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EU-funded research for a safe and efficient European rail system

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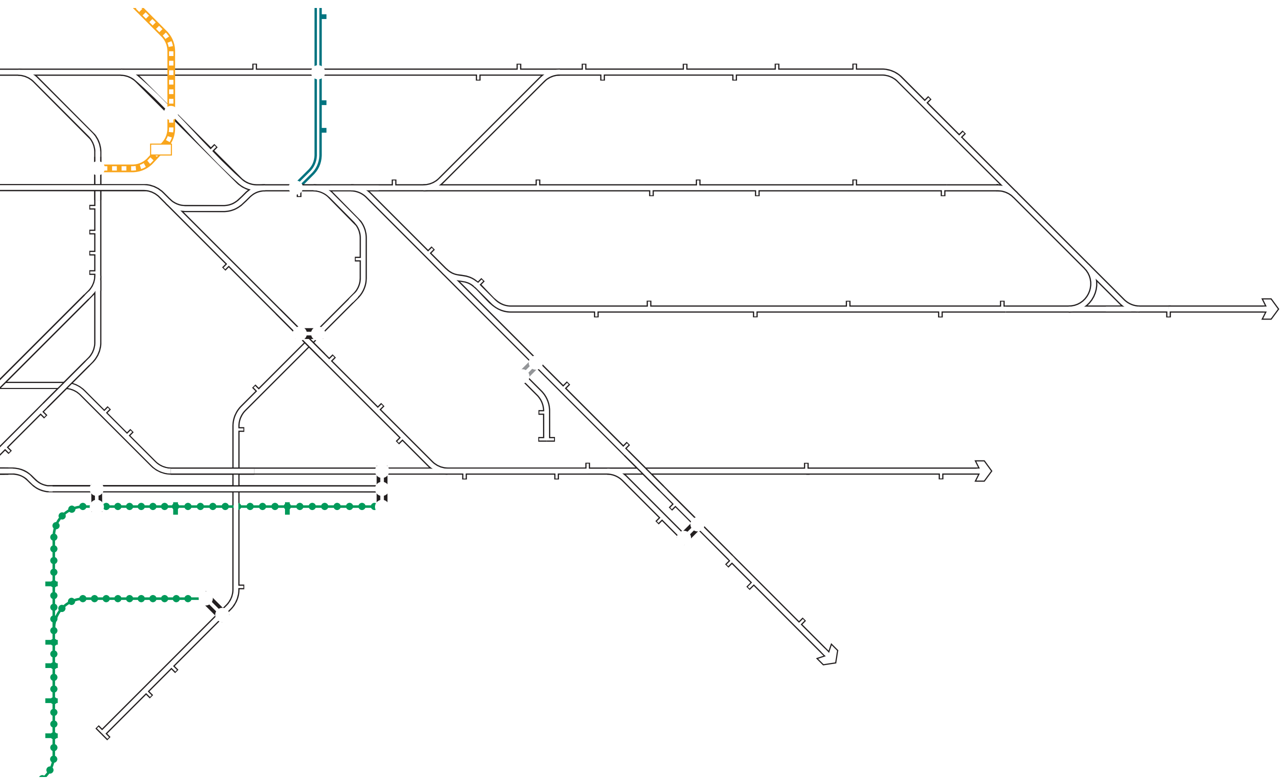

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FOREWORD

Anyone taking the train will, like me, understand the pleasure of rail travel. Not only is it enjoyable to see Europe passing by through the window, rail also offers the possibility of very low CO_2 emissions. In this respect, rail transport - particularly electrified rail - stands out compared with other forms of transport.

These days, our desire for mobility is greater than ever. It would be wise to consider curbing our appetite for transport in a way that could reverse the current trend of increasing greenhouse gases from transport. Europe needs to find innovative solutions to challenges like living with limited resources and preventing excessive climate change. Rail technology could be one of them, and it's within easy reach.

Anyone who makes regular train journeys will not only be familiar with the pleasure of rail travel, but will also know the inconveniences: the difficulties sometimes experienced when buying an international ticket, or of finding out how to travel the last few kilometres from the train to the final destination. For rail freight, factors like reliability and problematic operation across different rail networks also combine to reduce its attractiveness.

In order to turn rail into a serious transport alternative, the European Commission encourages research that looks for ways to exploit its full potential as an environmentally friendly, safe and efficient large scale means of transport. We support researchers from the rail industry and research institutions all across Europe who develop technologies and ways of working that reduce cost and improve efficiency, that ensure integration of rail with other modes of transport, and that contribute to sharing standards across borders.

At DG Research we believe in the power of these researchers' ideas, even more so if they can be launched successfully on the market. The many excellent research projects, past and present, included in this brochure show how European rail could gain that competitive edge to make it the preferred cost-effective and convenient transport choice, and a cornerstone of a sustainable Europe.

Robert-Jan Smits
Director-General of DG Research

TABLE OF CONTENTS

CHAPTER 1

EUROPEAN RAIL: A MUST FOR SUSTAINABLE TRANSPORT 8

CHAPTER 2

INTEROPERABILITY CREATING A COMMON EUROPEAN RAIL SYSTEM 12

CHAPTER 1

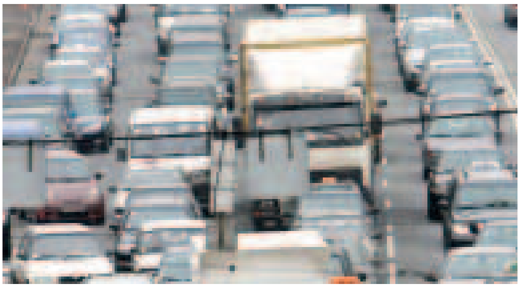
EUROPEAN RAIL: A MUST FOR SUSTAINABLE TRANSPORT

The European railway is a technical marvel: rail operators and infrastructure managers in close to 30 countries, each with their own system, cooperate to carry passengers and freight over great distances and every kind of terrain. Today, high-speed rail moves passengers between city centres far more quickly and conveniently than air travel, and under the right circumstances rail is highly economical for the bulk shipment of goods.

European rail companies provide work for more than a million people. A further 130 000 are employed by the rail equipment manufacturing and services industry, which supplies locomotives, carriages, tracks and signalling equipment, for example. These industries hold approximately 60% ([1]) of the global rail export market.

The EU has recognised that rail is a lynchpin in the European transport system, particularly considering its green credentials. Increasing rail's share of passengers and freight will substantially reduce the transport sector's carbon emissions while also decongesting the highways and facilitating trade throughout the single market.

1 In a response to a Commission consultation on Standardisation written in May 2010, UNIFE (the Association of the European Rail Industry) quotes more than 50% of the world market and over 80% of the European market.



Going off the rails

As the single market in Europe has grown, there has been increasing demand (roughly 2.8% a year) for goods to be delivered quickly across great distances. But rail has been unable to keep up with the demand for increased speed and flexibility. As a result, rail operators and infrastructure managers have lost market share to the highways.

Indeed, between 1970 and 1988 the share of goods transported on rail within Europe decayed from close to 20% to 8.4% while road traffic has soared. Transferring goods from train to truck in order to get them to their final destination is often too time consuming to be commercially viable. At present, around 44% of goods traded in the EU are picked up from northern ports and taken inland by lorries (for comparison, around 40% of freight is shifted by rail in Russia and the US, which benefit from having a single interoperable network).

Meanwhile, European railway passengers often experience inconveniences that arise from operational differences between countries. Ticketing and timing frustrations are common, train traffic is perceived as being noisy and simple linguistic misunderstandings can lead to disaster.

These problems are reflected in European rail use. For example, while passenger traffic in the EU-15 increased by 28% between 1990 and 2007, in this same period passenger traffic declined by 6% in what is now the EU-27, and overall rail traffic fell off by 14% (2). This was largely due to increased automobile ownership in the 'new' Member States, which limited the demand for rail services.

Finding solutions together, the EU research way

The railway comprises myriad technically and operationally inter-dependent systems. Ongoing scientific and technical research activities have sought to streamline and harmonise the European rail system since the early days of the EU's research Framework Programmes (FPs). Through these programmes the European Commission funds top European scientists and engineers to cooperate in finding solutions that improve safety, interoperability between countries, transitions between transport modes, environmental performance and noise emission, to name just a few.

Rail research is full of tricky problems. How can you make 30 different networks communicate with one another, when they have all been developed in different languages for unique systems and implemented at significant cost? How can you avoid lengthy changeovers at national borders, for example when a train from one country has its driver on the left, and from another on the right? More to the point, how can you design the ultimate European train and get all of the operators in Europe to buy it, when there are upwards of 30 companies operating trains in the UK alone?

Community research pools the expertise of the European rolling-stock (i.e. locomotives, carriages, multiple units, wagons) and infrastructure (i.e. tracks and signalling systems) managers, manufacturers, equipment and component suppliers and operators with research centres and universities. Together, they seek solutions to the seemingly countless technical and operational challenges facing the rail industry. Such collaboration is essential for attaining the EU's goal of achieving a truly sustainable surface transport system.

2 CEC, 2006b, CEC, 2009a.

The political picture

Strong political will is needed to ensure mutual recognition of rolling-stock and seamless interconnection of information technology (IT) systems. The EU supports the creation of a single railway market and is currently exploring legislation to set up corridors for international rail freight carriage. This will effectively create a Europe-wide dedicated rail freight network ([3]).

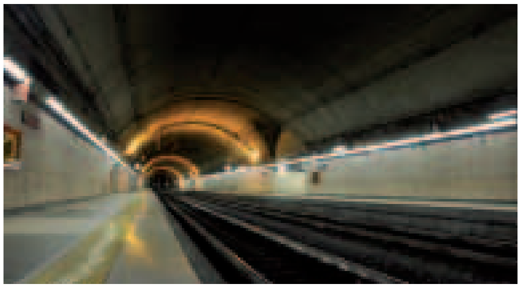
The European Commission has also urged the transport sector to strengthen links between different types of transport and to overcome technical barriers that slow down rail traffic between countries. To help shift more passenger and freight traffic back to trains, the Transport White Paper 'European transport policy for 2010: time to decide' (2001) proposed:

- making rail transportation more competitive in terms of punctuality, reliability and speed;
- ensuring the continuity of traffic across borders;
- creating trans-European rail freight networks;
- improving the interoperability of trains between different national networks and systems;
- improving the capacity of rail infrastructure throughout the EU.

The European Commission has stressed that transport policy must contribute to achieving the objectives of European energy policy, particularly in terms of limiting greenhouse gas emissions. This has important implications for rail, which is characterised by low CO_2 output.

Europe's railway operators (the companies that run the trains) and infrastructure managers (the ones that own the track) shell out close to EUR 250 million in research and development (R&D) each year, and rail supply businesses invest a further EUR 1 billion. However, these figures pale in comparison with R&D investment in other transport sectors such as road and air. This research funding imbalance has been widely acknowledged and corrective policies such as opening up rail freight transport to competition have been proposed.

3 See COM(2008) 852 of 26 June 2009.



ERRAC: A way forward

The European Rail Research Advisory Council (ERRAC), chaired by Professor Andrew McNaughton, is helping revitalise the European rail sector by fostering innovation and guiding EU-funded research efforts. ERRAC helps coordinate R&D activities amongst its members, which comprise manufacturers, railway undertakings, infrastructure managers, the European Commission, EU Member States, academics and user groups. As a European Technology Platform (ETP), it also serves to establish medium- to long-term research strategies.

ERRAC's Strategic Rail Research Agenda (SRRA) defines the most critical technologies that need to be developed, demonstrated and brought to market where they can make a real and lasting impact on the sector. Its goals include:

- doubling passenger kilometres in order to achieve a 12% market share of passenger traffic in the EU (with no detrimental environmental impact);
- tripling 'tonne kilometres' to achieve a 15% market share of freight traffic in the EU (with no detrimental environmental impact);
- increasing energy efficiency by 50%;
- reducing noise by 10 decibels (dB(A)) for freight trains;
- reducing pollution generated by rail products and services by 50%;
- halving the costs of travel to customers (freight or passenger);
- reducing fatalities by half to ensure that rail remains the safest mode of transport;
- reducing door-to-door transit time by up to 50%;
- ensuring that network capacity keeps up with the projected increase in traffic.

Networking for excellence

Realising the goals of ERRAC's SRRA will require cooperation on a large scale, which is a relatively new concept for the rail industry. To make the most of engineering and scientific talent in the rail arena, the European Rail Research Network of Excellence (EURNEX), chaired by Professor Wolfgang Steinicke, was launched in 2004 with help from the European Commission. The network comprises some 47 scientific institutes with expertise in rail research that are working together to integrate Europe's fragmented rail research landscape.

EURNEX forges partnerships between researchers in several countries, promotes dialogue between all areas of rail research on current and future challenges for the rail sector, and initiates R&D projects. The network helps researchers make the most of the financing available for rail R&D in Europe. EURNEX partners participate in rail research activities covering all aspects of the business, from safer high-speed driver cabins to leafy, noise-dampening tram tracks.

Innovation for sustainable growth

There is no shortage of good ideas: tapping into geothermal energy in metros, composite brakes for quieter trains, a standard European driver's cab and double-length trains with easy-on-easy-off containers, to name a few. But R&D timelines are long because Europe has so many systems to knit together and because change is expensive.

The transport market is constantly changing. In response, the railway sector is working on technological and management solutions to help it meet and anticipate customer demands. EU support for railway research is providing the means and the expertise to deliver solutions for sustainable growth in this important sector.

The purpose of this brochure is to highlight results of cooperative rail research under the European Framework Programmes in the key areas of interoperability, competitiveness, environmental impact and safety. The projects highlighted in this brochure have achieved success against enormous odds and form the fundamental building blocks for developments in rail technology – an essential component of sustainable surface transport in the EU.

CHAPTER 2

INTEROPERABILITY CREATING A COMMON EUROPEAN RAIL SYSTEM

Today, Europe is home to more than 20 train control systems. Its trains can have up to seven different expensive, bulky monitoring systems to make sure they can operate safely as they travel between countries. When crossing national borders, trains must also change operating standards, adding to travel time as well as to operational and maintenance costs. To compound the problem, there are countless technical differences in rail gauge, electricity voltage and the design of train cars.

European governments, the rail industry and researchers have worked together over the past two decades to create a common rail system in which there is an open market and trains can cross borders without stopping. In the late 1980s, the European Commission launched a project to analyse problems relating to signalling and train control, and in 1993 an Interoperability Directive was issued, kicking off work on common Technical Specifications for Interoperability (TSIs).

Directives >> Specifications >> Standards

EU Directives ensure that railway companies can operate trains across the different Member States. They also set out requirements that will allow rail equipment and infrastructure to be marketable in different Member States. TSIs ([1]) specify how, precisely, rail products and systems can meet these requirements.

Extensive research efforts have gone into defining standard European specifications for subsystems and components so that manufacturers and suppliers can deliver interoperable products. There are many TSIs, covering both functional (e.g. traffic operation and management) and structural (e.g. signalling) subsystems.

Getting it down on paper

TSIs for the high-speed rail system were completed first and are now being followed by those for conventional rail. These are more challenging mainly because most of the existing tracks were laid down more than a century and a half ago, when harmonisation was not a priority. Substantial research efforts have overcome the majority of technical barriers to interoperability, and continue to play an important role in resolving the few that remain. Nonetheless, TSIs for conventional rail are nearing completion, although some technical issues still remain to be resolved.

European Rail Research Advisory Council (ERRAC) Chairman Professor Andrew McNaughton explained that notwithstanding its fragmented history, Europe has more developed standards than in other parts of the world, particularly for passenger trains. Professor Wolfgang Steinicke, Secretary General of the European Rail Research Network of Excellence (EURNEX), explained that the TSIs represent a major step forward, as the process has required Member States to get their requirements down on paper. 'It's not easy,' he said. After a rough start, the functional requirements are at last in good shape.

1 TSIs are technical standards for interoperability prepared by the European Railway Agency.

Implementation: slow but steady

ERRAC's strategic research agenda ranks the implementation and progress of interoperability throughout Europe as a top priority for meeting the EU's 2020 targets. Progress has been slow but steady. More and more actors in the railway sector are specifying their needs to researchers and industry, which greatly facilitates market uptake.

To avoid the excessive costs of conversion, most interoperability requirements are applied only to new and upgraded rail components ([2]). To make the most of this situation, rail research has focused on creating market-relevant products that are modular or interchangeable and have a minimum of working parts.

Railway interoperability is indeed making progress on the market: a number of interoperable train sets, wagons and infrastructures are already in service ([3]). The demand for interoperable subsystems is also growing, particularly for rolling stock and signalling. Interoperability has been widely recognised as promoting transparency and clarity for market players, especially for those who are new to the game or wish to operate internationally.

A European Rail Traffic Management System

The European Rail Traffic Management System (ERTMS) is being rolled out thanks to legislation passed to ensure that trains can cross borders safely and simply, without needing to carry a diverse set of national train signalling systems (also called 'control, command and signalling' systems). ERTMS has combined the efforts of the rail industry, rail communications system providers and the European Commission to create unified specifications throughout Europe. These same European standards are also being increasingly applied throughout the world.

ERTMS has enabled unprecedented progress in cross-border cooperation. Railway operators and infrastructure managers, together with the supply industry, are uniting their efforts to realise an interoperable system. Since 1995, substantial research and development (R&D) efforts have gone into making ERTMS a reality. In 2005 and 2008, the EU and railway stakeholders agreed to further deploy ERTMS and identified six priority corridors.

2 See Directive 96/48/EC for high-speed rail system, 2001/16/EC for conventional rail, and 2008/57/EC for geographical scope of TSIs.
3 See the 2009 'Biennial Report on the Progress with Railway Interoperability in the European Union'.

Research into harmonising the next generation of signalling systems into a single, interoperable system is absolutely necessary to achieving the ERRAC goal of getting more freight on the rails. Research is virtually complete in this area. The challenge is to roll out the new system, which means re-equipping Europe's principal freight corridors.

ERTMS and Global Navigation Satellite Systems

Global Navigation Satellite System (GNSS) technology has revolutionised the transportation sector, and has special applications for rail. ERTMS now comprises an automatic European Train Control System (ETCS) and GSM-R (Global System for Mobile Communications – Railway), which provides voice and data communication between track and train.

GNSS can be used in navigation systems to make traffic monitoring more efficient, improving scheduling and connectivity. Incorporating GNSS receivers into modern signalling and other subsystems can improve safety, reduce distances between trains (so that more trains can be run) and provide a fully mapped transport infrastructure. As such, this has become an important area for research.

The GADEROS ('Galileo Demonstrator for Railway Operation System') project, under the Fifth Framework Programme (FP5), evaluated the integrity of a train location system for conventional trains on ERTMS. The European Space Agency project GRAIL ('GNSS introduction in the rail sector'), among others, supported the introduction of GNSS in the railway sector. GNSS rail applications have been developed on largely diverging paths, creating a barrier to interoperability as well as to reusability of products for different applications. The GRAIL consortium developed and tested a GNSS prototype that is compatible with ERTMS and ETCS onboard equipment.

The future at your heels: the problem of obsolescence

The GSM-R radio system used in ERTMS is based on second-generation mobile phone technology. Current mobile phones use third and, increasingly, fourth-generation technology, which gives an idea of the long timelines for deployment in the rail research arena.

'Any electronic system lives in a fast-moving world,' explained Professor McNaughton. 'What you face with something like a control system is that no sooner have you finished it than it is obsolete. Railway radio control signalling is built to last around 30 years, so the railways are facing a massive problem: obsolescence. As soon as you have researched, developed and implemented something across the railways, you need to already be researching the next generation and getting ready to roll that out.'

By the time ERTMS is rolled out across the whole of Europe, mobile phones will have moved on to the next generation. This situation underlines the importance of ongoing, innovation-focused research, and of making the most of limited resources through cooperation.

Intermodality

Substantial technological progress has been made in rail. However, in addition to developing systems, attention must also be paid to applications. For example, intermodality (easing the transfer of freight from road or ship to rail, and vice versa) can be improved by making better use of – and integrating – existing data. GNSS can also be better used to pinpoint the exact location of freight and to improve estimated times of arrival. This is important for reliability, security and just-in-time deliveries.

Intermodality demands standardised containers that can be easily handled by rail loading equipment, and that can be easily transferred between different transport modes throughout Europe, like the standards already in place for containers on ships. Several ongoing research projects, particularly under FP7, are focusing on both technical and business aspects of this issue. 'We have to succeed here pretty soon or we will not achieve the expansion of rail freight foreseen in the ERRAC goals,' Professor Steinicke warned.

Putting the pieces together

European rail research towards interoperability has focused on simplification, creating market-relevant interoperable products with as few parts as possible. This often means adopting a modular approach. Products developed with interchangeable components can be easily updated with features that benefit both customers and drivers.

MODTRAIN
the whole package

One series of projects in particular illustrates the advantages of modularity. MODTRAIN ('Innovative modular vehicle concepts for an integrated European railway system') has delivered open standards for a whole range of interfaces and interchangeable modules. The project's standards for man-machine interfaces, monitoring systems and onboard power systems, to name a few, are generic. This means they can be adapted to high-speed, conventional and possibly light (metro) rail.

For example, MODTRAIN researchers completed a cabin display (like an airplane's cockpit or car dashboard) that can be used by drivers with experience operating very different trains. 'Everyone was doing it differently, which didn't help cross-border traffic,' explained Mr Bernard Von Wullerstorff of UNIFE, the Association of the European Rail Industry. 'In France the driver sits on the right and in Germany on the left, so they're used to driving on opposite sides of the track.'

Previously, the European Driver's Desk (EUDD) project put together a mock-up of the cabin for high-speed trains in which the driver sits in the middle; in EUDD+, the product was adapted for local trains. MODTRAIN partners took this research further, completing the standardised cabin display. Using the new, interoperable design, different companies may choose different features but the basic display will be the same, serving as a recognisable standard.

Modularity is an important concept for interoperability. It also offers economic advantages and flexibility to railway suppliers and operators. For example, it can reduce manufacturing costs – which are considerable for rail – by offering economies of scale. As Professor McNaughton pointed out, rail is a low-volume business, even on a European scale. 'A train order might be 300 trains – and that would be a huge order,' he explained. 'Can you imagine BMW turning out only 300 cars?'

The researchers were able to cut production costs by 15% and reduce the number of working parts from thousands to hundreds. The new design makes use of all the technology available, and offers significant improvements in safety and handling.

But these achievements are only a small part of MODTRAIN's success. Within the larger project, modular solutions have been found for the entire vehicle, from control and monitoring systems (MODCONTROL) to chassis design (MODBOGIE) and train-to-train data links (MODLINK). In addition, the MODTRAIN approach has been adopted by several other research projects.

MODTRAIN achievements:

- reduced manufacturing costs by 15%
- drastically reduced reduced number of parts on standardised components
- standardised driver's desk

Innovative Modular Vehicle Concepts for an Integrated European Railway System

Coordinator | Union of European Railway Industries (Belgium)

Total budget | EUR 30 million

EU funding | EUR 16.86 million

Start/end | 01/02/2004 – 30/04/2008

Website | http://www.modtrain.com/

The consensus approach

MODTRAIN benefitted from a relatively new culture of cooperation: a consensus approach from industry, operators, researchers, standards bodies and others involved in EUDD, as well as from the operators and industries involved. This made it possible to get the product developed, prototyped and on the market rapidly.

The driver's desk has been tested and showcased. Drivers from all over Europe have provided feedback, and designs will continue to be optimised and adapted to different markets. But uptake of modular designs overall is slow and implementation remains a key issue.

'We need to make sure on the industry side that suppliers are offering these solutions and not just their own company's solution,' said Mr Von Wullerstorff. 'They should be offering the universal design, and the operators should be asking for them. The customers have to be convinced that it's a useful thing.'

Interfaces

Changing infrastructure requires a long-term deployment plan. Because everything can't be changed at once, it is important to develop interfaces so that new components can work with old ones and existing information systems can be networked.

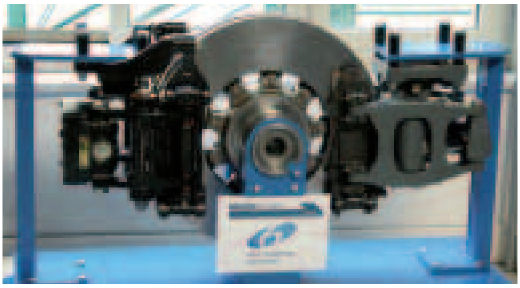
One challenge for interoperability is harmonising mainline information systems, which are used to track trains. At present the systems are not linked, so for example an operator based in Italy may not know where his train is in Switzerland and when it is going to arrive at the destination. The purpose of the INTEGRAIL ('Intelligent integration of railway systems') project was to create an interface so that these systems can work together.

INTEGRAIL's interface connects networks, getting information from the train to the ground (and vice versa) and storing information in an easily accessible database. This would be highly desirable for a number of potential customers. The coherent information system is ready to be implemented throughout Europe, and has been demonstrated in the Czech Republic, the Netherlands and the UK.

INTEGRAIL achievements:
- created a holistic, coherent information system that integrated the major railway subsystems
- improved the safety, capacity, average speed and punctuality of the European rail system
- defined new standards in accordance with TSIs

Intelligent Integration of Railway Systems

Coordinator	Union of European Railway Industries (Belgium)
Total budget	EUR 19.87 million
EU funding	EUR 11.2 million
Start/end	01/01/2005 – 31/03/2009
Website	http://www.integrail.info/



Braking power

Another issue tackled by researchers is braking. 'In one country you push the brake forward, and in another you pull it back,' Mr Von Wullerstorff explained. To avoid safety problems, for example if a driver needs to change trains, it is essential to have a standard. The braking system is one of the most complex subsystems of rail vehicles. Suppliers face an unnecessarily diverse set of brake system design requirements, not to mention testing, validation and maintenance procedures. The MODBRAKE project looked specifically at defining and standardising brake system interfaces – no small feat as this required competing manufacturing and supply companies to share information with one another.

Modularising the brake system can help suppliers reduce the complexity and costs of brake systems. The standardised modules developed in MODBRAKE are interchangeable in terms of both function and interfaces. Manufacturers can elaborate on the basic design, ensuring future technological progress.

In 2009, the project submitted its standards for brake modules and their interfaces (to be used in new high-speed trains and universal locomotives) to European standardisation bodies. This represented a significant step forward for implementation of standardised brake modules, and for interoperability.

MODBRAKE achievements:

- developed specifications for modular high-speed brake system
- increased performance and interoperability
- reduced costs

Innovative Modular Brake Concepts for the Integrated European High-Speed Railway System

Coordinator | Union of European Railway Industries (Belgium)

Total budget | EUR 5 million

EU funding | EUR 2.7 million

Start/end | 06/01/2006 – 31/10/2009

Website | http://www.modbrake.com/

Rail in the city

Metropolitan transport operates in an entirely different environment from high-speed and conventional rail. It is a highly complex system and faces a very different set of problems. Standards for harmonised light rail and metro systems have not yet been established, despite political progress made in this area.

MODURBAN researchers worked along the lines of MODTRAIN, designing and testing a common system architecture for urban-guided public transport. They also developed key interfaces for access, signalling and energy-saving subsystems.

The idea behind MODURBAN was to have a modular approach to building new lines and for renewing or extending old ones. The partners also looked for ways to make the migration to driverless operation cheaper. MODURBAN tested the integration of its subsystems on the Madrid metro system in late 2009. The demonstration showcased 'intelligent driving', interchangeable data communication system operations, passenger information systems and video surveillance systems (both on board and ground-based).

MODURBAN achievements:

- completed ready-to-use requirements, endorsed by all rail operators, covering systems ranging from manually driven trains to driverless operations
- reduced costs of buying and running urban rail systems
- defined an interoperable Fault-Tolerant Data Communications System (one network to support all applications)
- demonstrated 'intelligent driving' concept and passenger information system

Modular urban guided rail system

Coordinator | Union of European Railway Industries (Belgium)

Total budget | EUR 19 million

EU funding | EUR 10.4 million

Start/end | 01/01/2005 – 31/03/2009

Website | http://www.modurban.org/

The investment

Interoperability demands significant investment in compatible components, systems and infrastructure. Trains have been built to last for around 35 years, and tracks for around a century. Introducing new, interoperable rail subsystems can be very costly in terms of both public and private investment. It is simply not practical to switch quickly to an interoperable system. Ambitious targets have been set by EU legislation towards progressive implementation. However, full transition to an entirely seamless, interoperable network will take several decades.

Migration: a big challenge for industry giants

Research into ways of speeding up migration involves optimising countless individual subsystems, generating European standards and consolidating the TSIs. But it also involves careful examination and optimisation of business models.

The timelines for rail research are usually quite long. For example, the final stage of specifications for ERTMS (so-called 'Level 3'), which incorporates important automated train integrity-checking technology, is not yet complete. 'Twenty years into this project there are still open specifications,' said Professor McNaughton. 'But it is 95% there. By late 2011, I will regard it as for all intents and purposes complete.'

Improving the pace of migration depends only partly on technical advances.It also depends on how quickly standards bodies are able to work.

Tracking progress

The INNOTRACK project is a good example of efficient migration towards interoperability. Maintaining and repairing tracks represents about half of the annual maintenance costs in the rail sector, so savings in this area can make a big difference for operators. INNOTRACK assessed track substructure, rails and welding, switches and crossings with a view to improving life-cycle costs and logistics. The researchers identified several methods to improve track support and optimised designs for switches and crossings. INNOTRACK also put together guidelines for selecting rail grades, which is a chief consideration for areas where tracks curve or face mixed traffic. The project also presented a thorough life-cycle cost evaluation of several other new technologies.

Rapid implementation of innovation is generally difficult, but the conservatism of the railway sector compounds this problem. This conservatism is not without its reasons: 'Trial and error is not the best way to test innovation,' explained UIC's Dr Björn Paulsson, the Project Coordinator. 'If an infrastructure manager can fix what he knows, he will. If they do something new, no one pays for their mistakes.' INNOTRACK found that the best approach is to carry out research and development efforts in close cooperation with rail operators, infrastructure managers and research institutes and universities. 'This fosters a broad awareness, knowledge and trust in developed solutions,' said Dr Paulsson.

Perhaps more importantly, R&D results must be useable, easy to find and clearly documented. After INNOTRACK concluded in 2009, the results of the project were publicised in several ways. A widely distributed book explaining the results addresses well defined target audiences and presents key technical information succinctly. A complementary knowledge base is available on a public website. Dr Paulsson has actively sought to meet personally with infrastructure managers and suppliers, effectively communicating how INNOTRACK innovations can offer substantial cost savings that more than compensate for the upfront costs for heavily used routes. As a result, people changed the way they did things within months.

But commercial advantage is not always visible in the short term. Faster migration depends primarily on political will, and on the willingness of funding bodies to provide operators and infrastructure managers with adequate, consistent, long-term financing. Research into how such funding can be justified, and its expenditure made truly cost-effective, is of paramount importance.

INNOTRACK achievements:

- identified root causes of track problem conditions
- optimised design for switches and crossings
- developed rail grade selection guidelines
- life-cycle cost evaluation of two novel track forms

Innovative Track Systems

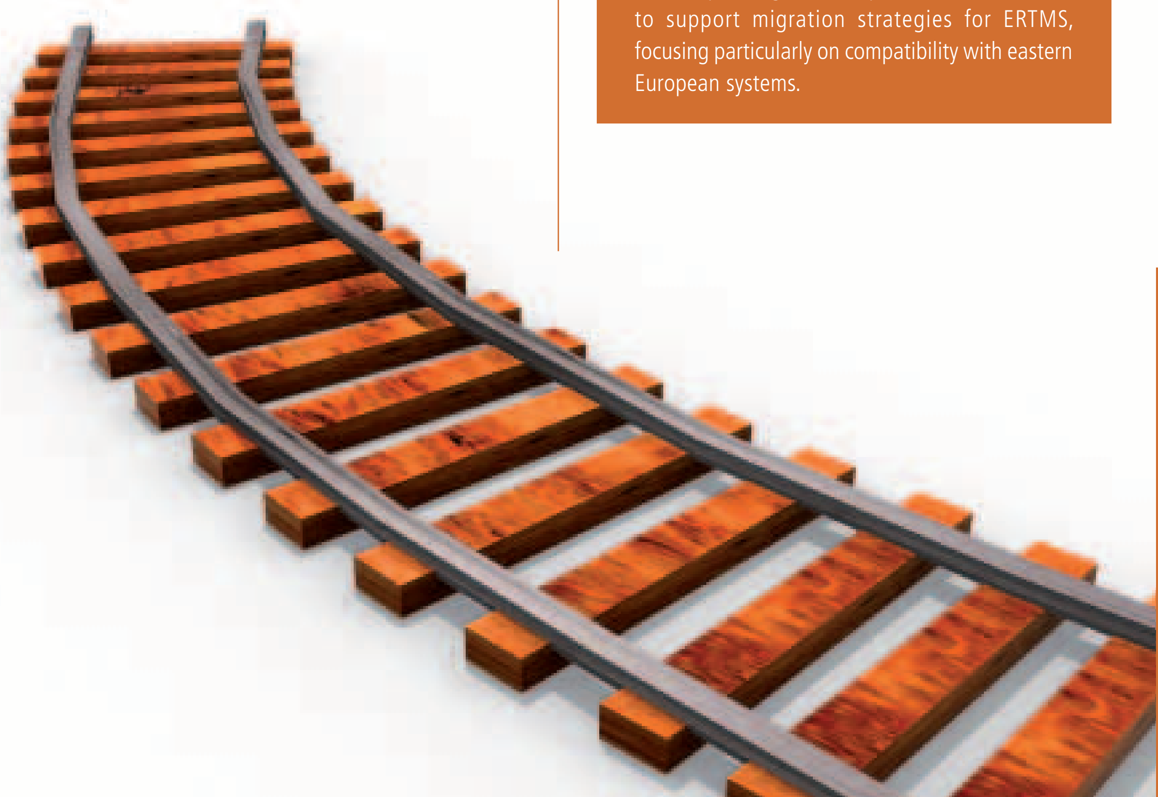
Coordinator	Union Internationale des Chemins de Fer (France)
Total budget	EUR 18 million
EU funding	EUR 10 million
Start/end	01/09/2006 – 31/12/2009
Website	http://www.innotrack.eu/

Rail in FP7

Interoperability remains at the top of the agenda for rail projects funded under FP7. Key interoperability issues are being addressed under TRIOTRAIN ('Total regulatory acceptance for the interoperable network'), a group of three large research projects (PANTOTRAIN, DYNOTRAIN and AEROTRAIN) that take on overhead line equipment, aerodynamics and track optimisation. In addition to helping to complete the TSIs, the project partners are working on a new way to ease certification for European rail vehicles and route approval, making the whole process faster, cheaper and better for everyone involved.

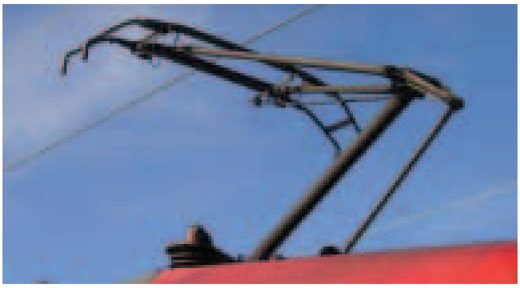
Together, the TRIOTRAIN projects aim to **r**educe the time it takes to go through the authorisation process from 2 years down to 6 months; to make it substantially easier for a vehicle accepted in one country to be authorised in another; and to reduce annual costs by at least EUR 20 million.

Beyond TRIOTRAIN, several other FP7 projects are focusing on interoperability. For example, the INESS project is working on specifications for a new generation of interlocking systems, which prevent conflicting movements through junctions. INESS industrial and infrastructure partners are also cooperating to develop new business models to support migration strategies for ERTMS, focusing particularly on compatibility with eastern European systems.



TRIOTRAIN

TRIOTRAIN is a cluster of three projects



PANTOTRAIN

Pantograph and catenary interaction: total regulatory acceptance for the interoperable network

PANTOTRAIN takes on one of the biggest barriers to rolling stock interoperability: overhead line equipment. Each country has developed its own version, with varying mechanical properties.

PANTOTRAIN researchers are adapting the current certification process, using modelling and simulation testing to reduce migration times for new interoperable solutions.

AEROTRAIN

Aerodynamics total regulatory acceptance for the interoperable network

Standards for aerodynamics vary between Member States. AEROTRAIN will use TSIs to consolidate methodologies, promoting interoperable rail traffic by reducing costs and time of certification. The consortium is working to replace existing crosswind and slipstream tests without reducing safety, and to introduce virtual testing. AEROTRAIN aims to set limits for aerodynamic loads on the ballast track, which will help streamline future generations of high-speed trains and promote energy efficiency.

DYNOTRAIN

Railway vehicle dynamics and track interactions total regulatory acceptance for the interoperable network

DYNOTRAIN project partners are checking for inconsistencies and open points in TSIs. DYNOTRAIN will make use of simulations and virtual environments, characterising track irregularities and the geometry of the contact between wheel and rail, for example. The goal is to lower the costs of certification without affecting safety.

Coordinator | Union des Industries Ferroviaires Européennes (Belgium)

Combined total budget | EUR 13.1 million

Combined EU funding | EUR 7.86 million

Start/end | 01/06/2009 – 31/05/2013

Website | http://www.triotrain.eu/

INESS

The INESS project aims to harmonise data file formats and design tools, provide testing tools for signalling applications and produce standardised functional requirements for new interlocking technology.

Integrated European signalling system

Coordinator	Union Internationale des Chemins de Fer (France)
Total budget	EUR 16.6 million
EU funding	EUR 10.2 million
Start/end:	01/10/2008 – 30/09/2011
Website	http://www.iness.eu/

The will to make it happen

Bringing interoperability about gradually has left a gap between the European TSIs, which apply to new and upgraded systems, and national rules, which apply to everything else. In addition, the costs related to the new procedures (e.g. learning time, staffing, certification, technical adaptations) are felt by small and medium-sized enterprises (SMEs). Interoperability will benefit the European network as a whole, but much of the expense will be borne by various Member States. This may cause some reluctance towards more rapid adoption.

The substantial technological advances in rail R&D over the past decade have helped clarify complex interlinking systems. Furthermore, research on socioeconomic and deployment strategies has helped key actors to overcome any reluctance caused by uncertainty, and has motivated them to adopt effective interoperability strategies.

Over time, the negative effects of changing to a new system will diminish. When the interoperability regime is well established and everyone is familiar with how it works, new business opportunities will arise and innovative products will make their way more easily to the market. The substantial efforts in rail research and innovation over the past decades have played – and will continue to play – no small part in making this monumental transition possible.

CHAPTER 3

COMPETITIVENESS AND CUSTOMER SATISFACTION

Of course an interoperable and environmentally friendly train system across Europe is only successful if people use it! This applies equally to freight and passengers. Rail transportation becomes attractive when it delivers what customers need, namely availability, reliability, ease of use, accurate information, integration with other transport modes, competitive pricing and comfort.

One of the major goals of transportation research is to improve the market position of rail compared to other transport modes, and to make business within the rail sector more competitive. As such, rail research and development (R&D) encompasses a wide range of technologies, safety aspects, economics and management, as well as work on efficient pricing.

Meanwhile, liberalisation of the rail market has opened up opportunities for supply companies to compete in making innovative – and interoperable – products.

Freight in focus

The European Rail Research Advisory Council (ERRAC) strategy foresees tripling the amount of freight on Europe's rail system. However, whilst passenger rail usage has grown, the volume of rail freight has substantially declined in recent years. In the current economic climate, road transport has been able to adapt by reducing prices; rail freight transport pricing is not as flexible and remains more or less fixed.

If rail is to get more freight business, it needs to compete by providing at least as good a service as road transport, particularly in terms of reliability, ease of use, door-to-door service and cost. Rail can also compete on the basis of its 'greener' credentials.

'Many of the problems for freight are political and management,' explained ERRAC Chairman Professor Andrew McNaughton, referring for example to rules for charging and time-tabling of freight on busy networks. 'But there are a number of areas where freight could become more competitive if a research strategy was carried out that enabled smoother operation or reduced cost.'

In 2009, ERRAC concluded that against the economic backdrop, freight is the top priority. The use of rail freight is much lower in Europe than many other parts of the world (e.g. China, Russia and the US) that have the advantage of operating competitively over long distances on a single network. Realising an interoperable railway would be ideal for a competitive European freight network.

The European Commission's 2010 call for research proposals reflected the European priority to improve freight transport. A large percentage of the selected projects focused specifically on finding technical and management solutions to boost the competitiveness of freight.

In tackling these socioeconomic issues, projects such as NEW OPERA and RETRACK have established the right mix of dedicated infrastructure, operability standards and market needs necessary to enable a large-scale shift in freight transport within a rejuvenated rail sector.

NEW OPERA

New European wish: operating project for European rail network

Coordinator	Consorzio per la Ricerca e lo Sviluppo di Tecnologie per il Trasporto Innovativo (Italy)
Total budget	EUR 4 million
EU funding	EUR 3.6 million
Start/end	01/01/2005 – 30/06/2008
Website	http://www.newopera.org

RETRACK

Reorganisation of transport networks by advanced rail freight concepts

Coordinator	The Netherlands Organisation for Applied Scientific Research (the Netherlands)
Total budget	EUR 24 million
EU funding	EUR 11 million
Start/end	01/05/2007 – 30/04/2011
Website	http://www.retrack.eu

The rail market: a public-private mix

One challenge for rail competition is the allocation of costs and pricing across the system. As a driver of the economy, transportation regularly receives public money to ensure public service obligations. This is essential for keeping people and goods moving, since revenues are often insufficient to cover the high maintenance and track costs.

National rail investment and public subsidies of this kind vary depending on political priorities and tend to wane during times of economic turmoil. Furthermore, market liberalisation across Europe enables consolidation of railway operators through takeovers and mergers.

Other issues include pricing for access to the rail network and time-tabling, which are especially complex given the rising demand for rail services during peak travel times, the considerable traffic operating across several national networks and the need to prioritise passenger trains over freight trains.

All of these factors impact competitive operation. European directives ([1]) implemented through the three 'railway packages' place obligations on Member States to open up their rail networks for fair and open competition. Such liberalisation should foster innovation amongst suppliers and operators, making rail more efficient and attractive to potential users.

Europe currently leads the world as a rail equipment supplier. But competition is intensifying between European equipment suppliers and producers in rapidly expanding Asian economies. For example, large Chinese equipment suppliers with lower production costs have now developed the technology and expertise needed to put in serious bids against established European providers.

Maintaining a technology-led competitive advantage for Europe is an ever-moving target. European researchers must continuously develop better products with improved functionality, longer life and lower maintenance – all at lower cost and without compromising safety. Crucially, these innovative products must also be successfully launched on the market.

1 See http://europa.eu/legislation_summaries/transport/rail_transport/ online.

Interoperability makes for healthy competition

Interoperability and competitiveness go hand in hand. Equipment and services for construction, operation, renewal and upgrading of the rail system can be applied to a larger European market if the network is interoperable. Such economies of scale enhance competition. As such, research activities that focus on removing technical and administrative barriers to an interoperable market are pivotal.

The more the market is harmonised, the bigger the available market for small companies to sell their new product, whether that product is better brakes or signalling equipment. Consequently, producers are less confined to a small national market and can sell across Europe.

According to an assessment of rail research carried out by the Transport Research Knowledge Centre ([2]), the use of advanced technology can increase railway competitiveness and interoperability. R&D is helping to reduce costs and enhance quality, for example by developing and deploying new kinds of tracks, optimising maintenance technology and stepping up efforts in standardisation and modularisation.

2 See http://www.transport-research.info/web/ online.

Overhead damage

Making railway lines more available so that more traffic can be run is an important area of research. Maintenance can be quite time consuming and often necessitates closing the line for long periods of time. Reducing closure time depends to some extent on more efficient maintenance measures and better prevention through monitoring.

For example, electric trains have current collectors that are connected to overhead contact lines, which are configured differently between networks. Careful monitoring of the interaction between the current collector (called a pantograph) and the overhead lines (catenaries) is essential for heading off any potential damage, which could lead to line closure.

The CATIEMON project found new ways to identify slightly damaged pantographs and catenaries without interrupting services. The project partners developed, integrated and deployed a sensor-based device that allows preventive action to be taken before more serious damage occurs. This is perhaps more of an achievement than it might at first appear, as it relies on simultaneous monitoring of train equipment and infrastructure: tools which are developed and operated by very different companies. The device identifies the source of the problem and notifies the appropriate party.

CATIEMON achievements:
- developed new device that checks for damage to pantograph and/or overhead lines
- new methods enable infrastructure managers to stop trains with faulty pantographs
- non-critical wear identified using the new method can be used to determine access charges

Catenary Interface Monitoring Coherent sensing technology for electrical railway infrastructure and rolling stock for interoperable cross boundary transportation

Coordinator	Siemens AG (Germany)
Total budget	EUR 5.7 million
EU funding	EUR 3.2 million
Start/end	01/04/2005 – 31/01/2009
Website	http://www.transport-research.info/

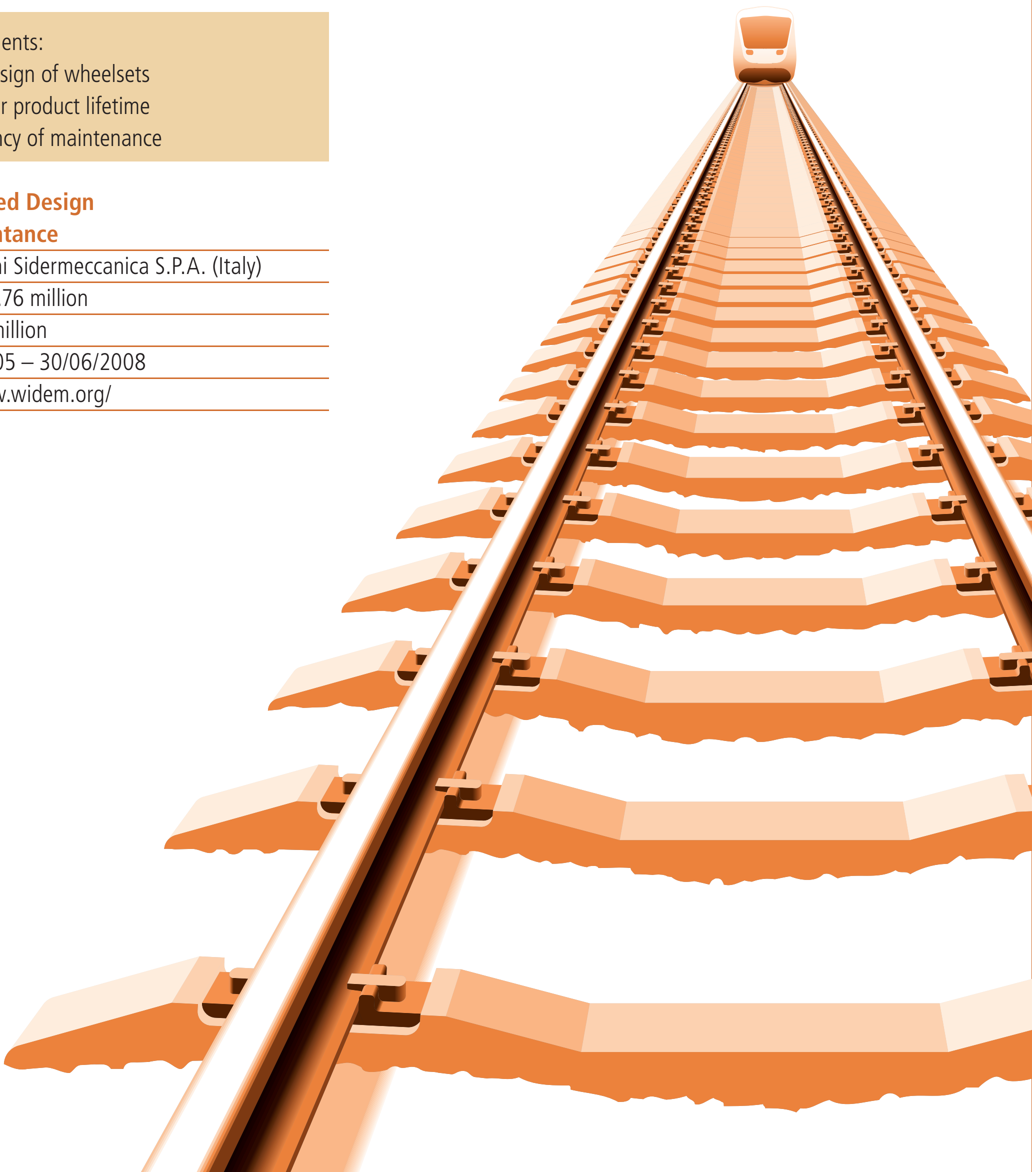
The WIDEM ('Wheelset integrated design and effective maintenance') project also contributed to reducing the monetary and time costs of maintenance. WIDEM project partners vastly improved the design of wheels and axles, creating a robust wheelset with predictable maintenance requirements. The costs of the new product are substantially lower over the long term than conventional wheelsets, and minimise the amount of time rolling stock needs to be taken out of service.

WIDEM achievements:

- optimised the design of wheelsets
- reduced cost over product lifetime
- improved efficiency of maintenance

Wheelset Integrated Design and Effective Maintance

Coordinator	Lucchini Sidermeccanica S.P.A. (Italy)
Total budget	EUR 3.76 million
EU funding	EUR 2 million
Start/end	01/01/2005 – 30/06/2008
Website	http://www.widem.org/



Competition means better service

A European rail transport system open to competition has driven the demand for improved quality of service. Advanced technologies that serve both customer and operator needs are an important goal of research. For passengers, this means interactive information and/or entertainment throughout the trip, which might be delivered from ground-based server stations. For freight customers it means reliability, 'one-stop shops' for purchasing freight services and real-time tracking of consignments. For operators, it means technologies that diagnose potential problems before any outward signs appear, or preventive maintenance that doesn't require shutting down the track for long periods.

EU-funded rail research harnesses new technologies – including information and communication technology (ICT) – to reduce the costs of operation, expansion and maintenance. Automation, ticketing and train control (including driverless operation) represent other research areas that have made important contributions.

ICT solutions will help freight and passenger companies monitor and plan journeys better, thus saving time on both domestic and international travel. Furthermore, cost-effective, satellite-based failsafe train location systems will allow the Europe-wide signalling system (ERTMS) to be extended, potentially reducing costs.

Multimodal transport: door-to-door service

Rail is rarely able to move your goods door-to-door, which is why research into seamless 'multimodal' transitions is so important. For example, getting freight from the shipyard onto trains for the long haul and onto lorries for the last leg needs to be easy, reliable and cost-effective. (Some rail companies have made serious headway towards this goal by acquiring local delivery services.)

For that matter, it should also be simple for passengers to connect between trains or to planes, buses or light rail, and to get up-to-date information on potential delays. This involves cooperation between competing modes of transport as well as between competing interests within those modes. Undertaking a long walk in the rain from a train station to home or to an airport terminal (with luggage) makes one keenly aware of the benefits of such cooperation.

For freight, innovative solutions making the best use of standardised containers, advanced loading/unloading technology and efficient consignment administration between ship, rail and road are essential to providing multimodal transportation that can outperform road-only services. The FERRMED Great Axis Rail Network global study ([3]) tackled several technological barriers to intermodal transport. The consortium designed new freight wagons and locomotives for double-length trains, which could reduce operators' costs and increase capacity by a third. They also identified technical solutions such as robust, synchronised air-braking systems for adapting existing trains to carry heavier loads. Finally, the initiative designed intermodal, low-floor flat wagons that are compatible with Europe's lorry fleet (at present wagons are only compatible with 5%), which could go a long way towards improving the attractiveness of road-to-rail transitions.

3 See http://www.ferrmed.com/fr/ online.

Modular metros

Availability is one of the most visible barriers to rail's competitiveness against road. In cities, a high volume of train and tram traffic is needed to provide passengers with the flexibility they need. It isn't cheap. A good part of the costs lie in maintenance, but installing new tracks is also pricey and shuts down traffic for long periods.

Technical issues increase project costs. For embedded tram tracks, the whole roadbed and sometimes the sewers need to be remade. Methods for track renewal and integration with urban activities leave a lot of room for improvement. Standardisation is lacking, even within individual metro networks, and functional requirements are not uniform between networks.

Furthermore, decisions are often not made on the basis of life-cycle costs – and no generally accepted methodologies have been available for assessing these costs in relation to metros and trams. In the URBANTRACK ('Urban rail infrastructure in a harmonised Europe') project, network operators and infrastructure managers worked together to find ways of reducing infrastructure costs while increasing the availability of the tracks for urban rail.

The project developed several 'maintenance-free', modular, standardised, pre-fabricated track infrastructure components that can be adapted to different environments. The consortium also developed a web-based tool that can be used to calculate life-cycle costs, and looked beyond the rail business to the socioeconomic costs of construction for local residents and shops.

URBANTRACK delivered technical solutions to availability such as automated track installation, fast renewal and refurbishment methods (i.e. tracks can be changed in the space of four hours), preventive and predictive maintenance methods, to name a few.

Demonstration projects in the Madrid metro illustrate how the new technology can be deployed quickly on networks with very different needs.

'If we can install a track in one month rather than six months, that's five more months of operation, and payback is quicker,' explained Mr André van Leuven of Dynamics, Structures and Systems International in Belgium. 'But the big part here is that if you can reduce your life-cycle costs by 25%, the customer – the operator – will be happy. If you look further, if the tracks are more available service is not interrupted, the passengers also benefit.'

Reducing life-cycle costs by 25% was a major achievement. But, happily for local residents, the project also came up with solutions for safety, noise and vibration issues.

URBANTRACK achievements:

- reduced life-cycle costs by reducing material costs
- reduced overall installation costs
- developed 'green' tram tracks using an absorber and tough, urban plants to reduce vibration and noise and collect dust
- created a maintenance-free interface between rail and street pavement for embedded tracks
- developed and tested embedded metro tracks
- created alternative, low-cost tracks for 'floating slab' in tunnels and on hills
- harmonised reference documents for track inspection and maintenance

Urban Rail Infrastructure in a harmonised Europe

Coordinator | Dynamics, Structures and Systems International (Belgium)

Total budget | EUR 18.6 million

EU funding | EUR 10 million

Start/end | 01/09/2006 – 31/08/2010

Website | http://www.urbantrack.eu/

East meets West

Cooperation is relatively new to the rail sector, but it has had a promising start. Professor McNaughton and Professor Wolfgang Steinicke of the European Rail Research Network of Excellence (EURNEX) agreed that there is increasing cooperation in the research community. 'This is driven by the EU harmonisation process – people are researching the same problems, so it becomes obvious why you would cooperate,' said Professor McNaughton. 'One of the strengths of the FP7 process is that it requires putting together a multinational consortium that covers the whole industry. You can't, as a single company or country, just dip in and take funding for your own idea. You have to work in a consortium with universities, businesses and infrastructure from different countries. This fosters cooperation both in Europe and across the industrial sector.'

Cooperation with Russia, the Ukraine and other points in the east is important for the European Research Area (ERA). European standards come into play here: Europe has put a lot of effort into establishing standards. Because they're there, they tend to be picked up and used in other parts of the world. Adoption of European standards in the east would provide a big boost for interoperability and the competitiveness of rail, especially considering the possibility of major rail freight links with Asia.

ERTMS and competitiveness

An important factor for increasing the capacity of the rail infrastructure is the rollout of ERTMS across Europe. The new signalling and communications technology could increase rail traffic and competitiveness without lowering service or product standards. By improving safety, reliability, punctuality and traffic capacity while lowering maintenance costs, the system will help to level the playing field with road transport. ERTMS, a European innovation, has also met with success outside Europe and has been adopted by China, India, Saudi Arabia, South Korea and Taiwan.

Showing the way

Research and development can provide the tools needed by the rail business to achieve interoperability and to make multimodal transport an attractive option. When this technology is adopted and deployed, the added value in terms of time and cost savings will be considerable. Demonstration projects are essential for illustrating this to operators, suppliers and infrastructure managers.

'If the industry becomes more competitive by developing technical solutions [to interoperability], everyone will benefit,' said Mr Bernard Von Wullerstorff of UNIFE, the Association of the European Rail Industry. 'The industry might not be happy that the prices are reduced, but if they're creating a larger market it's a win-win situation.' Nonetheless, he warned that interoperability research projects address only small parts of the global problem of making rail more competitive.

Professor Steinicke explained that the ERRAC strategy takes a step approach to market update, and that roadmaps for research in key areas are essential. EURNEX has an important role to play here because it prioritises knowledge sharing for European (not national or industrial) rail research. 'There are only a few networks of excellence that come close to achieving their objectives and EURNEX is one,' he said.

Through the EURNEX network, researchers can share their insights into rolling stock, for example, in a way that benefits the sector as a whole. 'We have to be better,' he said. 'This is what we're trying to do with EURNEX: supporting the ERA and providing knowledge for Europe.'

What next?

Rail's market share and competitiveness against other modes of transport is generally static, although there have been some notable successes within the domain of high-speed rail between key hubs. Despite policies adopted by the European Commission since 2001, including Trans European Networks (TEN-T) and investments by Member States, the rail sector has been slow to take up the challenges for a truly integrated European rail network for freight and passengers. Rail research offers technological and market solutions, but without adequate efforts to deploy these new technologies and methods the sector may continue to stagnate.

Research into business and management approaches, which has intensified under Framework Programme Seven (FP7), has shed light on the way forward. Market-focused rail research under FP7 is making headway by continuing to foster cooperation and consensus amongst players who are used to working alone.

CHAPTER 4

SAFETY

Europe's railways have an excellent safety record, particularly compared with other forms of transport. There are far fewer accidents on the rails than on the roads: according to the International Union of Railways (UIC), travellers are far more likely to be killed or injured when travelling by road rather than in a rail accident. Nevertheless, a train accident will always grab a bigger headline than a pile-up on the motorway.

In the EU, rail carries about 18% of inland freight transport, around 450 billion tonnes per kilometre per year. Around 60% of freight trains include at least one wagon carrying dangerous goods. The safety of passengers and freight is a clear priority for the rail sector.

Safety is built in to all technical features of Europe's rail system. For example, European and national rules require trains to have automatic safety systems that prevent a train from passing a red signal. The new Europe-wide signalling system's European Train Control System (ETCS) is built to ensure the highest safety standard. However, technology is not enough to resolve all safety issues: human aspects such as rest, stress and language also deserve careful attention if safety is to be assured.

Safety forms a cornerstone of European rail research and is the top consideration in all areas. Continuous improvement to the safety of all systems, subsystems and human factors are essential for passengers, crew and the public, and for ensuring customer confidence. Advances in safety, particularly signalling and control and improved equipment, also offer opportunities to shorten delays and lengthen product lifetimes.

Safety: the best policy

As national rail networks are being integrated towards a single European network, new common European safety targets and strict standards have been introduced, including new guidelines for risk-assessment methodologies that can be used by the entire railway community. In 2004, the European Commission issued the Railway Safety Directive ([1]) to ensure that railway safety is maintained and, where reasonably practicable, improved in a consistent and practical manner.

EU and national legislation set out specific safety-related tasks and responsibilities for everyone involved in European rail transport, including infrastructure managers, railway operators, the owners of rail vehicles, technical managers, companies in charge of loading freight and certified 'entities' that are in charge of maintenance.

Rail research endeavours to quantify and find solutions for rail safety issues, including the implications of large-scale traffic growth, higher-speed trains and the transition to the new traffic control and signalling systems. New findings are used as input for European standards and help to ensure interoperability across Europe. To date, rail research and development (R&D) has made substantial contributions in all areas of railway safety.

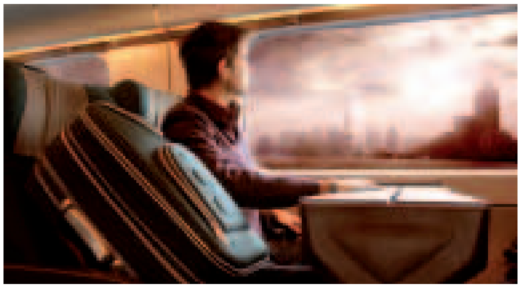
A safer, interoperable European railway

Safety and interoperability are intertwined. The Technical Specifications for Interoperability (TSIs) developed by the European Rail Agency contribute to railway safety across many aspects of rail transport, ensuring that all European railways apply the same (high) technical standards. The TSIs focus on many areas impacting operation, design and testing, for example the interface between vehicles and the network.

TSIs have changed the way rail vehicles and infrastructure are being designed and manufactured. The promise of a larger, more integrated European market drives the demand for more interoperable – and safe – products that may be deployed across Europe, offering manufacturers better economies of scale.

The drive for a single European Rail Area has also required Member States to align their national safety codes and safety management with common European standards such as the TSIs, which address most aspects of operations, design, certification, testing, acceptance and maintenance. Serious efforts have been underway to harmonise safety certificates and introduce in the TSIs common safety methods that are acceptable to all. One key objective of this initiative is to speed up the authorisation of new rail vehicles and facilitate operation across different national networks – a must for interoperability.

1 2004/49/EC (RSD), amended in Directive 2008/110/EC.



Competent and qualified staff

Rail R&D has produced truly innovative technological solutions and improved management approaches, most of which contribute to safety. The human dimension is pivotal: making sure that rail professionals such as drivers, engineers and track workers can use the technology properly is a basic requirement.

A safe, interoperable European rail network depends on well qualified staff, competent in their operational tasks. However, some national safety authorities have highlighted problems with recruitment. The European Railway Agency, together with the European Commission, is working on common requirements and procedures for assessing competence, training and certifying safety-critical staff.

Drivers are the first people to be directly affected by technical developments and changes in cross-border operations. The 2TRAIN project developed and evaluated computer-based driver training systems. The new technology helps drivers with driving in general as well as with operations and crisis management. 2TRAIN researchers also recorded trainees' actual behaviour while enacting crisis situations, and compared it to target behaviour. The results were stored in a database that informed the development of a virtual instructor.

2TRAIN achievements:

- created driver training software and a 'virtual instructor'
- developed European standards for driver training
- provided best-practice guidelines for computer-based training technologies
- developed common training simulation scenarios for crisis management training

Training of train drivers in safety relevant issues with validated and integrated computer-based technology

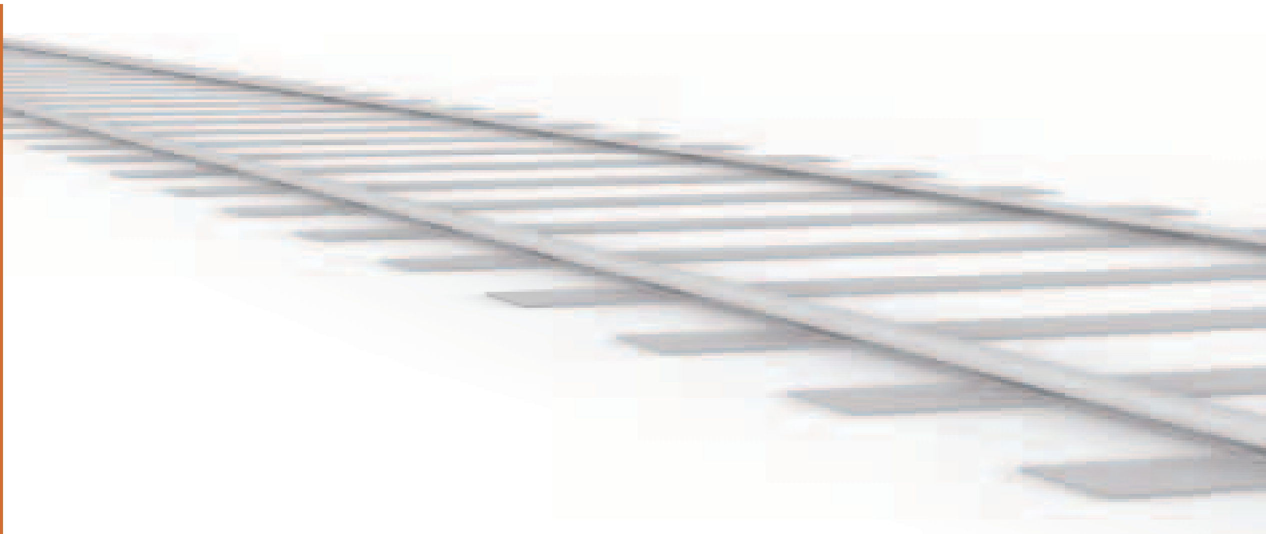
Coordinator | Bayerische Julius-Maximilians-Universitaet Wuerzburg (Germany)

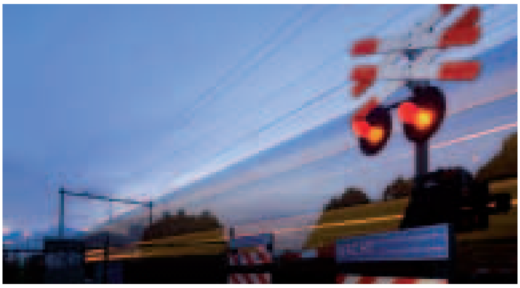
Total budget | EUR 3.7 million

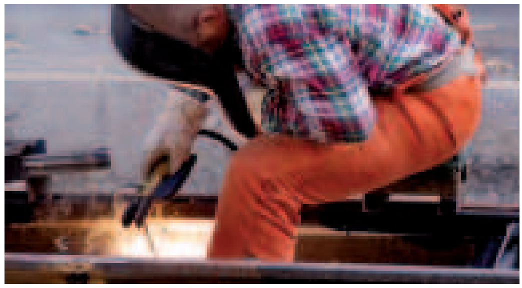
EU funding | EUR 2.2 million

Start/end | 01/10/2006 – 31/12/2009

Website: http://www.2train.eu/







Joint forces

Safety researchers seek predictability amongst the apparent chaos of a rail crash. In any given crash scenario, the structure should deform in a predictable manner. It should be clear whether the impact energy will be distributed or concentrated in one area (e.g. a welded joint). Accurate prediction allows vehicle designers to place energy-absorption devices where they can be most effective, thus creating a survival space.

The behaviour of materials under stress is of central importance. Since 1935, many European rail vehicles have been made using lightweight aluminium alloys joined together by welding. Tragically, during an accident welded joints have been known to fail along the entire length in an unpredictable way, known as 'weld unzipping'. Weld unzipping may compromise the vehicle's whole 'survival space' design, with dangerous consequences.

Consequently, the strength and crashworthiness of aluminium alloys has become an area of intense investigation. The ALJOIN project sought to eliminate weld unzipping (which is also encountered in the pipeline industry) in order to assess alternatives to fusion welding and to explore improved grades of aluminium for rail vehicles.

Computer simulation, or modelling, of collision behaviour is a mature area of research. But derailments and collisions between moving vehicles are extremely difficult to model accurately as there are many possible conditions, instabilities and configurations. Nevertheless, ALJOIN has managed to accurately model the collision behaviour of a rail vehicle; together with other project results, this has led to vastly improved structural integrity and crashworthiness of rail vehicles.

ALJOIN achievements:
- investigated welding techniques for strength, ductility and fracture toughness
- produced recommendations to improve weld performance in rail vehicles
- identified two good candidates for welding in future train vehicles
- recommended that the aluminium body parts should be thicker at the weld region
- outcomes taken up quickly by European rail vehicle manufacturers
- results incorporated into two industry standards

Crashworthiness of joints in aluminium rail vehicles

Coordinator	d'Appolonia S.P.A. (Italy)
Total budget	EUR 2.2 million
EU funding	EUR 1.2 million
Start/end	01/08/2002 – 31/07/2005
Website	http://www.transport-research.info/

Reinforcing crashworthiness of trains …

Every year, only around 100 passenger and crew fatalities occur in rail accidents within the EU, with those up front in the driver's cab being particularly at risk. SAFETRAIN researchers sought to reduce the number of fatalities and serious injuries in railway accidents by improving the overall design and crashworthiness of vehicle structures. They developed specific impact structures that help dissipate energy during a collision. Using the new technology, the vehicle is deformed in a controlled and progressive way and survival space is maintained – passengers and onboard staff are less aware of acceleration.

Using a modelling system similar to the crash-test dummy software favoured by the automobile industry, SAFETRAIN researchers determined that without a seatbelt the occupant is likely to sustain serious injuries to the head and legs; but with a seatbelt there is a risk for broken ribs and throat injury. A combination of airbag (inflated fully before contact) and knee bolster would offer the best protection for the cab occupant, they found, whatever his or her size and weight.

End-on collisions are the most severe type of accident. The consequences from such an accident depend entirely on the initial contact between the vehicles: if a train has a curved buffer, for example, the surfaces can slide over one another, causing one train to go up over the other. SAFETRAIN found that anti-climbers, which are now standard for many railway organisations, are effective and should be adopted universally. The project also proposed general specifications for these devices.

SAFETRAIN achievements:

- improved crashworthiness of train vehicle designs
- established safety requirements for driver cabins
- proved that anti-climbers are effective and proposed general specifications

Train crashworthiness for Europe: railway vehicle design and occupant protection

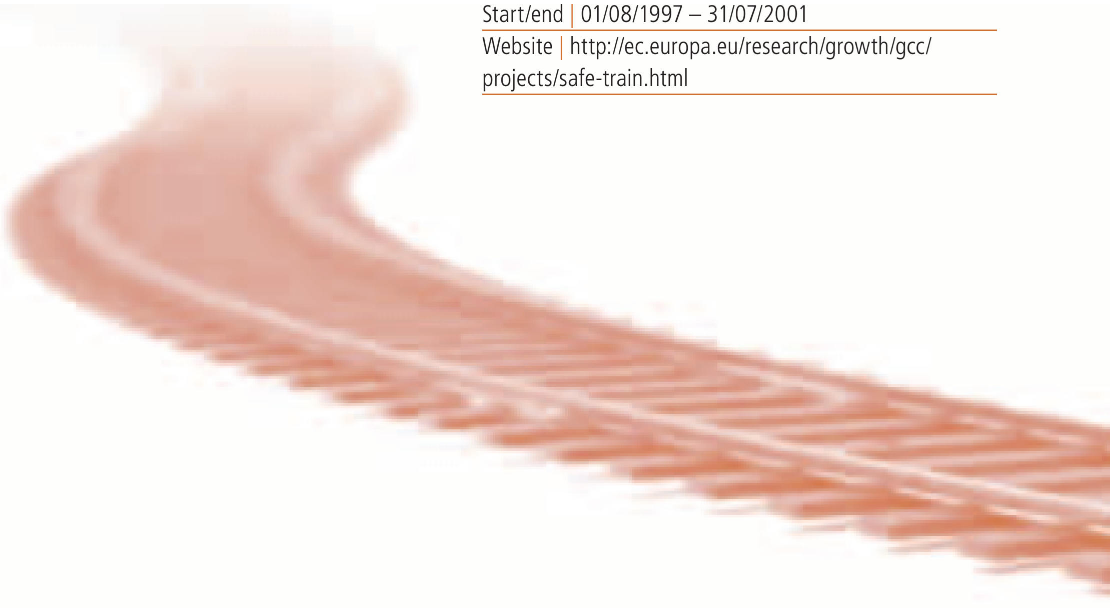
Coordinator | SOREFAME (Portugal)

Total budget | EUR 5.1 million

EU funding | EUR 2.27 million

Start/end | 01/08/1997 – 31/07/2001

Website | http://ec.europa.eu/research/growth/gcc/projects/safe-train.html



... and trams

Tramways are very different from railways in that they operate in a complex environment mixed with road traffic and with very basic signalling. Between 1994 and 2004, 3 050 casualties were reported by just 6 European tram operators. SAFETRAM partners addressed several important technical issues in tram safety, seeking to lower the risks for tram passengers and crew.

Trams already incorporate active safety systems such as signalling and high-performance braking systems, but passive safety must be assured for drivers and passengers as well as for people on the street. Ironically, because the modern, more environmentally friendly trams are lighter, they are not as crashworthy as their heavy predecessors. This difference is a key consideration for passive safety design.

Building on knowledge and lessons learned from projects like SAFETRAIN and from the automotive industry, SAFETRAM researchers came up with structural and interior design rules for city and suburban tramways to improve the vehicles' crashworthiness. For standing passengers, they used an innovative modelling tool to validate the results of research into interior collision scenarios. The project also devised guidelines for tramway construction that should decrease the incidence of injuries when accidents do happen.

The team developed two new modular design concepts for city and suburban tram vehicles. Replaceable components absorb energy in a collision, improving reliability and reducing the costs of repair over time. The city tram design (aluminium) incorporates a hydraulic buffer and a crushable aluminium extrusion, while the commuter train (steel) has side buffers and a central aluminium honeycomb. The modular approach offers several advantages, including a shorter design process and high manufacturing productivity.

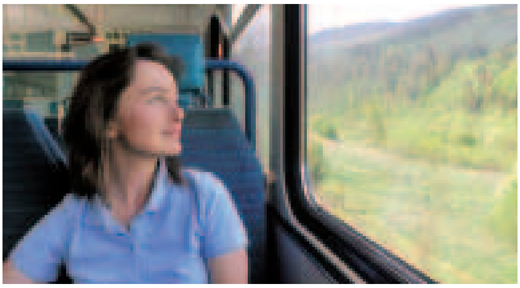
SAFETRAM drew up European standards to be incorporated into future vehicle designs. In addition to harmonising tram operator passive safety requirements, the project partners believe the results will help eliminate obstacles to a functioning single market for rail-based mass transit vehicles.

SAFETRAM achievements:

- rules ensure collision-resistant survival space in city and suburban trams
- rules lower impact forces and lengthen impact duration, minimising jerks
- proved that it is feasible to manage collision energy and acceleration using new technology at an acceptable cost

Passive Safety of Tramway for Europe

Coordinator	Bombardier Transportation Group Engineering (Portugal)
Total budget	EUR 3.2 million
EU funding	EUR 1.4 million
Start/end	01/07/2001 – 31/10/2004
Website	http://www.eurailsafe.net/



It's what's inside that counts

When a train is in motion, the vehicle and the people in it are travelling at high speeds. But when the train stops suddenly or goes off the rails, people and luggage continue moving. In a car they would be wearing seatbelts but on trains research has shown that seat belts offer very limited benefit. The level of injury depends on a number of factors, including how strong the vehicle is and how its potential collapse has been considered in the design. How the interior of the vehicle is laid out, the composition and shape of the fixtures and the positioning of occupants and objects are other important factors.

The integrity of passenger compartments and their compatibility with the train's expected acceleration or deceleration are the most important design considerations. The initial kinetic energy from the crash dissipates progressively, leading to structural deformation – the compartment must be formed and furnished to ensure the highest possible survivability under such circumstances.

Crashworthiness is paramount in rail vehicle design. This means optimising not only large structural features such as the panels and welding that make up the exterior, but also the way passengers are seated and how loose objects are stowed. For example, people may be facing one another or seated in rows, there may be a table between them or a chair-back table, and they may be seated or standing during the journey.

The SAFEINTERIORS project pooled the expertise of scientists and engineers working on safety-focused projects such as SAFETRAIN, SAFETRAM and the EU Driver's Desk (EUDD) to optimise the design of rail vehicle structures so that they offer the highest possible level of safety to train passengers and staff. They developed a general framework for structural design and provided recommendations for a European standard. One of their main goals was to reduce risks and determine the most effective survivability measures. The project worked in close collaboration with several other research undertakings, including MODTRAIN.

SAFEINTERIORS achievements:

- developed new measuring devices to predict human injury by reproducing loading on dummies and interior elements
- developed advanced tests for interior layouts
- set out new design specifications for interior equipment, furniture and layouts
- defined requirements for people with reduced mobility
- established new injury criteria based on new biomechanical data (INRETS and MIRA projects)

Train interior passive safety for Europe

Coordinator | Bombardier Transportation Gmbh (Germany)
Total budget | EUR 3.25 million
EU funding | EUR 1.95 million
Start/end | 11/07/2006 – 10/07/2010
Website | http://www.transport-research.info

All clear

Maximum loading gauge – how tall and wide railway vehicles need to be to pass safely under bridges and through tunnels – differs from one network to another and may even vary across a single network. In the past, a train-shaped piece of wood was run through the tunnels in a 'go/no-go' process, offering little measurement or location capability. Newer checking systems involve a rotating laser scanner mounted on a vehicle, run slowly across several kilometres of track. While the digital clearance measurements are an improvement, new technology was needed to avoid shutting down the track for the measuring run.

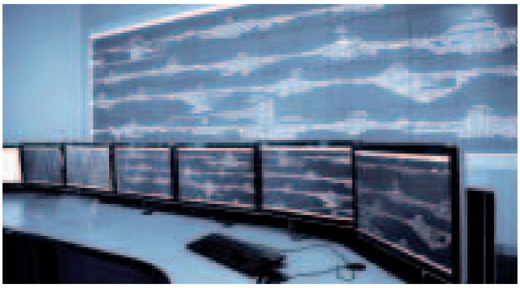
INFRACLEAR researchers used operational monitoring technology to optimise the way trains are cleared to go through tunnels. This is essential for ensuring that trains will be able to use the infrastructure to get where they're going safely and that the routes can handle larger trains carrying more cargo.

INFRACLEAR technology makes it possible to check clearance measurements at a normal running speed, without stopping commercial trains. The clearance system comprises sensors and processing computers installed in a protected container, which can be mounted on any classical freight wagon. This makes it possible to use the device on any track gauge. The new, integrated inspection system can perform on high-speed lines (up to 140 km/h), detecting obstacles and measuring for clearance – two essential aspects of security and safety. The solution is compatible across the European network and offers a simulation tool for determining clear and safe European routes.

INFRACLEAR achievements:
Developed a new, high-speed track clearance monitoring system which:
- can operate across Europe
- operates at commercial speed, keeping tracks open to traffic
- ensures that the infrastructure can accept larger, innovative vehicles such as tilting trains

Rail infrastructure clearance management

Coordinator | Cybernetix S.A. - Ingenierie des systèmes automatiques et robotiques (France)
Total budget | EUR 5.25 million
EU funding | EUR 2.6 million
Start/end | 01/02/2004 – 31/01/2008
Website | http://www.transport-research.info/



At the controls

Automatic Train Control (ATC) systems feature trackside and onboard components. As train traffic increases and high-speed networks expand, the safety features of these systems are increasingly in focus. Any ATC system used in Europe-wide signalling system (ERTMS)-compliant trains needs an interface between the driver and the controls (a driver-machine interface, or DMI) whose functions and ergonomic requirements are strictly defined.

The safety standards for DMIs are high (Safety Integrity Level 2). For example, the interface must not be overly complex as a driver might get distracted trying to sift through too much information. But different safety requirements have typically been specified by railway operators, rather than by a single European standard.

SAFEDMI ('Safe driver-machine interface for ERTMS automatic train control') researchers tackled safety issues regarding diagnostics and maintenance. They focused on visualisation, driver-provided data, information processing and wireless communication interface. Ultimately, the consortium designed a DMI that meets a higher safety standard than those currently on the market, and which features easy-to-use, safe wireless communication interfaces for diagnostics. The interface integrates current ERTMS onboard systems and comes with software for testing the interface by simulating a driver's actions.

SAFEDMI achievements:

- designed and developed a safe DMI integrated with onboard ERTMS
- developed hardware and software solutions that address safety and fault-tolerance issues
- integrated safe wireless communication interfaces for diagnostics
- designed and developed a tool that supports automatic test execution by simulating driver actions

Safe Driver Machine Interface (DMI) for ERTMS automatic train control

Coordinator	Ansaldo STS S.P.A. (Italy)
Total budget	EUR 2 million
EU funding	EUR 1.2 million
Start/end	09/2006 – 08/2008
Website	http://www.safedmi.org/

Keep on moving – safely

Safety research covers the whole gamut, from wheelsets to tunnels and signalling systems. SAFERAIL, for example, is minimising wheelset failures by developing a novel online system for inspecting wheels and axles on moving trains. Failure of this part of the train can damage a network and lead to accidents. The project's combined ultrasonic-electromagnetic system will enable faster and more reliable inspection of wheelset quality.

Looking ahead: intelligent infrastructure

Maintenance is about ensuring safety. Tracks, tunnels, switches, signals and the surrounding terrain must be checked carefully and regularly. For the most part, this means sending out skilled people to physically examine and test parts of the infrastructure. The process takes a lot of time and the talents of these technicians might be put to better use.

About 10% of total infrastructure cost is spent on carrying out routine safety tests on infrastructure. Self-diagnosing infrastructure could save a lot of time and money.

Self-diagnosis is not a new concept: a signalling system will send a message back to control when it expects to go out of service, for example. But with intelligent infrastructure, diagnostic technology is built in to all of the essential components. In the past, researchers would find ways of attaching new electronics to old system components – but sometimes they would fall off, become damaged or issue false alarms.

Automatic, mechanised inspection eliminates the need for (and can be more consistent than) manual inspection. For instance, a new generation of testing trains can examine and measure components using X-rays, ultrasound and other techniques. Onboard computers diagnose the results and send them back to control. Meanwhile, technicians could analyse the data rather than having to manually gather it.

This type of project customises existing technology from rail and other industries and applies them to rail to reduce costs. Similar work has made a lot of headway in mining, a promising area of collaboration for rail safety research.

Safety net

Significant progress has been made in harmonising equipment, but while a lot has been done, there are still barriers to overcome, particularly in terms of changes that are still required at national borders. The challenge for rail R&D is to progress in fulfilling the ERRAC Strategic Rail Research Agenda (SRRA) objectives whilst keeping an eye on economic performance issues. For its part, EURNEX is consolidating European research activities, maintaining focus on interoperability and safety.

The faster, safer, more comfortable trains that are already on the market are the result of years of research; further advances made in the past decade, particularly in interoperability, promise an even safer and more user-friendly rail system. Europe's rail networks are getting busier: its trains are travelling faster and carrying more people and heavier cargo. The existing (often elderly) infrastructure is under increasing pressure and the costs of continuous and stringent maintenance are high.

Nevertheless, the European railway continues to offer extremely safe transportation. As we move towards a trans-European, interoperable train system and the deployment of ERTMS, scientists and engineers continue to provide new insights and solutions for both technological and human aspects of rail safety.

CHAPTER 5

ENVIRONMENTAL IMPACTS

With very low CO_2 emissions and very high energy efficiency, rail offers strong environmental advantages over other forms of transport. Rail's market share is 6% of passenger traffic and 10% of freight traffic; however, its share of the European transport sector's total energy consumption is only 3% ([1]).

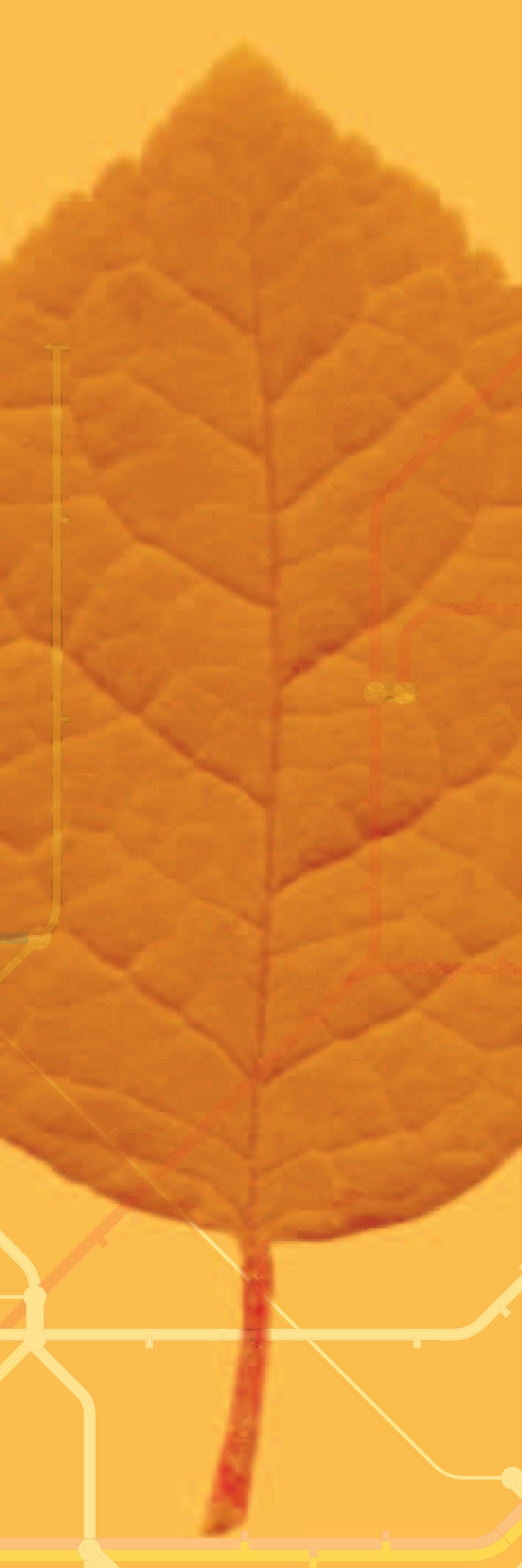
Transport by rail is twice as energy efficient as by road and up to 20 times more efficient than by air. It is at least four times less CO_2-intensive than travelling by car, accounting for less than 2% of transport emissions within Europe. Considerable efforts have gone into reducing that number still further. For example, between 1990 and 2005, the rail sector cut its CO_2 emissions by 21%. From an operational perspective, electrified rail, with the appropriate energy-generation mix, can be virtually carbon free.

Nevertheless, the rail sector is committed to cutting its greenhouse gas emissions by 30% compared to 1990 levels by the year 2020, and to making rail transport even more energy efficient. Since the 1970s, Europe has seen a doubling in transport activity, both of passengers and goods, and greenhouse gas emissions from transport continue to rise.

Although rail emissions are low responsible for less than 2% of the transport sector's emissions. In addition, noise and vibration from railways continue to be an environmental issue that hinders the wider expansion of rail services, particularly for freight and within urban areas.

Rail research consistently seeks further energy savings, reduced pollution, optimised land use and reduced noise and vibration. But while technical and management solutions certainly help to promote the case for rail, competitiveness remains pivotal. The biggest impact on CO_2 emissions can be made by simply attracting more road traffic to the rails.

1 *Rail Transport and Environment Facts and Figures* (2008), compiled jointly by the Community of European Railway and Infrastructure Companies and the International Union of Railways.



In the mix

The most energy-intensive aspect of rail transport is traction, which consumes approximately 85% of the total energy. Improvements in this area could lead to big savings in fuel. But the costs of fuel are relatively low for rail compared to other modes of transport, representing 7% of the total costs (for comparison, fuel represents a third of the costs of air transport).

While diesel locomotives are still used for many applications, 70% of Europe's rail system is electrified. This offers a clear advantage: rail can easily shift its energy-generation mix from fossil fuels to renewable or nuclear energy without any investment in new engines or engine parts.

The source of electricity generation for railway operation varies widely among countries, as does energy supply generally. For example, while Poland's railways still draw largely on coal, Sweden and Norway's trains are running on hydroelectric power and France's on nuclear power (86%). Denmark and Spain's rail systems are drawing increasingly on wind and biomass power.

Because energy is fed into the railways by local power lines and because the machinery does not distinguish between energy sources, positive changes can be immediately felt. The more renewable energy in the national mix, the cleaner the railways can be.

Shopping responsibly

To figure out how much energy a given railway operation will consume, many factors need to be taken into consideration. 'Some tracks are flat and some aren't: Holland's trains will have different energy profiles from Swiss or Austrian ones,' explained Mr Bernard Von Wullerstorff of UNIFE, the Association of the European Rail Industry. The idea behind the RAILENERGY project was to make a web-based tool to calculate energy consumption for any given train on any given track – a kind of shopping tool for operators.

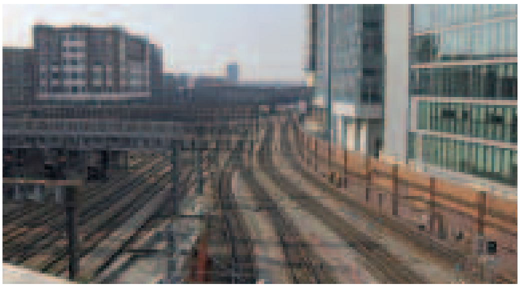
The new tool applies standard measurements to the whole system. Previously, each company was working with a different system of measurement. The topology of the track, whether frequent stops are required and whether the trains have batteries or storage systems onboard are predefined in the software. Users can enter in a track and a train to calculate the energy consumption and greenhouse gas emissions for any given combination. 'The new methodology is workable and understandable by all,' said Mr Von Wullerstorff.

The overall goal of the project was to optimise the railway system by reducing energy consumption by 6% by 2020. In addition to helping rail operators choose the most energy-efficient rolling stock for their lines, new technology developed within the project makes operators aware of energy consumption throughout their installation, as it happens. RAILENERGY's energy management module displays energy flow, energy distribution, power peaks and mean consumption in real time as well as providing overall statistics.

RAILENERGY achievements:
- developed a user-friendly computer programme to calculate energy consumption and life-cycle costs of rail subsystems and components
- developed energy-efficiency–oriented railway technologies for trackside and onboard subsystems and equipment
- created an energy management tool that provides an operator with a diagnostic of the complete installation

Innovative integrated energy efficiency solutions for railway rolling stock, rail infrastructure and train operation

Coordinator | Union of European Railway Industries (Belgium)
Total budget | EUR 14.6 million
EU funding | EUR 8 million
Start/end | 01/09/2006 – 31/12/2010
Website | http://www.railenergy.org



Stepping lightly

Transport infrastructure can take up a lot of space, sealing off the soil and generating pollution and waste. If placed inappropriately it can also isolate parts of a city, or lead to unfocussed sprawl. Rail infrastructure takes up between two and three times less land per passenger than road infrastructure and occupies less than 2% of the total land set aside for transport.

As an electric-powered mode of transport, rail does not contribute directly to pollutants such as nitrogen oxide or particulate matter (PM) levels, which cause problems in many cities. Non-electric locomotive engines have strict limits for these noxious emissions and offer higher energy efficiency. In terms of local air pollution, rail has distinct advantages owing to advanced combustion technologies, exhaust after-treatment and the continued electrification of lines.

In several countries (in order of usage: the UK, Baltic States, Ireland and Greece), diesel engines still make up the majority of the fleet. The emissions they generate affect local air quality and, accordingly, quality of life for nearby residents. However, diesel will always have some part to play on the rail system. Germany and France use diesel for specific applications and Switzerland's system, which is otherwise completely electrified, uses diesel for some maintenance operations.

Biofuels could offer improved sustainability for Europe's diesel trains, both in terms of environmental impact and security of energy supply. But more biofuel is needed to power a train and those on the market do not provide the same power as regular diesel. Biodiesel may have lower life-cycle CO_2 emissions than conventional fuels; however, as for all transport modes, any gain depends entirely on how the fuel is produced.

A better diesel engine

While renewable diesel fuel is beneficial, it makes more sense, particularly in the shorter term, to build more efficient diesel engines. The GREEN ('Green heavy duty engine') project has been developing a much lower-emission, intelligent, quiet, heavy-duty diesel locomotive engine that can achieve a maximum fuel conversion efficiency of 45%. The challenge is to adapt the technology for the global market at a reasonable cost.

The new engine technology uses advanced, integrated combustion and an after-treatment system in a single unit. Its flexible engine components reduce fuel consumption and allow it to run on both pure and biodiesel blend. The engine features closed-loop emissions control and operates at a very high power density.

Looking ahead, the Cleaner-D ('Clean European rail – diesel') project is developing and integrating emissions-reduction technologies in diesel engines. The project partners are also evaluating hybrid solutions that further reduce CO_2 emissions. The aim is to get very-low-emission, competitive rail vehicles to the market with a view to enhancing rail's sustainability and attractiveness compared to other modes of transport.

GREEN achievements:

- developed very-low-emission, quiet, heavy-duty rail diesel locomotive engine
- new engine can achieve a maximum fuel conversion efficiency of 45%

Green Heavy Duty Engine

Coordinator | Volvo Powertrain Aktiebolag (Sweden)
Total budget | EUR 21.75 million
EU funding | EUR 12 million
Start/end | 01/03/2005 – 31/05/2008
Website | http://green.uic.asso.fr/introduction.html

CLEANER-D objectives:

- enhance environmental performance of rail diesel vehicles
- identify essential interfaces for exhaust systems and after-treatment
- encourage engine suppliers to seriously consider using new, low-emission technologies
- provide guidance for sustainable change policy at the European level

Clean European Rail Diesel

Coordinator | Union des Industries Ferroviaires Européennes (Belgium)
Total budget | EUR 13.4 million
EU funding | EUR 8 million
Start/end | 01/06/2009 – 31/05/2013
Website | http://www.cleaner-d.eu/

Softly softly

Trains, cars and planes are noisy. For people living close to railway lines, this can be a very real problem, potentially leading to public action against expanding rail services. However, according to a 2004 study carried out by the European Commission, people usually find noise from road and air traffic to be more annoying and the quality of life near a railway to be higher than near a highway.

Several Member States have implemented legislation that sets strict limits on railway noise. This affects how many trains can be run on a given line, when, and how fast they can travel. Improvements in noise are absolutely essential to enable rail traffic to grow, consequently saving energy and reducing CO_2 emissions.

While new materials and innovative operating methods are needed to reduce noise, it is also practical to take a closer look at how noise is currently managed.

Train noise comes from rough running surfaces of wheels and tracks; making these surfaces smoother would make trains quieter. Braking noise is also important; replacing cast-iron brake-blocks with brakes made from a composite material (K blocks and LL blocks) offers considerable noise reduction. Rail and wheel dampers (absorbers) and track grinding can also help. Research and development (R&D) has made significant progress in this area, and the new measures now being applied are having a positive effect on the entire network.

Retrofitting vehicles and tracks with these technologies reduces the noise of running freight trains by between 8 and 10 decibels, making a huge difference for nearby residents – especially at night. But the cost of testing and retrofitting the entire European fleet is daunting. Accordingly, the major strategy for noise reduction has been to construct acoustic barriers and to fit sound-insulating windows along the tracks. These measures can provide some local benefit, but they do not offer a holistic solution.

The STAIRRS project demonstrated that overall the 'barrier' strategy is less efficient and costlier in the long run compared to retrofitting existing trains and rails with noise-reducing technologies. The team studied acoustically relevant geographic, traffic and track data for 11 000 kilometres of track in 7 European countries and found that the best solution is a combination of train and track retrofitting and 2-metre–high barriers. They created a tool that helps rail operators and infrastructure managers determine the most cost-effective combination of noise-reduction measures for their business. The tool takes into account various wheel and track factors, providing 'noise prediction', cost-effectiveness analysis and recommendations for optimisation.

STAIRRS achievements:

- found that retrofitting freight trains, alone and in combination with other measures, is the most cost-effective way to cut noise
- demonstrated that noise barriers, in particular high (4 metre) ones, are not very cost effective
- created a tool for determining the best combination of noise mitigation measures

Strategies and tools to assess and implement noise-reducing measures for railway systems

Coordinator | European Rail Research Institute (the Netherlands)
Total budget | EUR 4 million
EU funding | EUR 2 million
Start/end | 01/01/2000 – 31/12/2002
Website | http://www.stairrs.org/

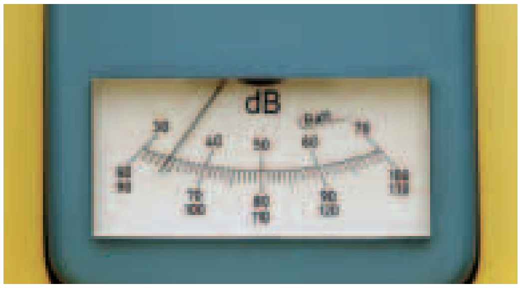
Two other European studies, SILENCE and QCITY, tackled urban noise problems caused by rail and road traffic. Modelling and simulation studies of urban noise scenarios helped researchers quantify noise perception (and annoyance) in several European cities. SILENCE produced a unique system of noise abatement technologies, tools and methodologies, and led to the establishment of a noise-abatement technology platform. QCITY researchers completed several noise-mapping and modelling studies around Europe, examining the noise made by specific vehicles and their interaction with road surfaces or rails. QCITY delivered a series of tools to help municipalities determine the best noise abatement solutions for their city and to come up with an action plan.

SILENCE achievements:

- delivered new technologies for quieter road and rail vehicles, rail infrastructure, road surface and vehicle-tyre-road interaction
- provided a toolkit for reducing noise through traffic management, road-side monitoring and in-vehicle driver-support systems

Quieter Surface Transport in Urban Areas

Coordinator	AV List Gmbh (Austria)
Total budget	EUR 15.7
EU funding	EUR 8.9 million
Start/end	01/01/2000 – 31/12/2002
Website	http://www.silence-ip.org

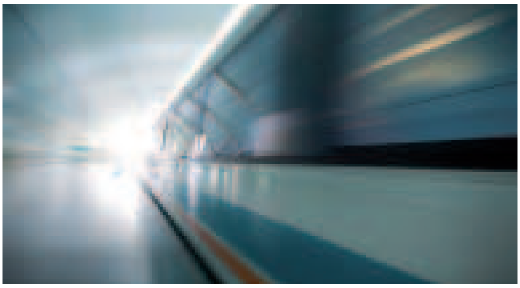


Q-CITY achievements:

- provided municipalities with tools to establish noise maps and action plans
- demonstrated noise-reduction solutions, such as quiet trams and low-squeal tracks, in several European cities
- provided municipalities with technical solutions for their specific 'hot-spot' noise problems

Quiet city transport

Coordinator	Acoustic Control Acl Ab (Sweden)
Total budget	EUR 13.5 million
EU funding	EUR 7.4 million
Duration	02/2005 – 01/2009
Website	http://www.qcity.org/



Every kilowatt counts

In urban areas where there are a lot of stops, braking energy can be used to recuperate hundreds of kilowatts. Energy conversion and regeneration are key technologies to reduce losses, particularly in electrified rail.

Hybrid systems are very attractive for urban transport as they offer energy efficiency without the exhaust from diesel or the visual clutter of overhead lines. The ULEV-TAP project created a hybrid bus and tram using flywheel energy storage, which can make use of the energy generated during braking. The new vehicles do not need to be constantly connected to the electric supply. They are also comfortable to ride and easy to drive.

The ULEV-TAP tram or trolley-bus features a small generator, fuelled by liquefied petroleum gas, and a flywheel system. It uses 35% less energy than a conventional diesel city bus, makes 50% less noise and offers a 90% reduction in greenhouse gas emissions. Following the successful demonstration of the trolley-bus in the Netherlands and of a flywheel tram (new technology fitted into a reconditioned, old-fashioned tram) in Germany, ULEV-TAP partners developed the core hardware for an entire series of flywheel-driven hybrids. Trams using this technology are now in service in Rotterdam, the Netherlands.

ULEV-TAP/ULEV-TAP 2 achievements:

- new flywheel hybrid improves overall urban transport system efficiency by 40% compared to diesel
- hybrid configuration offers 50% reduction in greenhouse gas emissions
- maintenance costs reduced by 50% compared to diesel-electric
- up-front costs reduced by a third compared to electrified systems
- noise minimised: 20 decibels lower than diesel
- products are on the market as operational vehicles

Ultra-low-emission vehicle transport using advanced propulsion

Coordinator | Siemens Transportation Systems, Mass Transit (Germany)

Project budget | EUR 6.6 million / EUR 4 million

EU funding | EUR 3.3 million / EUR 2 million

Start/end | 01/08/1997 – 31/07/2000 and 01/08/2002 – 31/10/2005

Website | http://www.ulev-tap.org/

The real costs

The cost of improving and expanding Europe's railway system is much discussed; however, the environmental costs of neglecting this important sector are much higher. The imbalance between transport sectors is striking. Given that the external costs of rail (e.g. accidents, congestion, pollution) are a fraction of those for other modes of transport, it is perhaps surprising that public investment is not stronger. However, in the coming decade, the Trans European Transport Network (TEN-T) will increasingly focus some of its EUR 270 billion budget on rail infrastructure to ensure the environmental sustainability of Europe's transport system.

'If you want a better ecological transport scenario, you have to take more traffic on the rails,' said Professor Steinicke. 'Rail is a really environmentally friendly mode, particularly with electrification and low fuel consumption. But you have to carry more and you have to be more competitive against other modes. You have to be more reliable and to invest. Otherwise you will never get the freight off the roads.' He emphasised that EURNEX researchers are making concerted efforts to find ways of improving intermodality, and that the enhanced cooperation fostered by the network has in recent years contributed to real progress in this area.

Professor Steinicke also warned against adopting an exclusively market-oriented approach to research. 'If you want to really turn the rail freight industry around,' he said,' you need to fill the box with good ideas and basic research activities before selecting the best ones to take to market. A healthy combination of step-improvements and breakthrough-oriented research will go a long way to ensuring rail maintains, and improves its environmental position in the highly competitive and ever-evolving European transport market.'

CHAPTER 6

CONCLUSIONS

Rising living standards and increased trade across Europe have fuelled demand for transport. While engines have become 'cleaner' and more efficient, transport-related greenhouse gas emissions continue to rise. In this context, rail offers important advantages over other forms of transport. Already largely electrified (70% of the European network), rail now offers the possibility of large-scale, almost carbon-free operation given an appropriate energy-generation mix. Consequently, more use of rail could in principle substantially reduce the European transport sector's CO_2 emissions. The challenge for Europe's railway sector is to expand services by providing attractive, competitive and integrated services both across Europe and within urban areas.

EU research has taken up the challenge of making rail more competitive, more integrated and more attractive to users – freight customers in particular – compared with other modes of transport. Central to this goal is the achievement of an interoperable European rail network that enables Europe's trains to travel smoothly across borders, and which enables rail industries to benefit from economies of scale.

The price of fostering such positive change through improved infrastructure is high, though the cost of not taking action is even higher – both to society and the environment. European research has maximised the value of this investment by ensuring smarter, more cost-effective management and optimised maintenance, which together can lead to a more efficient infrastructure.

Rail is a pivotal component of Europe's plan for sustainable transport. A holistic, 'co-modality' approach to transport makes the best use of each mode's strengths; this is essential for rail, which does not provide door-to-door service. Rail freight is more effective over longer distances, when the impact of transferring goods to other modes of transport becomes less important in the overall journey.

To optimise efficiency, rail must interface smoothly with other transport modes at ports, inland terminals and road freight hubs. European research projects have enhanced these interfaces, making it possible for freight to be transported (and tracked) door-to-door seamlessly. Importantly for customer satisfaction, the tools are now available for rail to deliver goods faster, more efficiently and more competitively. In addition, by choosing rail, freight customers can reduce their carbon footprint and benefit from the competitive advantage of providing a 'greener' product.

Although relatively clean in terms of CO2 emissions, railways do impact the environment in terms of noise and, to a lesser extent, land use. This presents a potential limitation to railway operation, particularly within urban areas. The railways are also seeking further improvements in energy efficiency to reduce operational costs, but have also made substantial efforts to minimise environmental impacts in all areas.

Over the past two decades competition has intensified for better and safer rail components and infrastructure. Many of the projects funded through the Framework Programmes have succeeded in reducing the costs of manufacture and maintenance without compromising safety. These projects have enabled, and greatly benefitted from, the new drive for interoperability and the adoption of modular design and manufacture. Europe's rail transport industries are market leaders. Their strong participation in European rail research helps to maintain the sector's lead against increasingly sophisticated foreign competition, supporting European employment in the transport sector.

Pre-competitive, cooperative research by enterprises and academia has led to significant technological and logistical breakthroughs, which have advanced the case for rail. However, an unstable economic environment has depressed investment and made implementing these changes difficult. Acknowledging this challenge, rail research is increasingly shifting focus towards ensuring market uptake.

A new spirit of cooperation in the rail sector has been fostered by the European Rail Research Advisory Council (ERRAC), which has galvanised efforts around its Strategic Rail Research Agenda (SRRA). EURNEX, the European network of excellence for the rail sector, has also had an important role to play in making the most of European engineering and scientific know-how – and by promoting a consensus approach between academic and industrial researchers.

'There is increasing cooperation in the research community, and it's driven by the EU harmonisation process,' said Professor McNaughton. 'Research has developed a number of common solutions, which are demonstrably the best solutions for rail at a given moment in time.' What holds it back, he explained, are neither technology nor finance but the decision-making process and the long time frames that characterise the rail sector.

Moving more freight (and passengers) farther and faster on electrified rail requires a number of difficulties to be overcome. The greatest of these is easing operation between different national networks, each of which has its own peculiarities. Interoperability tops the rail research agenda, particularly under the current Framework Programme (FP7), and is fundamental to achieving the objectives of the EU's 'railway package' directives. Creating integrated, affordable systems that share common standards is essential to realising a competitive trans-European rail network.

An interoperable network also requires innovation in business models and management. Fully integrated (and rational) ticketing systems, time-tabling and vehicle tracking would go a long way toward improving customer satisfaction. As a recent example, during the Icelandic volcano eruptions, some railway operators failed to impress many stranded passengers who needed to find their way home by travelling across several national rail systems. These passengers faced information, ticketing and availability frustrations. It is not yet possible to go to any station, check the times and buy a one-way ticket to any European destination. Such a vision is a challenge that research is gradually making a reality.

Rolling out the common signalling system (ERTMS) throughout Europe and achieving a safer interoperable rail network will go a long way to supporting cross-border travel and making rail a more attractive option for long distance transport. A truly interoperable network could make it much easier to connect European rail networks to the east, enabling overland transport from the Far East and China through Russia and facilitating direct transfer to rail for shipments from European ports. Progress in this area would bring substantial benefits in terms of faster freight links, reduced road congestion and lower environmental impact.

European research delivers technological and socioeconomic solutions to several long-standing problems. Bridging the gaps between research, innovation and implementation is an issue in many sectors. Rail is no different. It is an old industry that has been relatively slow to adopt new technology. The drive towards innovation is increasingly in focus. There is a political will to improve the interoperability of trains across Europe's many rail networks: this is now enshrined in legislation. Rail is a key component of the Trans European Transport Networks (TEN-T); these networks will be the first to be fully interoperable and, consequently, amongst the first to introduce innovative technologies and methodologies. The railway sector has the opportunity to take up this challenge and become more innovation friendly.

The state of the art is a continuously moving target: today's leading technology becomes tomorrow's normal working practice. European rail research has helped to drive down costs and ensure that the railways can function better and operate cleanly across Europe and beyond. With the leadership of ERRAC, rail researchers and industry have made significant efforts to collaborate and better structure their activities over the past decade. In pooling their substantial engineering and scientific talents to tackle the most important issues facing the sector, European railway researchers have shown that they are ready to take on the challenges of the future.

European Commission

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Improving rail transport is a priority for the European Union. This brochure offers a snapshot of European rail research activities. It explains how the results of EU-funded projects are helping to exploit rail transport's inherent benefits as an environmentally friendly and safe mode of transport. It provides information on the challenges faced by rail transport and outlines the European Union's response in terms of policy and research goals.

Projects profiled cover all aspects of rail research, contributing to themes such as pan-European standardisation, safety, customer satisfaction and sustainability. They give an exciting insight to the state of the art of rail research, and provide a glimpse of the rail technologies and systems we can expect to see in the near future.

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