year). While one centralised hub is used, volumes on major corridors also increase. However, it seems that eventually a multi-hub network becomes more cost-effective, reducing volumes on the longer section, major corridors, where rail would be most competitive.

As mentioned previously, new areas of business activity are developing, e.g. e-commerce, which require rapid movement of goods to customers, and as such provide potential markets for high speed rail freight. A particular example is the recent collaboration in Germany between Deutsche Post, Danzas and mail order companies in order to offer next day delivery to customers placing orders via the internet or telephone.

c) Mail

Characteristics of European Mail

Priority mail in Europe is normally 'day C' delivery. The pattern is to collect on day A, sort during the night of day A, transport to country of destination on day B, and sort during the night of day B for delivery within the destination country on day C. Transport is usually by road during day B. This is often over long distances (700 km or more), e.g. Amsterdam to Zaragosa, including collecting

Belgian mail en route. Because of low volumes, the normal practice is to route vehicles via concentration points.
Over longer distances, mail is flown both within Europe and inter-continentally. The flights used tend to be scheduled passenger services or alternatively, space may be booked on scheduled freighter aircraft.

Mail on standard services uses road throughout. The charges are based on road costs, with delivery specifications depending on the length of haul.
Postal organisations have been traditionally strong in the provision of relatively high quality, low cost services. However, those services may not be comprehensive enough to meet all demands emerging in the modern market place, and could lead to diversification to defend national markets from foreign competition, including competition in European domestic markets from integrators.

Characteristics of Domestic Postal Services within European Countries
Domestic postal administrations vary from one country to another in terms of quality of service. UK and Germany have next a day delivery option covering most of the country; in France, however, next day delivery is mainly restricted to destinations within the same *département* as the origin.
All of these three countries operate air networks. In the UK a multi-hub air network conveys about 215 tonnes per night, with payloads typically in the 3.5 to 5 tonnes range. This traffic is in addition to the mail carried by a significant number of dedicated trains. In Germany an air network until recently had a central hub at Frankfurt (with 350 tonnes per night), with a subsidiary hub at Leipzig. However, this has now changing to a multi hub system, with Frankfurt now carrying 250 tonnes per night. France has a centralised air hub at Paris Charles de Gaulle airport, with rail being used on the Paris-Lyon-Avignon TGV route only.
The volumes of mail moved over some routes within European countries are large. In the UK the London to Warrington and London to Newcastle routes each justify two mail trains per day.

Prospects for Moving Postal Traffic by Rail
The average length of haul of UK domestic air cargo is 350 km; a High Speed rail service with an average running speed of 200 km/h could link two terminals this distance apart in 1 h 46 min, about one hour longer than the block times (movement time between origin and destination terminals) of an aircraft. This indicates that rail has a potential in the mail market.
Mail traffic is likely to become more concentrated in future as postal administrations concentrate sorting operations at fewer, highly automated, hubs. This will also encourage larger volumes, so that the mail which remains on rail in future may be handled more cost-effectively and profitably. For example, the former British Rail (BR) responded to this concentration by operating a reduced number of mail trains with higher average speeds, though they are not truly 'high speed' services. Swedish Railways (SJ) also now moves pre-sorted mail concentrated on three rail routes, from Stockholm to Malmö and Gothenburg, and

Sundsvall to Malmö. Both SJ and the UK's Rail Express Systems are now investigating raising speeds of mail trains to 200 km/h. NS Cargo also have proposals to introduce a network of international rail services to Frankfurt, Zürich, Basel, Paris and Milan intended for airfreight and airmail traffic using wheeled containers to speed loading, but this will not use high speed trains.

Volumes of international priority mail are very low, often less than 5 tonnes per day between neighbouring countries. Currently this could only be carried by rail if combined with other (non-mail) traffic, though high speed is not an essential requirement except on very long hauls.

Volumes of domestic priority mail are much higher between major cities. Coupled with short transit windows, a niche exists for rail, though given the service requirements for mail, dedicated trains may be required. An example of this is "TGV La Poste", between Paris, Lyon and Cavaillon.

Interviewees felt that high speed trains would be expensive to operate compared to small air freighters. Because of volumes, small low-cost medium speed trains may be cost-effective, as true high speed rail would be likely to have higher charges than air in terms of unit costs. Royal Mail and SERNAM have adopted the medium speed small train option in the UK and France, and UPS may do so in Germany. Their assessment is that rail maximum speeds in excess of 200 km/h lead to rapid increases in costs in terms of capital, maintenance and energy consumption and that such trains cannot therefore provide cost-effective services.

Privatisation of national postal administrations may result in higher quality international services, due to co-operation. Volumes are likely to remain comparatively low, however, and mail operators would be in direct competition with couriers and integrators, offsetting some of the gains in volume.

Interviews with those postal administrations taking part in the study revealed only one specific requirement for a high speed train; that is between Willesden (London) and Shieldmuir (Motherwell, Scotland) to carry 15 tonnes of mail each way per night averaging over 200 km/h. However, this route is not part of the EHSRN proposals for new infrastructure and only parts of the route will be upgraded for speeds of up to 225 km/h. The cost by rail must be less than by air.

d) Express Road Freight

Characteristics of Express Road Freight

This sector differentiates itself from the general road freight industry in a number of ways, though definition is difficult because of the many overlapping activities of the operators concerned. The most important factor is that express road freight services are operated between a number of depots, allowing driving changes en route. As a result the load is kept moving rather than being delayed, unlike the traditional driver-accompanied system where the vehicle waits while the driver takes a rest period.

Express operators also tend to offer added value services. These include storage (sometimes inventory control) and distribution and consolidation of loads from several origins on behalf of one shipper. In addition, many operate regular groupage services (assembling a number of consignments, typically thirty, on one vehicle).

Premium freight rates are charged for such services, which appear to be about 10 per cent above normal road rates. In order to generate a greater premium, high speed rail must add value by generating time savings, which are of value to the shipper.

Prospects for Moving Express Road Freight Traffic by Rail

Large volumes on some corridors assist in taking advantage of trainload capacity. Main high volume corridors are Hamburg-Ruhr-Cologne/Frankfurt, trans-Alpine routes and Benelux-Ruhr. However, most of the traffic moved over these distances would gain little benefit from very high speeds.

Very long distance traffic, such as Northern Europe to Italy, could benefit from high speed trains. Long distance road traffic, with a length of haul of over 500 km, forms about 17 per cent of the total goods moved by road. Express operations constitute about 19 per cent of the total in the case of movements between the UK and Italy.

Though premiums over road rates may be charged, they are likely to be small in order to obtain volumes. For example, in the case of UK-Iberian traffic, only 0.27 per cent of the total volume paid the air freight premium, rising to 1.2 per cent in the case of UK-Mediterranean flows such as to Greece.

However, if rail were to offer high speed services to meet the requirements of the premium freight market, it is likely that a certain amount of the traffic currently moving by road might switch to rail, if attractive rates were offered. One example might be the movement of automobile parts in support of low inventory, just-in-time manufacturing operations.

2. Potential Traffic

A number of ways of determining the actual volume of potential traffic for HISPEEDMIX services were explored. A postal survey was undertaken to obtain data and to make contact with relevant companies, with a view to subsequently interviewing some of them in order to expand on the original information. 455 questionnaires were sent out to a range of organisations. Unfortunately the response was extremely poor, and it is suggested that in future exercises of this type consideration should be given to an additional or alternative approach using stated preference or modelling techniques.

Due to the lack of response to the questionnaire, the planned interview programme was considerably expanded in order to obtain the information needed. Interviews were therefore carried out with 6 Airlines and Freight Forwarders, 5 Airport Authorities, 3 Postal Administrations, 5 Integrators and Couriers and 7 Express Road Parcels/Groupage Operators.

Despite the efforts made to obtain data through the review of the literature, questionnaires and interviews, the information obtained from these sources is far from complete. This is due to the commercial nature of the information and the unwillingness of organisations to fill in the questionnaire and, in the interviews, to give hard information. What information has been obtained is also rather unsystematic. For this reason it has only been possible to take a view form a 'top-down' perspective, and the information obtained, although qualitatively good, is general in format, rather than giving specific detail relating to individual market and geographical segments.

In order to move the project forward an alternative method of estimating the demand for high speed freight rail flows was therefore developed. This was based on extrapolation of the current declared interest expressed by potential customers to certain high speed passenger operators. The methodology of this approach is described in Deliverable D3.

It was concluded from the study of the premium freight market that the main services that might be offered by high speed rail would be feeders into and out of hubs, or direct overnight services between gateways, or major centres of population, where volumes justified. Such operations demand either, journey times of 3 hours or less for feeders, or 9 hours or less for direct services. In addition, for the purposes of estimating potential rail traffic, it was proposed that if the same journey could be achieved by road within these time constraints, then, based the lower costs of road operation, it is likely that the traffic would go to road, and not to rail. Furthermore, for a train service to be counted as viable, the estimated volume of traffic had to be sufficient to fill at least half a potential train per day.

Based on these criteria, the estimated number of feeder trains for the three hubs considered are:

Brussels Hub	Year 2005	Year 2010
Amsterdam	2	3
Cologne	2	3
Frankfurt *	1	1
London	2	4
Paris	1	2

Frankfurt Hub	Year 2005	Year 2010
Cologne	8	13
Stuttgart	5	8
Brussels	1	1

Paris Hub	Year 2005	Year 2010

Amsterdam *	1	2
Bordeaux	2	3
London *	2	4
Lyon	4	6
Brussels	1	2

Note: * only 300 km/h trains are capable of completing these journeys within the 3-hour time window. The remaining journeys can be completed by trains with a maximum speed of 200 km/h.

Table 1 - Numbers of trains each day in each direction for feeder connections to different hubs.

It can be seen that rail can provide only a limited number of services in feeder operations to and from hubs. This is because rail can only fulfil the journey time criteria ≤ 3hours on a relatively small number of connections.

The estimated number of direct connections between the major centres of population are:

Year	2005	2010
Total Number of Trains	121	192
200 km/h	88	142
%	73	74
300 km/h	33	50
%	27	26

Table 2 – Numbers of trains each day in each direction for direct connections

In the case of direct connections, it can be seen that rail can provide a large number of the predicted flows, and interestingly, that 75% of the demand can be met by trains having a maximum speed of 200 km/h. This is significant since such trains would cost far less to operate than very high speed 300 km/h trains.
The study also found that of the possible 231 links between the 22 cities comprising the modelled network, 117 connections might be made by rail within the criteria rail ≤ 9 hours and road > 9 hours.

3. Performance criteria

a) Time requirements

Time requirements will essentially be linked to the time needed to load and unload the train. 40 minutes were reserved for these operations.
According to express couriers' organisational criteria, two cities need to be potentially linked in less than 9 hours. In order to have more time for rail transport and to avoid pre and post road haulage, the best theoretical location for a terminal is on the high speed line and at the airport (because most flows transit through the airport or its surrounding area). For the same reason, and in order to link more cities, it was decided to favour direct links to the hub and spokes system, which only leaves 6 hours for transport as 3 hours need to be dedicated to sorting operations in a central hub.

b) Price requirements and added values

The service proposed will necessarily be more expensive than road transport. This is the reason why it should be more efficient and quicker. It will also be less expensive than air transport. As this service is focused on high value goods, the price is not a very determinant factor in the demand as long as it is cheaper than air transport.
Two ranges of prices could be offered:

- one price for highly time-sensitive cargo;
- a lower price for less time-sensitive cargo via yield management.

This would permit the aggregation of volumes on trains when necessary.

C. Technology and infrastructure

1. Demands on rolling stock

a) Loading Capacity

The SNCF is endowed with 3.5 equivalent "TGV postal". 3 of them are composed of 8 freight vehicles and the remaining of only four cars. Moreover, each "TGV Postal" is composed of 2 locos. TGV postal are derived from TGV passenger trains that have been adapted for the transportation of freight. The loading capacity of TGV postal is 90 tons that are subdivided into:

- 65 tons of mail (packages, letters and press);
- 25 tons of containerised good.

Moreover, each wagon is able to contain up to around 30 postal containers. The maximum capacity of one train is 250 postal containers. Each wagon could be loaded up to 10.5 tons and is equipped with:

- door opening and closing control command, located on each side of the wagon, approximately in the middle;
- monitoring of the load transversal equilibrium, a signal is set in case the load is out of equilibrium for more than 1 ton per bogie.

The train is further equipped with:

- a check panel on wagon number 1 and 8 (those coupled with the locos), to allow the operator to monitor the equilibrium of the load, when boarding is completed;
- a remote command to close-open all doors, and to check the operation.

b) Loading Units and Loading Technique

Loading Units

This paragraph describes the features of the containers commonly used to carry the freight in the TGV postal. Since 1984 SNCF has decided to put mail into special containers to make the transportation simpler. The containers are mainly used to contain mail bags and boxes; also trays and free mail transportation is possible.

Three different types of containers are used, summarised as shown below:

- Container CP 820 T – Allowed to carry sacks and packs. It can be trailed.
- Container CL 93 – Allowed to carry parcels and small boxes. It cannot be trailed in present configuration.
- Container CS 93 – Allowed to carry sacks. It cannot be trailed.

CP 820 T is mainly a trolley with four removable sides; three of them are grids, whereas the fourth is plain. One of the grid sides can be opened. The highest half of the removable grid can slide over the lower. The latter can be opened as a door to give full access to the bottom tray. The trolley wheels are equipped with safety brakes.

The features of these containers can be listed as shown below:

- empty weight is variable from 45 Kg up to 100 Kg;
- load weight is variable from 220 Kg up to 550 Kg;
- useful volume up to 762 litres.

Every TGV's wagon is able to contain around 30 mail containers. The price of the containers is approximately 50 Euros. However, SNCF has been investing more than 10,000 Euros to purchase new mail containers.

With reference to the purchasing of new containers it is important to evaluate the feasibility of using airplane pallets and containers as unit load devices for railway freight transportation by high speed trains such as postal TGV. The interest in using airplane containers/pallets is especially oriented to the development of a feature train-airplane intermodality.

A pallet is a platform of wood, metal, fibreboard or other material on which cargo can be stacked and secured. Cargo is secured to pallets in many ways, including metal or plastic strapping, or with plastic stretch- or shrink-wrapping. Pallets are easily and inexpensively constructed and can be reused and handled by many standard types of handling equipment. On the other side pallets are more expensive than other ULDs (Unit Load Devices) because of their return cost from one-way movements and because they can be easily damaged, lost or thieved.

There are two types of pallets:

- American standard pallet;
- Europallets.

A standard pallet in America is usually 40 inches (1.02 meters) by 48 inches (1.22 meters). European pallets called Europallets, are basically the same size as those used in America, but they have several technical designs.
With reference to the airplane containers, most air containers have two designations, the first is used in the United States and Canada and is assigned by ATA (the American Transport Association) while the other is assigned by IATA (the International Air Transport Association). The number of standard airplane container is about 30. The features of the containers most currently used to carry on the cargo by air transportation depend on the Airline Company that has got the containers themselves. The shape and the dimension are extremely variable in order to allow them to be load/unload into the aircraft decks easily.
The dimensions of the airplane standard container change from 42x29x25.5 inches (107, 74, 65 cm) type E up to 96x238.5x96 inches (244, 606, 244 cm) type M2.
The use of 8x8x20 foot intermodal sea containers in air transportation is very expensive because of their weight that implies an extra consumption of fuel to carry the container's weight. An other problem is the positioning of 20 or 40 foot on the airfreighter: containers must be actually positioned inside the main-deck along the centre line because of the main-deck cargo capability, i.e. uneconomic solution causing waste of space on both sides of the container. Because of these considerations airline have decided to carry freight unitised on pallet rather than on 20 or 40 foot container. Moreover, because of the 20' container gauge and the available space in the TGV postal wagons it is not feasible to load the 20' containers onto the TGV postal.
Moreover other non-intermodal air containers such as Domestic A-2 and International (A-3) Igloo-type containers, either 88x125x86 inches, are extremely uneconomic when carried in a 747 airfreighter because they do not use the full stacking height inside the plane.
Other types of containers such as LD-7 (Type 8) and LD-3 are accommodated on the lower deck compartments of freighter airplanes.

Loading technique

The technique utilised to load/unload the container depends on the type of the container that has to be handled. Concerning the containers actually utilised by SNFC, the transportation and the load/unload operations are performed by means of tractors, trailing some trailers on which the containers are arranged, and by elevator platform stackers similar to forklifts.
Concerning the airplane containers the Air cargo handling systems are mainly classified into categories as summarised below:

- Airport Cargo Terminal container handling equipment
- Equipment system for smaller operations
- Air side ramp equipment
- Truck conveyors.

Airport Cargo Terminal container handling equipment:

- Elevating Transfer Vehicle (ETV) and multi-level mass storage systems

- Floor level Transfer Vehicles (TV)
- Mechanised Roller Conveyors
- Mechanised Right Angle Transfer and Orientation Decks
- Elevating Workstations for main deck cargo units
- Truck Dock Scissor Lifts with roller decks or orientation decks
- Multistage Scissors Lifts for container storage applications
- Trailer Levelling Hoist fir loading air side dollies
- Forklift propelled Slave Pallets
- Container weighing equipment.

Equipment system for smaller operation, such as off-airport forwarding and distribution centres:

- High performance operated Roller Workstation and Storage Conveyors
- Low profile Truck Doc Hoists which on recessed pit
- Slave Pallets
- Powered Transfer Vehicles
- High performance manually operated modular Ball Transfer Decks.

Air side ramp equipment:

- Ramp Trailers (dollies) for container transfer between the cargo terminal and aircraft
- Dolly height Static Racks for airside storage.

Finally, specialised Truck Conveyors are used for transporting containers by road between air side and off-airport facilities.

Some types of intermodal handling equipment at airports operate primarily in connection with freight on the main deck of freighter airplanes, while other types operate in connection with freight in lower-deck compartments of freighters. The main-deck of airfreighter is loaded and unloaded by a scissors lift platform, usually equipped with powered rollers. The price of these scissors lift platform depends on its capacity and it is above 15,000 Euros.

Freight in the lower-deck compartments of airplanes is loaded and off-loaded with automated container handling equipment, or by hand, with the aid of conveyor belts. The modern mobile conveyor belts are realised with an advanced design. Indeed they incorporate a forward control driving position for safer operation and a set of sensors that are positioned on the underside of the boom ends to detect prohibited movement from freight, providing so instantaneous belt operation shutdown.

To carry on pallets, containers and the other types of ULD from the aircraft to the cargo terminal and vice versa low trailers, pulled by a ruggedly constructed freight towing tractor, are commonly used. These tractors are easy to drive having a hydrostatic steering and an air actuated braking and leaf spring suspension. The output from diesel engines is transmitted to the heavy duty reduction rear drive axle through a three-speed reverse powershift transmission affording two pedal control.

To load the inbound and outbound ULD onto trailers semi automatic transfer vehicles, that operate in the airport warehouses, are used.

As conclusion, the use of some airplane containers/pallets and handling equipment to perform the TGV postal load/unload operations is a feasible solution.
The TGV postal wagons could be loaded/unloaded utilising this airplane handling equipment:
Specialised Truck Conveyors for transporting containers by road between air side and off-airport facilities, i.e. HISPEEDMIX terminals.
Electric tractor trailing dollies on which containers are arranged.
The tractor and the towing dollies are stopped in front of the door wagons in order to allow a quick and easy carrying out of the containers load/unload operations. The dollies should be as high as the wagon base is from the ground.

c) Vehicle Gauges

The internal dimensions of the trailers, in order to fit air containers would be:

- 16 833 cm of length,
- 2650 cm of high,
- 2438 cm of width.

Some modifications would have to be done in comparison with current passengers trains.

Conclusions
For a future HISPEEDMIX-traffic, vehicles based on existing high speed trains for passenger can be used. In France the "TGV La Poste" service exists already and it is in operation successfully.
Concerning loading units and equipment no special technology should be adopted but existing systems can be used. In this regard the European Project **Rolling Shelf** has developed an interesting solution for automatic intermodal transport and transhipment of pallets and small containers.

Ref: http://www.rollingshelf.com.

2. Demands on infrastructure

a) Track

No specific demands should be done for the track itself to be able to support the mixed traffic in comparison with the high speed passenger pure traffic.
The Deliverable on Technological Constrains showed that if the track fatigue index of a high speed passenger train axle is 100, the one of a conventional locomotive axle at 200 km/h is 120 and the one of a modern freight wagon axle at 100/120 km/h is 105/117. No inadmissible increase in track maintenance

requirements is produced by freight trains running on a high speed line, compared with high speed passenger trains.
On the other hand the worst effect of high speed trains on the track is the damage produced to the ballast by the vibrations caused in the wheel-rail contact. This effect depends basically on the speed. Therefore it will be not greater for the Hispeedmix trains than for the high speed passenger trains. To solve that problem, not specific of Hispeedmix, the trend is to increase the elasticity of the rail/sleeper interface.

Conclusions
Introducing HISPEEDMIX-traffic means increasing traffic on the track, and, for that reason, additional maintenance effort will be needed. Simultaneously, the time available for maintenance works will be shorter, asking for high performance maintenance methods, based on actual track condition.
In that sense, slab track (track without ballast), more investment-expensive than ballasted track, offers the possibility of minimising the maintenance needs.

b) Power supply

The main constraints for power supply systems in traffic increasing are the admissible overloads and the range of supplied voltages.
The admissible overload in high-speed lines for SNCF and SNCB is 50% for 15 minutes, 100% for 5 minutes. For DB lines the overload is 100% for 1 second. For FS new high-speed lines a peak of 80 MVA is admissible.
The ranges of the supplied voltages are given in EN50163 standard: "Railway applications supply voltages of traction systems".

Voltage requirements (V)

Electrification System	U_n	U_{min2}	U_{min1}	U_{max1}	U_{max2}	U_{max3}
d.c. (mean value)	750 1500 3000		500 1000 2000	900 1800 3600	950 1950 3900	1269 2538 5076
a.c. (r.m.s. value)	15000 * 25000	11000 17500	12000 19000	17250 27500	18000 29000	24311 38746

* 16 2/3 Hz

U_n	rated voltage
U_{max1}	maximum value of the voltage likely to be present indefinitely
U_{max2}	highest non-permanent voltage to be present for maximum 5 minutes
U_{max3}	overvoltage for 20 ms
U_{min1}	the minimum value of the voltage likely to be present indefinitely
U_{min2}	the lowest non-permanent value of the voltage to be present for maximum 10 minutes

The minimum headway and consequently the number of trains are also limited by the signalling system features and the acceptable braking space.

Conclusions

It is possible to verify that for a simple 2 X 25 kV track, 25 km long, 5 trains running at the maximum power are the limit condition for the voltage profile. In fact to operate adequately from the power supply capability point of view four trains is the correct condition.

Furthermore, this limit can be doubled in the case of lower speed trains (Sernam V200). The operation of maximum 4 trains (280-300 km/h) in the same track or maximum 8 trains (180-200 km/h) in the same track, produces the optimal exploitation of the power supply system, taking into account the train-sets mechanical characteristics.

c) GRADIENTS

The influence of the gradient and the gradient length on the speed loss of conventional freight trains (locomotive + wagons) have been quantified, for initial speeds of 100, 120, 140,160 and 200 km/h, hauled load between 200 and 800 metric tons, gradients between 0 and 40 ‰ and gradient lengths between 0 and 20 km.

For an initial speed of 200 km/h, the following gradients and gradient lengths would produce speed losses of 5% (reduction to 190 km/h) or 10% (reduction to 180 km/h):

Hauled load (t)	Gradient (‰) and gradient length (km) reducing the speed from 200 km/h to	
	190 km/h	180 km/h
200	28 ‰ (11 km)	32 ‰ (9 km)
300	20 ‰ (10 km)	22 ‰ (17 km)
400	15 ‰ (13 km)	18 ‰ (10 km)
500	12,5 ‰ (8 km)	15 ‰ (9 km)
600	10 ‰ (10 km)	12,5 ‰ (10 km)
700	10 ‰ (5 km)	10 ‰ (13 km)
800	10 ‰ (4 km)	10 ‰ (8 km)

The simulations carried out provide a basis (tables and charts) for the design of a new railway high speed line where, for commercial reasons, the traffic of freight trains may be interesting.

d) INTERCONNECTION OF MAIN LINE AND BRANCH LINES

The equipment installed on a junction should enable the trains to run with the minimum specific constraints. The turnouts switching the trains to main line or branch line will allow for running at line speed on main line, and at least 200km/h on branch line.

In case the junction is placed inside a big city, it will be desirable to construct a by pass, to make quicker the running of trains not needing the stop on the passenger station.

It is possible that the level and type of equipment existing on branch lines are different from those existing on main lines. In such a case the equipment of the interconnection should try to harmonise both kinds of equipment, avoiding the need of stopping or time-expensive shunting operations. This problem may be particularly serious on some lines giving access to the airport from the city, because these kinds of lines have been generally built to support the traffic of commuter trains at low speed. In other cases, like Paris Charles De Gaulle, there is a high speed link to the airport, but loading terminals do not exist.

Conclusions
All these demands require important investments to be planned and realised. It will be necessary to modify the network-infrastructure step by step according to a long-term strategy.

e) Demands on loading terminals

The best location for a terminal is on-line and/or on-airport.
Equipment requirement
Two possibilities:

- a manual handling terminal which represents the cheapest investment (3.9 million Euros);
- an automatic handling terminal that means a higher investment (7.3 million Euros), but might be less expensive and easier to run, although very good results are obtained with TGV Postal which uses manual handling.

In the first case, freight would be handled by trolleys and be sorted by the staff. In the second one, freight is carried on rolling beds and sorted automatically thanks to bar codes.
In both cases, EDI system link is mandatory.

3. RAMS

The results, obtained by considering as a reference a High Speed Line sample (300 km long), whose structural and operational characteristics are derived from the Italian High Speed System design, are summarised below.
In particular the following aspects, related to the system, have been looked into:

- Reference Conditions
- RAM Requirements
- Consignment Reliability
- Safety Requirements for Dangerous Goods.

a) Reference Conditions

The conditions under which the RAM Analysis and Allocation has been carried out are summarised in table 3**Error! Reference source not found.**~~**Error! Reference source not found.**~~*SEQARABIC*. These conditions establish the relationship between the RAM Requirements stated in the following §b) and the Consignment Reliability calculation performed in the following §c).

Table 3 – Reference Conditions for the RAM Allocation

Traffic Parameters		Model Parameters	
Cruising Speed	300 Km/h	Junction speed	120 km/h
Headway h_c	50 Km (10 min)	"On-sight" speed	30 km/h
Safe Headway h_c	12.5 Km (2.5 min)	Rate of acceleration	0.3 m/s^2
N. of trains per hours	12	Rate of deceleration	-0.5 m/s^2

b) RAM

The following Reliability and Maintainability quantitative requirements have been considered as typical values to be used for the Consignment Reliability estimation.

In table 4**Error! Reference source not found.**~~**Error! Reference source not found.**~~*SEQARABIC*, for each of the Main Components identified, the Reliability and Maintainability Requirements are stated in terms of MTBF and MDT and the corresponding population in the target High Speed Line is indicated.

Table 4 – RAM Requirements for the Main System Components

COMPONENT	**N**	**MTBF (h)**	**MDT (min)**
High Voltage Transmission Network	6.25	55000	5
Electrical Substation	6.25	35000	5
Overhead Contact Line	144	125000*	180
Continuous Track Train Communication System (Radio)	60	50000	60
Balise	125	1000000	52
Balise-Encoder Connection	125	200000	52
Radio Block Centre	3	50000	52
Local Control System	25	50000	52
Track Circuit	200	120000	240
Hot Box Detector	6.25	20000	120
Rail	12.5	1500**	240
Switch	12.5	350000	240
Rolling stock	-	5000	

*	per Km
**	per 100 Km
n=	number of elements of each type met in 300 Km
MTBF=	Mean Time Between Failure for each component
MDT=	Mean Down Time for each component

From the point of view of the maintenance re-organisation, creating new slots for HISPEEDMIX trains does not differ from creating slots for passenger traffic purposes.

Conclusions

Even if the traffic increase will require new slots and thus significant changes in maintenance procedures, no specific requirements related to the peculiarities of HISPEEDMIX vehicles are needed, according to the results found in the Technological Analysis, in undertaking the necessary maintenance policies upgrading.

The migration towards on-condition maintenance policies is strongly recommended in order to allow railway administrations to manage, in a flexible way, maintenance packages and to create time slots for HISPEEDMIX trains.

c) Consignment Reliability

In order to estimate Railway RAM performances related to HISPEEDMIX trains, Consignment Reliability is used. This is a bi-dimensional concept defined as the *probability* (1^{st} dimension) that the delay suffered by goods from source to destination is under a certain value D (2^{nd} dimension).

For the use of CR in this context the following assumptions are made.

Only technical failures during the transportation phase are taken into account, loading/unloading operations are excluded because not directly related to Railway RAM.

Operational causes of delay are excluded (e.g. traffic congestion).

According to the reference conditions identified in §a) and to the RAM Requirements identified in §b), the results obtained are presented below.

In **Error! Reference source not found.~~Error! Reference source not found.~~**~~SEQARABIC~~the delay distribution is shown, while in **Error! Reference source not found.~~Error! Reference source not found.~~**~~SEQARABIC~~ the parametric estimation of the Consignment Reliability is presented, as a function of the Maximum Tolerable Consignment Delay.

In the above mentioned conditions, as one can easily recognise, the Consignment Reliability is never lower than 0,983, it is to say that at most the 1.7% of the trains will suffer an unacceptable consignment delay (>0 minutes).

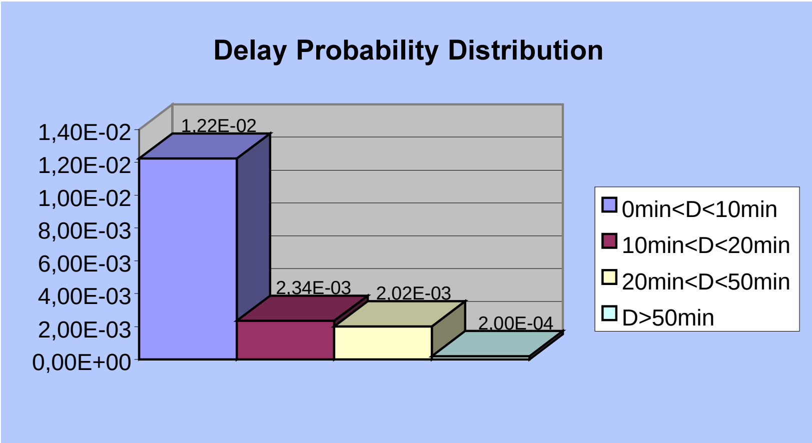

Figure 6 - Distribution of delays caused by technical failures

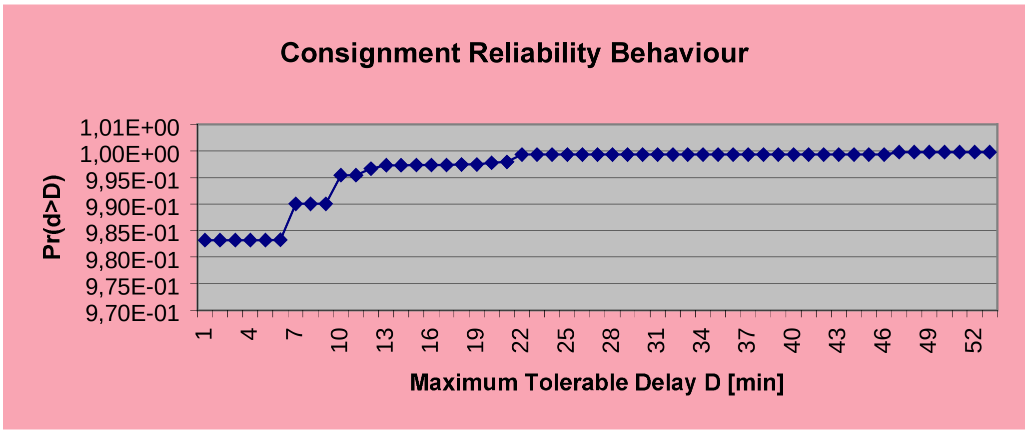

Figure 7 - Consignment Reliability for different Values of the Maximum tolerable Delay

Conclusions

The most significant effect that the introduction of freight traffic will have on the HSRN is a possible increase in delays, as increased traffic produces a higher risk of delay amplification.

That effect will call for current maintenance plans updating.

The need of an increase in maintenance tasks is due to an increase in traffic, which causes a higher stress and so a higher wear on the network and not to the larger number of "Hispeedmix trains" as they give less problems than passengers trains (passengers trains causes much more stress than freight trains as they have to stop and start many times).

The implementation of on-condition tasks is the best and most economic way of preventing failures and avoid their consequences. A monitoring and diagnostic system is used instead of inspections (much more expensive) in order to control the status of the system: if functional parameters are getting worse, or if abnormalities indicative of an impending failure are detected, then a maintenance action is required.

A maintenance plan and a maintenance cost estimation can be developed following the RCM programme.
At this point, to establish which is the best way to transport goods it is necessary to make a comparison between the various carriers (railway, road and air). In order to do this some quality indexes are required, in particular Railway Consignment Reliability can be used, that is the probability that the train delay during a generic trip will be smaller than a threshold value.

d) Safety Requirements for Dangerous Goods

The Recommendations on the Transport of Dangerous Goods are relatively well implemented through national legislation, but the degree of implementation may vary from country to country. Usually, national legislation for air and sea transport is based on the ICAO Technical Instruments and the IMDG Code, and therefore they are perfectly consistent with the UN Recommendations. For regulations applicable to road/rail domestic inland traffic (which is usually much more important than international inland traffic), governments have progressively adapted their own system to the United Nations system and national regulations in most countries of the world are now based on the UN Recommendations on the Transport of Dangerous Goods, even though variations may exist.
There is, at present, no instrument equivalent to ADR or RID for regulating international road or rail transport of dangerous goods outside Europe.
The market analysis found four possible types of goods suitable for high-speed freight, corresponding to typical just-in-time services. These are mail, couriers and integrators, express road freight and air freight.
Conventional freight is also possible, but it has to comply with two relevant constraints: "quality" rolling stock is needed. The rolling stock should not be aggressive to the infrastructure; axle load should be limited according to line load capacity, thus reducing the payload allowable.
The four special categories do not appear to be affected by particular problems of dangerous goods handling since the suppliers of the services have a consolidated policy for hazardous materials. On the other hand, if a speed increase is requested for conventional freight complying with the two above constraints, relevant safety issues are liable to occur. In fact, typical high speed load (mail, couriers, etc.) is usually made of small individual pieces, containing limited quantities of allowable goods; when dealing with conventional load, the operator has instead to cope with the concurrent presence of both relevant quantities of goods and higher speed (comparing with ordinary railway lines).

Conclusions
For the high-speed freight IATA Standard and RID should be harmonised in order to allow the building of an integrated logistic chain. Such a procedure should be completed taking into account the ongoing integration between RID and ADR. Further analysis should be performed about the feasibility of unified air-freight-road load units.

For the conventional freight further studies on the effects of high speed (≤200 km/h) should be undertaken in order to ensure a safety-compliant operation with respect to safety levels higher or equal to those achieved by railway transport of conventional goods. The cost effectiveness of conventional goods rail transport should be carefully evaluated since the technical constraints assessed for operation require the reduction of payload. From this point of view the profit margins for each ton/piece could represent a suitable mean of discrimination.
It should be noted that at present no goods category has been identified. The completion of this assessment will introduce valuable clarifying elements.

4. TSI-criterias

Essential requirements have to be defined for the whole of the Community which will apply to the Trans-European high speed train system.
The Trans-European high speed train system has been broken down into sub-systems:

- Basically structural areas:
  Infrastructures
  Energy
  Control and command and signalling
  Rolling stock
- Basically operational areas:
  Maintenance
  Environment
  Operation
  Users.

Each sub-system will be covered by a TSI and for each of them the essential requirements must be specified, the basic parameters laid down and the technical specifications determined for the whole of the Community.
TSIs will be published by the Commission in the Official Journal of the European Communities after becoming European standards (CEN-CENELEC-ETSI).

The basic parameters list is as follows:
BP1. Minimum infrastructure gauges
BP2. Minimum radius of curvature
BP3. Track gauge
BP4. Maximum track stressing
BP5. Minimum platform length
BP6. Platform height
BP7. Power supply voltage
BP8. Catenary geometry
BP9. ERTMS characteristics
BP10. Axle loading
BP11. Maximum train length
BP12. Gauge of rolling stock
BP13. Minimum braking characteristics
BP14. Boundary electrical characteristics of rolling stock

BP15. Boundary mechanical characteristics of rolling stock
BP16. Operating characteristics linked to train safety
BP17. Boundary characteristics linked to outside noise
BP18. Boundary characteristics linked to outside vibration
BP19. Boundary characteristics linked to outside electromagnetic interference
BP20. Boundary characteristics linked to inside noise
BP21. Boundary characteristics linked to air conditioning
BP22. Characteristics linked to the carriage of disabled people.

The TSIs, issued in their final form, at the project development time, have been taken into account in the project implementation. In fact, the project results have been built upon boundary conditions compliant with the TSIs. Some of them, particularly important for the project, have been summarised and reported below. However, being the subject under discussion, at that time, the definitions reported below could change before the final standardisation.

Minimum infrastructure gauges (BP1)
The minimum gauge of the infrastructure to be used for high-speed lines shall comply with the reference kinematic profile GC set out in the UIC Leaflet 506 (issue dated 1/1/1987).
Existing lines and lines to be upgraded will be brought up to the GC standard if an economic study demonstrates the advantages of such an investment.
A "Route Book" of loading gauges will be made available to identify the loading gauge of the rolling stock that can be operated on these lines.

Minimum radius of curvature (BP2)
The minimum radius of curvature is to be derived from the maximum speed, cant and cant deficiency.
In case of mixed traffic the cant excess of slow trains should also be considered and can lead to greater minimum radius, allowing lower cants to be used.
On service tracks the minimum value of 150 m is proposed for the theoretical radius, arriving till 125 m with the maintenance tolerance.

Track gauge (BP3)
The track gauge of the Infrastructure subsystem is set at 1,435 mm.

To the exception of the high speed lines Madrid-Sevilla and Madrid-Barcelona-French border, the lines of the Spanish network are laid with a track gauge of 1,668 mm, as well as in Portugal.
Projects for new lines in Finland shall keep the 1,520 mm national standard gauge.

Maximum track stressing (BP4)

Vertical forces:
-maximum static axle load:
180 kN for motor vehicles at $V \leq 250$ km/h
170 kN for motor vehicles at $V > 250$ km/h
170 kN for trailer vehicles at all speeds

-maximum dynamic wheel load:
180 kN at 200<V≤250 km/h
170 kN at 250<V≤300 km/h
160 kN at V>300 km/h

Lateral forces:
-maximum lateral force exerted by a wheelset on the track:
H_{lim} = 10 + (P/3) kN, P being the static axle load in kN
-maximum ratio of lateral to vertical forces of a wheel:
$(Y/Q)_{lim}$ = 0,8

Longitudinal forces:
-maximum longitudinal acceleration and deceleration:
2,5 m/s^2

Minimum platform length (BP5)
The operational length of a platform must be at least 400 m.
In Great Britain, the useful length of platforms must be at least 300 m for upgraded lines.
In Sweden, new platforms of 225 m will be built to cater for the more limited travel demand.

Minimum platform height (BP6)
The passenger step for access to vehicles must be optimised for the two platform heights of 550 and 760 mm that exist on the network.
Platforms used on upgraded lines in Great Britain shall have a standard height of 915 mm.

Power supply voltage (BP7)
High speed lines to be built:
25,000 V 50 Hz power voltage has been chosen for this type of lines.
In countries with networks currently electrified at 15,000 V 16 2/3 Hz, this system can be used for new lines. The same system can be applied on adjacent countries when it can be economically justified.
Existing lines (high speed, upgraded and connecting lines):
1,500 V DC
3,000 V DC
15,000 V 16 2/3 Hz AC
25,000 V 50 Hz AC
are the four systems chosen.

Access to the airports:
Other power supply voltages can be found on lines connecting the EHSRN with certain airports.

Contact line and pantograph geometry (BP8)
Contact wire height

Taking care of existing high speed lines two values are recommended, 5080 mm and 5,300 mm. The latter value should be used where ice loads have to be considered.
For DC lines a minimum contact wire height of 5,000 mm can be specified as the same level of safety as in the case of AC lines with 5,080 mm.
On upgraded and connecting lines the contact wire height is subject to the limits set by the local conditions.
Dimensions of pantographs:
The width of the European standard pantograph collector head is 1,600 mm with a working range of 1,200 mm and a length of collector strips of 800 mm.
Permissible lateral position of contact wire:
The permissible lateral deflection of the contact wire under maximum cross wind is 400 mm.

Boundary electrical characteristic of rolling stock (BP14)
The electrical characteristics of rolling stock are referred to the power and the power factor and to the interface with the signalling system.
The proposed solutions and scenarios for high speed freight trains will include:

- new generation of rolling stock derived from the high speed passenger trains of last generations. There is no problem concerning power and power factor in accordance with the standards described in AEIF documents. The "TGV postal" presents a power factor lower than 0.93 in certain operating conditions because of the old electrical drive included and it should be rejected;
- light load freight rolling stock like V200 Sernam (BB22200) 101, 145, 402b, 252 for the scenario at maximum speed of 200km/h. In this case particular care must be taken to V200 Sernam, since the locomotive BB2200 includes DC motors and naturally commuted rectifiers. The Spanish freight train 252 could be verified too.

Axle loading (BP10)
The track-bearing structures shall be designed to withstand the dynamic stresses exerted by high-speed trains and the effects of the loads from maintenance vehicles. The design loading diagram for the structures shall include UIC load model 71 with axle loads of 250 kN for the service and maintenance trains, and the necessary provisions to guarantee correct dynamic behaviour for high speed trainsets.

Maximum train length (BP11)
High-speed trains suitable for running on the interoperable network shall be made up of fixed-consist trainsets (indivisible in service), at least 100 m long and able to run either singly (single unit) or coupled together (multiple unit).
The length of the trains thus formed shall be between 100 m and 400 m.
To allow them to operate in the terminal stations on the network, the maximum length of the trains shall be compatible with the length of platforms on conventional lines served by the Trans-European network.

Vehicle loading gauge (BP12)
The reference contour for interoperable rolling stock shall comply with one of the vehicle gauges UIC 505, GB or GC, and their rules for application, as defined in UIC leaflets 505 & 506.
The choice of rolling stock gauge shall be made based on the routes over which the rolling stock is required to operate. The information required is defined in the «Route Book».

5. Demands on international regulations (UIC)

For the time being there are not any UIC leaflets or prescriptions for high-speed interoperability different from the TSI already mentioned. The reference to other norms like EURORADIO or EUROBALISE are implicit in the ERTMS description. The interoperability on freight transport on rail is currently governed only by COTIF and RIV agreements that are not characteristic of high speed freight and cover also commercial issues. Other specifications, like those deriving from the UIC-HERMES, or HIPPS or ORPHEUS (electronic documentation) have already been superseded by the internet and electronic mail evolutions. Nevertheless, a demand for some International agreements concerning information on rail (and multi-modal) freight transport (collection of data, assembly of information tailored by the customers, access rights, distribution rules, protection of information etc.) have to be identified.

D. Operational Issues

1. Capacity

The capacity of the railway lines plays a key-role in the project. It was investigated for 372 different trains (2010-scenario) whether it is possible to get the required slots on the tracks without competing with a long distance passenger train. The result is that for all these trains a slot could be found.
But, this was only possible by ignoring the night maintenance time in some countries when – today - the tracks are closed. More than 200 trains would be affected by this maintenance policy. Keeping this policy would take away the basis for this project.
Against this background possible capacity constraints for the pre- and end-haulage with trolleys for an on-airport-terminal (a terminal which is located directly at or in the airport) or lorries for an off-airport-terminal seem to be less important. Furthermore, for an on-airport-terminal it is unimportant whether the trolleys are used to feed a lorry or a train.
An important item is the dimension of a terminal. The capacity of a terminal depends on the timetable for departure from and arrival at the terminal. It is possible that the number of tracks in a terminal can be reduced by 18% by stretching the departure time of trains. Unfortunately, not all the necessary changes are feasible due to the timeframes for transportation.

Just as the number of tracks can be reduced the amount of the necessary rolling equipment can be reduced as well. Concerning the number of trainsets a decrease of more than 22% seems to be possible.
One of these trainsets contains 8 wagons, if a TGV postal is taken as an example. It is not to be expected that one customer will hire a complete train because the offered capacity is too large. In this case a share of the train capacity is sensible and would be accepted by the interviewed customers.

2. Timetabling

In most cases the required departure and arrival times can be guaranteed only if, as mentioned above, the maintenance policy is assumed to be changed and other networks adjust their maintenance work as well. Nevertheless, it would sometimes be necessary to have the trains start outside the desired timeframe, but these would be exceptions.
On all relations with more than 1 train as many trains as possible will run as twins to save costs for the track and drivers. If, for example, 7 trains were to run from Rome to Milan, six of them would run as twins (= 3 pairs) while the 7th would have to run as a single one.
The necessary coupling and uncoupling process for running trains as twins is not a problem with the existing technology and will last only few seconds. Assuming the use of TGV-Postal equivalents the length of one twin is in the range of ordinary passenger-platforms (400 m). Therefore, coupling is not necessary while the trains run as a shuttle.

Conclusions
It is possible to operate a high speed freight system in parallel to the existing high speed passenger system. Some of the lines would be used very intensively, in the long term view it will be necessary to upgrade lines or to build new lines. This has to be investigated in the future.
Depending on the freight containers to be used, more or less modified, existing designs of trains could be used. The trains must be able to use multi-current supply in order to cross borders without changing the power cars.
For the same reasons the drivers have to be, at least, bilingual and they have to know the different operating /signalling systems, apart from this, they and the terminal staff do not have to get special skills.

E. Case Study

1. Description

a) Why Paris - Brussels - Cologne?

It was initially planned that the case-study should concern the Lyon-Turin link, but, the volumes transported between these two cities were too low to make that link interesting to be studied in deeper details. Then the partners chose to study the Paris-Brussels-Cologne link because these Origin-Destination pairs gather more freight than any others in Europe do. Moreover, most of the high speed lines already exist or are being built.

b) Location of the terminals on Paris-Brussels-Cologne line

- Paris-Roissy Charles de Gaulle

The selected site is outside the airport but close enough to the high speed line to allow short transit time. It is situated on a building land and the regional council agreed upon the construction of such infrastructures. This place would permit to meet the requirements related to the transfer times.

- Brussels airport

The ideal place for a high speed freight terminal would be close to the high speed line and to DHL's hub. At the south of the airport, Runderenberg area could be a good place for terminal.
Another possibility would be Diegem area, it is close to DHL's hub, to Brucargo[1] and to the high speed line. The junction would have to go through a housing area, which might involve difficulties concerning noise regulations.
These two places would both offer a quick access to road network.

- Cologne/Bonn airport

The possibility to have a freight terminal on-airport and underground has been studied, this presents many constraints concerning size, flexibility and costs.
Another possibility would be to have a freight terminal directly in the cargo area with a junction to the high speed line dividing itself towards Frankfurt and Brussels. This solution would permit to have a terminal completely on-airport and close to the high speed line, which would make pre- and post-haulage transportation time nearly insignificant. This would allow us to have a freight terminal on ground floor and then to limit investments.

c) Demand and number of trains

Demand for transport would represent the following number of trains, both ways and per day:

[1] Name of Brussels cargo area.

	1997	2005	2010
Paris-Brussels	0.7	1.4	2.2
Brussels-Cologne	0.9	1.8	2.9
Paris-Cologne	0.8	1.7	2.7

If we aggregate the trains of all the origin-destination pairs passing through this line, we obtain the following results, both ways and per day:

	1997	2005	2010
Paris-Lille[2]	4	20	36
Lille-Brussels	7	28	47
Brussels-Cologne	5	22	35

[2] The trains do not stop in Lille, the difference of trains numbers between Paris-Lille and Lille-Brussels is due to the fact that some of the trains bifurcates towards London.

2. Technical issues

a) THE RAILWAY NETWORK

The case study railway network (fig. 8) is a subset of the Thalys line, which connects Paris, Brussels, Köln and Amsterdam; it's composed of five lines (Table 5~~Table 5~~~~Table 5SEQARABIC~~) and four junctions: Vemars, Croissiles, Sainghin and Y. Halle.

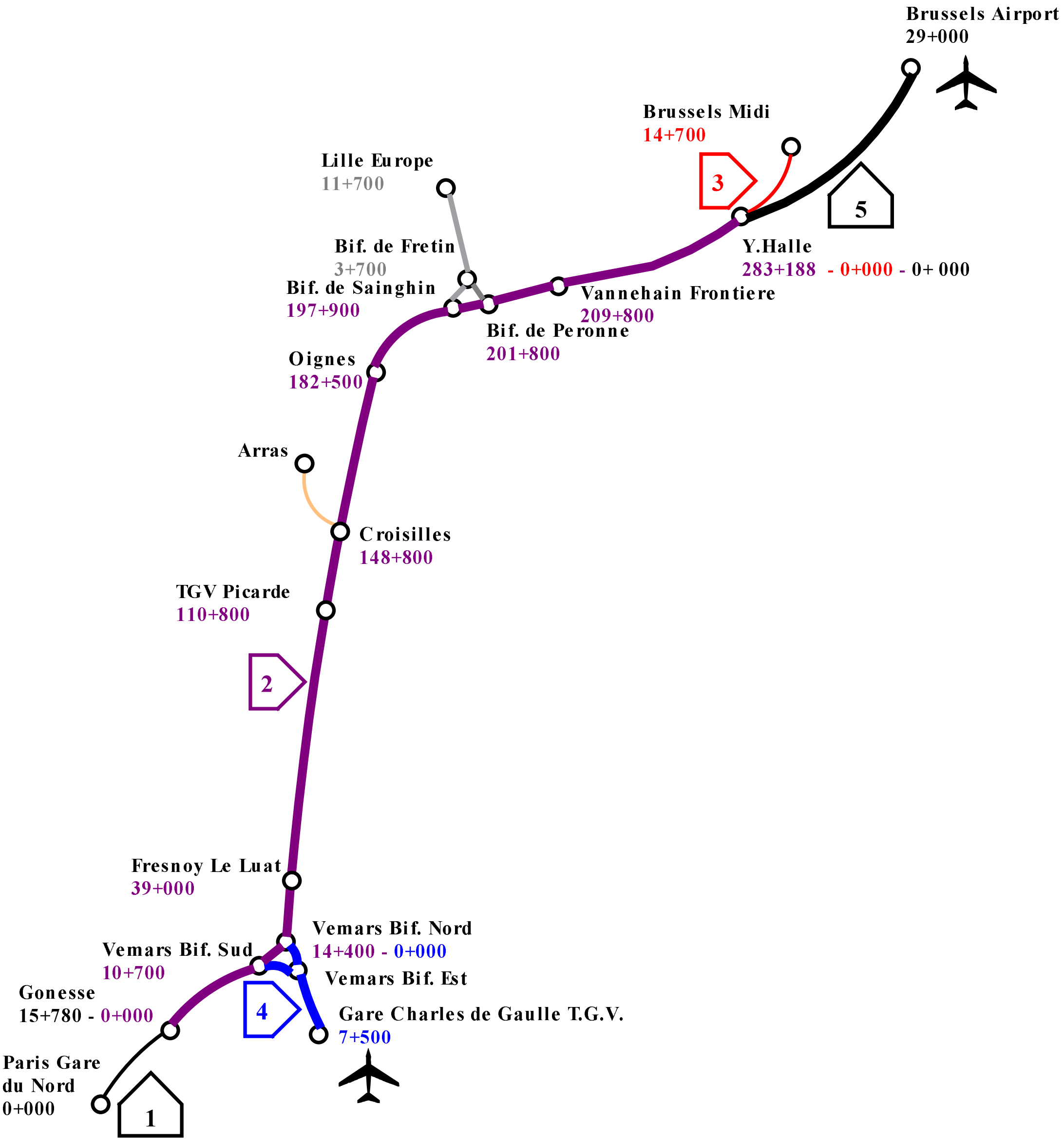

Figure 8: Case study railway network

Line number	From	To	Length [km]	Type
1	Paris Gare du Nord	Gonesse	15.8	Conventional
2	Gonesse	Y. Halle	283.2	High speed
3	Y. Halle	Brussels Midi	14.7	Conventional
4	Charles de Gaulle Airport	Vemars	7.5	High speed
5	Y. Halle	Brussels Airport	29.0	Conventional / High speed

Table 5: case study lines

In order to characterise the railway line profile from Paris Charles de Gaulle airport to Brussels airport, table 6 **Error! Reference source not found.Error! Reference source not found.***SEQARABIC*and Figure 9Figure 9Figure 9SEQARABIC show the track length percentage versus gradient values.

Gradient	Track length [m]	Track length percentage [%]
-2.5	9188	3.0
(-2.5, -2.0)	4860	1.6
(-2.0, -1.5)	5924	1.9
(-1.5, -1.0)	19222	6.3
(-1.0, -0.5)	34508	11.3
(-0.5, 0.0)	61786	20.2
0.0	38672	12.7
(0.0, 0.5)	64581	21.2
(0.5, 1.0)	35889	11.8
(1.0, 1.5)	13512	4.4
(1.5, 2.0)	8385	2.7
(2.0, 2.5)	1217	0.4
2.5	7444	2.4
Total	305188	100

Table 6: Paris Charles de Gaulle – Brussels Airport Line – track length percentage

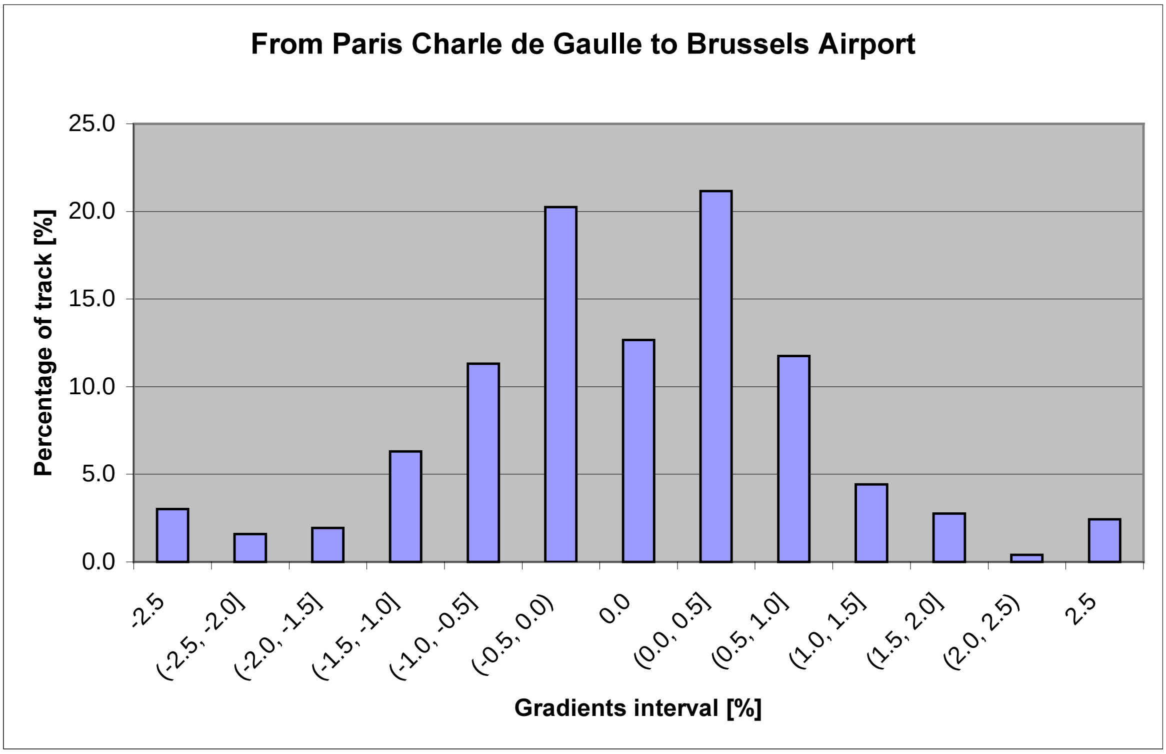

Figure 9: Paris Charles de Gaulle – Brussels Airport Line – track length percentage versus gradient values

b) SIGNALLING SYSTEM

Today the case study high speed lines are equipped with the TVM 430 cab signalling system. The lines are divided into fixed blocks about 1,500 [m] long. Under normal operation only one train may occupy any block at one time. Blocks are shorter than train's braking distance, so a braking sequence takes place over several blocks. The minimum allowed headway (time between two successive trains) is 3 minutes and the maximum train speed is 300 [km/h]. It has been assumed that a moving block signalling system will be installed in all case study lines.

c) THE CASE STUDY TRAINSETS

The following high speed passengers and freight trains have been chosen to verify power supply technological constraints and to evaluate trains energy consumption and running times.

	TGV Thalys	TGV La Poste	E404 4 VANS	E404 6 VANS	E404 9 VANS	ETR500 COMBI VAN	E402B 6 Z1*	E402B 8 Z1*
	1	2	3	4	5	6	8	7
Configuration	P+8T+P	P+8T+P	P+4T+P	P+6T+P	P+9T+P	P+5T+P	P+6T	P+8T
Service	Passenger	Freight	Freight	Freight	Freight	Freight	Freight	Freight
Top speed [km/h]	300	270	300	300	300	250	200	200
Length [m]	200	200	156	208	286	170	178	231
Tare weight [t]	385	345	304	388	514	296	316	394
Load weight [t]	30	73	60	90	135	160	72	96
Total weight [t]	415	418	364	478	649	456	388	490
Constant Davis coefficient [N] [1]	2700	2540	3009 [7]	3951 [7]	5365 [7]	3770 [7]	7372	9310
Linear Davis coefficient [N / (m / s)] [1]	118.8	120.4	0 [7]	0 [7]	0 [7]	0 [7]	0	0
Quadratic Davis coefficient (open air) [N/(m/s)^2] [1]	6.61	7.41	9.8 [7]	10.1 [7]	10.5 [7]	10.0 [7]	13.1	16.5
Rotational inertia coefficient [%]	4	4	4	4	4	4	9	9
Max service acceleration (normal operation)	0.6	0.25	0.5	0.5	0.5	0.5	0.5	0.5
Max service braking deceleration (normal operation)	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Braking type	Dissipative	Dissipative	Dissipative	Dissipative	Dissipative	Dissipative	Dissipative	Dissipative
Efficiency [2]	0.83	0.83	0.83	0.83	0.83	0.83	0.85	0.85
Power factor	0.95÷0.99 [5]	- [6]	0.95	0.95	0.95	0.95	0.95	0.95
Continuos Power [kW]	8800	6420	8500	8500	8500	8500	5200	5200
Auxiliary load [kVA] [3]	840	250 [8]	250 [8]	250 [8]	250 [8]	250 [8]	60 [8]	60 [8]
Maximum Current [A] [4]	464	450	497	497	497	497	340	340
Minimum pantograph voltage (indefinitely) [V] [9]	19000	19000	19000	19000	19000	19000	19000	19000
Minimum pantograph voltage (10 minutes) [V] [10]	17500	17500	17500	17500	17500	17500	17500	17500

Table 7: Case study trainsets

Notes:

[1] Davis coefficient are utilised in the following formula to calculate train running resistance: $R = a + b \cdot v + c \cdot v^2 \quad [N]$

where v is the train speed in [m/s] and a, b, c are the three Davis coefficients.

[2] η refers to the total traction converters efficiency from wheels to pantograph and it takes into account mechanical efficiency, engine efficiency and drive efficiency.

[3] Mean value of auxiliary loads at pantograph (all electrical device, except the traction device) in nominal operation conditions. The simulator assumes that auxiliary loads are continually absorbed at pantograph.

[4] The maximum pantograph current, absorbed by traction converters, is utilised to reduce tractive effort in function of pantograph voltage.

[5] 0.95 if slow speed, 0.99 if high speed.

[6] power factor is a function of train speed.

[7] data about Davis coefficients of different ETR500 configurations have been deduced from standard ETR500 configuration data (P+14T+P) by means of approximate formulae.

[8] these data have been supposed

[9] Minimum value of voltage likely to be present indefinitely.

[10] The lowest non-permanent value of the voltage to be present for maximum 10 minutes.

Table 7

~~Table 7~~

~~Table 7SEQARABIC~~ and **Error! Reference source not found.~~Error! Reference source not found.~~**~~SEQARABIC~~ main characteristics of the simulation trainset lists:

- First solution is represented by TGV Thalys that is actually running on the Paris Brussels line.
- Second solution is represented by TGV La Poste that is today running on the French high speed lines (Paris-Lyon and TGV Atlantique).
- Third, fourth and fifth solutions trainsets are a luggage-van version of Class ETR500 high speed passenger trains; they are made up of two Class E404 locomotives at each extreme of the train and respectively four, six and nine intermediate luggage vans.
- Sixth solution is represented by a trainset made up of two E404 locomotives and five experimental COMBIVAN wagons, which will be able to run up to 250 [km/h]. This solution is represented by the development of a new conception vehicle specifically conceived for high speed freight transportation. At present, no locomotive of FS traction unit fleet, for conventional hauled trains is able to exceed 220 [km/h]. Consequently, in order to operate a trainset made up of COMBIVANs at 250 [km/h], a couple of Class E404 locomotives, currently used for ETR500 sets, have been utilised.

- Seventh and eighth solutions are represented by a trainset made up respectively of 6 and 8 Z1 series luggage vans and a traction unit belonging to Class E402B locomotive.

TGV La Poste, luggage van versions of ETR500 and ETR500 COMBIVAN, belongs to very high speed trains, while E402B+6Z1 and E402B+8Z1 belong to the category of high speed trains.

d) THE CASE STUDY POWER SUPPLY SYSTEM

The power supply system of the Paris-Brussels line is mainly based on the 2x25 [kV] 50 [Hz] traction supply system, which includes electrical substations (ESS) and autotransformer points (AT). Each ESS is fed by the high voltage (HV) three phase network and is equipped with 2 equal rating transformers (60 [MVA]). Each AT is constitute of two autotransformers (10 [MVA]), which may be operated in parallel or may belong to different line sections in correspondence of a sectioning point. In normal operation conditions, each electric substation transformer feeds two or three autotransformer points; the length of each line section varies from 20 to 40 [km]. Substation transformers are not electrical connected.

e) ELECTRICAL SUBSTATION AND AUTOTRANSFORMER DATA

Rated frequency	[Hz]	50
Rated power	[MVA]	60
Short circuit impedance at secondary windings	[Ω]	2.28÷2.5
Transforming ratio	[kV/kV]	220 / 27.5 400 / 27.5

Table 8: 2x25 [kV] 50 [Hz] feeding system - ESS data

Rated frequency	[Hz]	50
Rated power	[MVA]	10
Series impedance	[Ω]	0.9
Transforming ratio	[kV / kV]	55 / 27.5

Table 9: 2x25 [kV] 50 [Hz] feeding system –

Autotransformer data

f) Feeding system line section

Figure 10**Error! Reference source not found.~~Error! Reference source not found.~~**~~SEQARABIC~~ represents the line cross section with the position of each conductor. **Error! Reference source not found.~~Error! Reference source not found.~~***~~SEQARABIC~~*Table 10 summarises the geometrical parameters of the conductors.

Group	Wire	Material	R [Ω/Km]	Diameter [cm]	Section [mm^2]	X [m]	Y [m]
1	Catenary 1	Bronze	0.503	1.04	65	-2.25	6.30
1	Contact wire 1	Copper	0.135	1.45	150	-2.25	5.08
2	Catenary 2	Bronze	0.503	1.04	65	2.25	6.30
2	Contact wire 2	Copper	0.135	1.45	150	2.25	5.08
3	Rail 11					-2.967	0
3	Rail 12					-1.532	0
4	Rail 21	UNI60				1.532	0
4	Rail 22					2.967	0
3	Ground wire 1	Aluminium Steel	0.127	2.20	288	-6.95	-3.10
4	Ground wire 2	Aluminium Steel	0.127	2.20	288	6.95	-3.10
5	Feeder 1	Aluminium Steel	0.127	2.20	288	-6.10	6.30
6	Feeder 2	Aluminium Steel	0.127	2.20	288	6.10	6.30

Table 10: 2x25 [kV] 50 [Hz] feeding system - conductors geometrical parameters

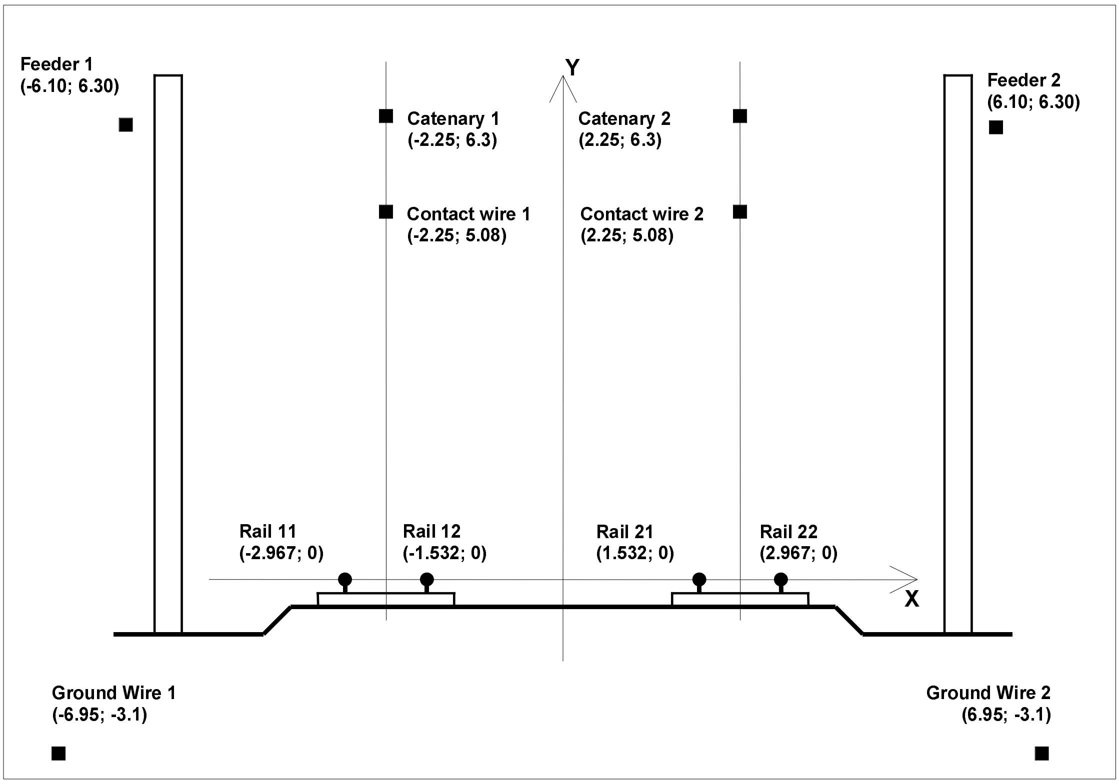

Figure 10: 2x25 [kV] 50 [Hz] feeding system - Cross section

g) ELECTRICAL FEEDING SYSTEM SCHEME

Table 11**Error! Reference source not found.**~~**Error! Reference source not found.**~~*SEQARABIC* reports the different electrical feeding systems equipped with in the analysed network lay-out of figure 8 on page 63. Lines 2 and 4 are high speed lines, fed at 2x25 [kV] 50 [Hz] AC, while lines 1 and 3 are traditional lines, fed respectively at 1.5 [kV] and 3 [kV] DC.
Line 5 is supposed to be fed at 3 [kV] DC in the first case study scenario, while at 2x25 [kV] 50 [Hz] AC in the second one.

	Electrical feeding system
1	1.5 [KV] DC
2	2x25 [kV], 50 [Hz] AC
3	3 [kV] DC
4	2x25 [kV], 50 [Hz] AC
5	3 [kV] DC / 2x25 [kV], 50 [Hz] AC

Table 11: Case study power supply system

The following tables and figures show the line sections in which the AC electrical feeding system is subdivided. Position of electrical substations and autotransformers is reported as well**Error! Reference source not found.**~~**Error! Reference source not found.**~~*SEQARABIC*.

Position [km]	Network line	Feeding system section	Code	Type
1+533	2	A	ESS 1	Electrical substation
13+000	2	A	AT 1	Autotransformer point
26+000	2	A / B	AT 2	Autotransformer and sectioning point
7+500	4	A	AT 3	Autotransformer point *
40+000	2	B	AT 4	Autotransformer point
53+697	2	B / C	ESS 2	Electrical substation
67+000	2	C	AT 5	Autotransformer point
76+000	2	C	AT 6	Autotransformer point
86+680	2	C / D	AT 7	Autotransformer and sectioning point
98+000	2	D	AT 8	Autotransformer point
107+944	2	D / E	ESS 3	Electrical substation
118+128	2	E	AT 9	Autotransformer point
133+950	2	E	AT 10	Autotransformer point
141+044	2	E / F	AT 11	Autotransformer and sectioning point
153+586	2	F	AT 12	Autotransformer point
164+195	2	F / G	ESS 4	Electrical substation
175+135	2	G	AT 13	Autotransformer point
183+687	2	G	AT 14	Autotransformer point
192+490	2	G / H	AT 15	Autotransformer and sectioning point
207+300	2	H	AT 16	Autotransformer point
215+000	2	H / I	ESS 5	Electrical substation*
226+000	2	I	AT 17	Autotransformer point*
237+000	2	I / L	AT 18	Autotransformer and sectioning point*
248+000	2	L	AT 19	Autotransformer point*
259+000	2	L / M	ESS 6	Electrical substation*
271+000	2	M	AT 20	Autotransformer point*
283+188 0+000	2 5	M N	AT 21	Autotransformer and sectioning point*
14+000	5	N	AT 22	Autotransformer point*
29+000	5	N	ESS 7	Electrical substation*

* data and position of these electrical substations and autotransformers have been assumed.

Table 12: Case study power supply system - ESSs and Autotransformers positioning

Figures 11, 12 and 13: generally each electrical substation point is made up of two transformers (each with a rated power equal to 60 [MVA]), which feed different sections of line. ESS1 and ESS7, being at the beginning and at the end of the feeding system, are made up of only one transformer.
Autotransformer points are made up of two autotransformers, each with a rated power equal to 10 [MVA]. Autotransformers may be connected in parallel (autotransformer point) or not (sectioning point); in this case each autotransformers belongs to a different line section.

Case study electrical feeding network is made up of eleven 2x25 [kV] 50 [Hz] line sections in the first simulation scenario and of twelve sections in the second. Section N is related to the fifth railway line from Halle to Brussels Airport, which may be fed both in DC or AC.

Data and positions in the Belgian lines have been supposed, assuming that each electrical substation transformer feeds 22÷24 kilometres of lines. Position of AT3 has also been assumed.

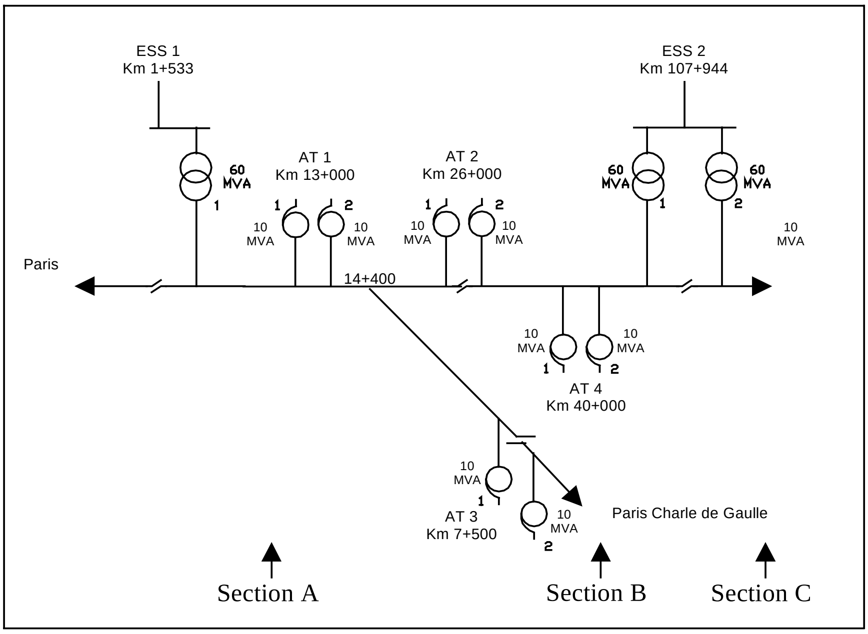

Figure 11: Case study power supply system - A÷B line sections

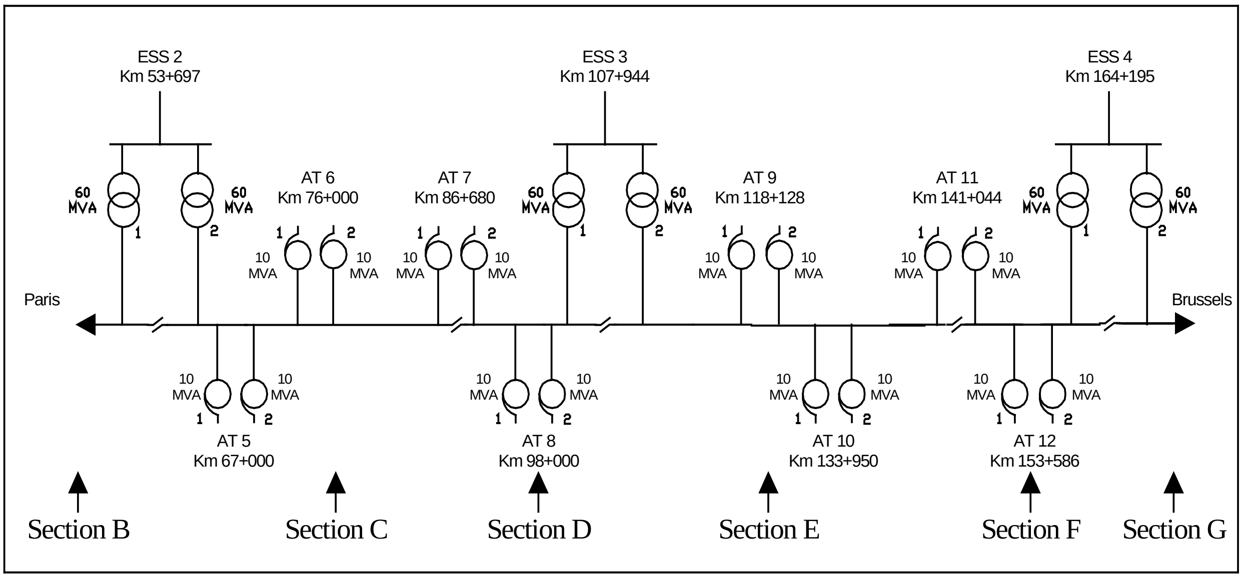

Figure 12: Case study power supply system - C÷F line sections

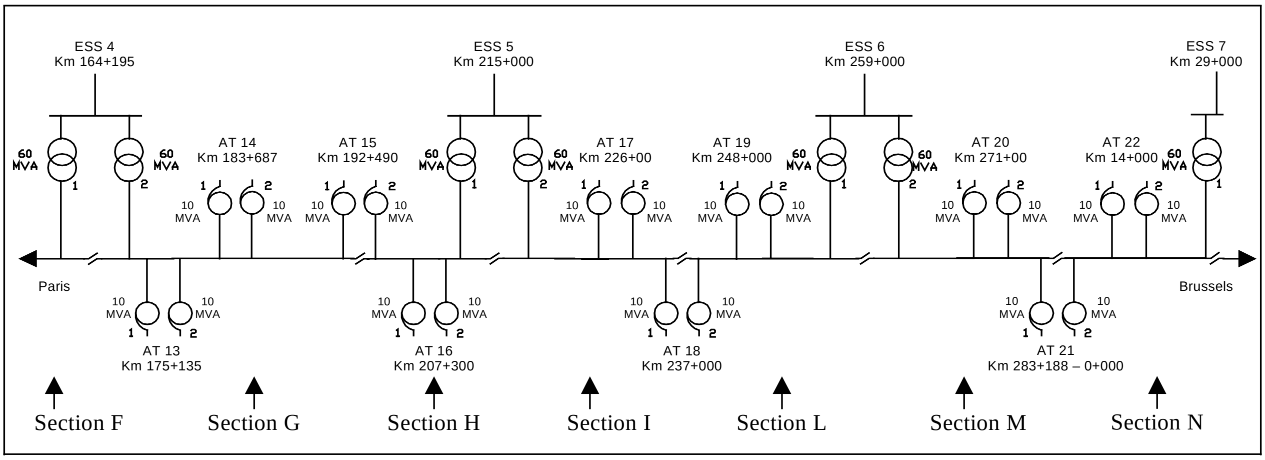

Figure 13: Case study power supply system - G÷N line sections

3. Limits and potentials

The application of the methodology adopted for the business plan applied to the Case Study is described. According to what was stated at the beginning of the work, a standard business plan activity does not fit with the accuracy and degree of reliability of the information achieved by this research study. On the other hand, it is sensible to apply the fundamentals of such a methodology in order to provide us with preliminary results, which could be useful for further steps under the same framework.

The objective of this work is not the definition of an exact and rigorous business plan, which rather fits much more with the activities and the mission of a purely commercial entity. Under this framework, the basic elements of an economic feasibility have been dealt with, in order to detect and identify the possible core business activities in the context of a forthcoming HISPEEDMIX operator.

This part of the work has two essential objectives:

- to verify the fitness of the HISPEEDMIX service supply to the transport demand, on the base of goods transport estimated flows for each O/D pair and users behaviours, constrained by the infrastructure capacity;
- to give some basic and general information about the economic and financial feasibility of the HISPEEDMIX concept, through revenues and main costs (i.e. fixed and variable circulation costs, terminal costs) analysis.

To hit the objectives of this work, a simplified methodology was applied; this choice is justified by the following considerations:

- first of all, HISPEEDMIX partnership changed during the Project, because of modification occurred in European Railway companies, that transformed their internal structure and became "divisional";
- secondly, the market analysis phase made it clear that rail transport customers have low confidence in railway service and they were somehow reluctant to provide the partnership with available information.

As a consequence of these reasons, the available information and data were not detailed enough to justify the application of the business plan methodology and a simplified approach to the work was made.

4. Costs (point of view of an operator)

The methodology adopted to evaluate the profitability of the whole network was to study the economical efficiency of each terminal on the network, considering all the connections starting from this point. Then, once the results are obtained for each terminal, the profitability ratios were calculated for the entire European network.

In order to estimate costs and revenues arising from the HISPEEDMIX service, different hypothesis concerning the terminal and the exploitation of the train set fleet were defined.

With regard to the number of train sets, a study was carried out in order to optimise their utilisation on each line and to determine a timetable. Its conclusions concerning the fleet needed were the base of the profitability study for the train sets investment. The train sets needed for each O/D pair was identified and the cost for one train set is about 12,200,000 €.

The number of trains run between each origin and destination, was used to determine the variable exploitation costs; another criteria concerning these costs was the number of kilometres between each origin-destination.

The terminal costs are linked to the number of train sets used on each line and to the general timetable of departures and arrivals in the terminal for every origin-destination pair. Actually, the number of train sets and the timetable determine the number of platforms that will be needed. So, the study concerning the timetable was also taken as an input to the profitability study in order to give the number of tracks and platforms needed in each terminal.

Finally, the amortisation of terminals and train sets is done over 30 years and the overhead costs were fixed at 15% of the whole costs. It was also considered that the land on which the terminals are built would be rented.

Both circulation and terminal costs are detailed in the following section.

Concerning the revenues, the selling price used was 0.17 € per ton/km, which corresponds to what could be accepted by the market. It is above road prices, but also far under air prices: this means that the profitability of the service, which yet is very good, could even be improved.

5. Results

Following the aforementioned statements, a cash flow analysis was carried out, according to the methodology adopted. The annual estimated financial flows (based on sales, circulation and terminal costs) were compared; they arise from HISPEEDMIX service during the considered period, which corresponds to the investment economic life (30 years).

The year of actualisation, which the changing value of money is referred to, was fixed to 1997.

As summarised in Table13, three different hypothesis of actualisation rate, which is necessary to verify the profitability of the high speed train service for freight, were identified: 0%, 8% and 20%. The three different Net Present Values arising from the application of the actualisation rates are the following.

Actualisation rate 0%: 7,576,914,340 €

Actualisation rate 8%: 767,108,210 €

Actualisation rate 20 %: -586,776,267 €

The Internal Profitability Rate, which makes the NPV equal to zero, corresponds to 11,75 %. It is possible to say that this ratio is good: effectively, a project is supposed to be reliable as long as its internal profitability ratio is above 8%, which is the case for Hispeedmix.

Table 13: Cash flow analysis and Net Present Value of the Hispeedmix service (Source SNCF)

In the following tables the estimated costs and results are described and summarised.
Particularly, Table 14 and 15 indicate circulation and terminal costs estimation denominate Euros. Table 16 and 17 illustrate the obtained results referred on two sample years: 2000 and 2010. Finally, Table 13 gives the results of the cash flow analysis and the obtained Net Present Valued based upon the whole considered period (30 years).

CIRCULATION COSTS			
Parameters			
Train set payload :		90	tonnes
train filling rate :		0,7	
Number of circulation days in a year :		260	days
Interest rate :		0,066	
Fixed costs : Capital			
Total cost train set		12.200.000 Euros	
taux de réserve		23%	
Amortization duration			
Amortization duration train set		30 years	
trainset duration		35 years	
professional tax: 1.6%			
Amortization installment A4:			
Train set		**1.160.670 Euros**	
Variable costs :			
	Maintenance :		
	Train set maintenance :	1,3	Euro/km
	Driver cost per km :	1,07	Euro/km
	Slot price:		
	Reservation fee :	0,63	Euro/km on HSL
	Circulation fee :	0,05	Euro/km on HSL
	total fee :	0,67	Euro/km
	Energy :		
	per km :	0,79	Euro/km
Total variable cost per train		**3,83**	**Euro/km**

Table 14 - Circulation costs estimation (Source SNCF – Amounts in €)

TERMINAL COSTS FEX 300 km/h		
1) Terminal feeding		
Terminal feeding cost :	228,67 Euros	per train
45,8 Euros/ 8 air containers		
40 containers/train -5 containers/trailer-8 trailers/train		
Cost for 2 terminals :	**457,35 Euros**	**per train**
2) Transfert		
2.1) Operational costs :		
Nb of posts per train set and per way :	16	
working hours per post :	1,5	
cost of 1 hour :	18,6 Euros	
Cost per train and per way (2 teminals) :	**892,54 Euros**	
2.2 Investment costs :		
2.2.1) At charge of airports		
Terminal area :	50000	m²
number of tracks :	3	
Annual rental cost per m² :	4.596 Euros	
Annual rental cost for 1 track :	76.605,63 Euros	
Annual rental cost for 1 train (2 terminals) :	153211,26 Euros	
2.2.2) At charge of railway companies		
Railway infrastructures costs for 3 tracks :	9.146.941,03 Euros	
for 1 track :	3.048.980,34 Euros	
Amortization duration :	30	years
Annual cost for one track :	235.908,6 Euros	
Annual cost for 1 train (2 terminals) :	471.817,21 Euros	
2.2.3) Tools		
Tools cost per track :	152.449 Euros	
Amortization duration :	10	years
Annual cost for one track :	21.305,66 Euros	
Annual cost for 1 train (2 terminals) :	42.611,48 Euros	
Total instalment investment for 1 train (2 terminals)	**667.639,95 Euros**	

Table 15 – Terminal costs estimation (Source SNCF - Amounts in €)

Profitability

Year: **2000**

					Costs					Balance & Turnover			
					Traction cost	Annual cost	Annual cost	Annual cost	Annual sum	Turnover	Balance	Turnover	Balance
Origin	Destination	Nb of trains per day	Number of Km	Nb of trains per year	ABBA per relation and per day	Traction	Terminal feeding	Transfer	Expenses per train	2 ways per train / year	2 ways per train / year	2 ways per train / year (positive only)	2 ways per train / year (positive only)
Amsterdam	Brussels	0,7	209 km	191	50728	13.189.391 F	1.145.954 F	4.335.520 F	18.670.865 F	7.041.430 F	-11.629.435 F	- F	- F
Amsterdam	Hamburg	0,9	886 km	229	90731	23.589.968 F	1.373.605 F	5.196.798 F	30.160.371 F	35.780.218 F	5.619.846 F	35.780.218 F	5.619.846 F
Amsterdam	London	1,2	596 km	316	107606	27.977.480 F	1.897.109 F	7.177.385 F	37.051.973 F	33.241.904 F	-3.810.069 F	- F	- F
Amsterdam	Manchester	0,8	916 km	208	83472	21.702.727 F	1.245.511 F	4.712.175 F	27.660.413 F	33.542.102 F	5.881.689 F	33.542.102 F	5.881.689 F
Amsterdam	Milan	0,5	1.350 km	136	66244	17.223.422 F	817.986 F	3.094.708 F	21.136.116 F	32.465.855 F	11.329.739 F	32.465.855 F	11.329.739 F
Amsterdam	Paris	0,7	522 km	177	57793	15.026.271 F	1.063.559 F	4.023.791 F	20.113.620 F	16.322.223 F	-3.791.398 F	- F	- F
Amsterdam	Stuttgart	0,5	861 km	140	54933	14.282.652 F	841.909 F	3.185.219 F	18.309.781 F	21.311.590 F	3.001.809 F	21.311.590 F	3.001.809 F
Barcelona	Madrid	1,2	624 km	302	104517	27.174.324 F	1.813.835 F	6.862.332 F	35.850.491 F	33.275.893 F	-2.574.598 F	- F	- F
Barcelona	Seville	0,6	1.095 km	162	70879	18.428.618 F	973.905 F	3.684.602 F	23.087.126 F	31.352.930 F	8.265.804 F	31.352.930 F	8.265.804 F
Berlin	Frankfurt	1,1	602 km	287	98002	25.480.599 F	1.721.938 F	6.514.655 F	33.717.193 F	30.476.238 F	-3.240.955 F	- F	- F
Berlin	Hamburg	3,2	292 km	842	237043	61.631.307 F	5.050.107 F	19.106.206 F	85.787.620 F	43.354.155 F	-42.433.464 F	- F	- F
Berlin	Munich	1,1	877 km	292	115078	29.920.151 F	1.749.874 F	6.620.346 F	38.290.370 F	45.118.397 F	6.828.027 F	45.118.397 F	6.828.027 F
Berlin	Stuttgart	2,0	811 km	516	196984	51.215.791 F	3.095.309 F	11.710.567 F	66.021.667 F	73.802.689 F	7.781.022 F	73.802.689 F	7.781.022 F
Bologna	London	0,6	1.530 km	144	74777	19.442.058 F	861.721 F	3.260.173 F	23.563.952 F	38.761.934 F	15.197.982 F	38.761.934 F	15.197.982 F
Bologna	Milan	2,2	202 km	568	150163	39.042.287 F	3.409.520 F	12.899.332 F	55.351.140 F	20.248.460 F	-35.102.679 F	- F	- F
Bologna	Rome	1,3	352 km	332	97482	25.345.242 F	1.994.752 F	7.546.800 F	34.886.794 F	20.643.290 F	-14.243.505 F	- F	- F
Bordeaux	Paris	0,8	549 km	213	70571	18.348.468 F	1.278.265 F	4.836.096 F	24.462.828 F	20.631.967 F	-3.830.861 F	- F	- F
Brussels	Cologne	0,8	216 km	218	58303	15.158.831 F	1.310.400 F	4.957.672 F	21.426.904 F	8.321.564 F	-13.105.339 F	- F	- F
Brussels	Hamburg	0,8	677 km	217	77285	20.094.006 F	1.302.680 F	4.928.465 F	26.325.151 F	25.928.283 F	-396.869 F	- F	- F
Brussels	London	1,2	387 km	300	89949	23.386.822 F	1.799.153 F	6.806.785 F	31.992.760 F	20.470.404 F	-11.522.356 F	- F	- F
Brussels	Manchester	0,8	707 km	197	71218	18.516.636 F	1.181.200 F	4.468.865 F	24.166.701 F	24.552.179 F	385.478 F	24.552.179 F	385.478 F
Brussels	Paris	0,6	313 km	168	48026	12.486.653 F	1.008.643 F	3.816.025 F	17.311.321 F	9.281.731 F	-8.029.590 F	- F	- F
Brussels	Stuttgart	0,5	652 km	133	46727	12.149.002 F	798.438 F	3.020.752 F	15.968.192 F	15.305.099 F	-663.094 F	- F	- F
Cologne	Hamburg	1,1	461 km	275	86405	22.465.247 F	1.649.682 F	6.241.286 F	30.356.215 F	22.358.796 F	-7.997.419 F	- F	- F
Cologne	Paris	0,1	529 km	23	7595	1.974.753 F	139.196 F	526.624 F	2.640.573 F	2.164.859 F	-475.714 F	- F	- F

Cologne	Stuttgart	0,6	436 km	169	52146	13.557.896 F	1.011.122 F	3.825.406 F	18.394.424 F	12.960.968 F	-5.433.456 F	- F	- F
Edinburgh	London	5,2	675 km	1345	478415	124.387.980 F	8.072.741 F	30.541.821 F	163.002.542 F	160.203.545 F	-2.798.998 F	- F	- F
Edinburgh	Manchester	3,4	425 km	883	271457	70.578.711 F	5.300.004 F	20.051.649 F	95.930.364 F	66.223.548 F	-29.706.816 F	- F	- F
Edinburgh	Paris	0,3	1.175 km	82	37163	9.662.505 F	493.193 F	1.865.911 F	12.021.609 F	17.037.356 F	5.015.747 F	17.037.356 F	5.015.747 F
Frankfurt	Hamburg	3,1	528 km	814	266428	69.271.204 F	4.885.653 F	18.484.024 F	92.640.881 F	75.840.967 F	-16.799.914 F	- F	- F
Frankfurt	Munich	1,1	453 km	282	88232	22.940.347 F	1.692.890 F	6.404.758 F	31.037.995 F	22.546.251 F	-8.491.744 F	- F	- F
Frankfurt	Paris	0,3	661 km	69	24245	6.303.653 F	412.239 F	1.559.635 F	8.275.526 F	8.011.203 F	-264.323 F	- F	- F
Frankfurt	Stuttgart	1,9	209 km	499	132559	34.465.420 F	2.994.512 F	11.329.219 F	48.789.152 F	18.400.079 F	-30.389.073 F	- F	- F
Hamburg	London	1,4	1.064 km	359	154800	40.248.058 F	2.156.566 F	8.158.996 F	50.563.621 F	67.460.846 F	16.897.225 F	67.460.846 F	16.897.225 F
Hamburg	Manchester	0,9	1.384 km	236	116211	30.214.803 F	1.415.852 F	5.356.633 F	36.987.288 F	57.610.469 F	20.623.181 F	57.610.469 F	20.623.181 F
Hamburg	Milan	0,6	1.383 km	155	76291	19.835.709 F	929.857 F	3.517.954 F	24.283.521 F	37.808.181 F	13.524.660 F	37.808.181 F	13.524.660 F
Hamburg	Munich	3,2	803 km	827	314686	81.818.465 F	4.964.915 F	18.783.899 F	105.567.278 F	117.212.708 F	11.645.430 F	117.212.708 F	11.645.430 F
Hamburg	Paris	0,8	1.189 km	202	91647	23.828.326 F	1.209.016 F	4.574.103 F	29.611.444 F	42.263.083 F	12.651.639 F	42.263.083 F	12.651.639 F
Hamburg	Stuttgart	5,6	737 km	1464	537989	139.877.079 F	8.782.316 F	33.226.378 F	181.885.773 F	190.293.476 F	8.407.703 F	190.293.476 F	8.407.703 F
London	Madrid	0,5	2.217 km	131	85491	22.227.628 F	785.157 F	2.970.505 F	25.983.290 F	51.176.364 F	25.193.074 F	51.176.364 F	25.193.074 F
London	Manchester	11,5	320 km	2991	858434	223.192.739 F	17.944.094 F	67.888.383 F	309.025.216 F	168.818.040 F	-140.207.176 F	- F	- F
London	Milan	0,8	1.328 km	214	103094	26.804.464 F	1.284.241 F	4.858.705 F	32.947.411 F	50.140.891 F	17.193.480 F	50.140.891 F	17.193.480 F
London	Paris	1,1	500 km	278	89554	23.283.960 F	1.669.792 F	6.317.369 F	31.271.121 F	24.545.942 F	-6.725.180 F	- F	- F
London	Stuttgart	0,8	1.173 km	220	99516	25.874.259 F	1.321.802 F	5.000.808 F	32.196.869 F	45.583.914 F	13.387.045 F	45.583.914 F	13.387.045 F
London	Zurich	0,5	1.132 km	131	58245	15.143.770 F	787.427 F	2.979.095 F	18.910.292 F	26.206.208 F	7.295.916 F	26.206.208 F	7.295.916 F
Lyon	Marseille	0,8	328 km	198	57260	14.887.691 F	1.190.524 F	4.504.141 F	20.582.356 F	11.480.458 F	-9.101.898 F	- F	- F
Lyon	Paris	1,7	432 km	437	134768	35.039.589 F	2.619.725 F	9.911.276 F	47.570.589 F	33.272.598 F	-14.297.991 F	- F	- F
Madrid	Paris	0,3	1.720 km	73	40888	10.630.918 F	440.175 F	1.665.327 F	12.736.421 F	22.258.780 F	9.522.359 F	22.258.780 F	9.522.359 F
Madrid	Seville	0,7	471 km	170	53741	13.972.779 F	1.019.792 F	3.858.208 F	18.850.779 F	14.121.470 F	-4.729.309 F	- F	- F
Manchester	Milan	0,5	1.648 km	141	76367	19.855.337 F	843.144 F	3.189.890 F	23.888.371 F	40.851.344 F	16.962.973 F	40.851.344 F	16.962.973 F
Manchester	Paris	0,7	820 km	183	70084	18.221.719 F	1.096.270 F	4.147.548 F	23.465.537 F	26.428.877 F	2.963.340 F	26.428.877 F	2.963.340 F
Manchester	Stuttgart	0,6	1.493 km	145	74272	19.310.650 F	867.804 F	3.283.185 F	23.461.639 F	38.091.544 F	14.629.906 F	38.091.544 F	14.629.906 F
Marseille	Paris	2,5	758 km	651	241778	62.862.158 F	3.903.796 F	14.769.338 F	81.535.292 F	86.996.877 F	5.461.585 F	86.996.877 F	5.461.585 F
Milan	Paris	0,5	831 km	120	46282	12.033.326 F	719.972 F	2.723.891 F	15.477.189 F	17.589.932 F	2.112.743 F	17.589.932 F	2.112.743 F
Milan	Rome	1,9	554 km	495	164603	42.796.827 F	2.972.822 F	11.247.158 F	57.016.807 F	48.420.133 F	-8.596.674 F	- F	- F
Munich	Paris	0,3	956 km	70	28615	7.439.901 F	418.927 F	1.584.937 F	9.443.765 F	11.774.525 F	2.330.760 F	11.774.525 F	2.330.760 F

Munich	Stuttgart	2,0	244 km	507	138137	35.915.688 F	3.043.093 F	11.513.018 F	50.471.799 F	21.829.935 F	-28.641.865 F	- F	- F
Paris	Rome	0,3	1.385 km	70	34587	8.992.562 F	421.222 F	1.593.622 F	11.007.406 F	17.151.754 F	6.144.347 F	17.151.754 F	6.144.347 F
Paris	Seville	0,2	2.191 km	39	25536	6.639.435 F	236.344 F	894.166 F	7.769.946 F	15.224.189 F	7.454.243 F	15.224.189 F	7.454.243 F
Paris	Stuttgart	0,5	712 km	124	44798	11.647.472 F	741.029 F	2.803.557 F	15.192.058 F	15.511.820 F	319.763 F	15.511.820 F	319.763 F
Paris	Zurich	0,3	671 km	74	26105	6.787.232 F	441.448 F	1.670.142 F	8.898.822 F	8.708.622 F	-190.200 F	- F	- F
Rome	Seville	0,6	2.670 km	163	120484	31.325.725 F	975.882 F	3.692.083 F	35.993.690 F	76.604.823 F	40.611.133 F	76.604.823 F	40.611.133 F

Table 16 – Profitability estimation of HISPEEDMIX project on year 2000 (Source SNCF – Amounts in FF)

Profitability

Year : 2010

					Costs					Balance & Turnover			
					Traction cost	Annual cost	Annual cost	Annual cost	Annual sum	Turnover	Balance	Turnover	Balance
Expenses per train		Nb of trains per day	Number of Km	Nb of trains per year	ABBA per relation and per day	Traction	Terminal feeding	Transfer		2 ways per train / year	2 ways per train / year	2 ways per train / year (positive only)	2 ways per train / year (positive only)
Amsterdam	Barcelona	1,1	1.615 km	275	147.586 F	38.372.398 F	1.648.790 F	6.237.913 F	46.259.102 F	78.286.212 F	32.027.111 F	78.286.212 F	32.027.111 F
Amsterdam	Berlin	1,1	1.254 km	279	130.188 F	33.848.901 F	1.671.328 F	6.323.182 F	41.843.411 F	61.617.861 F	19.774.450 F	61.617.861 F	19.774.450 F
Amsterdam	Bologna	1,2	1.552 km	316	165.768 F	43.099.773 F	1.894.832 F	7.168.769 F	52.163.374 F	86.458.905 F	34.295.531 F	86.458.905 F	34.295.531 F
Amsterdam	Frankfurt	1,0	652 km	269	94.626 F	24.602.725 F	1.616.902 F	6.117.271 F	32.336.899 F	30.994.079 F	-1.342.819 F	- F	- F
Amsterdam	Lyon	0,7	951 km	187	76.304 F	19.839.105 F	1.119.740 F	4.236.344 F	25.195.189 F	31.307.267 F	6.112.078 F	31.307.267 F	6.112.078 F
Amsterdam	Manchester	2,8	916 km	717	288.168 F	74.923.700 F	4.299.841 F	16.267.705 F	95.491.246 F	115.796.432 F	20.305.186 F	115.796.432 F	20.305.186 F
Amsterdam	Marseille	1,1	1.277 km	278	131.209 F	34.114.470 F	1.668.587 F	6.312.810 F	42.095.866 F	62.645.087 F	20.549.221 F	62.645.087 F	20.549.221 F
Amsterdam	Milan	1,8	1.350 km	471	228.692 F	59.459.924 F	2.823.909 F	10.683.771 F	72.967.604 F	112.080.936 F	39.113.332 F	112.080.936 F	39.113.332 F
Amsterdam	Munich	1,1	1.105 km	274	120.113 F	31.229.509 F	1.643.134 F	6.216.514 F	39.089.158 F	53.380.500 F	14.291.342 F	53.380.500 F	14.291.342 F
Amsterdam	Stuttgart	1,9	861 km	484	189.645 F	49.307.590 F	2.906.500 F	10.996.240 F	63.210.329 F	73.573.390 F	10.363.060 F	73.573.390 F	10.363.060 F
Amsterdam	Zurich	1,1	1.154 km	289	129.301 F	33.618.229 F	1.731.468 F	6.550.710 F	41.900.407 F	58.744.550 F	16.844.143 F	58.744.550 F	16.844.143 F
Barcelona	Brussels	1,0	1.406 km	261	129.449 F	33.656.804 F	1.563.656 F	5.915.823 F	41.136.283 F	64.635.915 F	23.499.632 F	64.635.915 F	23.499.632 F
Barcelona	London	1,7	1.593 km	431	229.878 F	59.768.361 F	2.588.608 F	9.793.552 F	72.150.521 F	121.235.393 F	49.084.872 F	121.235.393 F	49.084.872 F
Barcelona	Madrid	4,0	624 km	1.044	360.820 F	93.813.137 F	6.261.851 F	23.690.631 F	123.765.618 F	114.877.409 F	-8.888.209 F	- F	- F
Barcelona	Milan	0,7	1.021 km	186	78.573 F	20.429.054 F	1.116.143 F	4.222.734 F	25.767.930 F	33.503.705 F	7.735.775 F	33.503.705 F	7.735.775 F

Barcelona	Paris	0,9	1.096 km	242	105.665 F	27.472.841 F	1.451.227 F	5.490.468 F	34.414.537 F	46.762.032 F	12.347.495 F	46.762.032 F	12.347.495 F
Barcelona	Seville	2,2	1.095 km	560	244.695 F	63.620.589 F	3.362.185 F	12.720.246 F	79.703.019 F	108.238.816 F	28.535.797 F	108.238.816 F	28.535.797 F
Barcelona	Stuttgart	0,7	1.430 km	191	95.991 F	24.957.653 F	1.148.787 F	4.346.236 F	30.452.676 F	48.297.290 F	17.844.615 F	48.297.290 F	17.844.615 F
Berlin	Brussels	1,0	1.045 km	264	112.806 F	29.329.499 F	1.585.030 F	5.996.689 F	36.911.218 F	48.696.887 F	11.785.669 F	48.696.887 F	11.785.669 F
Berlin	Cologne	1,3	829 km	335	128.903 F	33.514.661 F	2.007.243 F	7.594.058 F	43.115.962 F	48.921.735 F	5.805.773 F	48.921.735 F	5.805.773 F
Berlin	Frankfurt	3,8	602 km	991	338.331 F	87.965.939 F	5.944.597 F	22.490.357 F	116.400.894 F	105.212.238 F	-11.188.656 F	- F	- F
Berlin	London	1,7	1.432 km	437	219.426 F	57.050.751 F	2.623.993 F	9.927.424 F	69.602.168 F	110.472.198 F	40.870.030 F	110.472.198 F	40.870.030 F
Berlin	Lyon	0,3	1.317 km	75	35.855 F	9.322.320 F	448.624 F	1.697.292 F	11.468.236 F	17.370.641 F	5.902.405 F	17.370.641 F	5.902.405 F
Berlin	Munich	3,9	877 km	1.007	397.279 F	103.292.475 F	6.041.039 F	22.855.228 F	132.188.742 F	155.760.945 F	23.572.203 F	155.760.945 F	23.572.203 F
Berlin	Paris	0,9	1.263 km	245	115.015 F	29.903.798 F	1.471.065 F	5.565.520 F	36.940.383 F	54.623.874 F	17.683.491 F	54.623.874 F	17.683.491 F
Berlin	Stuttgart	6,8	811 km	1.781	680.042 F	176.810.800 F	10.685.846 F	40.428.053 F	227.924.699 F	254.786.898 F	26.862.199 F	254.786.898 F	26.862.199 F
Bologna	Brussels	1,2	1.343 km	299	145.123 F	37.732.063 F	1.796.994 F	6.798.615 F	46.327.671 F	70.952.852 F	24.625.181 F	70.952.852 F	24.625.181 F
Bologna	London	1,9	1.530 km	496	258.151 F	67.119.259 F	2.974.895 F	11.255.000 F	81.349.153 F	133.816.708 F	52.467.555 F	133.816.708 F	52.467.555 F
Bologna	Paris	1,1	1.033 km	278	118.052 F	30.693.399 F	1.667.788 F	6.309.786 F	38.670.973 F	50.651.044 F	11.980.071 F	50.651.044 F	11.980.071 F
Bologna	Stuttgart	0,8	792 km	220	83.211 F	21.634.752 F	1.320.215 F	4.994.805 F	27.949.773 F	30.740.942 F	2.791.169 F	30.740.942 F	2.791.169 F
Bordeaux	London	0,5	1.049 km	143	61.159 F	15.901.399 F	857.795 F	3.245.319 F	20.004.514 F	26.454.913 F	6.450.399 F	26.454.913 F	6.450.399 F
Bordeaux	Lyon	0,9	784 km	224	84.476 F	21.963.754 F	1.345.788 F	5.091.558 F	28.401.101 F	31.019.886 F	2.618.785 F	31.019.886 F	2.618.785 F
Bordeaux	Marseille	1,3	640 km	334	116.589 F	30.313.255 F	2.005.434 F	7.587.212 F	39.905.900 F	37.734.239 F	-2.171.662 F	- F	- F
Bordeaux	Paris	2,8	549 km	735	243.630 F	63.343.886 F	4.412.918 F	16.695.514 F	84.452.318 F	71.227.146 F	-13.225.172 F	- F	- F
Brussels	Edinburgh	1,2	1.062 km	306	131.567 F	34.207.412 F	1.834.542 F	6.940.673 F	42.982.627 F	57.279.540 F	14.296.913 F	57.279.540 F	14.296.913 F
Brussels	Hamburg	2,9	677 km	750	266.808 F	69.369.959 F	4.497.205 F	17.014.398 F	90.881.561 F	89.511.464 F	-1.370.098 F	- F	- F
Brussels	Lyon	0,7	742 km	177	65.222 F	16.957.811 F	1.061.923 F	4.017.603 F	22.037.338 F	23.165.643 F	1.128.305 F	23.165.643 F	1.128.305 F
Brussels	Manchester	2,6	707 km	680	245.863 F	63.924.451 F	4.077.821 F	15.427.733 F	83.430.005 F	84.760.780 F	1.330.775 F	84.760.780 F	1.330.775 F
Brussels	Marseille	1,0	1.068 km	264	113.792 F	29.585.902 F	1.582.430 F	5.986.852 F	37.155.184 F	49.687.049 F	12.531.864 F	49.687.049 F	12.531.864 F
Brussels	Milan	1,7	1.141 km	446	198.872 F	51.706.740 F	2.678.098 F	10.132.122 F	64.516.959 F	89.837.871 F	25.320.912 F	89.837.871 F	25.320.912 F
Brussels	Munich	1,0	896 km	260	103.431 F	26.892.113 F	1.558.292 F	5.895.529 F	34.345.934 F	41.049.152 F	6.703.219 F	41.049.152 F	6.703.219 F
Brussels	Zurich	1,1	945 km	274	111.581 F	29.011.006 F	1.642.065 F	6.212.468 F	36.865.539 F	45.621.484 F	8.755.945 F	45.621.484 F	8.755.945 F
Cologne	London	0,5	229 km	143	38.496 F	10.008.947 F	857.161 F	3.242.920 F	14.109.027 F	5.770.920 F	-8.338.107 F	- F	- F
Cologne	Munich	1,3	680 km	329	117.266 F	30.489.209 F	1.973.382 F	7.465.952 F	39.928.544 F	39.451.862 F	-476.681 F	- F	- F
Edinburgh	London	17,9	675 km	4.645	1.651.619 F	429.421.043 F	27.869.291 F	105.438.651 F	562.728.985 F	553.066.086 F	-9.662.899 F	- F	- F
Edinburgh	Paris	1,1	1.175 km	284	128.298 F	33.357.589 F	1.702.636 F	6.441.631 F	41.501.856 F	58.817.574 F	17.315.718 F	58.817.574 F	17.315.718 F

Frankfurt	London	1,6	830 km	423	163.104 F	42.406.958 F	2.538.544 F	9.604.143 F	54.549.645 F	61.945.553 F	7.395.907 F	61.945.553 F	7.395.907 F
Frankfurt	Manchester	1,1	1.150 km	278	124.245 F	32.303.609 F	1.666.633 F	6.305.417 F	40.275.659 F	56.348.849 F	16.073.190 F	56.348.849 F	16.073.190 F
Frankfurt	Milan	0,7	1.114 km	182	80.329 F	20.885.627 F	1.094.556 F	4.141.065 F	26.121.248 F	35.848.474 F	9.727.226 F	35.848.474 F	9.727.226 F
Frankfurt	Paris	0,9	661 km	237	83.700 F	21.761.919 F	1.423.160 F	5.384.282 F	28.569.362 F	27.656.847 F	-912.515 F	- F	- F
Hamburg	London	4,8	1.064 km	1.241	534.412 F	138.947.213 F	7.445.052 F	28.167.068 F	174.559.333 F	232.893.135 F	58.333.802 F	232.893.135 F	58.333.802 F
Hamburg	Lyon	0,8	1.243 km	212	98.700 F	25.662.124 F	1.272.881 F	4.815.726 F	31.750.731 F	46.516.420 F	14.765.689 F	46.516.420 F	14.765.689 F
Hamburg	Munich	11,0	803 km	2.857	1.086.383 F	282.459.530 F	17.140.233 F	64.847.113 F	364.446.876 F	404.650.058 F	40.203.181 F	404.650.058 F	40.203.181 F
Hamburg	Paris	2,7	1.189 km	696	316.392 F	82.261.842 F	4.173.851 F	15.791.043 F	102.226.736 F	145.903.625 F	43.676.889 F	145.903.625 F	43.676.889 F
Hamburg	Stuttgart	19,4	737 km	5.053	1.857.283 F	482.893.614 F	30.318.938 F	114.706.467 F	627.919.020 F	656.944.690 F	29.025.671 F	656.944.690 F	29.025.671 F
Hamburg	Zurich	1,3	959 km	328	134.634 F	35.004.777 F	1.968.271 F	7.446.615 F	44.419.663 F	55.494.623 F	11.074.960 F	55.494.623 F	11.074.960 F
London	Lyon	1,1	929 km	293	118.553 F	30.823.895 F	1.757.997 F	6.651.079 F	39.232.971 F	48.015.477 F	8.782.505 F	48.015.477 F	8.782.505 F
London	Marseille	1,7	1.255 km	437	204.145 F	53.077.674 F	2.619.689 F	9.911.140 F	65.608.502 F	96.658.654 F	31.050.152 F	96.658.654 F	31.050.152 F
London	Milan	2,8	1.328 km	739	355.909 F	92.536.280 F	4.433.549 F	16.773.568 F	113.743.398 F	173.099.954 F	59.356.556 F	173.099.954 F	59.356.556 F
London	Munich	1,7	1.417 km	430	214.479 F	55.764.592 F	2.579.728 F	9.759.956 F	68.104.275 F	107.470.954 F	39.366.679 F	107.470.954 F	39.366.679 F
London	Stuttgart	2,9	1.173 km	761	343.558 F	89.324.961 F	4.563.218 F	17.264.146 F	111.152.325 F	157.368.036 F	46.215.711 F	157.368.036 F	46.215.711 F
London	Zurich	1,7	1.132 km	453	201.078 F	52.280.402 F	2.718.412 F	10.284.644 F	65.283.458 F	90.470.939 F	25.187.480 F	90.470.939 F	25.187.480 F
Lyon	Manchester	0,7	375 km	192	57.258 F	14.887.063 F	1.154.180 F	4.366.639 F	20.407.882 F	12.724.829 F	-7.683.052 F	- F	- F
Lyon	Stuttgart	0,5	766 km	130	48.520 F	12.615.222 F	780.174 F	2.951.652 F	16.347.048 F	17.569.823 F	1.222.775 F	17.569.823 F	1.222.775 F
Madrid	Paris	1,0	1.720 km	253	141.157 F	36.700.814 F	1.519.604 F	5.749.160 F	43.969.578 F	76.843.344 F	32.873.766 F	76.843.344 F	32.873.766 F
Madrid	Seville	2,3	471 km	587	185.530 F	48.237.823 F	3.520.599 F	13.319.579 F	65.078.001 F	48.751.144 F	-16.326.856 F	- F	- F
Manchester	Marseille	1,1	1.575 km	287	151.738 F	39.451.896 F	1.719.907 F	6.506.970 F	47.678.772 F	79.640.274 F	31.961.502 F	79.640.274 F	31.961.502 F
Manchester	Paris	2,4	820 km	631	241.947 F	62.906.317 F	3.784.621 F	14.318.461 F	81.009.400 F	91.239.652 F	10.230.253 F	91.239.652 F	10.230.253 F
Manchester	Stuttgart	1,9	1.493 km	499	256.406 F	66.665.602 F	2.995.893 F	11.334.445 F	80.995.941 F	131.502.342 F	50.506.402 F	131.502.342 F	50.506.402 F
Manchester	Zurich	1,1	1.452 km	297	150.392 F	39.101.994 F	1.784.722 F	6.752.186 F	47.638.902 F	76.187.628 F	28.548.726 F	76.187.628 F	28.548.726 F
Marseille	Paris	8,6	758 km	2.246	834.682 F	217.017.218 F	13.476.963 F	50.987.762 F	281.481.943 F	300.336.814 F	18.854.872 F	300.336.814 F	18.854.872 F
Marseille	Stuttgart	0,7	1.092 km	194	84.499 F	21.969.613 F	1.162.580 F	4.398.420 F	27.530.612 F	37.324.391 F	9.793.779 F	37.324.391 F	9.793.779 F
Milan	Paris	1,6	831 km	414	159.778 F	41.542.304 F	2.485.540 F	9.403.610 F	53.431.455 F	60.725.216 F	7.293.761 F	60.725.216 F	7.293.761 F
Milan	Rome	6,6	554 km	1.710	568.255 F	147.746.253 F	10.262.987 F	38.828.240 F	196.837.481 F	167.159.432 F	-29.678.049 F	- F	- F
Munich	Paris	0,9	956 km	241	98.787 F	25.684.556 F	1.446.249 F	5.471.634 F	32.602.439 F	40.648.855 F	8.046.416 F	40.648.855 F	8.046.416 F

Paris	Rome	0,9	1.385 km	242	119.403 F	31.044.762 F	1.454.174 F	5.501.616 F	38.000.552 F	59.212.505 F	21.211.953 F	59.212.505 F	21.211.953 F
Paris	Stuttgart	1,6	712 km	426	154.655 F	40.210.231 F	2.558.234 F	9.678.638 F	52.447.104 F	53.551.011 F	1.103.907 F	53.551.011 F	1.103.907 F
Paris	Zurich	1,0	671 km	254	90.121 F	23.431.366 F	1.523.998 F	5.765.785 F	30.721.149 F	30.064.526 F	-656.623 F	- F	- F

Table 17 - Profitability estimation of HISPEEDMIX project on year 2010 (Source SNCF – Amounts in FF)

VIII. Conclusions and future work

The results are encouraging for the European railway Companies which grasp the opportunity of starting a new business. It must be strongly emphasised that the success of the new service offered will be affected by organisational factors much more than by technical factors.

The HISPEEDMIX context is a potential new business area for railway companies, but it is necessary to verify the risk level for all interested partners, consisting of integrators, transport partners and airport companies as well. Therefore, the aim of a new HISPEEDMIX project is to carry out a complete analysis of the European high speed service for freight.

Therefore, the project may be developed into three further phases:

- phase 1: the partners will detail a feasibility study for pilot-business, consisting of decision on pilot-corridor/corridors, market performance description, respective market data collection and a first draft of a business plan to evaluate the business;
- phase 2: a business plan for a potential HISPEEDMIX company will be designed; particularly, first contacts with potential manufacturers will be established, as well as commercial and operational specifications for all assets needed and re-evaluation of return on invest will be analysed;
- phase 3: business and technical specifications will be set in order to ease the setting up of a HISPEEDMIX company. First of all, the partners will evaluate all the preconditions related to the business organisation, marketing, sales management, operation (i.e. time-tables for trains, staff, etc.) and establish all necessary equipment. Finally, as a consequence of the obtained outcomes, the business results will be re-evaluated.

In conclusion, a further research project following HISPEEDMIX will be able to provide management with the data, information and methodology necessary to found a HISPEEDMIX company, to purchase all assets and to prepare operation and business activities.

IX. List of publications, conferences, and presentations

Conferences

- WCRR '97 (World Congress on Railway Research) – Florence 16 – 19 November 1997.
- UIC Conference: "Shaping the Future of Rail II" Paris, 11 & 12 February 1999.
- The European Transport Research Conference "Paving the way for Sustainable Mobility" 8 & 9 November 1999, Lille.
- The Hispeedmix final workshop was held in Paris, at the UIC headquarters – 16, rue Jean Rey - on 27 April 2000. The presentations are available at the ERRI web site at the URL address: http://www.erri.nl/conference/hispeedmix_29_4.html

X. Acronyms

A	Availability
AAR	Association of American Railroads
ACS	Automatic Control System
ADR	european Agreement concerning the carriage of Dangerous goods by Road
AEIF	Association Européenne pour l'Interoperabilité Ferroviaire
ATA	American Transport Association
C	cross/meet point
C/C	Control and Command
CR	Consignment Reliability
CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation Electrotechnique
CER	Community of European Railways
COTIF	Convention Transports Internationaux Ferroviaires
CTT	Continuous Track Train transmission
DTT	Discontinuous Track Train transmission
EDI	Electronic Data Information
EHSRN	European High Speed Railway Network
ERRI	European Rail Research Institute
ERS	European Rail Services
ERTMS	European Rail Traffic Management System
ESS	Electrical Sub Station
ETCS	European Train Control System
ETSI	European Telecommunications Standard Institute

ETV	Elevating Transfer Vehicle
FMEA	Failure Mode and Effect Analysis
FMECA	Failure Mode, Effect and Criticality Analysis
FRACAS	Failure Reporting and Corrective Actions System
FTA	The Fault Tree Analyses is a graphical method of expressing the logical relationship between a particular failure condition and the failures or other causes leading to the particular failure condition
GIS	Geographical Information System
GPS	Global Positioning Satellite
h	headway
HBD	Hot Box Detector
HSRN	High Speed Railway Network
HVTN	High Voltage Transmission Network
HW	Hardware
I	intermediate station
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation.
IRR	Internal Rate of Return
ISO	International Standardisation Organisation
MDT	Mean Down Time
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
MTTRS	Mean Time To ReStore
N/A	Not Available information
NPV	Net Present Valued
OCL	Overhead Contact Line

R	Reliability
RAM(S)	Reliability Availability Maintainability (Safety)
RBC	Radio Block Centre
RCM	Reliability Centered Maintenance
RFS	Road Feeder Service
RID	Regulation for International transport of Dangerous goods
ROI	Return On Investment
RTRI	Railway Technical Research Institute (Japan)
SCC	Switch Control Circuit
ST	STation
STM	Specific Transmission Module
SSD	System Service Dependability
SW	Software
SWC	Switch
TV	Transfer Vehicle
UIC	Union Internationale des Chemins de fer
ULD	Unit Load Device
UN/ECE	United Nations Economic Commission for Europe
WCRR	World Congress on Railway Research

XI. References

Official documents of the:

- DEUFRAKO-report (Co-operation agreement France-Germany)
- European Project EUFRANET (Freight European Network)
- European project INTELFRET (Intelligent Freight Train)
- European Project AFTEI (Air Freight Transport and European Intermodality)
- Technical Specifications for Interoperability (in their final form at the time)
- European Union
- European Commission

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