ERRAC Work Package 05: Strengthening Competitiveness

John Amoore and Jay Jaiswal

ERRAC Roadmap

WP 05 Strengthening Competitiveness

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1. PRESENT SITUATION

General background, targets, references

The FP7 project ERRAC Roadmap commenced on 1st June 2009. The purpose of the project is to follow through on the ERRAC SRRA and supporting documents that describe the areas of research that need to be undertaken in order that the technologies identified as necessary for the vision for the future railway are delivered. Inevitably the vision for the future railway is not fixed, and as the impact of climate change, energy costs, road congestion and global competition for the railway supply industry are evaluated, the vision and technical strategy are modified. In addition, the impact of completed and ongoing projects within the EU Framework Programme and national programmes changes the definition of research needs.

As part of the Roadmap process, open workshops have been held on a biannual basis by all work streams to ensure that the widest range of opinions and knowledge sharing are available for inclusion in the developed maps.

The ERRAC Roadmap process is therefore

- Define the vision for the future railway based on the ERRAC RSA and updated from the EU White Paper 'towards a single European transport system', ERRAC Open Workshops and other authorities
- Develop the technology requirements to deliver the vision
- Examine past and current research projects to identify gaps in the research strategy for delivering these technology requirements
- Propose projects to deliver the research agenda in a logical sequence and timescale

The long-term framework for the SRRA sets out seven research priority areas. The following relate directly to the work of WP05

Test, homologation and security

The spread of European homologation and acceptance procedures requires less restrictive product approvals, the wider application of cross acceptance while reducing risk through improved safety management.

Competitiveness and enabling technologies

Increasing the competitiveness of the rail sector can be achieved by improving all aspects of product attractiveness for customers and reducing life cycle costs by the introduction of modern technology throughout the railway system including rolling stock, maintenance procedures, ticketing systems and infrastructure.

Strategy and economics

New accounting and planning models will provide a better understanding of the costs of operating and maintaining rail infrastructure and how these costs vary according to changes in the frequency and types of train service. This understanding will lead to incentives to provide high performance and attractive rail services for customers.

The collection of costs must be done at a sufficiently fine granularity to reflect true costs as an aid to building a business case for innovative products.

Infrastructure

Cost efficient condition based maintenance, and maintenance-free interoperable infrastructure systems will be developed that yield a reduction in the need for maintenance possessions, increases in traffic capacity, track loading and track stability.

Demographics - labor force

In addition to the influence of demographics on travel patterns and customer services, the other significance of the demographic shift will be the availability of manual labour to undertake many of the difficult and demanding jobs that ensure the continued safe running of the railway. Research is needed into the use of technology to increase the productivity of staff and remove some of the physical difficulties in order to both attract qualified staff to the railway and ensure that they are used to their full potential. Considerable investment is needed in education and life time training, not only to replace the increasing number of retirees but also to train for the new technologies that will be required.

The need for change

Railway assets traditionally have a long life cycle that may typically be forty years but for some structures may exceed a century. Therefore many investment decisions that we make today will have an impact on the railway system of 2050. Major investments in infrastructure must take into account the needs of the second half of the 21st century including:

- Changing socio-economic frameworks of societies, e.g. globalization, ageing and urbanisation
- Significant and growing ecological imbalances worldwide, e.g. climate change, scarcity of resources and degradation of biodiversity
- Increased regulation and use of new technologies in the transport sector, e.g. alternative traction concepts and information and communication technologies

This roadmap is based on a mid and long-term vision and has four target points in time:

- Year 2015
- Year 2020
- Year 2030
- Year 2050

1.1 Targets

Targets:

The Description of Work for the ERRAC Roadmap project defines the primary target for Strengthening Competitiveness as double passenger and triple freight traffic in Europe by 2020. This figure has been revised by the 2011 Transport White and extrapolated through to 2050 as:

30% of road traffic over 300 km should shift to other modes such as rail or waterborne transport by 2050

By 2050 complete a European high-speed rail network. Triple the length of the existing high-speed rail network by 2030 and maintain a dense railway network in all Member States. By 2050 the majority of medium-distance passenger transport should go by rail.

For Strengthening Competitiveness, other areas for action include:

- A capacity increase through the elimination of bottlenecks on trunk routes, especially on the TENs by 2020
- Maintenance costs reduced between 2000 and 2020 for both infrastructure and rolling stock
  The reduction in the cost of ownership of infrastructure will come from three areas:

  - Innovative products and new technology applied to infrastructure resulting in a reduced need or lower cost maintenance
  - A reduction in the need for maintenance and renewal as new technology applied to rolling stock reduces the wear and damage on both the infrastructure and vehicles.
  - The use of automation in inspection, maintenance and operation
- An increase in the availability of the network due to increased reliability and a reduced requirement (in number and duration) for maintenance possessions by 2020
- To reduce the cost of new build railway infrastructure and rolling stock by 2020

1.2 Megatrends

ERRAC has identified the following trends and challenges that are expected to have an impact on rail transport of relevance to WP05

Higher level

- Road congestion will be a barrier to economic growth
- European manufacturing industry will be challenged by products from China, India, Brazil and other emerging manufacturing centers
- Environmental consciousness and the increasing scarcity of fossil fuels will demand transport efficiencies
- More frequent extreme weather events will require highly resilient transport infrastructure
- Increased wealth and leisure time will require new transport services

Lower level

- An ageing society and a population with changing and variable needs, including those of people with reduced mobility will demand services such as barrier free door-to-door journeys.
- The development of a level playing field between transport modes reflecting true costs and avoiding distortions through the internalisation of external costs.
- Knowledge and information systems will result in worldwide competition based on best practice and the latest technologies
- The mobility of the workforce will increase; fewer people will make their entire career with one company or within one sector

Challenges

- Transport infrastructure will need to be extended to improve capacity
- Higher integration of different transport modes required to respond to a comprehensive mobility demand by users (door to door and producer or importer to point of sale)
- To develop innovative and advanced rolling stock, control and infrastructure solutions with cost competitive technologies, including retrofitting and reuse solutions
- To provide the technical capability for future increase in rail traffic, with product innovation in control command, infrastructure and passenger and freight rolling stock
- To reduce fleet and infrastructure operation and maintenance costs
- Improved interoperability of the rail system to develop new rail services and remove inappropriate barriers to trade.
- Coordination and integration of long, medium and short distance transport, both public and private
- Providing a suitably qualified work force by making the rail sector attractive to young engineers

1.3 Indicators

- Total cost per passenger-km and tonne-km normalised for different networks
- Route availability as percentage of 168 hrs/week
- Detailed annual maintenance and renewal spend per train km for long distance, regional and rural
- Market share for medium and long distance journeys
- %age of on time arrivals

2. STATE-OF-ART, RECENT PROJECTS, ONGOING RESEARCH

Over the past 30 years there has been much good research undertaken to help overcome the problems that railways commonly face, including poor adhesion, wheel rail and overhead line interfaces, ETCS etc. More recently the EU FP6 project InnoTrack, Sustainable Bridges and InteGRail have addressed questions of reducing track maintenance costs by introducing innovative products and processes, and an architecture for sharing data and information across the railway community. These and other strong projects have formed the basis for further EU projects developing the themes

Within the time constraints of the Roadmap project it is not possible to examine in detail all past national and international research relevant to the research needs. When potential projects have been identified, acknowledged specialists in the research domain have been invited to comment on research on this topic. Further detail relating to the state of the art, both in research and best practice will be investigated by partners at the proposal writing stage.

Past Projects of Significant Importance to WP05

Large integrated projects present problems for management and administration. They also bring an additional benefit that may be overlooked. Where a project includes a large number of leading European railway undertakings, infrastructure managers, representatives of the supply industry and universities, the partners bring to the consortium wide knowledge of both their national and international research within the scope of the project. The deliverables from the project in total represent the state of the art at that time, making the task of succeeding projects less complex in that there is a firm foundation of past knowledge to build upon. Such projects may be regarded as landmark projects.

The following are considered to be landmark projects

InnoTrack

The aim was to reduce the cost of track maintenance and renewal by the introduction of new products and processes. The areas for product and process innovation were track support, switches and crossings, rail including inspection and grinding, and logistics. Transversal work streams identified the problem conditions across Europe and developed life cycle costing (LCC) and reliability, availability, maintainability, and safety

(RAMS) methodologies for rail. The concluding technical report was in the form of a book pointing the reader towards the most relevant of the one hundred and forty documents developed within the project

Sustainable Bridges

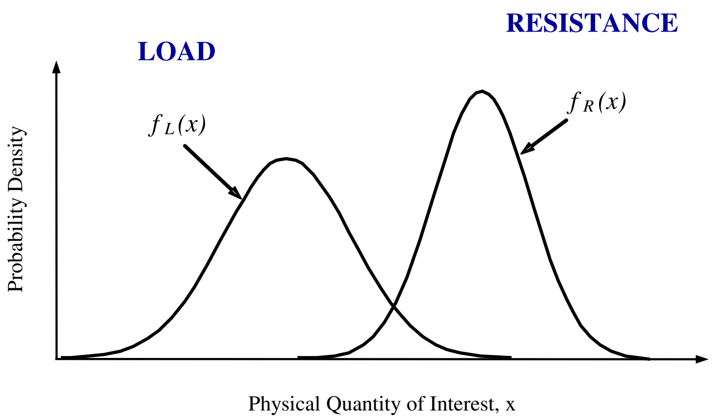
The technical objectives of the Sustainable Bridges project were to provide bridge engineers with state-of-the-art knowledge and tools used for operation, maintenance and management of bridges to allow them to meet the following overall project goals:

- Increase the transport capacity of existing bridges by allowing axle loads up to 33 tonnes for freight traffic at moderate speeds or by allowing higher speeds (up to 350km/hour) for passenger traffic with lower axle loads;
- Extend the residual service lives of existing bridges by up to 25 %
- Enhance management, strengthening and repair systems

Current Projects of Significant Importance to WP05

SustRail: The sustainable freight railway

This 9.5m€ project, proposed and developed by WP05 under the 3rd call, will deliver research that will facilitate the rail industry's need for the railway infrastructure to accommodate more traffic whilst at the same time reducing costs resulting from the deterioration of track. This will be achieved through reducing the track damage due to vehicles whilst at the same time increasing the resistance of the track to the loads imposed on it by vehicles. The result will be the sustainable achievement of increased speed, allowing the sharing of track between freight and passenger services, contributing towards making rail freight more competitive.



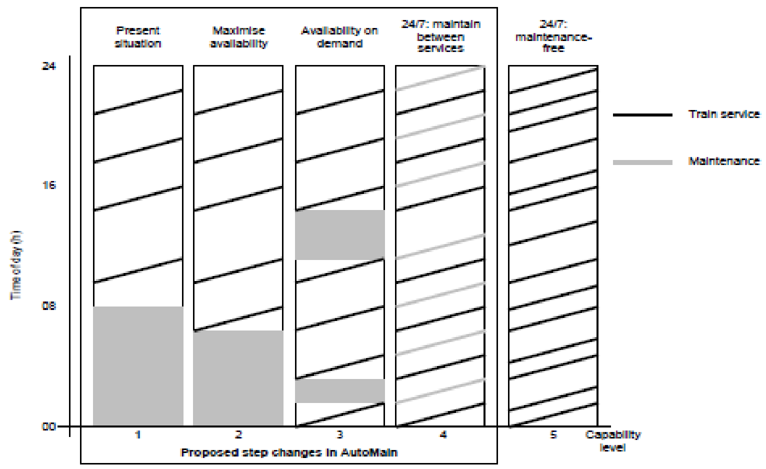
Both the loads imposed on the track by vehicles, and the resistance of the track to damage imposed by these loads have a probability distribution:

The goal of SustRail is to identify performance based design principles and complementary monitoring tools that will move the lower bound of the track resistance probability curve upwards through removing the causes of track failures at discrete locations with low damage resistance, combined with moving the upper bound of the vehicle damage probability curve downwards by removing the most damaging vehicles, will assist IMs and operators to move towards the zero maintenance ideal for the vehicle/track system.

AutoMain: Automated and cost effective railway infrastructure maintenance

Another 3rd call project from WP05, the aim is to find solutions that will reduce the time required for possessions or ultimately remove the need for them, leading to increased time capacity for freight and reduced maintenance costs. These solutions will deliver automated planning, maintenance and component renewal methodologies and techniques, building upon the current technologies in use in the railway sector and other recent research projects, as well as transferring advanced manufacturing technology and robotic experience from other industries.

AutoMain will look at 3 stages in improvement, firstly maximising availability by minimising the times of current possession blocks, secondly availability on demand, fitting in maintenance activity to have minimal impact on the timetable, and then finally maintenance between service trains



MainLine

Many major infrastructure assets are reaching the end of their service lives based on current design codes. In order to reduce the cost and disruption to traffic that would arise if these assets have to be replaced MainLine will seek to:

- Apply new technologies to extend the life of elderly infrastructure
- Improve degradation and structural models to develop more realistic life cycle cost and safety models
- Investigate new construction methods for the replacement of obsolete infrastructure
- Investigate monitoring techniques to complement or replace existing examination techniques
- Develop management tools to assess whole life environmental and economic impact and create a tool that can compare different maintenance and/replacement strategies for track and infrastructure based on traffic and whole life evaluation

- To improve existing damage and deterioration mechanisms, new cost effective replacement/renewal construction methods and logistics to identify and compare new surveying and monitoring technologies

Rolling Stock

ModTrain: Innovative Modular Vehicle Concepts for an Integrated European Railway System

An Integrated Project, MODTRAIN's 37 partners shared a budget of €30 million

The concept of modularity delivers economic advantages for both railway suppliers and operators, such as reduced manufacturing cost and economies of scale, increased productivity of new rolling stock as well as increased reliability. Collaboration between the suppliers and operators to determine the functional and physical interfaces, requirements and validation procedures followed by the design and development of interchangeable locomotive and rolling stock modules.

The technical and scientific work of the project arranged into four subprojects

- MODBOGIE- Running gear
- MODCONTROL - Control and monitoring system
- MODPOWER- On-board power system
- MODLINK- Man-machine and train-to-train interfaces

Current Projects of Significant Importance to WP05

TrioTRAIN:

Partners involved: 30   Start Date: June 2009

Project durations: AeroTRAIN, PantoTRAIN: 36 months   DynoTRAIN: 48 months

Total Budget: € 13,23 m (EC funding: € 8 m)

TrioTRAIN is a cluster of integrated research projects under the ECs 7th Framework Programme promoting interoperability by increasing virtual certification. The certification of a rail vehicle according to European regulations represents a significant element of both vehicle cost and time to market.

TrioTRAIN will contribute to the practical implementation of interoperability across Europe by leading to a faster, cheaper and better certification and authorisation process.

The projects will address three main technical issues for rail vehicle certification; vehicle dynamics (DynoTRAIN), the pantograph-catenary interaction (PantoTRAIN) and train aerodynamics (AeroTRAIN)

Economics

Previous EU projects relating to economics of rail transport

GRACE

The GRACE project has undertaken novel work in a number of key areas for pricing policy – namely, measurement of marginal social costs for all modes of transport, further development of the use of transport accounts for monitoring purposes, optimality complexity of transport prices, generalisation of marginal social cost estimates, and measurement of the impacts of marginal social cost pricing. Based on these studies, a number of policy recommendations have been reached which should assist policy makers in implementing more efficient pricing policies. These have been brought together in the executive summary and policy recommendations at the start of this deliverable

REFIT: Sustainability indicators for examining transport policy with regard to the economic, environmental and social aspects of sustainability

REFIT extends and integrates the methods used to evaluate policy impacts and develop a comprehensive assessment framework that links transport policy objectives and indicators with the tools and knowledge built up by previous European projects

The project will enhance Europe's ability to evaluate policy targets and indicators that are currently neglected It will create better linkages of policy analysis across economic, environmental and social dimensions

FUNDING: The development of a process for the optimisation of pricing and funding for all transport modes in the EU states and the methodology for a European multi infrastructure fund

The principal aim of the FUNDING research project is to develop a scientifically sound approach to the funding of large transport infrastructure investments in the EU. Two different avenues are explored for the funding of these investments. The first is the creation of an EU transport infrastructure fund financed by mark ups on transport activities. The second is the use of mark-ups on the users' costs charged by the infrastructure suppliers that make the investment. A number of alternative scenarios are formulated that range between heavy reliance on a European fund and low mark-ups and, at the other extreme, a small role for the European fund and an important role for the internal funding of investments via mark ups.

Data and Communications

InteGRail

The InteGRail project vision was to create a holistic, coherent information system to integrate the major railway sub-systems and deliver a higher level of coordination and cooperation between the key railway processes. The objective was to achieve higher levels of performance of the railway system in terms of capacity, average speed and punctuality, safety and the optimised use of resources.

By creating innovative concepts in the areas of train control and monitoring, maintenance, management and communications, the project re-defined the basic elements required by each system, assessing the needs of rolling stock, infrastructure, traffic management, train operation and establishes intelligent procedures to process all available additional information to its best advantage.

2.1 Priority areas

During the three years of this project many areas for research have been suggested. These range from short term projects delivering real but incremental benefits to large long term research topics targeted at step change in the railway system delivering increased capacity, improved services and reduced cost

The priority areas are defined here as the latter type, delivering step change

Cost Competitive: Whole System Costs

Benchmarking has demonstrated wide variation in costs for both infrastructure and train operating costs across the member states. Identifying the reasons for the most efficient operating costs and the factors leading to success, in terms of financial, organisational and political background including the level of investment, competition on and off track, contracting out, and incentives given by track access charges, performance regimes, and the approach to regulation should assist in determining what the lowest level of whole system cost may be, and the conditions under which this may be delivered.

The predominant problems encountered when investigating what the minimum life cycle costs for providing a complete railway system (passenger and freight) including infrastructure, rolling stock, and operations are

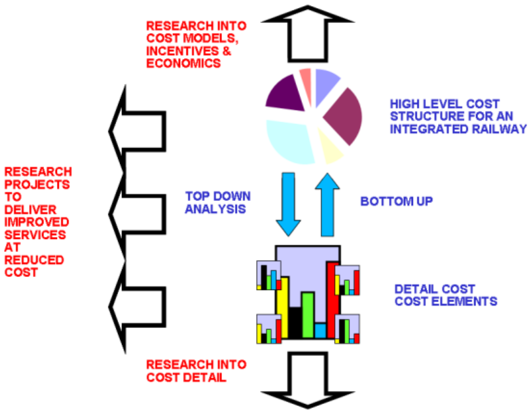
- Reluctance or inability of some railway undertakings to provide full cost details
- Variability of the cost of constructing and maintaining track due to geological conditions, tunneling etc of more than ten times from lowest to highest
- Variations due to the extremes of large countries with small populations through to small densely populated countries
- The lack of asset information, including the whole life cost at sufficiently fine granularity to permit normalization of costs for benchmarking and to drive innovation in the supply industry

Considering the above, there are few countries that share similar characteristics, and widely different conditions may be found in one country that has both mountainous sparsely populated regions and large centers of population with good communications. Despite this variability, further research is required to fully understand the whole system costs so that more accurate forecasts can be provided for the railway of 2050.

A starting point was the last published costs for British Rail from 1994. These were updated by the Institute for Transport Studies at Leeds University, and presented in open workshops in London and Brussels.

The high level model alone does not provide sufficient data for an informed decision on where research could deliver cost savings. Detailed information on the cost elements that contribute to the high level cost is necessary to determine the research activity most likely to deliver the greatest cost savings. Data on infrastructure maintenance and renewal costs by activity or asst type as a percentage of the total track cost is available for a number of IMs from the FP6 project InnoTrack.

The process of further developing this model will provide the following benefits



- Suggest areas where the greatest economic benefit will be found
- Assist other research streams in understanding the possible cost impact of project proposals
- Indicate where further research is required to understand the cost structure
- Provide information to those responsible for transport strategy on what may be realistic targets for railway cost reduction
- Lead to a better understanding of trade offs when considering improved services, capacity and sustainability

Cost Competitive: Economics and Vehicles

Cost competitive rolling stock and innovative and future proof vehicles

European vehicle manufacturers face difficult home market conditions due to the irregularity of demand. The number of contracts placed is relatively small but the successful bidder then has a limited time available for delivering the vehicles. This process is not cost efficient for the supply industry or conducive to global competitiveness.

The second issue is the life and weight of rolling stock. At the present time rail vehicles may have a life of 40 years or more. However, as stated elsewhere, much innovation is increasing exponentially and it is questionable whether 40 year old rolling stock can be sufficiently updated by refitting interiors and running gear to meet customer expectation, as the comparison will be made with the comfort and convenience of personal transport that will have developed through several generations by 2050. Research and demonstration activities in construction have developed techniques for reusing structural members from buildings that are no longer suitable for their original use. The carbon footprint of the new building may be significantly reduced by reusing the structural members from a building that has no further useful life in its present location. Reuse of body components in a new vehicle may be possible especially with the introduction of composite materials technology.

An alternative solution would be to design for a first use of ten to twenty years, having significantly reduced weight and specifically designed for cascading to rural or urban routes where the shorter duration of journeys means that a less modern vehicle is not so detrimental to customer perception. The possibility of cascading passenger stock for low density high value freight use, after modification, is another consideration.

Barriers to Innovation

Current potential barriers to innovation include:

- The way in which the competitive market, economic regulation, industry structure (including ownership) and incentives operate may act against innovation
- Standards processes
- Regulation
- Focus on short term economics, particularly first installed costs regardless of whole life issues, and the influence of political cycles
- Poor understanding amongst innovators of the business case or how to present it
- Non-standard railway, with systems and gauging varying across countries and even within the same country, leading to a small potential market for some components
- Lack of understanding and management of innovation risk
- Difficulty of access to track and technical constraints such as restricted loading gauge and under ballast services impacting on machine design and the possibilities of high speed maintenance and renewal
- Lack of a purpose designed railway test facility
- Lack of understanding of the whole railway system objectives, with infrastructure managers and operating companies often driven by conflicting incentives. The structure of track access charges is important here to align incentives more closely.
- The benefits from innovation are not always easily determined; this requires the development of a clear and agreed approach for assessing innovation

The research should focus on identifying and understanding these potential barriers in more detail (and the linkages between them), and also identifying good practice, before developing implementable solutions. For example, specific questions might include:

- How far do track access charging regimes - and rail industry structures / incentives more widely - impact on rolling stock procurement, innovation and development?
- How far do different approaches to competitive tendering impact on train operating and rolling stock costs and rolling stock procurement / development decisions?
- How can track access charging regimes be improved in terms of the level and differentiation of charges to strengthen incentives for innovation?

- How does the ownership and regulation of rail infrastructure, such as the use of fixed term control periods, impact on an IM's incentives to innovate? Does vertical separation make a difference?

Infrastructure, Maintenance and Capacity

Although in general terms detailed costs are required to understand where the greatest benefits from research may be achieved, the SRRA identified a number of areas where research would deliver cost and other benefits, and therefore members attending WP05 Workshops selected a number of identified longer term priority areas for research for inclusion in the proposals for the third call. These were priorities from the SRRA specifically targeted at:

- A reduction in the need for maintenance as new technologies applied to rolling stock and infrastructure reduces the wear and damage on both the infrastructure and rolling stock
- The use of automation in inspection and maintenance
- Capacity optimization
- Novel sensors for continuous health monitoring of rolling stock and infrastructure in order to move towards condition based maintenance regimes and the determination of residual life

The migration of freight and passenger traffic from road to rail will require greatly improved capacity from the existing infrastructure in addition to the construction of new track. Present capacity is limited due to infrastructure, rolling stock design, and speed differentials in mixed traffic and operational methods including signalling and the requirements for maintenance interventions. The solutions for capacity optimisation are different for every route and bottleneck, and therefore there is no place for the adoption of a single solution such as longer trains or the addition of a third track. In some instances the adoption of a simple solution has the potential to reduce capacity. Tools are therefore required that will aid decision support on the optimisation of capacity.

As stated above, the requirement for maintenance interventions, greatly restricts railway capacity, and prohibits twenty four hour operation. Passengers on journeys that involve connections or late evening travel may decide to opt for an alternative to rail travel due to the possibility that they will not complete their journey before rail travel is suspended for maintenance activities. The development of high speed and automated inspection and maintenance is a priority to achieve day and night functionality.

The introduction of higher speed rolling stock has not always been achieved without any cost increase to the infrastructure. Many new vehicles are heavier and less track friendly than earlier generations, and this trend must be reversed if the need for maintenance and associated costs are to be controlled. As the life of rolling stock and track may be forty years or more, urgent action is required to develop a railway system that has the lowest possible degradation rates, with the vision of non damaging interaction. The Roadmap for WP01 includes light weight trains as an aid to improved energy efficiency, and this need is repeated here as an enabler for reduced track degradation.

In parallel with the development of less damaging rolling stock, improved whole system models are required to determine how more damage resistant infrastructure may be designed. The combination of less damaging vehicles running on damage resistant infrastructure offers greatly reduced maintenance costs and higher track availability and capacity.

Interoperability and System Interfaces

In order that there is unhindered and competitive transport for people and freight, a fully interoperable railway system is a priority, with no barriers to onward travel at borders. Not only are standards required for new rolling stock and infrastructure, but also the best options to achieve the greatest interoperability with existing assets should be investigated.

System interfaces have in many cases evolved over many years on a national basis. A full understanding of the conditions at these interfaces must be achieved for full interoperability.

3. VISION

The future railway

The White Paper, ***Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system***, outlines the need to modernise transport within Europe to aid mobility, reduce congestion and sustain economic growth in a manner that is both sustainable and affordable.

Except for a few headline developments such as high speed trains and ERTMS, much rail development in recent decades has been incremental in nature. The preference for incremental development is partly due to the need to reduce risk, but also due to the high cost and lack of suitable facilities for long term testing prior to introducing new technology. As a result, railways have struggled to match the progress in the automotive and aeronautic sectors, where fierce competition and the need to develop product differentiation, has driven the development of innovative products that offer greatly improved reliability, comfort and economy. Indeed, it may be argued that where there is evidence of significant growth in the rail sector, this is in some part due to the congested nature of other transport modes, and not wholly due to the success of the rail sector in delivering greatly improved services exceeding customer expectations.

In order to meet the challenging growth targets described in the White Paper, the rail sector has to fulfill customer expectations not only of today, but the higher expectations of tomorrow. Innovation in the most dynamic industries increases exponentially, occasionally slowing before the next generation technologies are available for commercial exploitation. The rail industry, in contrast, experiences improvements in customer satisfaction, for instance, after the acquisition of new rolling stock or the introduction of new services, before some concerns return due to overcrowding, weather related delays with poor information, or ticket pricing issues, sometimes exacerbated by the media looking for headlines with little interest in the more complex issues. The rail industry therefore needs not only to reduce the gap between present expectation and customer experience, but also to meet the challenges that will arise from the perception that only rail can achieve the sustainability required for the twenty first century and the exceptional growth in rail transport, both passenger and freight, that this implies. The railways have an unprecedented opportunity faced with the prospect of sustained growth for many decades, but it should not be assumed that railways in their present form will survive as the preferred transport mode if they do not rise to this challenge.

How can the railway industry meet this challenge? If it is agreed that the challenges may be summarised as *SUSTAINABILITY, CAPACITY, CUSTOMER EXPECTATION, RESILIENCE and AFFORDABILITY,* then in the simplest terms

1. **Sustainability**

The strongest credential for the railways is that they are perceived as being the most sustainable, offering the possibility of transporting large numbers of passengers and freight with efficient use of resources, including land, in relative safety and comfort.

There remains much room for improvement, such as the management of train operations for minimum energy use (see WP01) and a minimum 50% reduction of infrastructure maintenance and renewal with its high embedded carbon content.

2. **Capacity**

Many key routes in Western Europe are already at or near to full capacity during the morning and evening peak travel times for commuters. The White Paper foresees a shift to rail or waterborne transport of 30% of road freight over 300 km by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors. To meet this goal will also require appropriate infrastructure to be developed and constructed.

Automatic train operation and control will allow more traffic on existing track, but transport hubs and other infrastructure will need radical redesign to cope with the doubling of traffic in situations where there is little or no available land for expansion of stations and freight handling facilities. Further capacity will be released by the reduction or even elimination of the need for maintenance possessions, through the development of new track forms, automated maintenance and the contribution of less damaging vehicle track interaction to a greatly reduced need for infrastructure maintenance.

3. **Customer expectation**

Over crowding, delayed services, poor information and value for money are all concerns for the customer that require attention if rail is to be the preferred choice for transport.

On long distance journeys of up to 1000km, the lack of any delay for rail travelers for check in and security, together with the ability to work productively, make high speed rail competitive with, and frequently preferable to air travel. The high speed rail service from Madrid to Barcelona has seen a modal shift from air to rail travel.

The increased availability of WiFi and mobile phone connectivity means that a five hour rail journey is no longer regarded as lost time, and free from interruptions may be at least as productive as an office environment.

For shorter journeys, however, the inconvenience and unreliability of public transport to and from the station, particularly in rural areas where public transport may be infrequent, means that the railway community needs to focus on the whole journey experience in order to reduce the reliance on private cars as the preferred method of commuting in less congested areas.

Congestion in urban areas, car parking costs and improvements in metro and tram services have contributed to a shift away from the use of the private car, improving the urban environment and encouraging the use of cycles. The development of the tram train will further encourage the use of public transport for the entire journey, but the customer will expect the introduction of 24 hour services and a secure environment at all stations and at all times.

4. **Resilience**

The trend for more frequent and increasingly severe weather events, either naturally occurring or due to climate change, will add to the attraction of rail transport against other transport modes. This will depend upon problems such as hot weather rail buckling, de-wirement in high winds and switch failures due to ice and snow, being satisfactorily resolved, providing a resilient railway transportation system. At the present time however, in severe weather conditions, it may be impossible for railway operators to provide a satisfactory service due to the difficulty of staffing a railway when the road system is unusable and rail staff living some distance from their work location due to the affordability of housing or other family and social needs.

5. **Affordability**

The investment needed for expansion of the rail system to provide the additional capacity required to meet the expected increase in demand, will depend upon rail being regarded as good value for money, and private companies being prepared to fund part of the expansion through the ability to generate a reasonable return on their investment. Today, with public funds under pressure, government financial support for rail is restricted, and therefore a greater proportion of increased costs for enhancements and new rolling stock will be passed on through ticket prices. The cost of rail travel is frequently compared by passengers to former times when travel was subsidized, the increased cost being attributed to inefficiency by the rail industry. Their remains however, much scope for improved cost efficiency.

4. ROADMAP DEVELOPMENT

Innovative infrastructure and maintenance technologies

Alternative solutions to conventional ballasted track

The basic construction of ballasted track may be traced back to the 19th century. Since then, there have been many improvements in rail design and materials, sleepers, rail fixings, geotextiles and the body of knowledge concerning the whole life performance and costs under specific conditions. Various designs of slab construction, generally using concrete as rail support material have been developed and installed in many countries. They have, however, failed to replace ballasted track designs as the preferred track form due to cost, noise and difficulty of adjusting the track in the event of any geological movement.

Track engineers may consider that there are just two basic alternatives when considering track design: either slab track or ballasted track with a number of variations of each. Modern track construction methods and materials however, mean that there is no distinct point of separation, and a slab track may be designed to be flexible and adjustable and a ballasted track may be designed to sit on a rigid or semi rigid support. The ballast may be industrially manufactured rather than quarried with a guaranteed performance and variable elasticity to absorb energy and noise. The construction of a new track or renewal of an old track could utilize a combination of different track forms depending on the subgrade conditions and anticipated train characteristics, whether high speed, mixed traffic or predominantly freight.

The Forum of European National Highway Research Laboratories (FEHRL) has set itself the challenge to develop a truly inspiring vision for how roads will be built and maintained in the 21st century. The result is the Forever Open Road – a revolutionary concept that will bring together the best of what we have today with the best of what's to come, and produce the 5th generation road. A road that is adaptable, automated and climate change resilient, based upon a concept for building and maintaining roads that can be applied whether motorway, rural or urban, and regardless of region or country.

Many of the concepts included in this project such as rapid construction, self healing with inbuilt sensors for traffic and condition monitoring, geothermal heating and communications networks present highly significant advantages to rail transport, and the alignment of a rail project to develop a new track form should collaborate closely with the Forever Open Road concept. Commonality of construction techniques together with embedded rails could ultimately lead to a rail track that could be used for road transport in national emergencies.

Automated and High Speed Maintenance

The AutoMain project has begun the task of investigating the reduction of maintenance possessions with the objective of moving towards twenty four hour rail services. The final stages of automating the maintenance process will depend upon the adoption of modular infrastructure designed for automated and high speed maintenance. This work stream will therefore continue for many years due to the long life of many assets and the prohibitive cost for removing major structures. Already the use of lean processes in this project, first developed in the motor industry, has demonstrated that there are significant performance improvements that may be made without the need for radically new technologies.

Modeling as a tool to Optimise System Interfaces and Support Maintenance and Renewal Decisions

The interaction of trains and infrastructure is complex and highly variable. There are no two identical sites where the interaction of trains and track produces the same degree of degradation. This is because the dynamic response of vehicles to track irregularities will differ according to speed, weight, condition of the bogies and wheels and the varying forces and frequencies will degrade the track depending on the properties of the ballast and subgrade.

Tools for the simulation of vehicle dynamic response to track irregularities are well developed, and are now used in the procurement process for new rolling stock, as these tools may be used to verify that the vehicle design is suitable for the route characteristics for which they will be used. Modeling of the response of track to the loading from vehicles is less advanced as the properties are not homogeneous and change in three dimensions as well as being influenced by water content and temperature.

The FP6 project InnoTrack demonstrated how numerical models verified by practical tests in track boxes could be used to model specific sites to test the benefits of alternative solutions. Maintenance decisions may be required for a specific site where there is a problem condition or an entire route of several hundred kilometers for strategic planning purposes. The InnoTrack project investigated both high resolution models (for local situations) and low resolution models (or strategic models) as an aid to determining track degradation rates. A general problem of low resolution models is that they incorporate generic degradation curves for track components and therefore provide average results often based on million gross tonnes (MGT) of traffic. High resolution or granular models may have highly variable parameters allowing close approximation to actual traffic and track characteristics, but require specialist operator skills. Maintenance teams therefore tend to fall back on accumulated experience when making decisions on the most appropriate remediation or rely on maintenance guidelines and standards. These decisions control the spending of more than 10billion Euros across Europe and also affect the reliability and availability of track for freight and passengers. A priority therefore is the development of models that are capable of simulating highly detailed local conditions and lower resolution whole route models for strategic decisions. Features of these models should be

- Easy to use with the minimum of training
- Plug and play modules that may be linked to combine different models covering all of the relevant infrastructure components and provide the introduction of new models as an aid to future proofing
- Combined with a cost function to generate comparative LCC studies

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