A GLOBAL VISION

FOR RAILWAY DEVELOPMENT

International Railway Research Board

INTERNATIONAL UNION OF RAILWAYS

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1. FOREWORD

Rail is a vital service to global society and the transport backbone of a sustainable economy. It has an unprecedented opportunity to achieve the sustainability which is required for the twenty first century. By doing so, Rail will be able to respond to the expected growth in transport demand, both passenger and freight.

The UIC International Railway Research Board (IRRB) has prepared the UIC Global Vision for Railway Development (GVRD) structured around the core themes set out in the strategic documents of the UIC Regions (e.g. Challenge 2050, Rail Technical Strategy Europe (RTSE), Asia-Pacific Regional Strategy and the strategy paper of the African Region, Destination 2040), as well as other relevant documents such as the Strategic Rail Research and Innovation Agenda (SRRIA) published by ERRAC, the European Rail Research Advisory Council.

The GVRD can help railways develop and optimise rail systems of the future in order to realise opportunities and satisfy customer and societal requirements.

To meet the numerous challenges ahead (demographic development, climate change, etc.) the global rail sector must increasingly rely on its innovative potential so as to deliver smart solutions as regards safety, security, punctuality, availability, accessibility, seamless operation, capacity, connectivity, sustainability and other performances.

The greatest challenge, however, is to meet all the above goals while remaining economically affordable for everybody in countries all around the world, and not only in those with a high per capita income.

In this strategic process which requires continuous improvement, fine-tuning and adaptation, UIC plays a crucial role as driver, disseminator, knowledge manager as well as platform for discussion and exchange of experience and best practice.

UIC takes a holistic approach, keeping in view the effects of each measure considered on the railway system as a whole, preparing the different possible ways to reach the future “Digital railway”.

Being a global organisation, UIC has the vision of global dimension of the railways, which requires for better efficiency and effectiveness a convergence of currently existing technical systems and solutions.

In order to achieve economies of scale and seamlessness of operation, UIC has continued its efforts to bring national and regional specificities of the rail system closer together – where such specificities are unavoidable – to optimise their inclusion into a globally coherent and interoperable system. International Railway Standards (IRS) are also an important factor in achieving this.

2. EXECUTIVE SUMMARY

In order to attract more passenger and freight customers and consistently satisfy their requirements, more innovative and cost-effective ways need to be identified and implemented to increase punctuality, safety-security and capacity, improve performance at a system level and remove barriers to seamless intermodal transport and railway interoperability.

The UIC Global Vision for Railway Development wants to provide a system-oriented reference to seek appropriate solutions for future challenges, using an approach which has originally been developed for road transport, the "forever open" concept.

The "forever open" concept comprises the following central elements:

- Adaptability: focusing on ways to allow operators to respond in a flexible manner to changes in users' demands and constraints.
- Enhanced Automation: focusing on the full integration of intelligent communication technology (ICT) and applications between the user, the vehicle, traffic management services and operation.
- Resilience: focus on ensuring service levels are maintained even under extreme operating conditions.

This vision aims to provide railways leaders, infrastructure managers (IMs) and railway undertakings (RUs) with best practice and guidance to support their own national strategies.

Rail being a technically much more complex transport mode than the road, it is essential to take an integrated system view. For this purpose, the following structure has been chosen:

The fundamental values of the railway system:

- Safety,
- Security,
- Sustainability.

Its main assets:

- Rolling Stock,
- Infrastructure,
- Control, Command, Communication and Signalling,
- Information Technology,
- Its human resources.

The vision of how the future should look like, objectives derived from that vision (how to get there) and the enablers, which will allow fulfilling the objectives. The chapters dealing with the respective elements of the Rail System have been structured accordingly.

The final part of this document deals with the principle tools used to make railways fit for the future, namely

- Training and Education,
- Standardisation and Harmonisation,
- Research and Innovation,
- Asset Management,
- Information Management.

3. RAILWAY MARKET SEGMENTS AND THEIR FUTURE TRENDS AND CHALLENGES

3.1 PASSENGERS

The passenger rail service deals with different categories of customers through specifically designed services. The various passenger rail market segments depend mainly on the distance travelled – long, medium and short distance – and on the territory served – regional, suburban and urban.

Each rail market segment (high speed, mainline, regional, urban and suburban) may correspond to specific customer needs mainly depending on the distance and purpose of travel as well as on their expectations depending upon their age, education, activity, gender, income and possible reduced mobility.

To satisfy these requirements, the relevant passenger market segments may require specific design, construction, manufacture, operations and maintenance conditions, and therefore may call for specific research needs summarised in the subsequent chapters.

3.1.1 High Speed and Mainline

High speed has been a very successful and innovative rail market segment for several decades in Europe and Asia and is often the preferred choice for journeys of up to 800 km or 5 hours door to door (including the "last mile").

Most long-distance services depend on an efficient combination of high speed and conventional line sections, especially for accessing city centres or connecting segments with less traffic demand.

Other mainline services are also essential to meet either very substantial or more specific long distance national and international travel needs (night trains, major events, tourism...).

In this segment rail is mainly competing with air-lines, long-distance-bus services, and - in countries with a good motorway infrastructure - also with the (private) car.

3.1.2 Regional

Regional rail serves as a backbone for local public transport (mainly commuter transport) in many countries around the world but has to compete with private cars and lower cost bus services. However, this rail market segment is also one for which existing rail infrastructure right-of-way is not used according to its potential for supporting more sustainable land use and transport policies. These services are mostly operated under public service contracts and they may share or not the infrastructure with mainline traffic. What is mostly at stake is an improved coordination with other public transport services (ticketing, information to passengers, etc.) and in regional mobility strategies whilst maintaining the "traditional" rail strengths, i.e. resilience, energy saving and capacity for mass transit.

3.1.3 Urban and Suburban

Railway networks in urban and suburban areas play a prominent role in the transport policies of major areas, as sustaining the viability of conurbations. This rail segment is serving the daily needs of urban population and is the best alternative to the use of private car in congested and polluted areas. It covers in fact several different groups of systems each of which plays its part depending on the traffic flows to be served and on the possibility to be protected or not from the road traffic or to be shared with or separated from the mainline rail traffic. The major sub-segments are: tramways segregated from general road and pedestrian traffic; light rail which are partially protected from road traffic; metros which are fully segregated are also known as underground, subway or Tube; suburban rail/regional metros which are rail networks serving the highest levels of rail traffic.

3.2 FREIGHT

Rail freight is a key element in the establishment of a sustainable transport system. The low level of external costs generated by rail freight should make it the mode of choice for freight customers looking to reduce their environmental impact. Indeed, rail is the most eco-friendly land transport mode for freight, with much lower CO_2 emissions and energy consumption per tonne-kilometre than road freight or transport by inland waterways.

Rail is the mode of choice for bulk commodities such as solid mineral fuels (coal, coke), ores and metal waste as well as an important mode for the transport of petroleum products and fertilisers.

Rail freight hubs worldwide are not only fed by railway lines but increasingly also by rail-road combined transport. In addition, due to the development of maritime containerised transport and road congestion, intermodal transport has developed dramatically in the past 30 years, becoming the fastest growing freight transport segment in Europe with a more important role for rail.

In North America, but also in Asia, freight operations generally meet better structural conditions than in Europe. Distances are generally longer, stops less frequent and the infrastructure allows for substantially longer and heavier trains, thus making freight operations less costly than in Europe. In some places such as in North America and Australia, railway infrastructure and operating undertakings are often single integrated companies, often with far less passenger traffic.

In the European Union the so-called rail freight corridors have been implemented in order to focus efforts to improve the framework conditions on designated lines with high economic importance.

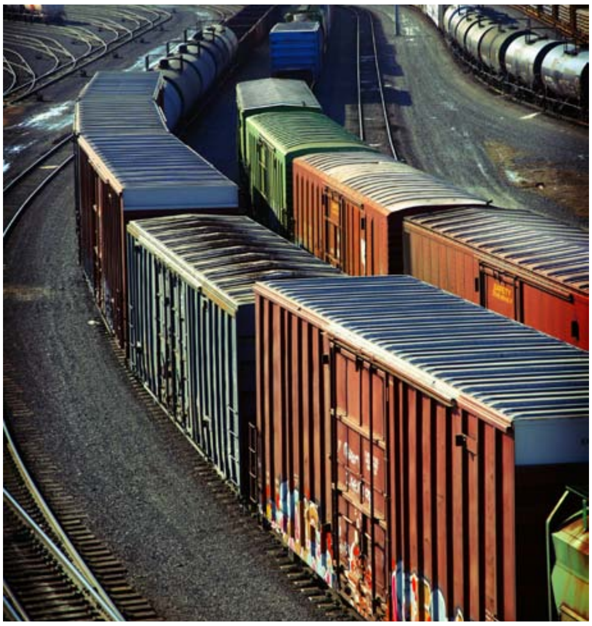
A similar effort is currently being undertaken on certain freight lines between Europe and China. These Asian-European rail freight corridors have a high business potential as freight trains operating on these routes are considerably faster than container ships and much more cost effective than air transport.

However, interoperability problems (both technically and operationally) in combination with legal and administrative obstacles have so far partly hampered rail freight transport between Europe and Asia from achieving equal economic importance as in North America.

Improvements to the simplicity, transparency and quality of the offered freight services (seamless transport and especially a controlled punctuality) are needed to attract customers to consider rail as their first choice mode for the transport of most goods.

The improvement of the quality of the infrastructure as well as ensuring technical interoperability is another major, however also cost intensive, parameter.

Among the most cost effective measures where a comparatively small investment can bring about significant reduction of journey times are those aimed at cutting time spent at border crossings. Harmonisation and synchronisation of certain procedures, such as the unloading and reloading of containers between different gauge systems and customs can save time and be more effective in speeding up transport than costly infrastructure measures which are also time consuming.



3.3 FUTURE TRENDS AND CHALLENGES

3.3.1 Trends and Developments

Rail transport demand is steadily expanding worldwide, in particular in metropolitan areas with soaring populations. Even in Europe where population growth is slower, forecasts show a rise in the railway share of transport.

Also on other continents, passenger rail transport demand is being driven by a surge in demand for intercity and interurban mobility. Well integrated public transport involving rail, metro, tram and bus transport is already capturing increased market shares in urban and regional markets not just for commuting but also for leisure trips, and this trend is expected to accelerate as urbanisation spreads.

The demand for long distance rail journeys is already growing in many countries and this growth is expected to increase with further development of the high speed rail network in Europe and particularly Asia. The commercial speeds on high speed lines are expected to average up to 300 km/hour allowing up to a 1,000 km distance in a still attractive travelling time of 5 to 7 hours door-to-door. Express freight will also be offered. Expectations of rail experts see substantial revenues of these infrastructures attracting private market investments to contribute to their cost and thus relieving public budgets.

Demographic evolution and changes in lifestyles will affect transport demand. In the industrialised countries the number of elderly (including especially 80+) people will continue to grow during the next decades with increasing public investment in health and care services. The elderly will use trains more frequently in particular in urban areas and for long distance journeys.

The lifestyles of younger age groups with fewer car owners are expected to change by following multimodal travel options, particularly within cities, including walking and cycling. Public transport and rail operators are expected to provide additional solutions for first and last mile door-to-door long and medium distance travelling.

Diversification of labour markets and differences in prosperity between regions will lead to more differentiation in pricing policies, with a strong growth in yield management systems and low cost carriers on busiest intercity routes.

From a technological point of view, innovations are expected to operate towards more energy and resource efficient systems for rolling stock and infrastructure and to converge towards a worldwide more and more "digital railway". Integrated services for ticketing and traveller information and guidance, also in case of disruption, are expected to be further improved towards real time level. There will also be a worldwide convergence of quality, safety and security management systems based on best practise and the vision of a global rail system with a maximum degree of interoperability and a global railway supply market.

Major innovation trends in the rail sector are based on integration technologies, i.e. analogue components converging more and more with digital (computerised equipment, servers, sensors... interconnected by different more and more open communication networks...). Rail users are expecting full functional digital communication and information transmission travelling by rail.

Urban and heavy rail are further converging in particular in urbanised areas and with regional rail into tram-train or metro-train (regional metro) concepts. High speed rail may promote lifestyles in which long distance commuting on a daily, week-end or some days per week frequency become an increasingly common phenomenon.

Semi or fully autonomous and alternatively propelled car systems are seen to be a major competitor in 2030 to electrified rail mass transit if they are able to reach and demonstrate the safety level expected for driverless and public transports. However, limited range will continue to restrict the use of electric road vehicles for long distance passenger traffic and heavy freight. In dense and urbanised metropolitan regions of tomorrow it is expected that rail transit will retain its major role, which is to prevent congestion and open space consumption by moving and parking cars.

Sustainable mobility measures, namely local climate policy and planning aimed at carbon emission reduction in cities and city regions are causing a modal shift towards rail transport. Park and ride and other commuting facilities will be further enhanced so as to constrain car travelling to inner city centres in line with more and more parking and access restrictions to be expected in urbanised areas throughout the world. These development strategies are enhancing as well long distance rail services by making car travelling in intercity relation less comfortable than years ago.

Long distance rail travelling services must face the effect of climate change. More resilient infrastructure with improved emergency maintenance services are foreseen by experts towards 2050, including passenger information which in case of disruption also provides travel alternatives to reach destinations in time. The smart grid of the future will not be limited to the energy system, but will represent a generalised facility for the future transport and rail network in general.

The overall vision for the future foresees passengers to enjoy seamless journeys in a comfortable, valuable, yet affordable, attractive, safe and secure environment, reassured by the availability of real-time traffic and whole-journey information that keeps them abreast of their varying journey options should problems arise with inter-connection with another modes or degraded operating conditions.

As for freight, rail will increasingly replace road transport, in particular as regards dangerous goods. Technical and operational interoperability on international rail freight corridors will substantially increase the competitiveness of rail as compared to other transport modes. Perceived nuisance factors such as noise and vibration will be limited to tolerable levels, thanks to technical innovations, e.g. composite brake blocs.

As containerised rail service improves, the length of the minimum competitive hauling distance in the US has decreased in some cases from perhaps 1000 km to 550 km.

3.3.2 Resulting Challenges

Significant improvements in cost-reductions as well as reliability, availability, and maintainability of the railway system has to be achieved to make the vision described above a reality.

Outstanding interdependent safety and security records remain the core feature or the rail system. Safety and security criteria will further be harmonised and rationalised, thus becoming a facilitator for shifting to rail rather than forming a barrier for interoperability.

The rail system has to be affordable, accessible and attractive for all passengers, whatever their social and income status, their age and individual characteristics along their lifetime, and their possible physical impairment including persons with (temporally or permanently) reduced mobility.

Delivering reliable, affordable and attractive rail services - in close coordination with other transport modes and especially public transport - is the core of seamless and sustainable mobility.

The priorities are therefore the following:

- Take into account the growing demand for mobility at various territory scales (from international to very local) and the demographic change impacts on customer needs,
- Stress the important social focus on personal well-being and
- Highlight changing trends in consumer behaviour as well as required behavioural changes to guarantee the efficiency of sustainable transport policies.

As a support to the improvement of customers' experience, research shall contribute to develop a competitive and attractive service, especially in the following areas:

- LCC-approach (Life Cycle Cost based on total cost of ownership) and mechanisms and especially the link between a dedicated requirement and the consequences of its modification in terms of cost and benefits,
- Enhancing big data analysis and management competence,
- Analysing specific consequences of dedicated degraded or failed technical functions on safety, so as to enable most robust design on functions that are most safety relevant,
- Develop and improve tools used for transportation planning, mobility monitoring or mobility guidance. Improving the efficiency of the transportation systems requires a better understanding of user behaviour and a better knowledge of potential customers' expectations as well as their possible reactions to innovative mobility measures and services (by rail, by public transport and co-modal between public transport and individual or shared private modes), including new traffic and travel information services, or to the creation of new transport infrastructure or facilities, or even to new land use development and management policies,
- Data collection and analysis improvement and harmonised statistics are essential for sound and convincing economic studies and traffic forecasts and for building customer oriented business models,
- Studies have also to address the user's response to pricing policies both to facilitate their travel by rail and public transport through integrated charging and payment systems or to influence their modal choice and travel consumption through pricing and taxation of transport infrastructure and transport means. They have to cover the analysis of impact on behaviour of various regulations favouring or restricting the ownership or use of transport modes depending on the area to be sustained,
- Forward planning and investment – including new urban rail systems - provides new capacity on busy corridors where the route allows and where improvements in operational arrangements are insufficient.

4. THE "FOREVER OPEN" CONCEPT

The "Forever Open" Concept was originally generated for roads. It is aimed at ensuring that roads are able to meet the global challenges of the future, such as:

- Climate Change,
- Carbon Reduction,
- Energy Generation,
- Global Financial Crisis.

To achieve this, the next generation of roads shall comprise the following three elements:

- Adaptability: focusing on ways to allow road operators to respond in a flexible manner to changes in users' demands and constraints,
- Automation: focusing on the full integration of intelligent communication technology (ICT) applications between the user, the vehicle, traffic management services and operation,
- Resilience: focusing on ensuring service levels are maintained under extreme operating conditions.

Meanwhile, the "Forever Open" concept has been extended also to other transport modes. The "Forever Open Railway" concept includes in particular the following features:

- Ensuring a non-discriminatory access to infrastructure for operators and carriers, freight operators and forwarders - to the railway system as a whole (which requires the creation and maintenance of necessary reserves, with well-defined business targets, in traffic and carrying capacity). However, this does not apply to North American Operations,
- Client-oriented, adaptable control of the transportation process based on use of information technology, allowing to combine implementation of individual requirements of customers in terms of routes, transportation speed etc. as well as ensuring high utilisation of infrastructure and rigid schedules,
- High level of automation on the basis of sophisticated communication technologies between clients, sales departments and traffic control, locomotive and train crews and infrastructure services, the use of "smart trains", as well as the application of "unmanned" automated systems, including self-propelled rolling stock operating in standalone mode,
- Formation of open intermodal systems for the global commodity circulation based on (or at least with participation of) railways,
- Fault tolerance and interoperability of traffic control in real time mode,
- Organised, reliable, qualified staff, open for interaction with customers and partners, for the perception of innovation and capable of ensuring efficient operation of the railway system,
- Elimination of language barriers as one of the basic requirements towards further improvement of traffic control system,
- Development of techniques to improve communication skills between train employees, traffic operating departments and dispatch staff.

5. THE RAILWAY SYSTEM – VISION, OBJECTIVES AND ENABLERS

5.1 OVERVIEW

Rail is first and foremost a service business oriented system with physical and functional areas which must be designed, constructed, operated and maintained in an integrated manner while taking into account the importance of the interfaces between its constituent parts, some of which are safety critical and upon which the integrity of the system depends. No part of the rail system should therefore be developed without due consideration of the effects of the resulting changes on other parts of the system.

In this system-based approach, complexity is managed by means of standardisation leading to improved interoperability. Resilience and efficiency can be ensured by fostering the interaction of system components, the adoption of modular construction principles and the support of automation.

Crucial to a successful rail system is the development of a set of harmonised operating processes responding to International Rail Standards (IRS). This level of system convergence is for the benefit of deriving harmonised technical, operating and maintenance (asset management, integration, evolution...) requirements for rail technology and the implementation of the railway services. This is needed for reliable interworking and will foster the development of compatible components to facilitate cross-utilisation throughout the system and to reduce the cost of production and maintenance. The IRSs are “Railway driven” standards, guidelines for maintenance, operation, integration, evolution, safety and security management and are expressing the corresponding functional requirements. The IRS are compliant with:

1. Industrial norms like EN, ISO, IEC more “supplier driven” and defining the products, the sub-systems and are expressing the operation and maintenance exported constraints.
2. EU Directives and TSI and national laws and regulations.

Essential to the growth of transport services is the reduction of overall life cycle exploitation costs of all rail sub-systems, minimisation of the effects of obsolescence and the effective migration of emerging technological innovation.

Cost drivers must be transparent and technology and standards adapted to local operating conditions without compromising the safety of the rail network. Investment in new, more resource-efficient technologies has and will continue to reduce the sector’s costs.

These modern technologies will reduce the start-up timescales and costs for new services and products and accelerate and facilitate processes. The railway system will operate cost-beneficial passenger and freight services on a “forever open” basis that is accessible and highly available (see above).

Optimisation of the management of rail traffic is essential to minimising the cost of the railway system and to improving capacity. This requires not only a high level block system (as ETCS) but needs a more extended bilateral communication between the trains and the traffic management systems.

High reliability of system components will lead to a highly reliable system which is a prerequisite for the development of track capacity. Targeted expansion projects will encourage capacity growth and meet the sector’s own high punctuality requirements.

Service frequencies and train capacity will be such that passengers get the type of seat they want and shippers the type of service they need at times that suit them.

The system will be highly automated both operationally and for monitoring vehicle and infrastructure condition and maintenance. On the rare occasions when disruption occurs, services are automatically and dynamically reconfigured and customers advised.

Business continuity is optimised by real-time traffic management, maximising capacity, conserving energy and minimising inconvenience to the passenger and the freight user.

Stations and terminals of the future will be designed around the need to blend in sympathetically with their surroundings but also to be able to match capacity, accessibility requirements and security aspects and support connectivity with other modes and feeding the 'last mile'.

The following chapters will deal first with the fundamental values of the railway system, then with its assets respectively subsystems and finally with the railways' most important "asset", its human resources.

5.2 FUNDAMENTAL VALUES

There are basically three fundamental values which should govern the rail system, i.e.

- Safety,
- Security,
- Sustainability (both in environmental and economic terms).

Any strategic vision or objective should be oriented at this set of values. Neglecting any of these values with the consequence of an unsafe, insecure and/or unsustainable railway will lead to socially, environmentally and/or economically inacceptable results.

Furthermore, the aforementioned values are interdependent: on the one hand an unsafe and insecure railway will – at least in the long run – not be economically sustainable. On the other hand only a railway which is economically sustainable is able to generate the financial means for investments necessary to maintain safety and security, without having to depend too strongly on government subsidies.

5.2.1 Safety

Vision

Rail is the safest mode of land transport and any railway strategy should be aiming at maintaining that position. Rail will actively move towards being the safest mode of all transport sectors and thereby be even more attractive to the customer.

Infrastructure managers and railway undertakings shall all identify, evaluate and put in place an advanced safety management that includes also the quick recovery after unexpected events like failures and accidents. For the most frequent situation, system performance in degraded mode shall be as close as possible to that in normal operational mode. Intelligent and consistently fall-back architectures shall take into account every critical sub-system and component. The goals of the advanced safety management is to substantially reduce the risk before an accident occurs and provide the conditions for a quick restart.

On the basis of regional experience with common safety targets, these considerations shall apply also to international rail freight corridors, thus introducing a safety harmonisation that is not be a barrier to interoperability.

With a growing potential and reliance on automated interventions the human factor still remains a critical link and shall be carefully taken into account. New paradigms for innovative staff training methods and tools should therefore be introduced, supported through research.

Objectives

Rail is the safest form of land transport and safety-related research activities shall contribute to retention of that top spot. Safety of the system shall be continuously improved through progressive automation of the railway systems.

The operational risk caused by third parties at critical interfaces, such as level crossings, shall be significantly reduced.

Critical interfaces shall be effectively managed between all parties in the railway sector and the verification, certification and authorisation of safety management systems and vehicles shall become easier and faster.

Close monitoring of the system shall attract customers, reassuring them of their personal safety whilst using rail services.

Having processes and automation in place is important but it is the human factor that sometimes can be the weak link and this aspect must continue to be taken into account. The important task of training people to understand change and innovation and the impact on safety is imperative.

This is why the Railway Operating Community (ROC) must progressively improve the quality management which spans around the whole system and its processes and not only focused on the conditions of technical products.

There will be a greater reliance on automated intervention and performance methods in particular with regards to monotonous routing tasks, so as to eliminate negative impacts of the human factor. Research shall be targeted accordingly.

Enablers

- International collaboration and exchange of best practice will improve effective management of critical interfaces between all parties, e.g. as regards the reduction of level crossing accidents.
- A group of experts on improving safety at level crossings at the initiative of UIC and hosted by UN-ECE with the objective to produce a strategic report and recommendations covering key important areas of level crossing safety.
- Internationally coordinated campaigns will continue to increase risk awareness, e.g. the International Level Crossing Awareness Day (ILCAD).
- Harmonised processes, first at regional, then at international level, will lead to a common safety method, interoperable safety management and ultimately, international safety certification.
- Intelligent and consistently applied fall-back systems will assure safety during degraded mode designed into every critical sub-system and component.
- Open functional software (“open model” formal provable) as the preferred choice will significantly improve software quality and robustness as a main safety contributor. Each future computerised modules should be seen by each IM or RU as a “functional white box” (e.g. formal computerised module functions exhaustive description) that allow to facilitate the functional validation and safety demonstration (obligation of result and no more only obligation of means).

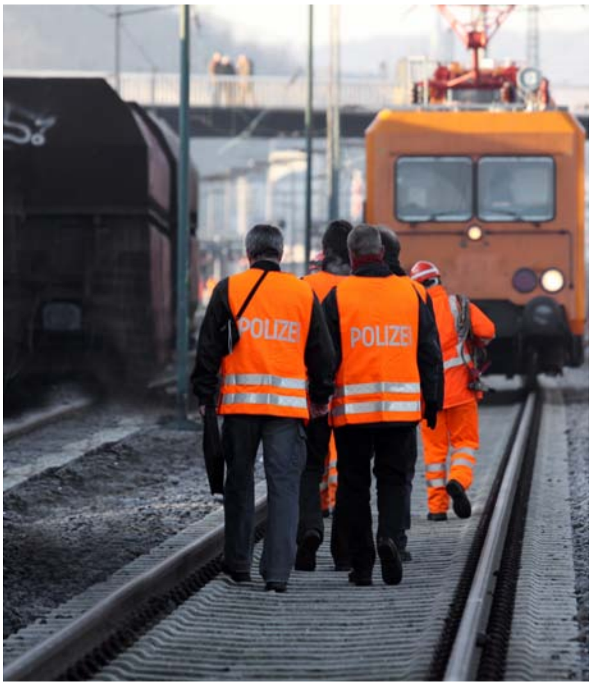
5.2.2 Security

Vision

Rail is generally a secure mode of land transport, but it sometimes generates a feeling of insecurity which in some cases prevents people to use it.

Research in the area of railway security should concentrate on two main challenges:

1. Providing maximum security with a minimum of adverse effects on the free flow of traffic. To meet this challenge, surveillance by means of Closed Circuit Television (CCTV) can provide an adequate instrument, as it is more and more developing from an instrument of prosecution of crimes already committed to one of proactive identification of potential threats by means of highly sophisticated software.
2. Making the railway system more resilient to criminal attacks, i.e. minimising the effects of rail service disruption due to security incidents. This shall also help prevent other transport modes from becoming overwhelmed by the cascade effect. Innovation would lie in a standardised and multimodal approach to managing such disruption and minimising the impact on performance and recovery costs.



Objectives

Research and innovation shall aim at increasing the level of security along the supply chain and between modes without hindering the free flow of persons and freight. This could be achieved by increasing the interoperability of transport security intelligence within and between transport modes. This type of data has considerable sensitivities surrounding it and a standardised approach across all transport modes would lead to a structured set of access conditions for data regarding transport security.

Increasing mobility demands will lead to more multimodal transport venues (stations, terminals, car parks, etc.). These are potentially attractive targets to criminality due to their complex layouts and organisational management structures. Multimodal transport will need an integrated security system. The development of security management systems at multimodal transport areas would provide a continuous security system approach independently of the transport mode used.

In this multimodal context, a standardised and multimodal approach to managing such disruption, which rail would lead, will help to share workload and costs.

Rail should work with technology providers and other transport modes to develop more effective security equipment and adapt existing technology to the specific requirements of the railway business.

Enablers

- System architecture - cyber threats could be minimised by resilient architectures and by additional layers of security including sophisticated firewalls between operational systems.
- Automatic back-up and dual redundancy should be built into all key systems.
- Advanced connectivity by "Internet of things" as a basis for emergency response.
- IT systems such as those used by customers on trains or in stations, should be independent from key operational systems especially those with a safety-critical impact.

- Active and passive systems to provide constant vigilance against terrorism and cyber-attacks, supplemented by trained staff. Incident-related functions should include detection, analysis, development prevention, incident elimination and post-incident security recovery. Incidents should be tracked and documented on an ongoing basis.
- Strict application of behaviour rules for staff involved in handling of software and hardware, to exclude "infection" or transmission of malware.
- Interfaces with security services and police and other law enforcement agencies.

5.2.3 Sustainability

Overview

The term "sustainability" is mostly used in terms of protection of the environment and describes a concept that avoids or at least minimises adverse environmental effects.

Usually, the concept has three dimensions: economic, ecological and social. The social dimension comprises responsibility as an employer, safety and security for employees and customers and responsibility towards society in all aspects.

However, the concept of sustainability is also used to describe a self-sustaining economic enterprise which is able to finance necessary investment internally, i.e. by the profits it generated without having to rely on external subsidies for the continuation of its existence.

Following this distinction, this chapter will deal first with environmental sustainability, followed by economic sustainability and its main preconditions, i.e. the affordability of railway transport and – closely related therewith – the intermodal competitiveness of the railways.

Generally, environmental and economic sustainability are apparently conflicting objectives, as environmental measures – at least from the microeconomic point of view of the individual company – generate costs without corresponding direct profits. However, indirect profits of proactive environmental measures of an individual company might be the avoidance of even higher costs resulting from legislative or administrative measures or measures to repair damages including the treatment of contaminated sites, accidents with dangerous goods, damages to reputation from an environmental incident etc.

There is one area, however, where there is clearly no conflict between environmental and economic sustainability: energy efficiency. Therefore, a special third paragraph shall be dealing with this topic.

Environmental Sustainability - limiting adverse effects on the Environment

▸ Vision

By the middle of this century rail will most probably have lost its advantage in terms of environmental sustainability as compared to the road due to the rapid development of technical possibilities to store electric energy, in particular the spectacular increase of battery capacity over the last decades, although it might still be more energy efficient than road transport. On the other hand, road transport will be negatively impacted by congestion and because of the difficulties of expanding road capacity in cities and urban areas and the inability to provide sufficient parking capacity. Of course, the advantage depends also on the capacity (a full train is more efficient than a car driven by a single person) and the origin of the electricity used (renewable vs. fossil).

However, there is a fair chance that railways will at least not to fall behind other transport modes, if they are able to adopt technology which had been developed for electric road vehicles for railway use, thus saving substantial costs for research and development.

The money saved by tapping into the know-how of electric car manufacturers can be invested in creating and implementing railway specific solutions for the abatement of noise and vibrations. Lighter materials, composite brake blocks, noise-reducing bogies and other innovations will significantly reduce noise and ground vibrations to an extent where they are at least perceived as tolerable by the population. However, the long-term economic viability of the rail sector must not be jeopardised by these measures.

In 2008 CER adopted voluntary targets for greenhouse gas emissions. These were later developed and expanded in partnership with UIC to include targets to be achieved by 2020 & 2030 in addition to a vision for 2050. In December 2010 the UIC Regional Assembly approved the targets and vision for the four most important environmental impacts associated with the European rail sector:

- Greenhouse Gas Emissions (GHG),
- Energy Efficiency,
- Air Quality (PM & NO_x emissions),
- Noise and Vibration.

The first 3 items are supported by objective and measurable targets for which UIC collects data directly from European members and reports progress on an annual basis. To ensure credibility, these data are reviewed by external NGO's and shared with official institutions, including the International Energy Agency & European Environment Agency. A qualitative target was set for Noise and Vibration. All targets were developed following a thorough process of analysis and consultation and designed to highlight the sectors strengths. A very conservative approach was adopted to mitigate any risk of failing to achieve the targets.

So far good progress has been made. It is expected that all numerical targets will be achieved. The performance of the sector with respect to reducing Green House Gas Emissions has been so strong that in 2015 GHG targets have been recalibrated to reflect current performance and support credible positive communication.

Objectives

Rail is an essential part of the solution for how to achieve sustainable development and how to combat the increasing impacts of climate change.

The objectives in the field of sustainability can be summarised as follows:

- Contribute to the solution/mitigation of general environmental challenges (e.g. climate change, greenhouse-effect, CO_2 emissions.
- Solve/mitigate specific, railway induced environmental challenges (e.g. noise, vibrations).
- Find new and improve existent technical solutions to reduce energy consumption.
- Defend the environmental advantage of the railways against competing transport modes.

Enablers

Infrastructure

- Reduction of negative environmental impacts from materials.
- Closed cycle waste management systems for a high level of recycling.
- Concept to deal with the legacy of existing infrastructure (e.g. creosote sleepers).
- Concept to reduce pollution from rail sources (e.g. chemical treatment against vegetation) without compromising safety.
- Technology to reduce electromagnetic interference.
- Reduce overhead lines losses.
- Improve efficiency in substations.
- Thorough analysis of needs and requirements of member railways.
- Definition and continuous updating of common strategies for sustainable mobility and the environmental advantage of railways.
- Sharing of best practice.
- Cooperation with manufacturers.
- Cooperation with other transport modes.

Economic Sustainability - Fostering Affordability and Intermodal Competitiveness

▶ Vision

As mobility is a basic need of any population around the globe and also an instrument for the development of less populated regions, rail transport will offer the best value for money to provide such mobility, of course not compromising safety and sustainability.

Road transport might have appeared cheaper a few decades ago, as it does not require a costly infrastructure, but the ever increasing price of fossil fuel and rising concerns over CO_2 emissions will have considerably narrowed that gap.

Intra-modal competition, among railway operators, competition among railway suppliers and inter-modal competition will keep fares affordable even in countries with low per capita income.

Furthermore, technological developments in other industries (e.g. autonomous driving, asset intelligence) will be adapted to the railway sector thus opening the market to universal providers with mass production and interchangeability.

Global technical standardisation led by UIC will enable railway manufacturers to substantially increase their production lots, thereby lowering the costs of the single item.

The enhanced competition will make suppliers pass on the productivity gains as described above to their customers from the ROC.

As the ROC members are – even to a greater extent than the manufacturers - subject to competition, they too will have to pass on the advantage from decreasing purchasing prices to their customers, the consumers.

Such competition, however, requires a level playing field in terms of a defined level of quality, security and safety by a harmonised regulatory framework.

Whilst for a transition period such defined levels do not necessarily have to be the same worldwide, but can differ geographically,

there should be a long term global conversion of such standards. The best practices of other transport modes have to be taken into account, e.g. the global safety and security standards of the aviation industry.

As regards quality in terms of travelling comfort, there will be a differentiated offer of different comfort levels from highly individualised luxury to “no frills” mass transportation where the main selling point is the price of the ticket.

Past experience (e.g. the substantial drop in passengers travelling medium and long distances on Deutsche Bahn after liberalisation of long distance bus traffic in Germany in 2013) has shown that the competitiveness of a transport mode first and foremost depends on its price and that consumers show an enormous sensitivity to any changes in price relations between competing transport modes.

In the freight business this development has been even more drastic with a huge shift away from formerly thriving rail freight to road and waterways.

In order to increase competitiveness of railway services, it seems to be advisable to insert under priorities also the point on ’externalities’– it might have greater influence on the opinion of decision-makers and the publicity. The question of internalisation of externalities is mentioned below, however, it is not yet figured among priorities.

▶ **Objectives**

- Internalisation of external costs created by each mode of traffic in order to arrive at a fair level playing field for competition ("same constraints for all traffic modes regarding subsidies and taxes").
- Definition of performance indicators that help to identify the specific strengths and weaknesses of each mode of transport in order to achieve an optimised modal split.
- Monitoring of performance indicators, forecasts of social migration, forecasts of industrial development, etc., in order to contribute to the long-term planning of transport infrastructure by governments.
- Provision of more precise, specific and individual forecasts on decisive parameters based on the needs of the customer, what are their priorities for choosing their transport mode (time, price, frequency, reliability, availability ...).
- Standardisation approach for fostering interoperability along international railway corridors (e.g. Asia-EU-Freight corridors).

▶ **Enablers**

- On-line information and actual forecast capability for the entire transport chain.
- Management of complexity in interaction of multiple parameters in order to support dynamically the decision making for transport options as well as for changes in case of disturbances.
- Widely accepted criteria for measuring impacts of transport modes in order to adjust the regulatory framework for equal possibilities for all players.
- Creation of International Railway Standards (IRS).

Energy Efficiency

▶ **Vision**

Rail will provide an attractive and resource-efficient solution for sustainable mobility and transport and a significant contribution to reductions in greenhouse gas (GHG) emissions and dependency on oil.

▶ **Objectives**

Powering the rail system is a constant task whether it is for traction power or for heating, comfort, lighting and other such operational needs. The railway can profit of the most efficient and alternative sources of renewable energy.

Even though rail is a very energy-efficient and green transport mode, research is needed on energy efficiency and ecologic designs and implementation to improve further the performance of rail.

The management of the rail system for minimum energy use and better traffic management based on the development of new technologies will enable energy savings and a better efficiency of the overall railway system.

Rail should develop a system which consumes energy but within which operations also generate respectively recycle energy. Stations, terminals and other railway installations should use alternative energy sources wherever this is feasible for safe and efficient operation.

▶ **Enablers**

System

- Smart grids to aid adaptive feeding and eventually energy.
- Rationalised power supply infrastructure that provides monitoring, reconfiguration and management of the operational status of the electric subsystem.
- Sustainable energy procurement - careful consideration of environmental, economic and societal aspects.
- Monitoring, analysing and benchmarking the sector's emissions.
- Harmonising offered services (i.e. timetables) and energy management.

Trains

- Recovery of energy from trains (regenerative braking systems).
- Minimising energy consumption through energy efficient driving.
- Use of modular architectures.
- Optimisation of energy consumption of on- board equipment and functions (i.e. HVAC, parking...).

5.3 ASSETS AND SUBSYSTEMS

5.3.1 Rolling Stock

Vision

Energy and mass-efficient, high capacity and optimised LCC rolling stock will meet the evolving needs of its customers. Rolling stock will be critical for the provision of quality, accessible and reliable rail services as well as for the competitiveness of the sector.

The future generation of trains needs to be more efficient in order to reduce today's travelling times and to be less aggressive towards the track and on the environment, including noise and vibration and with lower LCC.

Faster, more reliable and flexible freight trains will be able to increase the reliability and cost-competitiveness of this market segment. IT systems that enable buying and selling of capacity in wagons and a reliable door to door track and trace of loading units and goods and real time information of the actual and forecasted train position will further attract the customer to rail.

The performance of the vehicles needs to be improved. Power trains will consume less energy, components will become lighter, standardisation of regenerative braking and recuperation of kinetic energy. New vehicles will be built to be recyclable and innovative materials will be used.

Objectives

There are many things that attract the customer to use rail but it is the trains themselves that are the focal point of the customer experience. Train interiors that are comfortable, pleasant and adaptable to the needs of different groups of users such as families, business travellers or people with reduced mobility, will encourage these customers to use rail over and over again.

For the operators too, to meet customer requirements and for their own business success, reliability, availability, maintainability and safety-security are the main requirements that shall match the expected – and promised – mission profile.

Trains should be sensitively designed to be staff and customer-friendly. This should involve the operator as a client in the early stages of the development so as to ensure design specification quality that is based on common rail sector standards for performances and quality assurance. The trains of the future will be built using a modular approach with components that can be easily interchanged on a 'plug and play' basis to maximise flexibility and reliability whilst minimising maintenance downtime. The modular approach shall dramatically reduce the cost of the developments, whose baseline shall become highly standardised, as in general the whole LCC.

Modular vehicle design will allow possible and low-cost upgrades during a vehicle's service life. This would respond to changing customer perceptions and requirements, business needs and usage and obsolescence mitigation - and thus be more sustainable.

Trains need to be self-diagnosing and transmitting information about (predicted) failures directly, in order to indicate which, when and where maintenance is needed.

Trains shall also introduce a number of relevant self-fixing functions to fully exploit their robust architectures and easily complete their mission to the next maintenance stop.

Increase of performances of the on-board systems and interfaces (train–track, train–energy and train-control command and communication system) shall be considered since the early stages of design. Rolling stock designs and operation need to be cost effective while taking into account the positive revenue of the investments according to the evolving marketing conditions of exploitation and maintenance.

IT systems that enable buying and selling of capacity in wagons and a reliable door to door track and trace of loading units and goods and real time information of the actual and forecasted train position will further attract the customer to rail.

For the freight customer, faster, flexible freight trains with performance similar to passenger trains are needed to enable rail to deliver the reliability and cost-competitiveness that are key to exploiting market segments until now largely untapped by rail.

They would also support improved capacity utilisation of the network.

The improved technologies for coupling, power distribution and braking will facilitate long and heavy freight trains between mega hubs on main transcontinental freight corridors.

Enablers

General

- Full application of common requirements management (shared functional specifications).
- Common International Railway Standards (IRS) for the functionalities and performances in the development phase of rolling stock.
- Standardised and modular architecture to facilitate interoperable infrastructure and operation.
- Sational energy management on trains.
- Environment friendly technology (e-mobility, low noise).
- Use of mechatronic technology to improve rolling stock standardisation of functionalities.
- Fitness for redesign and sustainability, i.e. modular white box approach and design-sensitivity against obsolescence: long-term stable standardised interfaces (mechanical, electrical, data, performance, etc.) inside rolling stock, between vehicles and with the infrastructure interface.

Freight services

- Better brake performance.
- Introduction of central couplers for easier assembling and reduction of pull and stress forces between wagons.
- Distributed traction power.

Passenger services

- New design concepts for future trains which will introduce improved safety and comfort for basic passenger subsystems: door, air-conditioning, lighting, toilets.
- Tailor-made on board passenger information management; predisposition for new services and, new commercial offerings.

5.3.2 Infrastructure

Vision

Infrastructure should be able to offer a level of performance, which guarantees traffic flows with minimum disruption, based on high levels of operational availability, safety and security.

This must be achieved at optimum life cycle cost, necessitating effective maintenance, planning and asset management.

The rail system will support vital Global rail corridors and co-modal links with other continents – a practical demonstration of the technological and operational innovations that have made it a global leader.

Interoperability will ensure trains cross state and operational borders without delay or operational constraint, offering a smart and competitive alternative to short and medium-distance flights and water and road-borne freight flows.

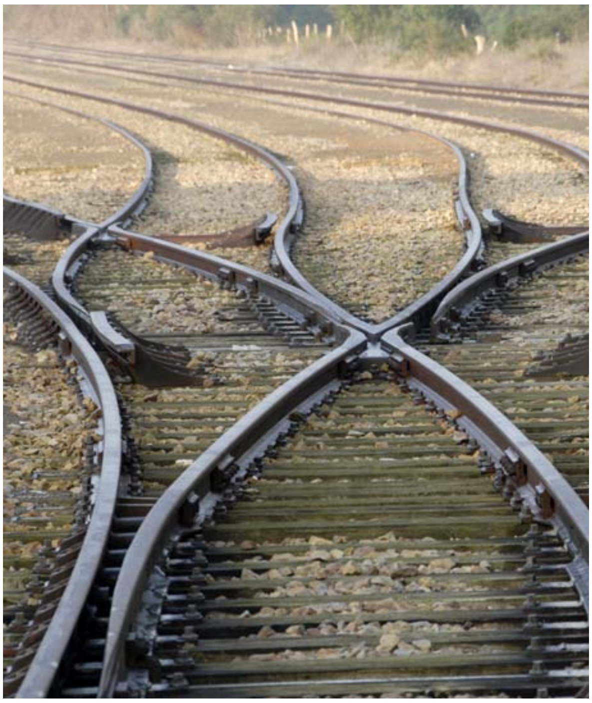
Building on expertise from within the rail sector and from other modes, network infrastructure availability will be developed to a high level and is resilient. This will be measured by performance regimes for passenger (included high density, high speed and conventional traffic) and freight traffic.

Bringing together innovative technologies and concepts, the design, construction, operation and maintenance of network infrastructure shall be more reliable, safe and secure, supportive of customer needs, cost effective, sustainable, adaptable to future requirements, automated and resilient to hazards.

Stations and terminals will be designed to meet the needs of the future customer and are the cornerstone for the provision of quality, accessible and reliable rail services and sector competitiveness.

Objectives

Rail system infrastructure must be designed to be intelligent (i.e. develop from being a passive to an active railway) and safe. It should adopt relevant infrastructure technologies from other sectors. Intelligent infra-



structure will be fatigue and wear resistant as well as energy efficient; system components will be monitored autonomously in real time. The use of new operational and track engineering techniques across the network will reduce the need for intrusive maintenance and greatly improve the train/infrastructure interaction at conventional and high speeds such as the wheel/rail interface.

Understanding and management of rail contact fatigue, including the investigation of the influence of traction unit slip control, rail re-profiling, rail lubrication and friction modifiers will facilitate a system that is designed to optimise maintenance intervals and be cost-beneficial.

A focus on intelligence provided by the system (remote condition monitoring), will enable the establishment of what, when and where maintenance is needed. This will ensure that there is low impact through system interruption and maximisation of product availability to the customer.

Asset management tools will be developed that allow comparison of maintenance and/or replacement strategies for track and infrastructure based on traffic levels and whole life evaluation.

The future freight terminal must be designed for swift throughput and loading and unloading of trains.

The freight customer must have easy access to terminals. Optimising processes for train preparation will reduce the noise and vibration from terminal operations and increase efficiency.

The railway should be operated on a "forever open" basis. Passenger stations should be adapted to new information needs. Ensuring that rail has "always informed passengers" will be facilitated by new IT capabilities, removal of barriers (between modes, between stations and the city) and maximising the role of stations in the city and in the transport system.

Enablers

For all infrastructures assets:

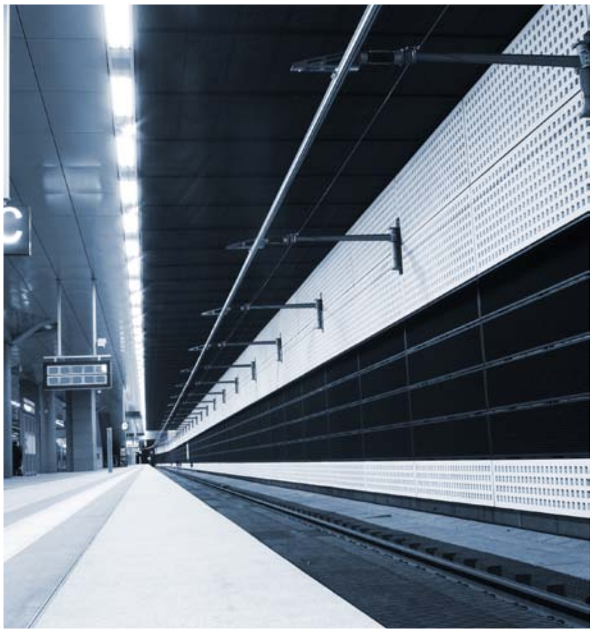
- Asset management friendly components, sub-systems and systems... regarding a global "system" point of view specific to each typical sub-network (high density passenger lines, high speed lines, regional lines, freight corridors and mixed conventional lines)
- Optimisation of maintenance planning and scheduling
- Cross-modal transport infrastructure management systems
- Security of infrastructure materials and components
- Overcoming infrastructure limitation to heavy and long trains
- Non-intrusive infrastructure monitoring
- Modular "plug-and-play" design of infrastructure
- Use of wireless progressive telecommunications to enhance operation, maintenance, passenger support and make possible intelligent trains and stations
- Development of technologies for facilitating the operation of services between systems with gauge differences – speeding up the changeover process

Track and Structures

- Future ballasted or slab track systems with improved performances. Both technologies have their advantages, for both HSL or passenger lines and freight corridors
- New developments and concepts for switches and crossing
- Innovative ballasted and non-ballasted track-form designs
- Optimised noise and vibration control
- New methods of clearance measurement taking into account the maintenance operation of the structures and/or the tracks

Station and Terminals

- New design concepts including universal accessibility and ageing society needs: Functionality, space management, information, way-finding, lighting systems, connections to other modes, people-friendly, train/platform interface
- Station management in the new passenger-centric perspective: balancing passenger satisfaction, commercial interest, rail operation and conserving the cultural/architectural heritage of stations
- Development/adaptation for rail of more efficient and proactive technologies and processes for station security



5.3.3 Control, Command and Signalling (CCS)

Vision

Infrastructure should be able to offer performance, which means guaranteeing traffic flows with minimum disruption, based on high levels of operational availability, safety and security.

This must be achieved with more effective maintenance, planning and asset management.

The network will be engineered for resilience and optimised by interoperable real-time traffic management that allows for intelligent, predictive and adaptable operational control of train movements, maximises system capacity and saves energy. In addition to "interoperable" systems it is advisable to use equipment designed upon "open architecture" principles that allow products from different vendors to communicate with each other.

Intelligent combination with other technologies, in particular satellite technology should in any configuration or sub-network and in combination with coherent trains function (train completeness…) reduce the costs of the signalling systems whilst assuring a right level of safety.

Due to the convergence of the signalling systems worldwide railways will be able to choose from a variety of manufacturers. Global competition will bring about moderate prices and high quality levels. Of course, this can only be the case when "signalling modules" and their interfaces (functional, time and physic aspects) have been formally defined, as well the regarding "operation principle" and "degraded mode" management rules.

Objectives

CCS development will go beyond being only a contributor for the safe separation of trains and become a flexible, real-time intelligent traffic management system. Enabling this to happen is a key aspect of future innovation within the rail sector.

In this sub-system as in others, rail will investigate the use of technologies developed in other sectors to identify where they can be adapted for railway use. This will allow access to more widely available components and lead to reduced costs.

The concept where trains can be run at very close headways, such as moving block and through the concept of convoying, is already understood. However, this has only a limited application to date; making this happen for rail and developing it to an even more innovative practice would enable optimal capacity and rail system utilisation.

Enablers

For all signalling assets:

- Asset management friendly components, sub-system and systems, regarding a global "system" point of view specific to each typical sub-network (high density passenger lines, high speed lines, regional lines, freight corridors and mixed conventional lines)
- Cross-modal transport infrastructure management systems
- Safety and security of signalling infrastructure materials and architectures regarding the right security and safety management system
- Overcoming signalling infrastructure limitation to heavy and long trains
- Non-intrusive signalling infrastructure monitoring
- Modular "plug-and-play" design of signalling infrastructure system architectures
- Use of wireless progressive telecommunications to enhance operation, maintenance, passenger support and make possible intelligent trains and stations

Signalling and traffic management systems

- Signalling and traffic management systems should be sensitively designed to be staff and customer-friendly. This should involve the operator as a client in the early stages of the development so as to ensure design specification quality that is based on common rail sector standards for performances and quality assurance. These infrastructures of the future will be built using a modular approach with components that can be easily interchanged on a ‘plug and play’ basis to maximise flexibility and reliability whilst minimising maintenance downtime. The modular approach shall dramatically reduce the cost of the developments, whose baseline shall become highly standardised, and in general the whole LCC.

- Considering the future digital signalling infrastructure, there is an imperative need for “open functional software” (“open model” interpreted able in real time vs. “open source” specific to each suppliers choices) as the preferred choice will significantly improve software quality and robustness as a main safety contributor. Each future computerised modules should be seen by each IM or RU as a “functional white box” (e.g. formal computerised module functions exhaustive description) that allow to facilitate the functional validation and safety demonstration (obligation of result and no more only obligation of means).
- Open functional software (“open model” formal provable) as the preferred choice will significantly improve software quality and robustness as a main safety contributor. Each future computerised signalling modules should be seen as a “functional white box” (e.g. formal computerised module functions exhaustive description) that allow to facilitate the functional validation and safety demonstration (obligation of result and no more only obligation of means).
- Improved interfaces for the CCS sub-system:
  - Rolling stock: on-board equipment that receives the messages from the CCS system will have to have standardised modular structure with most components easily exchangeable and interchangeable
  - Infrastructure: this requires clear and comprehensive system architecture for future command and control systems
- Implementation of a “system engineering approach” to systematically develop standardised systems. This will be a breakthrough for the railway sector: system engineering approach isn’t the management by exigencies used today
- Use of **formal methods** for supporting the development of the specifications for future generations of train control equipment and other sub-systems, as well as their functional validation on site. This will be a breakthrough for the railway sector: test on site or in lab for modern signalling system can no more give expected right safety level
- Wireless data transfer as confirmation of train completeness.

For railway monitoring:

- Remote obstacle detection especially on plain line and covering threats that the signalling systems cannot detect.
- Standardised approach to remote diagnostics maximising performance and reducing maintenance and operational costs.

5.3.4 Information Technology

Vision

The railways will develop a coordinated approach to the management of the information needed to run the operational system and keep customers informed about their journey and services available.

New revenue streams are based on improvements in the service to the customer, the exploitation of rail information and reduced operating costs.

Objectives

Delivery of a quality product to the customer depends on the provision of reliable information to the operational and maintenance staff. The information needed is, by and large, currently available but it is the process of bringing it all together and tailoring it to the customer that will provide value.

Customers of information are not only passengers and shippers - there are also internal customers.

Rail must be able to embrace all the varieties of information coming from the use of new technologies and to encourage the design of standard systems architecture and the integration of information systems throughout Europe. It must be capable of managing information over the life of assets, which varies a lot and can be several decades in some cases.

Real-time linked data and services published by everybody and everything on the web should be used to generate smart solutions to mobility problems of both passenger and freight operations.

Customers should enjoy continuous access to their personalised journey information systems and all freight be traced and tracked in real-time through all stages of transit, whatever the mode.

Data and business intelligence will play an important communications role, not only for broadcasting vital operational information to customers, such as train delays, but also for providing targeted offers and services to all customers. It is important that the customer

has clear and reliable information, whether it is about fares and tariffs or alternative arrangements during service disruption.

By tailoring IT solutions, rail can be able to create a specific customer experience; by aggregating and analysing customer data (within the limits of data protection laws) it can identify trends and opportunities for new products and services.

Passengers must be able to enjoy seamless origin-to-destination journeys in a comfortable, safe and secure environment, reassured by the availability of real-time traffic and whole-journey information that keeps them abreast of their varying alternatives including inter-connection with other modes, should problems arise with their journey. Rail services will adapt to customer needs, be attractive and easy to use.

The systems used by rail will allow passengers to plan easily the most cost-effective, time-efficient and convenient co-modal journeys.

Enablers

- Shared information platforms and robust IT tools that make possible real-time data exchange between rail service providers and other transport modes.
- Production of common interface standards to ensure that the customer experience is seamless.
- Coherent management policies and protocols, together with the clear identification of data owners and development leaders.
- Support for the real-time management of a system that is resilient to external influences.
- Customer experience applications developed for both passengers and freight, and brought to the customer by a vibrant competitive market of innovative, independent suppliers.
- Access to continuous high speed data, allowing passengers to treat their journey as a seamless extension of their working or leisure environment.
- The concept of the end to end journey applies (journey/shipment planner, seamless/contactless ticketing/tariff arrangements, journey/shipment tracking).
- Seamless ticketing without queues or physical barriers at stations.
- Electronic systems (smart phone etc.) for revenue collection and security controls based on electronic systems.
- New information technologies on board trains and at the station.

5.4 HUMAN RESOURCES

5.4.1 Vision

The concept of the "forever open railway" depends on organised, reliable, well trained and professional people who enable the efficient operation of the system.

The railway sector will be considered as one of the most attractive employers and the products and services it provides will depend on skilled, committed and adaptable people delivering an efficient and customer-focused railway.

The rail sector will be able to further improve its attractiveness for personnel who are highly motivated and committed to providing a modern, flexible and crucial service.

5.4.2 Objectives

As the pace of technological and technical changes accelerates, there must be a culture of continuous improvement, effectiveness and putting the customer first. People working in the rail sector must be equipped with the necessary skills to cope with the new technologies and techniques.

Technology advancements are designed to take account of the increasingly scarce human capital on the labour market. Future designs must consider the skills and capabilities available as well as demographic trends.

It is essential that rail is run as a system and so it is important that its people understand and adapt to new working practices, for example adopting the concept utilised by "High Reliability Organisations".

Developing the commercial and customer service skills of railway personnel is essential for attracting customers to use rail services.

The railway sector should therefore champion and develop technical railway schools. It should actively support the push for better gender balance in technical professions. Enterprises acknowledge the importance of investing in the personal development of every member of staff throughout their career to promote continuity in organisations and continuous quality improvement.

As the railway sector works increasingly in a business-like manner, it should benefit from a larger set of transferable skills. It needs to ensure that it has arrangements in place to draw upon a broader pool of skills from other sectors.

Rail must also utilise the expertise of universities, schools, industry etc. to offer best education/training opportunities for railway people to stay in or to enter the business and increase their knowledge. The staff on the other hand must embrace the concept of "lifelong learning".

5.4.3 Enablers

- An international education platform for all levels (young professionals, experts, senior and top management) offering tailor-made programs that cover the needs of the sector to reduce people costs at company level.
- A coordinated standardisation framework and a network of best practices to reduce the cost of implementing new products.
- Research institutes, industry and the ROC are used to develop good products and import best relevant practice based on activities from other sectors/industries.
- Product/concept deployment strategies that include explanations of the system and human impact and how to implement the innovation with human resources/ existing knowledge.
- Modern IT-based knowledge management systems to preserve and spread relevant information about railways and to structure and guide decentralised coherent collaboration, e.g. requirements management.
- Assessment of the skills requirements for the future railway.
- An open and balanced collaborative process for the recruitment and transfer of staff.
- Improved learning methods to maximise benefits from new technology and roles designed with people in mind and a clear idea identification of the user and what is her/his need.
- Automation of repetitive and arduous tasks wherever possible and holistic management of the interface between man and machine.
- Elimination of language barriers as one of the basic requirements towards further improvement of traffic control system.
- Elaborate certain techniques to develop communication skills between train staff and traffic operating departments and the dispatching officers.

6. TOOLS FOR CONTINUOUS IMPROVEMENT OF THE RAIL SYSTEM

6.1 EDUCATION AND TRAINING

The purpose of training and education efforts is to contribute to the enhancement of the rail sector by fostering a better match between the human resources needs to make railways a more competitive and innovative sector and the offer of skills coming out of the various research based education and training institutions.

A partnership for innovation, skills development and jobs is envisaged to mobilise support and getting the different players to work together in a collective effort to spread ownership and excellence.

Knowledge-transfer from other sectors is a key aspect for the future of rail transport in a cross-sectoral approach: even though partnerships may be assigned to a specific sector, they often work across different business sectors.

Lifelong learning will be a well-accepted practice for professional development throughout a professional career. Staff will be prepared for technology transitions and involvement in professional situations with a strong interdisciplinary nature, involving technology, economics and business, people and regulatory and policy contents.

Learning programmes make full use of current virtual learning environments and e-learning technologies to explore networking of specialists and introduce newcomers and specialists to real operational situations.

The following objectives can be identified:

- Forecasts of the skills that railway will need and analysis of gaps in skills,
- Enhance and expand educational access to railway courses,
- Enhance educational quality in the railway area (academic, stakeholders),
- Create mechanisms to put forward courses not offered by existing institutions,
- Develop e-learning based courses and promote the production of course materials,
- Promote Joint PhDs using bilateral and multilateral programs,
- Promote joint international MSc programs in different rail related areas,
- Develop and deliver short training courses (STC).

6.2 STANDARDISATION

A successful future railway system needs its assets to be of high performance and meet the criteria of reliability, availability, maintainability and safety (RAMS). The service to the customer has to be adapted to contemporary expected functionalities performance and sustainability.

This will be ensured through the development, publishing and implementation of excellent standards by the sector, including both industrial standards for the design of the components and ROC standards for the definition of the system functionalities, performances, operation and maintenances. Both families of standards, written in a regime of complementarity and harmonisation, define completely the railway system and are suitable for the delivery of railway services. Any avoidance of double work is thus assured. Maintaining and improving these standards in accordance with business needs, customer expectations and the provision of a positive travel experience will demonstrate the competence and the responsibility of the Railway Operating Community (ROC) in collaboratively developing and continuously improving the rail system, so as to allow it to meet the challenges of the future.

The targets of the railway for standardisation thus fully takes into account the context of promotion of technical cooperation, the exchange of best practices and experiences, the coherent worldwide development of the railways according to a full system approach and the improvement of the fundamental values like safety and interoperability.

The global dimension of the railway system and market pushes towards an international approach to railway standardisation to support of the above mentioned needs of the Railway Operating Community and contribute to assure the convergence of the continuous improvement of the sector.

The International Railway Standards (IRS's) take into account these concepts and also their worldwide applicability when some specific characteristics of the railway system are to be considered, like the efficient amortisation of investments, the creation of sustainable transitions between system configurations in actual operation and the optimisation of available developments.

It is very clear that railway standardisation cannot and will not be a panacea, neither for manufacturers nor ROCs nor even for the legal framework because the ROC is and remains the railway system integrator and the entity which is legally responsible for the provided services.

This state of the art arrives well before any other consideration of opportunity, because it is inherent to the railway service.

For this reason railway standardisation cannot be done only by manufacturers, because they sometimes tend to pursue strategies which fits neither with the expectations of the railway customers nor with the sustainability of the ROC.

If, for example, a manufacturer succeeds in making a unique feature of his product become a requirement in a standard and this standard also happens to be relevant for an authorisation procedure for putting into service the item in question, this particular manufacturer has obtained – at least temporarily – a monopoly.

Apart from its function as a strategic tool to defend or improve his market share, sometimes manufacturers see standardisation primarily as a means of reducing his costs of production. Consequently, in the lifecycle of a product he will mainly focus on the phases of production and "after sales", i.e. the warranty period, whereas a member of the ROC is interested in the entire life cycle. The longer the lifecycle of a product, the more this difference in priorities becomes visible. In the case of products with very long lifecycles which characterise the railway business, it is therefore essential to ensure that the ROC's perspective is adequately represented in the relevant standardisation working groups.

In view of the strategic importance of standardisation for their market share and its high impact on the costs of production the manufacturers regard standardisation as part of their core business and invest accordingly. The ROC, for which standardisation is not a part of its core business, cannot compete with the manufacturers in terms of budgets and manpower and therefore often finds itself dominated by the manufacturers in the working groups of the general standardisation organisations. In this situation it is of strategic importance to have with the UIC a competent railway standardisation organisation where purely railway business driven requirements are set up and which can offer the platform for a mirror group to coordinate the interests of the ROC, enabling them to discuss standardisation issues with the manufacturers "on eye level".

The changed context in the domain of railway standardisation have induced UIC to revise its standardisation approach.

The traditional *products* - the UIC leaflets - are evolving to be more closely and efficiently integrated with other recent standards and regulations both at regional and worldwide (international) level.

IRSs are geared to complement other standards issued by other Standardisation Organisations and so they consider the vision of the different stakeholders.

The main documentation source for IRSs are the updated UIC leaflets; nevertheless other standards or research and innovation project results are also taken into account and are referenced in the development of IRSs.

The Cooperation Agreements with the other worldwide standardisation organisations ensure proper alignment of programs, work and development with existing standards at regional or global level.

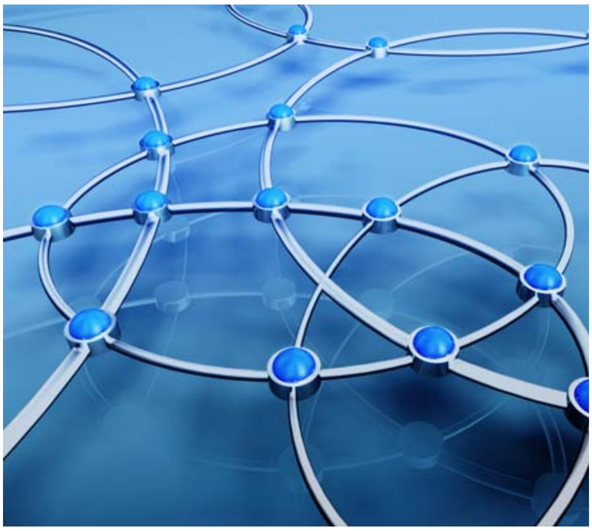
IRSs must always be in line with the law. For instance IRSs respect and are continuously checked to ensure they are compatible with ERA documents or European legislation and other relevant texts.

Standardisation does not necessarily stifle innovation, at least to the extent that a standard does not require a certain technical solution.

On the contrary, standardisation is also a suitable dissemination tool for the results of technical research projects. New standards might emerge from research even though service proven solution should be given priority.

Standardisation is the best way to provide the opportunity that the results of a research project are quickly and competently implemented.

Furthermore, standardisation can potentially help the creation of economies of scale, reducing unit cost and thus substantially reducing the cost of railway subsystems worldwide.



6.3 RESEARCH AND INNOVATION

Rail should strive to create an ecosystem for innovation involving excellent research institutions, vibrant companies devoting time and energy to R&D and demonstration activities. The innovation chain from blue-sky research, applied engineering up to demonstration (roll-out/deployment) must be addressed at international level by bringing together critical technologies in new advanced designs, feasibility proof at concept levels as well as demonstrations and roll out efforts.

Cost and technology drivers as well as societal expectations (e.g. user rights, new markets, security, and environment) are to be considered. Several key thematic areas can be identified where there is still scope for knowledge creation and subsequently progressing to technology developments in higher levels of technical readiness. High capacity Infrastructure, sensors, energy storage and smart grid technologies, high-capacity modular Rolling Stock with efficient new generation braking and bogie designs, use of lightweight materials and information systems to improve customer services and reduce life-cycle cost are just examples with a strong potential for innovation.

Excellence in customer oriented railway operations and services, environmental gains and intermodal competitiveness call for the stakeholders of the railway sector to set out for each rail market segment the appropriate business visions making use of current technical experience and future knowledge and capabilities to deliver those aspirations.

Research should target the adoption of a sector-wide framework supporting the implementation of change and subsequent improvement to reliability, availability, maintainability and safety (RAMS). This will be a significant step towards a consistent and robust rail system.

Research and innovation should also address new operational and assets management and engineering techniques, allowing to monitor autonomously in real time intelligent infrastructure, rolling stock and other system components, and to maintain infrastructure safely as a result of greater reliance on state-of-art automated intervention methods. This will also help to maximise the effect of maintenance budgets for assets by renewing assets with optimised timing and methods.

The following enablers for successful research and innovation can be identified:

Managing research and development

- Support the long-term vision, strategic objectives and the innovation agenda with updated rail business scenarios.
- Update and improve the research and innovation roadmaps by defining research priorities, milestones in technology breakthroughs leading the research agenda around specific thematic areas and also taking account of the whole rail system dimensions.
- Identify business prospects and promote market uptake: ensuring real/proper market uptake of the technology, operations, services, business models developed in the research project. Clearly identifying the customer/implementer, the surrounding conditions for the business implementation and the mechanisms to close the gap between the end of project and market readiness.
- Establishing and further refining a coherent knowledge management that creates links between technical requirements and consequences of such requirements in terms of opportunities, risks and cost.
- Provide information on the availability and range of funding sources and of potential new resources for funding transport facilities.

Nurturing cross-discplinary cooperation

- Provide access to industrial expertise and promote knowledge transfer processes from academia and research institutions through specific coordination actions and research based training and education initiatives.
- Foster collaboration and joined-up thinking by facilitating sustainable partnerships involving the sector, SMEs, academia and R&D institutions.
- Facilitate cross-fertilisation from other sectors.

6.4 ASSET MANAGEMENT

6.4.1 Vision

The discipline of Asset Management is now considered by all railways as a 'mainstream' expectation for competent organisations. It draws from both business and financial management and also from technical, engineering, operations and maintenance management.

The longer the lifecycle of the assets in question and the higher their value (as it is typically the case in the railway business), the bigger the potential for significant benefits and added value to be gained by any organisation or business that chooses to apply Asset Management properly. Asset management is targeting an enhancement of the value of an assets portfolio by purchasing- selling actions.

In the railway business Asset Management comprises all systems, methods, procedures and tools to optimise costs, performance and risks for the complete rail infrastructure life cycle.

However, there is no reason not to apply Asset Management also to rolling stock or infrastructures, which can also have lifecycles of up to fifty years and even more.

The aim is to realise the best 'value for money' by meeting stakeholder interests, finding a balance between the requirements and the overall cost and creating full transparency.

Relevant aspects are: Focus of the organisation on the company mission, its shared values, leadership and communication, Information and knowledge management, risk awareness, long-term vision and the presence of adequate instruments.

Asset Management provides the techniques for converting the fundamental aims of the organisation into the practical implications for choosing, acquiring (or creating), utilising and looking after (maintaining) appropriate assets to deliver those aims. And we do so while seeking the best total value approach (the optimal combination of costs, risks, performance and sustainability).

Asset Management gives any interested organisation the knowledge and tools to use chosen assets to achieve its purpose. Moreover, these techniques and processes allow such an organisation to demonstrate that it is managing its assets optimally – often of great interest to many stakeholders, whether owners, customers, regulators, neighbours or the general public.

In the field of railways infrastructures, Asset Management tends to preserve and enhance the railway network in order to make the best of it:

- Public policies underpin this scheme: which strategy for the network?
- The time target is necessarily middle, long or even very long-term as long as the sustainability of the network - or a part of it – remains secured.
- Therefore Asset Management consists of driving the implementation of the network strategy under financial constraints, while minimising the life cycle cost.

We can summarise as follows, Asset management is prescribing technical frames of reference and undertaking maintenance (upkeep and regeneration), to ensure prescribed performance is achieved, within resource constraints, route by route (sub network by sub network), keeping overall possession costs to a minimum.

6.4.2 Asset management in practice in the railway domain

Main goals and targets of Asset Management:

- Systematise and professionalise asset management such that railways achieve the best practices seen in other asset intensive sectors.
- Develop specific methods and tools that will enable IMs to take and implement better decisions that will deliver the required infrastructure outputs for the lowest whole life, whole system cost.

Targets:

- Define a common, railway specific, framework for asset management activities based on the most widely adopted asset management standard.
- Develop methods and tools to support a wide range of asset management decisions e.g. optimised maintenance and renewal strategies.
- Foster exchange of asset management good practices in member organisations and other sectors.
- Develop understanding of key cost and performance drivers to support benchmarking.

Asset management in practice:

- Asset management is the art of striving for high performance in a context of shortages (constraints) – managers of resources do not have an overview of all shortages.
- What is meant by "shortages" and in which sectors:
  - Human resources, competent and available personnel, in-house and external,
  - Monetary resources and funding,
  - Operational constraints (work possession bands, train-path access...),
  - Environmental constraints (access to tracks...),
  - Material and tooling resources.

This is particularly complex as regards infrastructure as the rail network never sleeps (the asset manager is like a surgeon who has to operate, with the operation being carried out on a "living" body, the rail network).

Stakeholders in each situation of shortage (of resources) are different and do not link up with each other "naturally":

- State => funding in €, continuity, long-term view... But no precise vision on questions of capacity and industrial fabric,
- Operation and access to the network => capacity, TSL possibilities (non-permanent speed restrictions),
- Maintenance and works => personnel, technical means (specialised equipment, service providers...), implementation, state of assets...
- All => safety of traffic and staff, and of future network...

It is a question of making these resources available within a "unique time and space". Project management must be able to synchronise resources and planning. Sales operations continue during work, with inevitable repercussions on capacity! Therefore, governance is needed!

Demonstration tools:

Asset management has a need for tools to simulate the future/demonstration tools. Simulations enable the asset manager to respond to the need to:

- Represent and assess each possible scenario objectively, with regard to the management authorities (in-house or external financing), the condition of the installations, the performance, the quality level and the associated costs/in order to break with received opinion (a renewal scheme can always be put off to tomorrow but maintenance costs generally remain constant....),
- Anticipate the different possible outcomes, according to various scenarios,
- Set priorities for the action to be taken (within the constraints) in accordance with the network strategy,

- Evaluate the impact (to a greater or lesser extent) of the various possible technical strategies/to not follow the "fashion" or yield to pressure from the industry (lobbying, black box...).

For simulations, it is necessary to know the condition of the network, its usage, failure modes and the implications of failures:

- Description of assets, usage, environment, established strategic objectives,
- Feedback from past experience, in particular regarding new designs and components,
- Laws of asset behaviour.

Simulations enable assets managers to "clarify strategy regarding the consequences of their choices." Insofar as they are maintainers they will have to take responsibility for their choices! The need for tools to simulate the future/demonstration tools:

- The strategy of the Asset Manager = to assist owners to make to right strategic choices (define their strategies) – without directing them by advising them, while encouraging them to face their responsibilities",
- "To be capable of stating the consequences of not acting", calmly, without rancour, to be capable of comparing the different possible scenarios (not to "convince" with any sense of overcoming, winning, but to clarify the possible decisions, explaining calmly and clearly).

Governance:

Asset managers continually have to make both short- and long-term decisions:

1. They need to have:
   - a technical and economic strategy for the network,
   - macro and micro work scheduling,
   - control of choices of investment and renewal techniques.
2. They must anticipate all aspects of issues related to the management of constraints:
   - choice of routes where optimum performance will be ensured, fixing of resource and technical choice priorities on other routes according to the implications of failures,
   - structural measures such as definition of designs, functional boundaries, optimum interfacing between maintainer and traffic, to facilitate subsequent maintenance and operation.

⇨ It hinges on three processes: strategic and financial; according to route and node capacity; industrial with different stakeholders: the state, railway undertakings and organising bodies, sub-contractors, partners, ourselves...

And so the necessary conditions are there but not to a sufficient extent to ensure the function of the asset manager includes:

- Strategic and financial processes ensuring a long-term vision, in terms of network performance and renewal paths (time frames longer than 5 years),
- Stabilising the impact of maintenance and work route by route on a 5 year time frame,
- Stabilising production needs over a 2-3 year time frame.

The conditions are necessary but not sufficient. Each railway should work on:

- Aligning stakeholders on these different time frames,
- Flexibility in 5-year programming,
- An iterative process of hypothesis revision in order to adapt the short and medium term permanently to any hiccups.

It is clear that the control of technical choices (in investment and renewal) should allow the impact on capacity, operational modes and LCC to be defined and so be integrated into these processes. These technical choices should be directed towards bringing greater flexibility to future operations.

Example: rapid follow-up densely populated area: the production optimum is for 3 or 4 hours of work per night; choice of ballasted or ballast-free track according to the network topology.

Applied to the railway system Asset Management needs to be:

- Multi-disciplinary, i.e. cross *departmental and discipline boundaries*, focusing on net value-for-money to allow comparability,
- Systematic: rigorously applied in a structured *management system,*
- System-oriented: looking at assets in their systems context, based on their net total value,
- Risk-based: incorporating risk appropriately into all *decision-making,*
- Optimised: seeking the *best compromise between conflicting objectives*, such as costs versus performance versus risks, and short-term versus long-term impacts,
- Sustainable: plans must deliver optimal asset *life cycle value*, including ongoing system performance, environmental and other long term consequences,
- Integrated: at the heart of good Asset Management, value (and value-for-money) must reflect the mix of stakeholders and their expectations, and the best way of satisfying these potentially competing expectations with available funding and any absolute (e.g. legal) constraints.

The way to a good Asset Management system for railway assets is the clear connectivity between the organisation's strategy on the one hand and the day-to-day activities of individual departments (planning, engineering, procurement, operations, maintenance, performance management etc.) on the other hand.

6.5 OPERATION AND CAPACITY MANAGEMENT

The next generation of railway operation management should produce a step change in capacity in order to enable the railway system to accommodate a substantially increased passenger and freight traffic.

In order to achieve this aim the main areas of research and development required are:

- A better understanding of the range of operational strategies that are available, or should be developed, for considering the trade-offs and outcomes when different strategies are employed; for example consideration of the varying strategies for interweaving slow freight trains between regular and high speed passenger traffic. Approaches should be formally documented for wider dissemination and advantages and disadvantages should be logged.
- Development of models and simulators that help planners understand the implications of different operational strategies in terms of: capacity generation, traffic flow, resilience to perturbations, ability to recover from disturbance. Such tools are particularly important when operating railways at high capacity.
- Approaches, the majority of which will be fully automated, that help planners decide on optimal strategies to increase capacity, as well as being useful for real-time punctuality management.
- Research that focuses on the data systems that are able to provide ubiquitous data on train position and state that enable automatic decision support systems and operations and planning staff to make better decisions.
- Increasing capacity by better methods for timetable planning and operational traffic. Research in timetable planning and operational traffic can be subdivided into the following areas:
  - Capacity definition and methods,
  - Capacity on a strategic level (infrastructure planning),
  - Capacity on a tactical level (timetable construction),
  - Capacity on an operational level (real-time traffic management).
- To analyse and evaluate capacity of infrastructure and new traffic systems. This concerns models for analysis of railway capacity, and the use of available capacity within strategic planning (long-term infrastructure construction), tactical planning (yearly timetabling) and operative planning (daily dispatching). The task is to review existing models, both proposed in the literature and commercial models used by infrastructure managers.

6.6 PROCUREMENT AND QUALITY MANAGEMENT

Quality problems of the manufacturers of railway material directly concern the ROC as the passenger or freight customer usually does not care about the cause of a delay but will put the blame on his contractual partner, the operator.

Therefore, it is legitimate that railway operators and infrastructure managers try to impose quality standards and quality management measures on their suppliers in order to ensure a constantly high level of product reliability.

Excellent and state-of-the-art product standards (see 6.2 above) constitute a necessary, however not sufficient precondition for an excellent product. It must be also ensured that the manufacturer's production process constantly and continuously generates products of the desired quality.

Manufacturers of railway material have set up a worldwide quality management standard named IRIS (International Railway Industry Standard), which is supposed to support this goal. However, as IRIS is "owned" and managed by the manufacturers themselves with only very few railway undertakings on the supervisory board, there are not sufficient possibilities for the ROC to influence the modus operandi of IRIS according to their business needs.

Instead, almost every railway undertaking has its own quality management and supplier qualification process. The fact that one supplier has to undergo such process separately for each major customer makes railway material unnecessarily expensive. There is a considerable savings potential if manufacturers would have to comply only with one uniform quality management system.

In order to be acceptable for the ROC, such quality management system would have to fulfil two main preconditions:

1. It should be jointly controlled and managed by suppliers and ROC on an equal basis.
2. It should allow modifications and "add-ons" by individual companies in order to meet their specific business needs.

It is obvious that the last precondition constitutes an additional cost driver and it is the strategic decision of each buyer demanding such "add on", if the added value of this additional or modified quality control measure justifies the resulting increase of the purchase price.

A basically harmonised quality management system would have the advantage of allowing coordinated research activities of suppliers and ROC with the aim of making the quality management process more efficient, thereby improving product reliability, lowering costs and making railway transport more attractive for the end-user.

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