THE FUTURE RAILWAY
THE INDUSTRY’S RAIL TECHNICAL STRATEGY 2012
SUPPORTING RAILWAY BUSINESS
TSLG is an RSSB-facilitated cross-industry expert body made up of senior executive staff, charged with developing and championing implementation of the Rail Technical Strategy, supporting communication, managing strategic research, identifying opportunities, barriers and actions.

TSLG engages with the Rail Delivery Group (which endorses this strategy) and with other industry groups with a leadership role including the Planning Oversight Group and National Task Force. TSLG’s remit and terms of reference are agreed by the Board of RSSB.

TSLG members
The railway industry in Great Britain is undergoing a renaissance, with growth in passenger and freight custom to levels not seen for almost a hundred years. The industry is responding by providing ever better levels of service, underpinned by investment in trains, stations, infrastructure and service provision. At the same time, it is improving its financial performance and efficiency so railway users and taxpayers get better value for money.

To support this drive for improvement, the industry has developed this technical strategy, which describes a range of solutions to its principal technical challenges over the next thirty years. In doing so, it offers the prospect of a radical transformation of the technical landscape of the railway. This technical improvement is not an end in itself, but a means to secure the railway’s business base and to provide its current and future customers with an unparalleled service and further value for money.

This edition of the Rail Technical Strategy (RTS), developed by the industry, builds on the first edition published by the Department for Transport in 2007. It recognises that we are in a new environment in which the government is funding a rolling programme of electrification and supporting the development of a new high-speed rail network. The new edition, RTS 2012, takes account of the work during the intervening five years led by the Technical Strategy Leadership Group (TSLG), addressing ways to improve the railway’s performance in four primary areas: customer satisfaction, capacity increase, cost reduction and carbon reduction. In addition to the continuous efforts to improve levels of safety, TSLG’s work demonstrates how industry, working together and with the valued support of government, can map out and pursue a course of actions that offer major improvements in each of these areas.

RTS 2012 supports delivery of the railway industry’s forthcoming Strategic Business Plan and its more detailed Route Utilisation Strategies. In taking a longer-term view, RTS 2012 also offers the potential for the industry to deliver an even better railway.
RTS 2012 recognises that its strategies have to be delivered within the context of a disaggregated industry structure, the five-yearly regulatory planning process, the commercial arrangements associated with passenger rail franchises and private freight operations. These aspects present both opportunities and constraints such as letting longer franchises. RTS 2012 presents a prospectus that encourages all in the industry to take advantage of the opportunities and overcome the constraints, to gain and share the large prizes available.

Customers of the railway, both passengers and freight users, are at the heart of RTS 2012 and the technical innovation it promotes. Everything in the strategy is intended to enable service providers to produce a future railway that fulfils customers’ needs and expectations.

RTS 2012 is intended to be particularly valuable for suppliers to the railway, by presenting an industry view of the direction of technical developments over the coming decades. Even in areas where certainty is not possible, a sense of the options to be explored should provide useful indicators of where the industry would expect effort to have most potential to yield value.

For those within the core railway companies, RTS 2012 provides a long-term holistic vision of the future railway from a technical perspective, not readily available in any single part of the industry. I hope that by doing so, it will inspire the industry to collaborate effectively to deliver that future, for the benefit of all.

Steve Yianni
Chair of the Technical Strategy Leadership Group
On behalf of the Rail Delivery Group I am delighted to endorse this second edition of the Rail Technical Strategy. It represents a significant component of the rail industry’s vision to improve the efficiency, health, safety, commercial and operational performance of Britain’s railways over the decades to come.

Railway companies recognise that catering for the burgeoning growth in demand for our services within the physical and economic constraints we face in Britain requires new and innovative ways to deliver what our customers want. Technical initiatives, such as those described in this strategy, will enhance our ability to meet the challenges over the coming years to improve railways’ competitive position and contribute to the health and wealth of our society.

Technical innovation through applying new technologies or changing processes can enable the railway to deliver increased capacity at reduced costs, both highlighted in the Rail Value for Money study and of prime importance to our customers.

I commend the way the whole industry, through the Technical Strategy Leadership Group, has come together and taken the responsibility to produce this strategy. It is now a live document which can be used to guide shared industry and company delivery plans.

Tim O’Toole
Chair of the Rail Delivery Group
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXECUTIVE SUMMARY</td>
<td>08</td>
</tr>
<tr>
<td>1 INTRODUCTION</td>
<td>11</td>
</tr>
<tr>
<td>BACKGROUND</td>
<td>11</td>
</tr>
<tr>
<td>AIMS</td>
<td>11</td>
</tr>
<tr>
<td>SCOPE</td>
<td>11</td>
</tr>
<tr>
<td>POLICY AND PLANNING CONTEXT</td>
<td>11</td>
</tr>
<tr>
<td>SUPPORT FOR RAILWAY BUSINESSES</td>
<td>12</td>
</tr>
<tr>
<td>OWNERSHIP AND IMPLEMENTATION</td>
<td>12</td>
</tr>
<tr>
<td>A VISION OF THE RAILWAY IN 2040</td>
<td>13</td>
</tr>
<tr>
<td>RTS 2012 STRUCTURE</td>
<td>14</td>
</tr>
<tr>
<td>2 THEMES</td>
<td>17</td>
</tr>
<tr>
<td>CONTROL, COMMAND AND COMMUNICATION</td>
<td>17</td>
</tr>
<tr>
<td>ENERGY</td>
<td>25</td>
</tr>
<tr>
<td>INFRASTRUCTURE</td>
<td>33</td>
</tr>
<tr>
<td>ROLLING STOCK</td>
<td>43</td>
</tr>
<tr>
<td>INFORMATION</td>
<td>51</td>
</tr>
<tr>
<td>CUSTOMER EXPERIENCE</td>
<td>57</td>
</tr>
<tr>
<td>3 COMMON FOUNDATIONS</td>
<td>65</td>
</tr>
<tr>
<td>WHOLE-SYSTEM APPROACH</td>
<td>65</td>
</tr>
<tr>
<td>INNOVATION</td>
<td>73</td>
</tr>
<tr>
<td>PEOPLE</td>
<td>83</td>
</tr>
<tr>
<td>4 COMMON DESIGN CONCEPTS</td>
<td>89</td>
</tr>
<tr>
<td>5 ABBREVIATIONS AND ACRONYMS</td>
<td>93</td>
</tr>
<tr>
<td>6 GLOSSARY</td>
<td>95</td>
</tr>
<tr>
<td>7 ACKNOWLEDGEMENTS</td>
<td>100</td>
</tr>
</tbody>
</table>
EXECUTIVE SUMMARY

TRANSFORMING THE RAILWAY – THE 30-YEAR VISION

Britain’s railway sets the benchmark for service quality, customer satisfaction, and value for money by being safe, reliable and resilient, meeting capacity and service requirements and contributing to the growth of the economy.

The purpose of the railway is to satisfy its customers. To maintain the ability to do so and continue to attract more passenger and freight business, it needs to remove barriers and find more innovative and cost-effective ways to increase capacity and improve performance.

The rewards available to a railway that takes advantage of technical and technological developments are huge. The Rail Value for Money study put forward potential savings of £3.5bn through incremental changes by 2019. The Rail Technical Strategy 2012 (RTS 2012) is based on a different paradigm. It seeks to transform the cost base by eliminating many of the causes of cost, including: lineside signalling, oil-based traction fuel, service interruptions caused by asset failure, frequent unplanned maintenance, customer experiences of unreliability in the system, compensation for failure. The numbers are big, for example, traction energy costs £600m/year and rising; system reliability £600m/year and lineside signalling maintenance costs £100m/year. But the prize is not just cost reduction. Equally important is the opportunity to win new business and revenue by increasing capacity, satisfying existing customers and attracting new ones.

RTS 2012 sets out the technical strategies in six themes to support the transformation of the railway and deliver rewards over the next 30 years.

CONTROL, COMMAND AND COMMUNICATION

Real-time intelligent traffic management systems deliver a high-capacity, energy-efficient, on-time railway. In-cab signalling has largely displaced the need for lineside signalling infrastructure. Communication systems are optimised for operations and customer services.

ENERGY

An extensively electrified network has reduced reliance on fossil fuels and non-renewable resources. Asset specification drives energy efficiency. Sensors, energy storage technologies and smart grid technologies monitor and manage energy use for maximum efficiency.

INFRASTRUCTURE

A resilient 7-day railway with world-class asset management which improves reliability, increases capacity and service levels and reduces delays. Trains and track equipment are specified through a whole-system approach to monitor each other and cause less damage. Intelligent maintenance provides accurate timely information for condition-based intervention.

The industry’s Sustainable Development Principles are embedded in technical and operational designs. The railway is carbon-neutral and resilient to the impact of climate change.

An extensive high-capability strategic freight network connected to future-proofed terminals provides freight customers with flexible and timely responses to their operational and planning requests.
ROLLING STOCK

Reliable, energy-efficient, low whole-life cost rolling stock is based on modular designs to meet the evolving needs of rail customers. Rolling stock/infrastructure interfaces are optimised to minimise costs. Plug-and-play train fitments for sub-systems simplify replacements and upgrades without costly, time-consuming refits. Improved, more efficient braking systems and bogie designs are deployed.

INFORMATION

Integrated modular information systems improve customer service, reduce operating costs and generate value through commercial exploitation. Data and information management, based on common architectures and open source technology, make information available in useable form when and where needed.

CUSTOMER EXPERIENCE

Rail is the customers’ mode of choice for reliability and ease-of-use, integrating with adjacent modes to create seamless door-to-door journeys. Passenger-friendly stations without queues or physical barriers feature revenue collection and security controls based on electronic systems.

RTS 2012 also describes three common foundations to support a cultural shift towards achieving the technical development and implementation.

WHOLE-SYSTEM APPROACH

A whole-system approach features coordinated planning and operations, consistent and aligned asset management and the adoption of an industry-wide framework to help the industry to implement change and improve reliability, availability, maintainability and safety (RAMS).

INNOVATION

The rail industry has overcome inhibitors to innovation, including the misalignment of risk and reward, to become dynamic and attractive to entrepreneurial talent. Support for innovators includes identified priorities and test and trial facilities to simplify the introduction of novel technical solutions for operations and engineering applications.

PEOPLE

Skilled, committed, adaptable people are attracted to working in the customer-focused, efficient rail industry. The leadership and technical skills are supported by learning and development systems. Repetitive tasks have been automated. A reliable supply chain provides specialist people support.

The themes and their common foundations are not independent, but aspects of the industry’s holistic approach to transformation. Each chapter of RTS 2012 describes how this can come about in its particular area. Together, they express the passion of the industry to succeed for its customers.
Delivery of RTS 2012 will come from its integration within industry planning processes:

- Industry Strategic Business Plan (ISBP)
- Concerted actions of government in setting and delivering related policies and plans
- Office of Rail Regulation’s industry reform programme to align incentives
- Opportunities afforded by longer franchises

The industry’s Technical Strategy Leadership Group has overseen the development of RTS 2012. The Rail Delivery Group has endorsed these strategies, which are also reflected in the current work being developed by the Planning Oversight Group, in the ISBP, Route Utilisation Strategies and Long Term Planning Framework.
INTRODUCTION

BACKGROUND

1.1 The first edition of the Rail Technical Strategy (RTS) was published by the Department for Transport in 2007 in conjunction with the white paper Delivering a Sustainable Railway. It set out a long-term vision of the railway as a system and explored how technologies and technical approaches could help respond to key challenges.

1.2 A cross-industry group of senior stakeholders – the Technical Strategy Advisory Group (TSAG) – was established to develop and implement the strategy. Now renamed the Technical Strategy Leadership Group (TSLG), it has produced this new edition to reflect progress in technology and technical processes since 2007.

AIMS

1.3 The Rail Technical Strategy 2012 (RTS 2012) aims to assist the industry’s strategic planning processes, inform policy makers and funders about the potential benefits of new techniques and technologies and provide suppliers with guidance on the future technical direction of the industry.

1.4 TSLG has based the development of RTS 2012 around its 4C challenges of increased capacity, reduced carbon, lower costs and improved customer satisfaction. Responses to TSLG’s 2010 consultation about the railway’s strategy confirmed widespread stakeholder support for continuing to focus on the 4Cs as strategic objectives. They are also consistent with government policy objectives.

1.5 The ultimate aim is to benefit railway customers, on whom the whole industry depends, by helping the industry to provide services that meet their needs and to go beyond that where possible.

SCOPE

1.6 The geographical scope of RTS 2012 is the mainline railway in Great Britain and its interoperability with continental European networks.

1.7 The 30-year timeframe of the strategy reflects a balance of the varying life-spans of railway assets, which range from 100 years or more for stations and structures, to 25-40 years for rolling stock and much fewer years for electronic equipment and software.

POLICY AND PLANNING CONTEXT

1.8 Since the first edition of the RTS, the policy environment has changed significantly. The Rail Value for Money study and the government’s response to this acknowledged the challenge facing the industry to deliver a more affordable railway with lower costs and improved efficiency. The government continues to recognise the value of the railway as part of the country’s economic development. To this end, it is funding a major rolling programme of electrification and supporting the development of a high-speed rail network. It has introduced longer franchises for passenger services and is supporting innovation through the new Transport Catapult and Enabling Innovation Team. All of these developments offer opportunities for the industry to deliver a better-performing, more sustainable railway.

1 Reforming our Railways: Putting the Customer First, DfT. March 2012
1.9 The broader policy context for RTS 2012 includes the European Commission’s white paper *Roadmap to a single European transport area* (2011). This identifies the need for railways to shift passenger and freight traffic away from the road to ease congestion, reduce environmental harm and facilitate economic development. In the face of growing global competition, the paper asserts that delayed action and timid introduction of new technologies could condemn the European transport industry to irreversible decline2.

1.10 RTS 2012 does not make independent forecasts for the development of the strategies, but relies on assumptions set out in the Network RUS. These assumptions broadly indicate the continuing need for a core mixed traffic railway with some dedicated high-speed and freight-only operation. The RTS 2012 technical developments also support other scenarios. One example is the Foresight Studies for the Sustainable Rail Programme (T713) in which the scenarios are based on different future economic outcomes and societal attitudes.

**SUPPORT FOR RAILWAY BUSINESSES AND THE ECONOMY**

1.11 RTS 2012 is intended to be particularly valuable to railway suppliers by presenting a unified view of where the industry is expected to direct its technical development over the coming decades. It also intends to help operators, infrastructure managers and industry planners understand how technical developments could support them in delivering a higher-capacity, better-performing and more cost-effective railway.

This is important as the railway could play a bigger role in supporting economic growth if it could be more attractive and affordable for its passengers and freight customers and attract new business.

1.12 RTS 2012 recognises the context of a disaggregated industry structure, the five-yearly regulatory planning process, commercial arrangements associated with primarily franchised passenger operations and private freight operations. This organisational and commercial mix presents both opportunities and constraints for delivery of the strategy. RTS 2012 works with the Office of Rail Regulation’s industry reform programme to reduce the effect of misaligned commercial incentives.

**OWNERSHIP AND IMPLEMENTATION**

1.13 RTS 2012 has been developed by TSLG with significant contributions from the industry’s System Interface Committees (SICs) and representatives from government and suppliers.

1.14 The Rail Delivery Group (RDG), which provides leadership for the industry and direction for the objectives and priorities for the TSLG, has endorsed RTS 2012.

1.15 RDG will promote the implementation of RTS 2012 and TSLG will lead its ongoing development.

1.16 TSLG will maintain RTS 2012, evaluate new concepts and support those with potential to the point where industry is ready to implement them as part of its day-to-day business.

---

2 COM (2011) 144 final: Roadmap to a single European transport area – Towards a competitive and resource efficient transport system
1.17 Many technical developments focus on the interfaces between systems and span the boundaries of traditional technical domains. The SICs will continue to be important to the implementation and delivery of integrated solutions.

**A VISION OF THE RAILWAY IN 2040**

1.18 The transformed railway is available seven days a week and is reliable, resilient, safe and sustainable.

1.19 A whole-system approach across the industry has fostered innovation and attracted the best talent. Entrepreneurs and innovators have the right conditions to develop new products and services and the export market is expanding.

1.20 Network capacity is optimised to meet all requirements for passengers and freight. Intelligent maintenance has increased train and track availability and reduced perturbations and delays. World-class asset management is aligned across the industry to improve performance, lower costs and reduce business risk.

1.21 Flexible, real-time intelligent traffic management and in-cab signalling has reduced headways and decreased traction energy consumption. Control centres know the precise location, speed, braking and load of every train on the network to optimise operational performance and keep passengers informed.

1.22 Carbon emissions have decreased through the widespread electrification of the network and sustainable, energy-efficient solutions for the remaining non-electrified routes. Energy recovery systems in rolling stock and alternative fuels allow trains to lower costs and run on and off the electrified network. Sustainable Development Principles are embedded in the design, construction and operation of infrastructure and rolling stock assets and the railway is resilient to climate change.

1.23 The industry is increasingly cost-effective as more efficiencies are introduced. Unplanned maintenance and damage to track and train are minimised through enhanced industry-wide condition monitoring. Generic designs for buildings and rolling stock interfaces are used instead of costly bespoke solutions to simplify expansion, upgrades and replacements. Operational and customer communications are supported by equipment that can be updated with plug-and-play fitments.

1.24 Rail services are integrated with other transport modes so that passengers have seamless door-to-door journeys. Station information systems and personalised messaging offer passengers all the relevant information to travel easily and reliably to their destinations. Passenger-friendly stations eliminate the need for queues or physical barriers. Revenue collection and security are based on electronic systems.

1.25 High-speed 1 links to the continent and is augmented nationally by High-Speed 2 which provides high-capacity, high-speed links between London, Birmingham, Leeds and Manchester and direct links to Heathrow Airport.

1.26 An extensive high-capability strategic freight network with increased route availability provides freight customers with flexible and timely responses to their operational and planning requests. The selective availability of higher axle loads and greater loading gauge have improved intermodal traffic.
RTS 2012 STRUCTURE

1.26 RTS 2012 is organised into three main sections:
- Themes
- Common foundations
- Common design concepts

1.27 The themes and common foundations work together to facilitate the realisation of technical and technological developments to create a future railway.

THEMES

1.28 Strategies addressing the main operational and engineering technical domains in the rail industry are described as themes:
- Control, command and communication
- Energy
- Infrastructure
- Rolling stock
- Information
- Customer experience

1.29 Although the strategies are presented separately, they are not independent of each other. Together they form the industry’s desire to transform the railway for the highest possible customer satisfaction.

1.30 The Themes are described in chapter 2.

COMMON FOUNDATIONS

1.31 Common foundations support all the themes:
- Whole-system approach
- Innovation
- People

1.32 Common foundations are described in chapter 3.

COMMON DESIGN CONCEPTS

1.33 Common design concepts are technical issues that stakeholders have consistently identified as applicable to all the themes:
- Whole-system reliability
- Resilience
- Security
- Automation
- Simplicity
- Flexibility
- Sustainability

1.34 Common design concepts are described in chapter 4.
VISION, OBJECTIVES, STRATEGY AND ENABLERS

1.35 Four elements, vision, objectives, strategy and enablers (VOSE), are used to address each theme and common foundation:

- **Vision** - What would a really good future look like?
- **Objectives** - What are the specific outcomes to be achieved?
- **Strategies** - How will the objectives be delivered?
- **Enablers** - What tools and/or techniques are required to achieve the strategy?

1.36 A VOSE is presented as an overview of the main criteria for each theme and common foundation.
CONTROL, COMMAND AND COMMUNICATION
An array of positioning systems contribute to accurate, real time knowledge of train position. Drivers receive information to optimise their speed. Control centre optimises the positions of trains in real time. Trains travel closer together. Energy saved through optimising acceleration and braking. Customers are happy with the reliable service. Every train is at the right place at the right time.
VISION
Intelligent traffic management and control systems dynamically optimise network capacity and facilitate highly efficient movement of passengers and freight

OBJECTIVES
Maximum benefits from the introduction of ERTMS
Increased automation
Operational optimisation of the railway
High-speed and high-capacity communications services for rail operations and customers

STRATEGY
Introduce driver advisory systems (DAS)
Centralise network control
Deploy in-cab signalling using ERTMS Level 2/3
Develop intelligent automated traffic management systems
Automate driver operation

ENABLERS
High-capacity voice and data communication systems
Accurate real-time train position and performance data in control centres
CONTROL, COMMAND AND COMMUNICATION

CONTEXT

2.1 Control, command and communication (CCC) systems are a key strategic technological capability for the delivery of the 4Cs over the next 30 years. New technologies are challenging the existing principles of how train movements are controlled, for example, control of the proximity of trains could allow train convoying. The application of these technologies has the potential to deliver improved capacity, decrease traction energy consumption and carbon emissions, reduce operational costs and provide better onboard communications for passengers.

2.2 New CCC systems will also offer opportunities for benefits in other areas such as crashworthiness in rolling stock design, driver route knowledge and reduced wear and tear on track and trains. Consequently, a whole-system approach will be the best way to deploy solutions for these issues and for related technological developments.

2.3 Since 2007, progress in CCC systems includes:

- Progressive rollout of GSM-R
- Commissioning of the first European Rail Traffic Management System (ERTMS) project
- Initiation of Network Rail’s control centre consolidation strategy
- Pilot projects for Driver Advisory Systems (DAS)
- Planned use of automatic train operation (ATO) on Thameslink and Crossrail

VISION

2.4 Highly reliable and resilient CCC systems offer network-wide traffic management capabilities for intelligent, predictive and adaptive operational control of train movements. The systems track the precise location and current status of every train on the network. Data for speed, acceleration, braking and load is available at all control centres for improved operational decision-making. Train movements are optimised to meet a variety of goals and perturbations are resolved rapidly so that there is a minimum impact on customers.

2.5 High-speed, high-bandwidth communications networks are in use across the rail network and on trains and provide dependable connectivity for both operational and customer-facing applications for the railway and customers. Data is made openly available to support door-to-door journey information.

2.6 In-cab signalling is used instead of lineside signals and the only traditional features of lineside signalling are point operating equipment and level crossings. Signalling system designs are standardised and the design, testing and commissioning procedures are automated.

2.7 The use of ATO is widespread across the network. Fully automatic operation of trains is possible on some parts of the network.
OBJECTIVES

2.8 Benefits from the introduction of ERTMS across the network for in-cab signalling include:

- Lower capital costs for signalling systems
- Less need for, and maintenance of, expensive track-based infrastructure
- Optimised network capacity that is more flexible than conventional lineside signalling systems
- Easier deployment of other technologies including intelligent traffic management systems and ATO

2.9 Benefits from automation of routine tasks associated with traffic management and train driving include:

- Greater capacity from consistently predictable train movements
- Higher reliability for passengers and freight
- Lower costs through less need for manual intervention
- Quicker and more efficient response to perturbations
- More efficient use of energy, infrastructure and rolling stock

2.10 Intelligent traffic management systems are highly flexible and capable of optimising railway operations at network, route and individual train levels. Objectives for a variety of traffic can be met at different times of the day. Capacity, speed, timekeeping, energy savings, operating costs and asset management can be prioritised in real-time according to requirements. The systems are highly reliable and resilient to support the delivery of normal or near-normal services during all but the most exceptional circumstances.

2.11 Mobile communication providers, in association with railway operators, offer dependable high-speed, high-capacity seamless communications for rail customers across all modes of transport. These systems use standard commercial products to reduce capital costs and the risk of obsolescence. Similarly, standard commercial communications systems support a wide range of data- and communications-intensive applications to be used on the rail network for both operational and asset management purposes.

STRATEGY

2.12 Introduce DAS to make a significant contribution to railway operations, offering benefits including:

- Traction energy and fuel saving
- Improved customer satisfaction through trains being stopped less frequently, for example at red signals
- Reduced risk of signals passed at danger
- Minimisation of acceleration and braking demands, which reduces the related wear and tear on track and trains
- Optimised use of traction energy power supplies at peak times without risking overload
- Enhanced route knowledge through provision of route knowledge in the cab

2.13 Initially DAS operate as stand-alone systems on trains but in the medium term should be connected to traffic management systems to increase benefits. In the longer term, ATO and intelligent traffic management systems should incorporate DAS functionality.
2.14 Network control should be centralised into a small number of major control centres to eliminate the need for about 800 small signal boxes and relay interlockings. This would lower operating costs, improve regulation of traffic and perturbation management and simplify the deployment of intelligent traffic management systems.

2.15 ERTMS Level 2 without lineside signals should be deployed across the network to replace lineside signals. Level 3 could be introduced on some routes to eliminate the need for track-based train detection equipment and offer significant further benefits in maintenance costs and reliability. At the same time, the rail industry in GB should continue to work with the European Railway Agency and others on the technological development of ERTMS and the evolution of Command, Control and Signalling (CCS) Technical Specifications for Interoperability (TSI). Developments should include:

- Increasing the system capacity on routes where there are large numbers of traffic movements in small geographical areas, for example stations
- Deployment of 4G/LTE mobile communications to replace GSM-R, which is currently used for ERTMS
- Technological and functional convergence with communications-based train control systems (CBTC) that are currently in use on metro systems

2.16 Advanced intelligent and automated traffic management systems should progressively replace existing systems in control centres. TSLG’s FuTRO project is developing the frameworks for the concepts, requirements and architectures of next generation traffic management systems. These systems should be dynamic and able to optimise the use of the rail network, minimise delay, optimise traction energy use and maintain train connections for passengers. Data from trains and the infrastructure should predict where and when conflicts are likely to arise and offer/implement solutions in real-time. Operating data should also be used to feed automated long-term planning systems to optimise train timetabling and infrastructure use. The FuTRO business case estimates that the current value of benefits will be £200-£400m/year by 2035 derived from capacity increase, better information and operational efficiencies.

2.17 ATO should be deployed widely across the network to provide considerable benefits in standardising the driving operation. This is particularly important as metro-style and urban/suburban operations require predictable timekeeping to deliver intensive services. Combined with intelligent traffic management systems, ATO could offer benefits on other types of routes.

---

3 DfT ERTMS National Implementation Plan, September 2007, states that rollout should be completed by 2038.

4 4G: Fourth generation telecommunications standard for mobile communications; LTE: Long-term evolution, a telecommunications standard for wireless high-speed data communication; GSM-R: Global System for Mobile Communications - Rail
ENABLERS

2.18 The provision of appropriate high-speed, high-capacity data and voice communications systems is important for many CCC developments and for customer-facing services. GSM-R and publicly available Wi-Fi on trains is unlikely to meet operational demands in the future. 4G /LTE offers an industry standard that should meet the foreseeable needs of the railway and its customers. It will need to be adopted when GSM-R becomes obsolete and unsupported by suppliers, as expected from ~2024 onwards.

2.19 Intelligent traffic management systems require accurate and real-time data to make correct decisions. For this, train communications systems need to relay the precise location of each train, its velocity, acceleration, braking capability, operational performance and other items of data. This data also facilitates a variety of other capabilities, including:

- Providing information to customers
- Dynamic adjustment of the distances between consecutive trains to optimise capacity
- Tracking freight movements
- Enhanced level-crossing protection
- Improved on-track personnel safety
- Support for remote condition monitoring of train and infrastructure assets
- The facilitation of third-party development of new products and services associated with train operations
Intelligent traffic management and control systems dynamically optimise network capacity and facilitate highly efficient movement of passengers and freight.
ENERGY
Using lightweight trains with alternative specifications for track and train could mean less intensive operation, which could mean alternative signalling solutions. Away from the mainline, there could be additional lower-spec energy options alongside AC electrification, including battery-power.
VISION
A low carbon, energy-efficient railway

OBJECTIVES
Reduced reliance on fossil fuels
Reduced reliance on non-renewable materials
Energy-efficient operations, rolling stock and infrastructure

STRATEGY
More 25kV electrification
Develop energy-efficient specifications for railway assets
Leverage intelligent traffic management to optimise energy use
Adopt smart grid technologies
Maximise the use of low carbon materials

ENABLERS
Robust, lower cost electrification
Improved electrification protection and control
Energy-efficient systems
Technology brokerage
Improved sensors and monitoring systems
ENERGY

CONTEXT

2.20 Rail is an energy-intensive industry. Between 80 and 90% of the energy that rail uses – over 3 TWh of electricity – and more than 680 million litres of diesel are used for traction purposes\(^5\) at a cost of over £600m. The remaining 10-20% of energy consumption is for stations, depots, control centres and for signalling, communications and other rail systems.

2.21 Large amounts of energy are also required to maintain, renew and enhance the railway. This includes the production, transportation and installation of materials and products such as concrete and steel and processes such as tamping and rail grinding.

2.22 More energy will be used in absolute terms in the future to accommodate passenger and freight growth and new high-speed rail services. The industry’s main focus should be to operate in an energy-efficient way and to encourage a shift away from less efficient and more carbon-intensive modes.

2.23 Progress in the railway’s approach to energy since 2007 includes:

- Government electrification programme including the Great Western Main Line, the Trans-Pennine route between Manchester and Leeds and the Midland Main Line
- Enabling regenerative braking on both alternating and direct current rolling stock
- Successful trials of DAS
- Fitment of energy meters to several electric rolling stock fleets
- Energy efficiency targets in new rolling stock specifications
- Diesel rolling stock modifications including the fitment of more efficient engines and control systems that switch off one or more engines on diesel multiple units (DMUs) according to power demand
- Widespread use of eco-driver training
- Installation of renewable energy technologies at some network sites
- Energy efficiency improvements at depots and stations, for example, Accrington Eco-station
- Successful trials with fuel containing up to 20% biodiesel on existing diesel rolling stock
- Research on innovative electrification, DC to AC conversion and reducing electrical losses

VISION

2.24 The railway has expanded in an energy-efficient way, reducing unit costs to attract passengers and freight from other modes. The vast majority of journeys are on electrified routes. Low carbon and recycled materials are used where safety, reliability and practicality allow.

OBJECTIVES

2.25 Rail relies less on conventional fossil fuels which will become increasingly scarce, expensive and environmentally unsustainable.

\(^5\) ORR National Rail Trends 2010 –11 Yearbook, Table 9.1a
2.26 Materials from renewable sources and/or with low-embedded carbon are used for building, maintaining and renewing rolling stock and infrastructure.

2.27 New and refurbished rolling stock and infrastructure are designed, built and maintained to deliver high levels of energy efficiency. Energy-efficient operations include avoiding unnecessary stopping, starting and empty running of trains and keeping load factors up.

2.28 Accurate and timely information shows how energy is being used across the industry. This can be used for procurement strategies, as support for operational measures to improve energy efficiency and to help the infrastructure manager get more out of electrification infrastructure.

**STRATEGY**

2.29 Further electrification would reduce the direct use of fossil fuels and provide a secure supply of energy that will become less carbon-intensive as the power generation sector decarbonises. Electric trains are cheaper than diesel to buy, operate and maintain and are more efficient, quieter, cleaner and comfortable. Electric freight locomotives have a higher power to weight ratio than their diesel equivalents. They can haul longer loads and/or travel faster and regenerate energy when braking. Research\(^6\) estimated a potential reduction of 56% in the carbon footprint of the railway by 2050. This is based on current and proposed initiatives and takes into account the decarbonisation of the grid.

2.30 The 750V direct current (DC) third-rail network is limited in the amount of power it can provide efficiently for train services. It could be replaced progressively with the more resilient 25kV alternating current (AC) overhead system for better energy efficiency. Research\(^7\) estimated the net benefit of converting the current DC network to 25kV AC overhead line equipment (OLE) to be £2bn. This includes conversion costs and benefits accrued over 60 years, but not potential capacity or linespeed benefits, which would further strengthen the case for conversion.

2.31 Train specifications should drive improvements in energy efficiency and weight reductions. Installed power should be appropriate to the type of operation with the ability to recover as much braking energy as practicable, whether by regenerative braking or onboard energy storage. Train performance should adapt by location to optimise energy efficiency with, for example, higher accelerations on intensively-used routes. For lightly-used parts of the network that are unlikely to be electrified in the near future, trains should be self-powered, for example:

- Life-extended DMUs with more energy-efficient engines or transmission systems
- Lighter and more efficient new diesel trains
- Hybrid DMUs with additional onboard energy storage to capture kinetic energy while braking

---

\(^6\) RSSB T913 Whole life carbon footprint of the rail industry, September 2010

\(^7\) RSSB T950 Investigating the economics of the third-rail DC system compared to other electrification systems, August 2011
• Bi-mode trains which use electrical infrastructure where available and run on diesel elsewhere
• If the technology develops sufficiently to be cost-effective, larger scale energy storage on electric trains to provide them with the ability to run on non-electrified routes
• In the longer term, conventional fossil-based diesel may be replaced by more sustainable alternatives such as biofuels or hydrogen

2.32 Existing electric rolling stock with significant residual life could be made more energy-efficient during refurbishment by upgrading traction equipment and providing regenerative braking capability. Diesel trains with similar life-spans could be fitted with more efficient engines, transmissions and possibly energy recovery and storage systems. Recent DfT research\(^8\) suggested, for example, that fitting more efficient transmission systems and better turbo-chargers to older DMUs could deliver fuel savings of up to 13% and 3% respectively.

2.33 Onboard heating, lighting and ventilation systems should be energy-efficient and adjust to ambient conditions and passenger loads. Better system specifications could reduce mass and energy consumption and improve reliability.

2.34 Pantograph cameras and/or monitoring systems should be fitted to an increasing number of trains. These will provide valuable evidence of failure modes and equip the industry with the knowledge to develop more resilient designs. Pattern recognition technologies will help to automate the inspection process.

2.35 Infrastructure layouts could be designed to minimise energy consumption, for example by enabling trains to maintain optimum speed at junctions and avoid unnecessary stops. Careful location of depots, refuelling and stabling points could also help to reduce empty running. Stations, depots, offices and other infrastructure assets should be designed to maximise energy efficiency. High levels of insulation and materials with low-embedded carbon, for example recycled and locally sourced materials could be used. Efficient and intelligent heating/cooling and lighting systems and renewable energy generation would deliver further benefits.

2.36 Intelligent traffic management programmes such as FuTRO could generate energy-efficient timetables for a better match between passenger demand and train capacity. By optimising traffic flows in real-time, such systems can also reduce conflicts between services, minimising delays and improving energy efficiency. Extending the concept to automatic control of train acceleration and speed could deliver additional energy and reliability benefits.

2.37 Smart grid technologies could provide improved real-time information on rail energy consumption and generation, for example from regenerative braking or renewable energy sources, as well as on the performance and spare capacity of electrification assets such as transformers. This information could inform energy management strategies and the replacement or upgrade of electrification assets.

\(^8\) GB Rail Powertrain Efficiency Improvements, TRL & Ricardo, March 2012
Energy generation and storage techniques could reduce energy costs. For example, parts of the rail estate could be suitable for wind turbines or photovoltaic arrays which would provide commercially attractive rates of return, especially if the electrification infrastructure allowed these locations to be connected economically to the electricity grid. Similarly, hydrogen fuel cells are a cost-effective solution for remote power for maintenance activities or emergency back-up.

ENABLERS

Reducing electrification costs, for example through standard designs of common building blocks, new technologies, economies of scale and a rolling programme of work would improve the case for further electrification. Tailoring the design of new electrification so that it is not over-specified for a particular route may also offer opportunities to reduce costs.

Where an existing route is being electrified, building techniques are needed to allow rapid OLE installation, with minimum disruption to the working railway. The electrification system design could support improved energy efficiency, for example through the choice of transformers, power electronics, monitoring systems and conductor wire.

Longer, higher speed commuter and intercity services on conventional lines require electrification for trains running at up to 140mph, with multiple pantographs at a range of spacings from ~85 to 200m. This may require lightweight, possibly active pantographs or alternatively, high voltage auto-couplers.

Rationalised electrification system design offers considerable savings in distribution equipment costs and provides a sub-station infrastructure compatible with smart grid technology for future benefits. Using industry standard IEC61850 Ethernet protocol to communicate between circuit breakers and sub-stations allows offsite pre-commissioning and reduces access requirements to deploy new equipment.

Initiatives in the section Innovation could identify technologies being deployed in other sectors that may be adaptable for railway use, for example:

- Energy storage technologies and appropriate control systems suitable for on-train or lineside applications that deliver robust, cost-effective energy storage
- Biofuel technology, when sustainable and cost-effective, for existing diesel rolling stock
- Technologies such as energy storage and hydrogen fuel cells as alternatives to conventional diesel traction
- Low carbon, lightweight materials, innovative building and construction techniques, lighting/heating technologies and renewable energy generation could be applied to both rolling stock and infrastructure applications such as stations and depots

Low-cost sensors and monitoring systems for rolling stock and infrastructure are required to help the railway manage its energy consumption more effectively. These must be easy to install, require minimum maintenance and deliver robust data streams using standard communication protocols. Harvested ambient energy, for example, heat, light or vibration could power these devices and avoid the need for batteries or additional power supplies.
Automated maintenance is quicker, safer and more cost-effective.

Well-targeted maintenance enables more train paths to be available at night.

Advanced suspension system minimises noise and vibration.
VISION
A simple, reliable and cost-effective rail infrastructure which meets customer requirements and is fit for the 22nd century

OBJECTIVES
Improved reliability and fewer delays
Increased capacity and service levels delivered safely and securely
Increased sustainability and resilience
Low-cost generic designs for infrastructure

STRATEGY
Demonstrate world-class asset management
Use future-proofing strategies to extend asset life
Embed sustainable development
Develop a set of cost-saving generic designs for infrastructure

ENABLERS
New condition assessment technologies and prognostic tools
Supported industry planning for future infrastructure requirements
Innovative projects, solutions and new materials
Standard infrastructure designs
**INFRASTRUCTURE**

**CONTEXT**

2.45 Infrastructure accounts for approximately one-third of the railway’s operating costs. In 2009/10, £1bn was spent on renewals, £2bn on maintenance and £1bn on enhancements within a total of £12bn. Network Rail (NR), where the largest portion of costs lie, has been lowering costs since 2007 and aims to cut a further £2bn against a background of rapidly increasing passenger numbers. Proposals for this are included in the Initial Industry Plan (IIP) for CP5 which ends in 2019.

2.46 Most track maintenance is periodic preventive maintenance based on long-established rules and augmented by ad hoc intervention when faults occur. Traffic requirements demand that most of this labour-intensive work is carried out at night generally by low-skilled staff under pressure. These staff are the most ‘at risk’ on the railway.

2.47 Unplanned maintenance has high costs. Research\(^9\) has estimated that reducing this type of maintenance can save up to £130m/year.

2.48 As passenger volumes increase, some stations are nearing maximum capacity. For example, East Croydon will be too overcrowded by 2020 to function successfully without intervention. Passenger numbers are rising at an average of around 3% per year. To cater for further modal change, the industry needs to accommodate more passengers without necessarily increasing station sizes. Research\(^10\) has identified an extra 10% handling capacity through gate-line, ticketing and information solutions at stations. This would extend the capacity of stations without the need for larger space and could save in the region of £140m/year. Further changes to station design and operation would be needed to cope with more intensive train service patterns.

**VISION**

2.49 Asset management is world-class. Lean methodologies have streamlined maintenance cycles and automated machines carry out routine activities. High-speed tamping and other processes have reduced maintenance requirements further. Progressively short-cycle maintenance operations have been introduced between service trains. Asset failures seldom occur and track availability is rarely impeded.

2.50 Intelligent maintenance based on trainborne inspection provides accurate, timely information for condition-based intervention and reduces the need for workers to be on or about the operating railway.

2.51 Network resilience and integrity are high as tolerance of adverse conditions is designed at inception. Natural hazards and unforeseen occurrences cause minimal disruption.

2.52 Low carbon materials and processes are used without impeding performance, cost or safety. Environmental factors such as vibration and noise are included at the design stage.

2.53 Generic designs are used for cost-efficient, holistic infrastructure layouts. Train suspension characteristics are included in track designs

---

\(^9\) RSSB T935 Making the case for a whole-system strategic approach to reliability improvement, July 2011

\(^10\) RSSB T916 Research into station design and crowd management, April 2012
to minimise damage on train/infrastructure interfaces and optimise system-level costs.

2.54 Infrastructure and signalling systems increase network availability for freight and facilitate the fast introduction of new connections to meet the changing freight business requirements as more traffic switches to rail. Freight terminal designs are future-proofed, for example, by incorporating automated cargo handling, 1500m sidings, fast connections to main lines and electrification of freight routes. Gauge clearances to W10/12 are available on more routes and Continental Gauge is introduced where there is a business case for increasing intermodal traffic.

2.55 In the longer term, signalling systems use nanotechnology to become self-healing and have the capabilities to remedy some of their own defects. Infrastructure is designed with provision for integrated power systems and communications and to sense and report on its condition. As train designs become more sophisticated and market needs change, infrastructure can accommodate increasingly demanding operational requirements.

OBJECTIVES

2.56 Preventive and predictive maintenance techniques are deployed to avoid limitations to track availability. More diversionary routes bring greater redundancy to the network. Reliability is improved and passengers rarely experience delays or disruptions.

2.57 Intelligent asset management maximises the operational benefits at minimal cost through automation, the knowledge to predict intervention needs and the use of intelligent maintenance techniques.

2.58 New designs of switches and crossings reduce failures to negligible levels and reduce the costs and disruptions associated with maintenance interventions.

2.59 New assets are future-proofed to support increased capacity and service delivery requirements. Life-cycle analysis is applied to existing infrastructure assets to evaluate the costs for maintenance, inspection and support in comparison to the cost of replacement.

2.60 Platforms, train doors, train positioning and escalator siting are synchronised to help passengers transit busy stations. Full advantage is taken of e-business transactions to minimise the need for traditional ticket offices and barriers.

2.61 The infrastructure is resilient to degradation from climate change and extreme weather conditions. Measures for noise reduction, vibration and low carbon construction processes have increased the sustainability of the infrastructure.

2.62 Innovative track designs combine the maintainability and initial low cost of traditional ballasted track with the stability of slab track. Better geometry, reduced tamping and improved longevity combine to minimise long-term costs.

2.63 A suite of standard designs is created for 80-90% of infrastructure assets. Low-cost bespoke designs are created for the remaining 10-20%. Electronic systems are equipped with standard interfaces for easy replacement and technologies with short life-spans have proactive life-cycle management. Whole-life savings offset possible higher capital costs.
STRATEGY

2.64 Asset management capability should continue to be developed to achieve world-class standards. Specific actions should include:

- Compile and maintain a single industry-wide infrastructure asset register
- Improve the understanding of life-cycle costs and degradation to move towards fewer inspections and reduce intervention times
- Apply in-depth theoretical modelling to give accurate predictions of the minimum life or failure of assets to make more efficient ‘maintain or renew’ decisions
- Optimise deployment and site management to target the tamping workload better
- Improve location accuracy of defects and fault-finding for quicker problem resolution
- Improve the identification of problem sources rather than the symptoms, for example, an extensive sleeper re-padding programme prevents much more expensive damage to rail assets
- Maintenance of telecoms, electrification and plant assets is part of the risk-based inspection and servicing regimes

2.65 To create a sustainable infrastructure, design criteria for assets should include a whole-system approach for track and train interfaces and long-term use. Modest increases to capital costs for new or replacement infrastructure could be offset by significant through-life savings.

2.66 Research into vibration, noise reduction and low carbon construction processes should be carried out to minimise the impacts of new and current lines on the surroundings and the environment. Buildings should be designed environmentally for reuse to reduce the impact of embedded carbon. Materials that function in normal operating conditions with only visual inspections should be investigated and promoted.

2.67 New and more effective ways of delivering standard designs of infrastructure, including modular designs for bridges, could reduce project timescales and costs. A range of innovative station buildings based on common design parameters could be scaled or expanded to allow for growth in passenger numbers. Consistent materials and layouts across the network would simplify planning authorities’ acceptance.

ENABLERS

2.68 Industry-sponsored research provides a clear impetus for using remote condition monitoring (RCM) across the railway to save significant costs and improve performance. Recommendations include:

- Adopt international RCM standards across the rail industry
- Integrate existing and isolated RCM models and practices
- Integrate RCM with business modelling for whole-life cost estimates
- Use infrastructure fixed points to monitor rolling stock and use rolling stock to monitor fixed infrastructure

2.69 The development of intelligent infrastructure maintenance offers the prospect that automated systems could carry out routine maintenance checks in areas where trains would have to be stopped for manual checks. Automation could also be used for other repetitive tasks, for example track relaying, ballast renewal, tamping and alignment.
2.70 Every few months, an ultrasonic train unit analyses all the track in the country and identifies potential rail defects, which then need to be verified by a trained ultrasonic tester. Defect verification carried out by remote sensors could remove the safety risk and reduce the chance of human error.

2.71 The introduction of Non Destructive Testing (NDT) is vital for proactive maintenance. Using service trains – both passenger and freight – to monitor the infrastructure could offer a huge opportunity.

2.72 Europe-wide research through the EC Framework Programmes and initiatives such as Shift2Rail will examine new infrastructure technologies. This will include new track forms, switches and crossings and their potential for commercial development and introduction and consideration of the interfaces between infrastructure and trains, energy and more.

2.73 Coordinated planning for infrastructure, rolling stock and a wider operational strategy is needed to prepare the infrastructure requirements to accommodate traffic growth.

2.74 For new infrastructure, there is a need for modelling tools to analyse whole-life, whole-system energy and carbon impacts. The application of new materials and construction techniques could offer significant improvements in infrastructure performance as well as delivering reductions in cost and embedded carbon.

2.75 Track 21 is a project to improve understanding of the complex mechanisms of railway track governing stiffness, robustness, longevity and noise and vibration performance. This could optimise track performance in terms of engineering, the environment and the economy.

2.76 A specific example of the work covered in Track 21 is tampless track. Tamping causes damage to the ballast and surrounding infrastructure and having to tamp the track to restore ideal geometry can be costly and time-consuming. Ballast that requires little or no tamping will help to drive down costs.

2.77 Understanding the condition of substructure is vital for maintaining good track geometry. Techniques such as better ground-penetrating radar and stiffness measurements will provide the best information for remediation of embankments and cuttings and for determining the most suitable type of track - ballast or slab. Work is underway to improve the understanding of slab and ballasted track and the potential benefits of each will be essential to run the network in the most efficient manner. Better track geometry and drainage will increase resilience to flooding.

2.78 The development of new premium steels offers exciting prospects to reduce maintenance costs. As more of these materials are produced, the industry needs to understand the benefits and costs to make informed decisions for the future infrastructure capability.

2.79 The use of plastics and composite materials on the railway, for example for sleepers and fastening systems, will help lower carbon emissions and reduce asset management activities.

2.80 Replacing bespoke infrastructure designs with modular systems and fast-change components will facilitate the introduction of more automated maintenance.
2.81 The range of modular station buildings currently being trialled in Coulsdon South and Uckfield stations will provide useful lessons for further implementation of modular buildings.

2.82 Right-sizing existing infrastructure and new designs could reduce initial costs. Preferential over-engineering for buildings, signalling, electrification and plant, telecoms and track, should be avoided. Redundant assets could be removed.

2.83 The Shift2Rail Joint Technology Initiative aims to provide a Europe-wide focus for the development of infrastructure.
# Demonstrate World-Class Asset Management

## RTS Infrastructure

- **Asset Management**
  - Produce & maintain and industry-wide asset register
  - Improve whole-life modelling, analysis and predictive tool-set

- **Infrastructure Reliability**
  - Whole system reliability modelling
  - Reliability improvement programmes, e.g. intelligent infrastructure
  - Phased and coordinated delivery of technology and approaches to improve whole system reliability
  - Develop ‘intelligent infrastructure’ concept
  - Methods of monitoring and recording reliability performance over the long term
  - Improve and automate NDT, associated analysis and asset upkeep

- **Remote Condition Monitoring**
  - New condition assessment technologies and prognostic tools
  - Support Whole System Approach to develop and implement RCM

## Use Future-Proofing Strategies to Extend Asset Life

- **Design Criteria**
  - Strategic guidance on long-term requirements associated with customer, cost, capacity, carbon
  - Support and engage with Shift2Rail JTI

- **Infrastructure**
  - Introduce right-sizing design techniques for infrastructure
  - Asset upgrade, modernisation and development requirements proposed to design stage
  - Renewal projects aimed at enabling infrastructure management and optimising life

- **Stations**
  - Identity and evaluate technologies to deliver significant capacity enhancement to existing stations
  - Infrastructure upgrade programmes

## Embed Sustainable Development

- **Environment**
  - Sustainable railway principles
  - Influence incentive regime, industry attitudes, procurement approaches to focus on cost-saving opportunities
  - Systematic and organised consideration of the potential to employ advanced and new materials in the rail sector

- **Carbon**
  - Materials research programmes
  - NR & EU R&D into low carbon infrastructure
  - Promote/subsidise the use of low carbon materials

## Develop a Set of Cost-Saving Generic Designs for Infrastructure

- **Designs**
  - System Architecture
  - Establish a whole system architectural description for use in determining modularisation opportunities
  - Adopt industry-wide practices and standards – regarding modular approaches
  - Identify and evaluate opportunities for modularisation to deliver cost savings
  - Inclusion of modular designs consideration of new approach to asset optimisation in fleet and infrastructure procurement
  - Asset optimisation: COTS/rail specific, standard/innovative, whole BA/capital cost

### Vision

A simple, reliable and cost-effective rail infrastructure which meets customer requirements and is fit for the 22nd Century.
ROLLING STOCK
Sensors pick up defects and send automated reports which get turned into a maintenance schedule. Emerging defects are picked up before failure.
VISION
Mass- and energy-efficient, low whole-life cost rolling stock meets the evolving needs of its customers

OBJECTIVES
Rolling stock designed, built and operated to minimise whole-life, whole-system costs
Continuous improvement of rolling stock mass, energy and carbon efficiency
Optimised rolling stock interface with infrastructure systems
Rolling stock better adapted to meet passenger and freight requirements

STRATEGY
Continue to adopt and adapt new technologies for cost and operational improvements
Develop a range of appropriate alternative traction power sources
Produce standard architectures for rolling stock sub-systems
Improve the operational capabilities of freight rolling stock

ENABLERS
Improved sub-systems
Open interface standards to facilitate plug-and-play technologies
Guidance documents – Key Technical Requirements for Rolling Stock
Shift2Rail Joint Technology Initiative
Cross-interface remote condition monitoring
ROLLING STOCK

CONTEXT

2.84 The maintenance and financing of rolling stock in the UK is valued at £1.8bn/year, approximately 15% of the total railway operating cost. The passenger fleet consists of 64 classes with 12,000 vehicles and an average age of 17.3 years. The purchase of rolling stock for Thameslink, Crossrail and the Inter City Express Programme (IEP) is likely to reduce the overall average age of rolling stock and will increase carrying capacity markedly.

2.85 The supply chain for rolling stock is international, with the UK a relatively small part of the market for major manufacturers. This strategy assumes that train operators work in conjunction with rolling stock asset owners. Train operators, who understand their markets, will specify requirements and suppliers will deliver product and service solutions from their portfolios. To promote system optimisation, TSLG can support the development for a better understanding of interface issues and the introduction of appropriate market incentives into technical requirements, franchise agreements and other commercial contracts.

2.86 The continuing success of rail freight, up by more than half over two decades, risks being trammelled by technical limitations. Freight rolling stock is designed for and operated on, standard 60 and 75 mph services, which are increasingly out-of-step with line speeds on mixed traffic routes. Poor acceleration and deceleration causes freight trains to be held back on loop lines, waiting for paths that will not interfere with faster traffic.

VISION

2.87 Rolling stock is mass- and energy-efficient and engineered for flexible use under a range of operating concepts, including approaches such as train convoying. Whole-life costs are reduced continuously through the rapid introduction of new technologies that improve reliability and operation.

2.88 Optimising at a whole-system level, rolling stock design takes account of the interfaces with infrastructure. Standardised sub-system interfaces contribute to improved cross-system efficiency.

2.89 Efficient drive-trains are powered by a range of sources with associated energy recovery systems, which allow locomotives and multiple units to operate on and off the electrified network. Adhesion-aware braking systems have been introduced and contribute to reduced train headways and increased network capacity.

2.90 A new generation of freight rolling stock is designed to optimise the gauge and allows more freight trains to operate compatibly with intensive passenger train operation.

2.91 Comfortable and attractive train interiors create a more satisfying environment for passengers. Cabin layouts make the best use of available gauge and the capabilities of new materials.

11 Rail Value for Money study, 2010/2011
12 National Rail Trends Yearbook, 2010/2011
OBJECTIVES

2.92 Rolling stock is designed to meet business requirements and takes account of the whole-life cycle. Standard system architectures have flexible designs for cost-effective upgrades and fewer maintenance processes. Couplings, train control and onboard systems support diverse operating approaches such as train convoying.

2.93 Rolling stock design and operation is improved continuously, for example:
- Mass efficiency balances strength, safety and capacity
- Energy for traction and recovered from braking systems is optimised continuously
- Energy losses from other systems are minimised
- Upgradeable rolling stock designs encourage the use of new low carbon materials and processes

2.94 A whole-system approach, which optimises the interfaces between rolling stock and other systems, reduces track wear, suspension and body fatigue, improves condition monitoring and minimises environmental impacts such as noise, vibration and waste disposal.

2.95 New vehicle interior layouts reflect changing patterns of demand and passenger demographics. The interiors are optimised for purpose, such as fast boarding and alighting for commuters, or comfort and facilities for long-distance high-speed or rural trains. New materials are used to reduce mass and increase durability and attractiveness.

STRATEGY

2.96 The adoption and adaptation of new technologies, processes and tools should continue to optimise whole-system, whole-life performance, for example:
- Components and sub-systems would be designed to meet performance objectives
- The ability to upgrade vehicles through their life would be developed to improve mass and energy efficiency
- Reliability, availability and maintainability would be improved

2.97 Good links with developments in materials science should be maintained, for example through the Transport Systems Catapult and evaluation should be sponsored to understand how new materials can be adapted for rolling stock use.

2.98 In collaboration with the supply chain, rolling stock drive trains should be developed with multi, dual or hybrid energy sources that are capable of working on or off electrified parts of the railway. This work should include:
- Low or zero carbon fuels
- Stored energy
- Multi-fuel engines
- An active, constant watch and assessment of traction solutions and hybrid engines from around the world
2.99 Diesel engine efficiency and lifespan should be improved to maximise the life of current diesel-powered rolling stock. Adjacent diesel technology, especially marine, should be assessed for the transferability of developing technologies.

2.100 Modular build using standard designs could further reduce costs. The European project MODTRAIN identified a 15% cost reduction for manufacturing and a drastically reduced number of parts on standardised components.

2.101 A vehicle-based functional architecture should be produced and maintained. This should be supported by appropriate common sub-system architectures and open interface standards for hardware and software that promote the development of modular approaches to system design, development, upgrade and maintenance.

2.102 Work should be undertaken with freight operators to specify the next generation of freight rolling stock.

ENABLERS

2.103 The overall efficiency and effectiveness of rolling stock will be delivered increasingly through progressive improvements in sub-systems, including:

- Mechatronic bogies
- Adaptive braking systems
- Improved passenger compartments
- Integrated diagnostic systems

2.104 Innovative bogies designs could minimise track impact and wear while extending the operating range of trains and reducing track access charges and energy use.

2.105 Matching braking forces with adhesion and speed while maximising energy recovery may be achieved through using a combination of braking systems such as pneumatic, magnetic and eddy current\(^{13}\).

2.106 New materials may allow thinner, thermally-efficient passenger compartment ‘skins’ to reduce weight and energy loss.

2.107 Technical Specifications for Interoperability (TSI) and other standards and guidelines for the development and qualification of railway systems are being developed, updated and consolidated. This, coupled with work by the Enabling Innovation Team (EIT) to present common sub-system architectures, will promote the development of efficient plug-and-play equipment and sub-systems.

---

\(^{13}\) RSSB T860 Benefits of all-electric braking (in progress)
2.108 Key Technical Requirements for Rolling Stock, an ATOC publication, assists procurers of new rolling stock by providing guidance on key requirements under a range of headings: technical, performance, passenger-facing, driver-facing and communications/diagnostics.

2.109 The Shift2Rail Joint Technology Initiative aims to provide a Europe-wide focus for the development of rolling stock.

2.110 A cross-industry commercial and technical framework needs to be established to allow asset condition data to be shared and exploited across all infrastructure and rolling stock asset types. This could improve asset performance and reduce asset maintenance costs.

2.111 Deployment of RCM technology and associated analytical toolsets improves rolling stock reliability and maintainability. This would lead to increased availability, which would reduce cost and capture potential revenue. Cross-interface RCM (XIRCM)\(^{14}\) has identified significant savings by associating train and infrastructure RCM – trains monitor infrastructure and vice-versa.

\(^{14}\) RSSB T1010 Cross-interface Remote Condition Monitoring Programme (in progress)
## Themes - Rolling Stock

### Continue to Adopt and Adapt New Technologies That Provide Cost and Operational Improvements

- **New Technologies**
  - **Support & engage with Shift2Rail joint Technology Initiative**
  - **Catapult to evaluate new technologies**
  - **Maintain technology watch**

- **New Processes**
  - **Employ Remote Condition Monitoring on rolling stock**

- **New Tools**
  - **Cross Industry RCM Group**
  - **Deploy new remote condition monitoring technologies**

### Develop a Range of Appropriate Alternative Traction Power Sources

- **Rolling Stock Sub-systems**
  - **Evaluate, develop and apply adhesion-independent & other braking technologies**
  - **Mechatronic logistics - identification and development of applications with a business case**
  - **Energy efficient drive systems**
  - **Improve passenger train interior designs for comfort, access, durability**

- **Traction Power**
  - **Multi, dual & hybrid traction drives**
  - **Monitor and evaluate new fuels**
  - **Active monitoring of traction solutions and hybrid engines being/employed around the world**
  - **Improve diesel engine efficiency and life**

### Produce Standard Architectures for Rolling Stock Sub-systems

- **General**
  - **Agreed on-board systems architecture (including definitions and interfaces)**
  - **Develop white system modelling to examine interactions**
  - **Advance modelling techniques**

- **Trains**
  - **RST TSI (High Speed)**
  - **Design criteria for versatile passenger rolling stock**
  - **Design criteria for versatile freight rolling stock**
  - **Promote right-mass train design**

- **Sub-systems**
  - **EU MODTRAIN Project**
  - **Determine and advise on use of open standards within the rail industry**

### Improve the Operational Capabilities of Freight Rolling Stock

- **Freight Rolling Stock**
  - **WAG TSI**
  - **Improve overall operational capability of freight trains & wagon**
  - **Improve freight train and locomotive performance (speed, acceleration, braking)**
  - **Production freight specific system requirements**

---

**Vision**

Mass and energy efficient, low whole-life cost rolling stock meets the evolving needs of its customers.

### Industry Delivery Activity

- **TSLG Completed activity**
- **TSLG In progress**
- **TSLG Planned**
- **TSLG Potential**

All dates and durations should be regarded as indicative.
VISION
Information is a valued rail asset that improves customer services, reduces operating costs and generates revenue

OBJECTIVES
New revenue streams from the exploitation of rail information
Improved customer services
Reduced operating costs

STRATEGY
Define common information architectures and protocols
Produce an optimised cross-industry information flow model
Exploit rail information through commercial partnerships

ENABLERS
National Information Systems Catalogue (NISC)
Open architectural standards
Data management
Resilient systems
Excluding Network Rail’s own information systems, research\textsuperscript{15} discovered over 130 information systems maintained by approximately 20 suppliers were in operation in 2011. Maintaining individual legacy systems is expensive and inefficient. Information cannot be shared or exploited efficiently and this inhibits whole-system approaches for technology-based improvements.

The EU project InteGRail identified that integrated systems using common standards can improve whole-system reliability by up to 50\% by optimising maintenance and the cost of maintenance could be reduced by 10\%, amongst other benefits.

To improve efficiency, mitigate costs and identify opportunities for better use of the vast amounts of collected data, the rail industry would benefit from a coordinated approach towards system architectures, information management and information exploitation. An initial study to understand the current information make-up of the sector and catalogue and map the industry’s information systems is underway\textsuperscript{16}.

The businesses in the industry are information-rich and use that information effectively to enhance and drive decision-making processes. Advanced and appropriate decision support tools are in place and in use on a daily basis.

The industry realises the value of its data for customer and internal purposes and improves its costs, attractiveness and performance as a consequence.

The businesses make use of externally and internally generated information sources and support customers’ preferred devices.

Rail businesses are capable of integrating a variety of information sources to produce new information and adapt their business strategies.

Information systems are built for expansion and easy replacement of outmoded parts. Costs are minimised through the use of commercial off-the-shelf (COTS) programmes and uniform testing and acceptance procedures. Agreed architectural standards, protocols and service level agreements support connectivity, improve the capability to share the information resources and facilitate a whole-system approach.

European standards\textsuperscript{17} have harmonised procedures, facilitating information exchange between railway computer systems across Europe and opening opportunities to explore new revenue streams.

The improved information systems and management allow the rail industry to exploit its data catalogues and build strategic partnerships to provide customers with personalised information and services that correspond to their individual needs.

\textsuperscript{15} RSSB Project T962 Information systems architecture for the rail industry, an initial overview, September 2011
\textsuperscript{16} ibid
\textsuperscript{17} TSIs Telematics applications for passengers and freight (TSI TAP and TSI TAF); also the InteGRail project
OBJECTIVES

2.122 The value of information gathered in the rail sector is recognised and exploited as new revenue streams are identified.

2.123 Rail businesses collaborate to make the best use of information sources. New business models are developed to exploit data. Vendors are able to develop applications and services to generate income and improve customer services.

2.124 Information-sharing and exploitation to reduce costs, including transaction costs such as ticketing, are facilitated by common architectures, protocols and dictionaries. Duplication of effort and information is avoided. Bespoke products are replaced with lower cost COTS technologies and applications, which are also more cost-effective to maintain.

STRATEGY

2.125 Common architectures and protocols would facilitate integration and information-sharing. Costs would be lowered and services improved. A suite of common and open standards would allow COTS products and services to be implemented with fewer specific industry modifications. Suppliers would be encouraged to invest in developing new systems as the marketplace becomes effectively larger. A common information framework would allow the industry to benefit from new technologies more quickly and efficiently.

2.126 To facilitate the development of common architectures, existing data and information flows need to be mapped to create a cross-industry information flow model. The key requirements to create and maintain a future dynamic architecture are:

- Agreed information systems architecture and standards
- Common ontology and data dictionaries
- Security classifications for data
- Storage requirements
- Agreed suites of data types, for example asset and rolling stock data

2.127 Commercial partnerships would focus on mutual benefits and shared opportunities and risks. The Innovation section describes opportunities for innovators and commercial developers to exploit railway data and create new revenue streams.

ENABLERS

2.128 Completing the National Information Systems Catalogue (NISC), started by TSLG, provides an important baseline. The NISC will help the industry to understand and analyse current railway data and architectures as the basis for a new holistic architecture and a whole-system approach to data and information management. The analysis will identify duplication and gaps and facilitate solutions for integrating new systems into the existing architecture.
2.129 The common standards proposed in InteGRail and the TSIs Telematics applications for passenger services (TAP) and Telematics applications for freight (TAF) would support European interoperability as well as provide useful guidelines for the development of open architectures for the rail sector in Britain.

2.130 Coherent management policies, protocols and clear identification of data owners are needed to support a whole-system approach and maximise the benefits of data sharing, analysis and exploitation.

2.131 All information systems must be resilient to cyber-attacks and appropriate protective measures based on risk assessment must be built into the systems within the common framework.
Information is a valued asset that improves customer services, reduces operating costs and generates revenue.
CUSTOMER EXPERIENCE
On board multi-media systems and telematics

Mobile communications gateway prioritises data transmission for multi-media services.

Communications are supported for video/surveillance/CCTV and driver, crew, operator and maintainer oriented services.

Safety-related control data prioritised over customer infotainment.

On train communication network selector decides optimum data transmission, e.g. 3G, 4G, LTE, satellite to support laptops, mobile phones, iPhones, tablets, iPads, etc.

On board multi-media systems and telematics.

Customers receive real-time updates, tailored to their specific journey.

The trains have downloaded bulk data from the previous station using WiFi Max.

On-board multi-media systems and telematics.
VISION
Rail is customers’ preferred form of transport for reliability, ease-of-use and perceived value

OBJECTIVES
Continuous improvement of customer satisfaction
  Seamless journeys
  Accurate and timely information
  Freight customers have a competitive advantage

STRATEGY
Improve the door-to-door journey experience
  Improve customer access
  Control health, safety and security risks
  Provide information to distribution channels
  Integrate rail and freight customer information systems

ENABLERS
  Customer information systems
  Demographics and behavioural modelling
  Contactless ticketing technologies
  Sensor technology
  IT solutions for freight system integration
2.132 Passenger journeys have almost doubled to approximately 1.5bn in the 15 years to 2011/12 and are expected to continue to increase. Similarly, passenger demands of value for money, comfort and facilities are expected to rise.

2.133 Freight use of rail has also increased significantly over the same period by approximately 50% by tonne-miles although rather less in terms of tonnes lifted and unevenly among commodities. Parallel to passenger expectations, freight shippers expect ever higher levels of service quality and reliability and greater integration of rail services within their overall logistics.

2.134 Responses to the 2010 RTS consultation document suggest wide support for the rail industry to address the 4C challenge of raising passenger satisfaction to the highest possible levels by 2037. As a first step the IIP for CP5 set a target of at least 90% customer satisfaction to be achieved by 2019.

2.135 RTS 2012 is ultimately for the customers' benefit, addressing customer requirements such as punctuality, reliability and higher network and passenger capacity through system improvements. This section covers aspects which contribute to the overall customer experience.

2.136 Rail is the preferred form of transport for passengers and freight customers. Every customer can rely on excellent service provision that is consistently punctual, reliable and good value and offers easy interchanges with other forms of transport.

2.137 Rail offers personalised, convenient yet mass transit-based services that meet customers' needs. Information about journeys, related travel and other added-value services are readily available and customer-focused staff are helpful at all times.

2.138 Passengers arriving, departing and changing trains have smooth transitions through stations. Clearly defined and spatially efficient routes maximise throughputs and minimise delays.

2.139 All rail customers, passenger or freight, receive consistently outstanding levels of service and reliability from rail businesses. The train-lengthening programme has increased passenger capacity and real-time traffic management has optimised network capacity. Market sectors may have different demands but overall, train interior designs and upgradable facilities will aim to satisfy the needs of customers in all sectors.

2.140 Rail services will be fully integrated within the transport system so that a customer can plan and purchase door-to-door journeys with confidence. Interchanges, including those with other transport modes, make transfers easy, comfortable and reliable and timetables are planned to minimise inconvenience.

2.141 Improved information technology, management and exploitation and cross-industry collaboration provide passengers with personalised services for journey and ticket information, entertainment and communication services. Station and staff information systems and personalised messaging help passengers to find the right platform and carriage to board their train quickly and get a seat, which will also help
to reduce dwell times. During a rare disruption, train operators keep passengers informed – at home or on the move – and offer alternative arrangements.

2.142 The integration of service scheduling, real-time traffic management and terminals’ management systems with customers’ own systems, allows the railway to be a fully effective part of the management process for freight customers. Consignments are tracked throughout the journey and real-time information is available for consignees. Rescheduling is easily facilitated if required. Information systems help business performance reviews. The removal of lineside signalling allows faster and less expensive planning and implementation of connections for new freight terminals. These are either bespoke facilities or multi-modal consolidation centres outside major cities to facilitate environmentally-friendly urban distribution, as required. Rail freight satisfies an increasing share of non-traditional markets, in line with European white paper aspirations.

STRATEGY

2.143 Door-to-door journeys are typified by seamless modal changes, with multimodal services available from a single booking. Improved interchanges between modes are required to reduce overall travel time and associated risk, with easy-access transport hubs and informative signage.

2.144 Stations and trains should continue to improve onsite customer accessibility and services. Wheelchair users and passengers with pushchairs or cumbersome luggage should have step-free access to trains and platforms.

2.145 Access to information, tickets and best prices should be improved and simplified. Reading devices for tickets with codes that can be displayed on mobile devices would be a useful initial solution. Later, one-stop online shops for all ticketing requirements would simplify the process and reduce the time a customer spends purchasing tickets. Paper tickets should be phased out and replaced with a single smartcard technology that offers interoperability between all transport modes in the UK and Europe. Reading devices on trains could also be introduced. Passengers would be offered the best available fare when boarding and leaving a train without having to purchase a ticket in advance.

2.146 Passengers could be kept better informed through intelligent traffic management systems that identify real-time train location and distribute this information to passengers. Personal mobile devices could automatically receive updates about train positions and other relevant information. Through strategic relationships, technological advances in the telecoms and entertainment industries could be exploited to provide rail customers with better information and onboard entertainment services.

2.147 Improved relationships between passengers and service providers could lead to the ability to establish and update passenger profiles automatically for bespoke services. If journey carbon content is given at the planning stage and shown in the ticket information, customers could also make ‘carbon-wise’ choices.
Through information technology (IT) developments, the logistics industry is making continuous improvements to its operational efficiency but the rail components of the distribution system have often been excluded. Overcoming this deficiency would encourage rail business growth. As railway IT systems are developed, including those for train positioning, intelligent trains and intelligent infrastructure, there is a big opportunity to integrate fully with customer systems to provide a seamless service to the customer and drive costs further out of the operation.

As far as possible, IT platforms that interact with customers’ existing technology without compromising the security of railway operating systems should be developed. Bespoke systems for non-safety critical information are unnecessary and inconvenient for customers. The EU’s draft TSI TAP will allow the harmonisation and standardisation of procedures, data and messages between railway computer systems, infrastructure managers and ticket vendors to provide reliable information for passengers.

In 30 years, demographic changes will result in a generally older population. The implications this could have for customer accessibility and mobility should be considered when designing and operating public services. Individuals, on average, are also becoming larger. Demographic modelling of the likely impact of these trends is required as part of a review of key assumptions in the Passenger Demand Forecasting Handbook, a business planning reference document used by industry and government.

Technologies for seamless ticketing are progressing. Regional systems offering intermodal electronic ticketing are in use and expanding. To counteract the diversity of ticketing systems - over 9,000 in the UK in March 2012 - initiatives such as the European Interoperable Fare Management project are providing valuable standardisation for a single technology framework to improve door-to-door ticketing, including journeys beyond the UK and for more than one mode of transport.

With simpler fare structures, contactless card technology could evolve to the point where passengers purchase travel by walking past a sensor by the train doors, or registering the start and finish of a journey. Evidence of purchase, including a breakdown of ticket price could be sent automatically to the passenger’s personal mobile device.

Countering security threats could benefit from the increased use of passive electromagnetic, chemical and acoustic sensor technologies. These technologies would provide a sensor grid which assesses threats and is monitored automatically. Human interaction is signalled only when the conditions of defined threat levels have been detected.

18 The next steps for mobile ticketing hardware, in Rail Technology magazine, Feb/Mar 2012.
2.154 Finding the most effective and efficient means to align IT with freight customers’ systems will be complex as there are many freight customers and many systems. Generic IT platforms would be the simplest solution for integration but this requires careful assessment and planning. Collaboration between businesses to examine the feasibility would be an initial step towards producing heterogeneous results. Benefits could be derived at local and system levels. Similar to the TSI TAP, the TSI TAF will harmonise the functional and technical standards for exchanging information between the parties involved in rail freight transport.
WHOLE-SYSTEM APPROACH
Specifying assets in a whole-system context and a whole-life perspective, they will initially cost more... but the components will work well together, the system will be reliable and passenger needs fulfilled... customers will be impressed and more will arrive.

...subsystems will be ‘tuned’ to the wider system, assets last longer, maintainance cheaper, less downtime, safer and more reliable railway.

Sensors send signal from the track and train to satellite

Pantagraphics and wires work in harmony

Train tuned to track, track tuned to train

STATION

TICKET RECEIPTS
VISION
A whole-system approach enables the rail industry to implement change easily and improve reliability, availability, maintainability and safety.

OBJECTIVES
An industry-wide framework for a whole-system approach
- Coordinated planning, delivery and operations
- Integrated asset management techniques

STRATEGY
- Adopt a whole-system approach
- Improve industry whole-system modelling capability and tools
- Develop a set of aligned asset management plans for the railway

ENABLERS
- Effective cross-functional and cross-industry communication
- Common modelling and planning tools
- Common asset information systems
- Best practices in whole-systems approaches
WHOLE-SYSTEM APPROACH

CONTEXT

3.1 The RTS 2012 whole-system is the rail sector, its assets, organisations, operations and stakeholders. It is the railway’s people, processes and systems. The railway has many thousands of assets owned, operated and maintained by a range of organisations, each with their own business objectives, priorities, timescales, policies and incentives.

3.2 The inherited railway was often designed as single sub-systems and not as a whole. This legacy presents many constraints on service quality and requires a whole-system approach for a cost-effective and efficient upgrade.

3.3 The whole-system engineering challenge has been recognised:

- TSLG has been formed to provide technical leadership for the industry
- System Interface Committees (SICs) have been established to examine and improve performance and cost across sub-system boundaries
- The Rail Delivery Group (RDG) has been established
- Industry initiatives for a whole-system approach are increasing, such as RTS 2012, cross-industry remote condition monitoring (XIRCM), cross-industry information systems (XIIS) and whole-life and cost asset management.
- The RUS process supports planning on a whole-industry basis (eg Network RUS: Passenger Rolling stock)

VISION

3.4 The rail industry adapts easily to change and implements innovative new designs and methods using a whole-system approach.

3.5 The industry’s embedded whole-system approach has increased reliability, availability and safety at reduced cost and is easier to maintain. Advanced signalling and traffic control systems have reduced the likelihood of train collisions and a whole-system approach has reduced the rolling stock collision requirements and saved train weight, cost and energy consumption.

3.6 Cross-industry coordination of the design and development of sub-systems and components reduces duplication and minimises negative cross-system impacts.

3.7 Improved remote asset monitoring, including RCM and fewer asset failures increases the reliability of infrastructure and rolling stock. Across the industry, updated maintenance policies and tested contingency plans result in customers rarely experiencing disruption.

OBJECTIVES

3.8 A whole-system framework has been established within which suppliers can develop products with confidence to meet the industry’s requirements. Cross-industry strategic planning allows new solutions to be developed and implemented easily. The diverse planning horizons within the industry are aligned to deliver whole-system, whole-life solutions.
Greater collaboration within the industry fosters coordinated planning and operations which has led to increased levels of reliability and resilience. Customer satisfaction is raised through the improved service levels.

Asset management is aligned across the industry. Excellent asset knowledge and evidence-based decision-making improves performance at lower cost and with less business risk.

**STRATEGY**

A cross-industry, whole-system approach to design, maintenance, delivery and safe operation should be adopted. A holistic understanding of the railway is needed to identify risk factors during design stages to allow for any necessary adjustments. This approach would avoid duplication of effort, reduce negative impacts and simplify the introduction of new components and processes.

Effective whole-system planning requires models suitable for industry, innovators, academia, suppliers and investors. These models could be used to understand the impact of changes to the whole system and support whole-system research and development by:

- Using a virtual design and development environment
- Defining requirements, especially across sub-system boundaries
- Analysing priorities between competing options
- Testing resilience
- Optimising the system

Life-cycle costing tools would optimise decision-making processes for maintenance and renewal. The tools should be able to model a variety of options, including the impact on services, passengers and technicians, to provide comprehensive assessments for work volumes, costs and outputs.

The industry should collaborate to develop a set of aligned asset management plans for the railway. Common policies and strategies, that encompass a full range of outputs ranging from service delivery to environmental impacts, are required to manage the industry’s assets. Aligned asset management plans should facilitate the implementation for other parts of the industry, operations and external parties.

**ENABLERS**

Better organisational structure and communication channels between all industry stakeholders are necessary to improve technical and asset interfaces. Improved collaboration between rail operators, engineers and asset managers and close interaction with planners will help to develop and deliver appropriate rail technologies.

Cross-industry alignment and planning need to remove constraints on operations and services for future infrastructure requirements - be it passenger, freight or international traffic. Alterations to infrastructure system capability/flexibility should be within the prevailing processes and procedures and adhere to whole industry requirements.
3.17 Infrastructure routes and train operating companies (TOC) should form alliances to communicate better and work towards common goals. Collaboration could address issues at the wheel/rail interface, such as rolling contact fatigue (RCF) more efficiently through Vehicle-Track Interaction Strategic Model (VTISM) and TrackEx. Work carried out by the five SICs, including VTISM, demonstrate the importance of understanding the impact of operational change on individual railway assets.

3.18 The industry needs to establish a common standard language and catalogue for sub-components. Currently, each railway asset is assigned a code by each organisation that uses it. For example, a set of automatic doors at a station may be numbered DR001 in NR’s asset register and SEF102 in the TOC’s register. A single industry asset register which is accessible, accurate and provides real-time updates is very likely to simplify and improve the quality of asset information.

3.19 Asset information underpins a modern approach to asset management. Adopting ISO 55000, the international development of the British PAS 55 standard for asset management, would offer a more consistent approach throughout the rail sector and improve the flow of information for risk-based safety, maintenance and other operational decisions. Consolidating existing system types of asset information, for example, ORBIS (Offering Rail Better Information Services) would also improve consistency across the sector.

3.20 Careful attention should be given to learning from proven best practices. For example, different approaches to route-based alliances could provide useful best practice lessons to aid the development of a whole-system approach for the railway. This would help the rail industry to adapt faster to changes in technology and accelerate potential cost savings.

---

19 TrackEx is a systems analysis tool used to plan and manage track degradation. It is an NR bespoke product and used by the industry.
A whole-system approach enables the rail industry to implement change easily and improve reliability, availability, maintainability and safety.

### RTS Whole-System Approach

<table>
<thead>
<tr>
<th>Approach</th>
<th>Rail Delivery Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>Cross-industry whole systems leadership</td>
</tr>
<tr>
<td>Business Models</td>
<td>Developing whole system business models</td>
</tr>
<tr>
<td>Planning</td>
<td>Cross industry alignment of planning</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Vision and leadership feeding into and from Transport Catapult, Innovation Funds ERRAC/RTI</td>
</tr>
<tr>
<td>Benchmarking</td>
<td>Establish knowledge exchange practices</td>
</tr>
<tr>
<td>System Models &amp; Tools</td>
<td>Whole system reliability monitoring</td>
</tr>
</tbody>
</table>

### Improve Industry Whole-System Modelling Capability and Tools

<table>
<thead>
<tr>
<th>ISO55000 (PAS55)</th>
<th>ISO55000 established</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset Management</td>
<td>Produce set of cross-industry aligned asset plans</td>
</tr>
<tr>
<td>Asset Information</td>
<td>Consistent approach to asset information (sharing &amp; sharing)</td>
</tr>
<tr>
<td>Asset Programmes</td>
<td>Whole system reliability monitoring</td>
</tr>
</tbody>
</table>

### Develop a Set of Aligned Asset Management Plans for the Railway

<table>
<thead>
<tr>
<th>YRSM Model Developed</th>
<th>Whole system reliability monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRACAS</td>
<td>FMeca</td>
</tr>
</tbody>
</table>

### VISION

**PRE 2010**

- **CP 4:** Rail Value for Money Study
- **CP 5:** Developing whole system business models
- **CP 6:** Enhancing cross-functional and cross-industry communication
- **CP 7:** Transport KTN established
- **CP 8:** Developing whole system business models
- **CP 9:** Implementing rail industry standard for whole system management

**2011 - 2020**

- **CP 4:** Initial ISO5500 audit of whole industry
- **CP 5:** Developing whole system business models
- **CP 6:** Establishing knowledge exchange practices
- **CP 7:** Transport KTN established
- **CP 8:** Implementing rail industry standard for whole system management
- **CP 9:** Developing whole system business models

**2021 - 2030**

- **CP 4:** Section-wide adoption of ISO5500
- **CP 5:** Whole system, whole life, whole cost modelling capability
- **CP 6:** Whole system reliability monitoring
- **CP 7:** Whole railway system models to aid simulation/experimentation
- **CP 8:** Whole system, whole life, whole cost modelling capability
- **CP 9:** Whole railway system models to aid simulation/experimentation

**2031 - 2040**

- **CP 4:** Whole railway system models to aid simulation/experimentation
- **CP 5:** Whole railway system models to aid simulation/experimentation
- **CP 6:** Whole railway system models to aid simulation/experimentation
- **CP 7:** Whole railway system models to aid simulation/experimentation
- **CP 8:** Whole railway system models to aid simulation/experimentation
- **CP 9:** Whole railway system models to aid simulation/experimentation

All dates and durations should be regarded as indicative.
INNOVATION
VISION
A dynamic industry that innovates to evolve, grow and attract the best entrepreneurial talent

OBJECTIVES
Innovation makes a significant and continuing contribution to rail business success
An industry with an international reputation for innovation, which contributes to an expanding export market
An integrated cross-industry system for innovation
Innovation requirements are fully supported

STRATEGY
Continue to remove barriers to innovation
Achieve Innovation Capability Maturity Model Level 5 amongst leading rail companies during CP6
Develop commercial models to facilitate the use and exploitation of intellectual property
Support innovators with facilities, identified priorities and funding

ENABLERS
Guidance on standards for the benefit of innovators
Identification of priority technical areas
INNOVATION

CONTEXT

3.21 Transport is an increasingly competitive sector which needs to innovate constantly to produce future products, systems and services and to become more attractive to new investors. Railway investment in innovation has been less than in other transport sectors, reported as 0.5%\(^{20}\) against international best practice of 3.5%\(^{21}\). The railway must continue to foster innovation across the industry to realise the significant cost savings identified in the RVfM by 2019 and contribute to the longer term 4C challenges.

3.22 The railway is capable of learning from other industries and transport sectors. The Transport Knowledge Transfer Network (KTN) and the proposed Transport Systems Catapult Centre show that there is much common ground in both the challenges and the potential solutions. Other sectors have been successful in achieving substantial investment to develop and secure the UK capability in key technologies and improve business prospects. For example, over £400m of government funding supports the automotive industry in its extensive demonstration programme for low carbon vehicles. Aerospace has secured £200m of government research and innovation funding since 2011 to ensure that the UK retains a world-class aerospace industry.

3.23 Research on barriers to innovation\(^{22}\) identified actions (see Table 1) and led TSLG to make the case for innovation funding in CP5, which has been recognised in the High Level Output Statement (2012). To take this initiative forward, TSLG has now established the Rail Industry Enabling Innovation Team (EIT) and the Rail Innovation Fund.

3.24 TSLG has collaborated with the Technical Strategy Board in three significant initiatives:

- The launch of the Transport KTN to encourage and facilitate communication between research bodies and suppliers to embed new knowledge and ideas
- The jointly funded £10m R&D Accelerating Innovation in Rail competition, to develop projects between companies
- The case for the £30m/year Transport Systems Catapult technology innovation centre

3.25 TSLG is actively supporting complementary initiatives, including:

- The Rail Industry Association’s (RIA) Unlocking Innovation programme
- The European Rail Association’s Shift2Rail proposal for a joint technology initiative, which has potential funding of £800m for the railway

3.26 EIT has been established to assist the industry to match challenges with potential solutions and secure funding where appropriate. This innovation may be led by business, technology or the supply chain. The challenge may include an approach, perhaps technology-enabled, from another domain or railway and prove the case for its adoption in the rail industry in the UK.

---
\(^{20}\) Rail Value for Money study, 2010: estimated investment in £11bn turnover in 2009/10
\(^{21}\) RSSB T934 Enabling Technical Innovation in the Industry – Barriers and Solutions, 2010
\(^{22}\) ibid
VISION

3.27 The railway in the UK is recognised as a dynamic and key contributor to the world-wide integrated transport sector, excelling at delivering cost-effective and timely innovative products, services and systems. Maintaining Level 5 of the Innovation Capability Maturity Model (ICMM) demonstrates the industry’s continuous improvement approach to enabling innovation.

3.28 The rail industry is a magnet for the best entrepreneurial talent, attracted by opportunities to develop, implement and use leading-edge technical applications for business benefit.

3.29 A holistic approach is embedded in the rail industry, with a wide range and quantity of innovative ideas progressing rapidly through technical readiness levels (TRL) through increasingly rigorous business cases. Innovators are supported further by:

- Clarity on the priority areas for innovation
- Access to industry experts
- Access to development and test facilities
- A range of funding sources

3.30 EIT, on behalf of the rail industry, provides innovators and investors with knowledge of risk and expected rewards associated with innovative concepts. Incentives within and between industry players have been aligned by matching investment cycles and provision of value transfer mechanisms between stakeholders.

OBJECTIVES

3.31 Clear direction and guidance from EIT provides the basis for innovators to make valuable contributions to the rail industry. This helps the railway to address the 4Cs and maximise timely business success for its stakeholders.

3.32 Achievement by leading rail companies of ICMM Level 5 during CP6 (2019-2024) demonstrates the rail industry’s commitment to enabling a persistent innovative culture. The commercialisation of innovation leads to increased export sales for UK-based businesses.

3.33 A pan-industry system, designed to achieve a step-change in the innovation ecosystem, allows the full scale and scope of RTS 2012 to be realised. Innovation operates across functional and commercial boundaries and along the supply chain, from component SMEs to customers. Effective mechanisms evaluate and apportion benefit, cost and risk.

3.34 To support investors, technical priority areas are identified, development and test facilities are available and adequate funding is secured. UK academic and industrial capabilities are understood so that investment can be prioritised to achieve the maximum benefits.
STRATEGY

3.35 Research\(^{23}\) has identified barriers to innovation in leadership, industry capability and risk reduction. The actions begun in 2010 should continue to address these barriers. Table 1 summarises the progress and actions remaining.

Table 1: Actions for three specific areas of strategic interventions

<table>
<thead>
<tr>
<th>INTERVENTION</th>
<th>ACTION</th>
<th>STATUS DECEMBER 2012</th>
</tr>
</thead>
</table>
| Create system leadership              | 1. Establish a rail system leadership function.  
2. Establish a top-level sponsor function.  
3. Create cascaded specifications for contract conditions to align industry incentives.                                                                                               | 1. Done. TSLG provides the leadership function; EIT leads the everyday activities.  
2. Done. RDG provides the top-level sponsor function.  
3. To be started. EIT will develop commercial models to encourage alignment of incentives and clear ownership of intellectual property.                                                                                                                  |
| Enhance industry capability for innovation | 1. Design and develop effective mechanisms to translate ideas into demonstrable, de-risked, system-level radical innovation projects.  
2. Build upon existing materials and disseminate models of good practice.  
3. Promote and provide culture change programmes.  
PROMOTE OPEN INNOVATION\(^{24}\) FOR THE FRONT END OF THE INNOVATION PROCESS.                                                                                         | All to start: EIT will support the industry to address these issues and increase the industry innovation capability. Progress should be measured against the ICMM.                                                                                                                                 |

---

\(^{23}\) RSSB T934 Enabling technical innovation in the GB rail industry – barriers and solutions, 2010

\(^{24}\) Open Innovation is a concept/paradigm that encourages sharing and trading of knowledge across and between organisations to improve an industry and/or organisation’s innovation and know how capabilities.
Table 1 Continued

<table>
<thead>
<tr>
<th>INTERVENTION</th>
<th>ACTION</th>
<th>STATUS DECEMBER 2012</th>
</tr>
</thead>
</table>
| Reduce the risks of introducing innovation to the system | 1. Create support and coaching resources/ombudsman for acceptance processes and standards.  
2. Develop industry agreement on acceptable types of test results from other environments.  
3. Take steps to ensure good access to appropriate test facilities.  
4. Find mechanisms to manage the commercial risk of testing on the operating railway. | 1. In progress: RSSB is exploring what type of leadership role it can take on behalf of the industry to rationalise and harmonise railway interface standards as proposed in the report *Specifying Successful Standards*.  
2. In progress: TSLG has commissioned research.  
3. In progress: TSLG has published a guide on access to test facilities as a first step.  
4. To be addressed by EIT. |

3.36 RIA has developed the general five-level ICMM for the railway's approach to innovation. An overview of the ICMM and the growth curve that leading rail companies should aim to follow to achieve Level 5 during CP6 is shown in figure 1.

3.37 The scale and ambition of RTS 2012 demands a fit-for-purpose innovation system. A new approach should be defined, drawing on emerging concepts from industries recognised as best-in-class for innovation.

3.38 The railway’s innovation system should develop commercial models to allow intellectual property (IP) to be accessed, shared and evolved for cross-industry benefits. These models need to ensure that rights in and ownership of foreground IP, where appropriate, are secured. Background IP should be protected but support the exploitation of foreground IP. The commercial model and returns should be based on the respective level of investment made in background and foreground IP to be acceptable for all parties. Further, the commercial model should support a quicker development cycle. This would allow products and services to enter the market more quickly and provide opportunities for wider exploitation throughout the rail industry and beyond.

---


26 RSSB T965 Testing and trialling. A good practice guide for testing and trialling new technology for Britain’s railways, November 2011

27 Foreground IP is the intellectual property developed or acquired from the start of the contractual agreement.

28 Background IP is the intellectual property that has been developed or acquired before the start of the contractual agreement.
3.39 Facilities owned by or available to the rail industry should be open to innovators, researchers and developers. Where facilities do not exist, the case to develop new facilities should be explored so that innovative projects have the necessary environment to progress rapidly.

3.40 TSLG, through EIT, should define technical architectures by operational concept, using these to identify priority technical areas for innovation. This would allow the rail industry to focus on the developments that deliver the best business and technical results and meet the long-term rail strategy. These priority areas should identify, build on and where appropriate, develop the rail industry’s technological strengths.

3.41 The railway should continue to secure funding sources for innovation and set benchmarks again other more successful innovating sectors.

ENABLERS

3.42 The railway has a necessary range of standards that need to be considered when developing new products, services and systems. The breadth and depth of these standards is often cited by innovators as a barrier to innovation. To remove this barrier, guidance will be given about these standards, how they fit into the railway system and how the standards processes contribute to innovation.

3.43 Priority areas with the potential to drive economic growth and exports will be determined through analysis of industry and academia capabilities in the rail sector. The results will be used to enable both EIT and industry innovators and investors to make informed decisions on where to employ their financial and technical resources. EIT will provide guidance and information to allow the innovator to understand the early business case and process for such innovation.

---

29 RSSB T965, November 2011
Figure 1: Using initiatives to raise the innovation maturity level

### Level 5: Integrated/Adaptive
**Feature:** Integrated and strategic approach across transport sectors

**Characterisation:** Widely used mechanisms across systems and down supply chains direct innovation efforts. Sector strategy and capability are pursued. The strategy is integrated with other national strategies, e.g., transport, energy, communications, manufacturing and exports.

- Integrated national infrastructure strategies
- New collaborative business models
- Extended commercial horizons

### Level 4: Optimised
**Feature:** Rail sector fully coordinated and focused

**Characterisation:** Rail sector technology and innovation strategy is visible and used by organisations to set direction. System perspectives prioritise and pursue best options. Research and technology base is integrated with supply chain innovation. Technology demonstrators are extensively used to reduce risk. Innovation within and between organisations is widespread and methodologies are continuously refined. Good facilities and resources

- Support for integrated and large scale demonstrators
- Initiatives for testing to reduce risks with new technology
- Whole system / cross industry demonstrators for integrated approach to 4Cs

### Level 3: Managed
**Feature:** Limited coordination within supply chain and with key clients

**Characterisation:** Organisations are developing their individual innovation strategies based on their understanding of customers’ needs. Bilateral relationships within supply chains are being formed to support innovation. Research outputs are disseminated for wider benefit

- Initiatives for testing to reduce risks with new technology
- Transport Systems Catapult established
- Knowledge transfer, open innovation and sharing needs, priorities and strategies
- Enabling Innovation Team formed

### Level 2: Competent
**Feature:** Competent but uncoordinated

**Characterisation:** Organisations innovate effectively individually but find it difficult to manage up and down the supply chain. Integration and testing/trialling of new products and systems is difficult and few mechanisms manage the risks of introduction

- Knowledge transfer, open innovation and sharing needs, priorities and strategies
- Enabling Innovation Team formed

### Level 1: Initial
**Feature:** Inconsistent

**Characterisation:** Innovation is ad-hoc, conducted by individual organisations independently with in-house facilities. Little use of UK research base

- Knowledge transfer, open innovation and sharing needs, priorities and strategies
- Enabling Innovation Team formed

CONTINUE TO REMOVE BARRIERS TO INNOVATION

ACHIEVE INNOVATION CAPABILITY MATURITY MODEL LEVEL 5 AMONGST LEADING RAIL COMPANIES DURING CP6

DEVELOP COMMERCIAL MODELS THAT FACILITATE THE USE AND EXPLOITATION OF INTELLECTUAL PROPERTY

SUPPORT INNOVATORS WITH FACILITIES, IDENTIFIED PRIORITIES AND FUNDING

Leadership
- TSLG Enabling Innovation (Barric to Innovation Research)
- Address the barriers identified in TSLG’s ‘Enabling Innovation Report’
- Transform Industry Innovation Leadership
- EIT to develop commercial models to support innovation and align incentives
- Innovation policies established: standards, resources, knowledge base
- Align innovation activity with long term planning for the industry

Increase Capability
- Develop mechanisms to enable and de-risk innovation programmes
- Demonstrate models of good practice
- Establish Transport Systems Catapult
- Promote ‘open innovation’

Risk Reduction
- Transport KTN Established
- Reduce the risks of introducing innovation to the system
- Provide guidance on railway standards for innovators

ICMM
- Risk Industry Maturity Model
- ICMM Level 1: Initial
- ICMM Level 2: Competent
- ICMM Level 3: Managed
- ICMM Level 4: Optimised
- ICMM Level 5: Integrated & Adaptive

Approach
- Support collaborative working to develop whole system solutions
- Cross Industry Technology watch
- Technology requirements list maintained

Commercial
- Develop commercial models to allow IP to be used for cross industry benefit

Facilities
- Secure funding to develop appropriate test/trial development facilities
- Maintain appropriate access to test facilities
- Develop mechanisms to manage risk of testing on the operating railway
- Identify priority areas for railway innovation

Priorities
- Range of established funding sources
- Continue to secure funding sources for innovators

A dynamic industry that innovates to evolve, grow and attract the best entrepreneurial talent

THE FUTURE RAILWAY | THE INDUSTRY’S RAIL TECHNICAL STRATEGY 2012
PEOPLE

THE FUTURE RAILWAY | THE INDUSTRY'S RAIL TECHNICAL STRATEGY 2012
VISION
Skilled, committed and adaptable people delivering an efficient and customer-focused railway

OBJECTIVES
A culture of continuous improvement, effectiveness and customer service
Excellent leadership and a workforce supporting all aspects of the railway
A reliable supply chain for high-quality skills provision

STRATEGY
Assess the skills requirements for the future railway
Adopt a common standard for effective collaboration between organisations
Improve learning methods to maximise benefits from new technology
Design technology and roles with people in mind
Automate repetitive and arduous tasks

ENABLERS
Skills forecasting
Partnerships with education providers
Employee skills passport
National competencies database
Decision-support tools
3.44 People are key drivers as well as enablers in business. As the pace of technological and technical changes accelerates, people working in the rail industry must be equipped with the necessary skills to cope with the new technologies and techniques. With a whole-system approach, people need to understand and adapt to new working practices.

3.45 International competition and uncertainty about demand is risking the availability of suitably skilled people for the industry, although not all the required skills are railway-specific. Sometimes availability is low and costs are artificially high because technical and professional competence is not recognised without railway experience or qualifications.

3.46 Work carried out by NSARE suggests that a major gap in engineering skills is likely to develop unless remedial action is undertaken. It identified that only 17% of the engineering workforce has qualifications at higher academic levels (above 'A' level).

3.48 Learning programmes take full account of the implications of technological transitions and training prepares staff for technology-driven changes. Virtual learning environments and simulations are used to rehearse responses to both routine work and unplanned situations.

3.49 Strategic relationships with other sectors include learning from industries that have made radical technological transitions to understand the skills that are required and minimise the risk in adopting new skill sets. Railway companies have confidence in the supply chain to provide qualified additional or specialist resources.

3.50 Leaders drive the industry towards achieving the 4Cs and facilitate the technological changes. There is a shared vision of customer focus across the industry and a common desire to optimise performance. Rail is the employer of choice and knowledge is transferred with people from other sectors into the rail industry.

3.51 The culture and leadership style inspires staff to strive for continuous improvement in all aspects of the railway’s business. This is demonstrated by efficiency, effectiveness, quality and value in all operations and a palpable ethos of customer service.

---

**NSARE is the National Skills Academy for Railway Engineering, a key facilitator for matching specialised training requirements for rail employees with appropriate providers**
3.52 The future railway is likely to be technologically complex, more automated and managed by fewer but highly skilled people. A coordinated long-term view of the required skills, competencies and potential has identified skill sets and defined roles. These skill sets enhance mobility of personnel and career development and present opportunities to fine-tune skill mixes across the industry.

3.53 A reliable supply chain secures a consistently high-quality level of expertise for the industry.

**STRATEGY**

3.54 The operation, maintenance and development of a more technically advanced railway will require a suitably adapted management style. A systematic approach to career development, adopted by companies across the industry, would equip the Class of 2020 with the technical and leadership skills to run the railway in 2030 and beyond. These skills need to include an appreciation of cross-organisational business requirements and how to practise a whole-system approach.

3.55 Realising the potential of new technologies, adapting to the pace of change and the expectation of longer working lifetimes will require appropriate staff training. The industry will need to pay attention to the core skills of potential employees, engage with those who set the curriculum and teach in schools, colleges and universities and influence them to develop the skill sets that meet the needs of the industry.

3.56 Coherent standards for collaboration would lead to more effective cooperation between organisations to improve operational and business performance. Benefits of cooperation would include:

- An established common language and consistent approach
- Improved risk management
- Clear paths for continued improvement
- If certification were introduced, a mutual understanding of an organisation’s base capability

3.57 Skills to handle an increasingly rich data environment and to manage the real-world environment efficiently will require appropriate training methods. Improved methods could include virtual reality and simulation, role play and improved on-the-job training.

3.58 Design and introduction of new technology should take careful account of the people who will use it and match the planned level of human engagement. The effect of this interface on success is often under-appreciated, with detrimental business consequences. Understanding the people dimension is fundamental to planning new schemes.

3.59 New technologies in the industry will alter the workplace and automation could take over repetitive and arduous tasks. The railway has the opportunity to use these techniques and technologies to create an attractive work environment that makes it the employment sector of choice.
ENABLERS

3.60 Forecasts of the skills the railway will need in the future and analysis of any gaps in skills is essential to direct the planning effort. A continual process of resource planning and preparation is necessary to develop people with the appropriate range of skills to meet future requirements.

3.61 Workforce education, training and CPD will be enabled through:

- Widening the scope of NSARE beyond engineering, working across the industry and in partnership with independent education providers
- Development of continuous learning programmes

3.62 NSARE is also involved in developing tools designed to increase the flexibility of railway staff to work across the industry. These include:

- Skills passports showing portable competencies to support academic and professional qualifications
- A national database of competencies in core areas such as engineering

3.63 These educational initiatives could also improve the industry’s retention of corporate memory and guard against skills fade.

3.64 New technology will bring increased amounts of data, information and intelligence which require enhanced interpretation skills for decision-making. The workforce will also be assisted by the introduction of a new generation of decision support tools, including timetabling and maintenance schedule planning.
**Common Foundations - People**

<table>
<thead>
<tr>
<th>Activity</th>
<th>PRE 2010</th>
<th>2011 - 2020</th>
<th>2021 - 2030</th>
<th>2031 - 2040</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Management</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Career Development</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Manpower Planning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NSARE</strong></td>
<td>NSARE established</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Collaboration</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Culture</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Decision Making</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Human Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Automation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Vision**

- Skilled, committed and adaptable people delivering an efficient and customer-focused railway

**Assess the Skills Requirements for the Future Railway**

- Examine potential future technologies that are able to automate rail activities
- Use innovation to propose future automation
- Develop Human Factor Engineering discipline across the industry
- Understand the range and type of decisions that need to be made to sustain future railway operations
- Create virtual and simulation (safe) environments to practice decision making skills and understand consequences
- Implement National Competencies database
- NSARE established
- ADOPT A COMMON STANDARD FOR EFFECTIVE COLLABORATION BETWEEN ORGANISATIONS
- Design technology and roles with people in mind
- Automate repetitive and arduous tasks
- Improve learning methods to maximise benefits from new technology
- Adopt a common standard for effective collaboration between organisations
- Industry Delivery Activity
- Industry Development Activity
- TSLG Completed activity
- TSLG In progress
- TSLG Planned
- TSLG Potential

All dates and durations should be regarded as indicative.
COMMON DESIGN CONCEPTS

4.1 Common design concepts traverse the specific rail strategies and are relevant to the development plans that may result from RTS 2012.

WHOLE-SYSTEM RELIABILITY

4.2 Reliability is fundamental for customer satisfaction and lower costs and each part of the system contributes to the overall reliability. Reliable assets mean fewer delays for customers and less unplanned maintenance for technicians. If the approach to reliability were the same as for safety, there would be a step change in performance.

4.3 Explorative studies sponsored by TSLG sought to understand how reliability as a business objective could be improved and how unreliability constrains the ability to increase network capacity. Two distinct areas for reliability improvement emerged: operations and assets.

4.4 Performance targets addressing both railway assets and operations need to be set at system level if improvements are to be optimised.

4.5 Detailed modelling work has shown that the existing railway could double its capacity and still provide the current levels of public performance measures if these conditions were met:

- Some key infrastructure, such as points, underwent a step change in performance
- Train reliability performance at the level of the best
- A significant reduction in vandalism, cable thefts, suicides
- Shorter and more tightly controlled dwell and turnaround times

- Trains running at two-minute headways, at the right place and speed everywhere to reduce the three-minute tolerance significantly

4.6 Testing and trialling is an important factor for reliability – for assets, timetables and people. Innovative technologies need to be thoroughly tested and demonstrated at sub-system, then system level – away from the live railway and in environments that will be experienced in service.

RESILIENCE

4.7 The future railway should be resilient to:

- Operational disruption
- Externally caused disruption
- Climate change, extreme weather and other climate issues

4.8 A flexible timetable and network-wide control systems contribute to a resilient rail by minimising the effects of perturbations, allowing operations to continue as normal across the wider network, without causing secondary delays.

4.9 A whole-system approach would reduce asset failure and enhance the overall resilience and reliability of infrastructure and rolling stock. Improved asset monitoring, for example by RCM and maintenance policies have the potential to eliminate many in-service asset failures. Research\(^3\) estimated a potential reduction of 15% delay, valued at £90m/year, if RCM were effectively deployed. Of this, £12m/year is derived from sharing RCM data across industry boundaries.

\(^3\) RSSB T844 Mapping current remote condition monitoring, April 2009
4.10 Automated and manual contingency plans that are regularly updated and practised could improve response times. Disruptions to passenger journeys would be minimised and the majority of customers would experience no reduction in service levels.

4.11 The railway’s resilience to external events, normally outside its control, could be augmented through strategic relationships with supply, service and security sectors. For example, an electrified railway draws about 1% of the UK output. Distributed and alternative power routing could provide options for power supplies. Self-powered rolling stock should be able to sustain short-term operations until normal service can be resumed.

4.12 Planning and design tools for resilience, together with a more integrated approach to managing risk, aim to reduce the consequences of extreme external events caused for example, by terrorism. Without detracting from the primary function of rail, resilience engineering and materials could be deployed to mitigate risks in key areas.

4.13 Tomorrow’s Rail and Climate Change Adaptation (TRaCCA) report provides the basis for understanding the expected impacts on asset management of climate changes over the next 20 years. Areas covered in the report include:

- Climate risk assessment for rail operations
- Mathematical models to assess climate change impact by areas
- Preliminary asset management policies for climate change

4.14 Adapting to climate change is increasingly important and needs to be embedded in the core of railway businesses. Potential solutions need to be evaluated from a whole-system perspective for sustainability. For the electrification programme, for example, overhead power systems are more resilient to extreme rainfall than third-rail above-ground systems but may need to be re-evaluated for resilience to extreme heat.

SECURITY AND RISK MITIGATION

4.15 Britain has one of the best safety records when compared to other national rail organisations and this record will need to be maintained and improved in the face of new threats, challenges and risks. Several programmes are underway and more are outlined for delivery in CP5. Continuous improvement and preparation to cope with new and emerging threats, whether from terrorism or crime, are integral in RTS 2012.

4.16 In the longer term, technologies such as automatic facial recognition could be deployed for preventative security. The cost of complying with safety, security and health requirements is already embedded in operating costs. Careful choice of deployment and whole-life strategies could offset initial cost drivers for new risk mitigation initiatives.

4.17 System security should be maintained and continually checked and tested against a number of security threats, for example:

- Cyber threats could be minimised by resilient architectures and by additional layers of security including sophisticated firewalls between operational systems
4.18 For health, the increasing world population and mobility heighten the risk of pandemic viruses. Rapid responses to mitigate outbreaks are already in place but the longer term strategy requires increased preparedness for such an event. Preparations could include: cleaning technologies, anti-viral technologies and increased sensors.

4.19 Contingency plans should be in place and rehearsed to respond to a variety of security alerts. Governance procedures should be reviewed regularly and periodic staff training carried out to keep personnel up-to-date and aware of risks.

4.20 Train and station designs should be revised regularly to include new safety measures and materials where appropriate.

### AUTOMATION

4.21 The introduction of automated systems should be based on analyses to show which systems should be operated by staff, which should be partially automated and which should be fully automated to maximise efficiencies and service quality.

4.22 Increased levels of automation could provide benefits in three main areas:
- Operations
- Customer service
- Maintenance and asset management

4.23 Driver aids, such as ATO, improve predictability of train movements and precise control of traction energy and fuel usage, as well as potentially increasing network capacity. Similarly, intelligent traffic management systems are expected to enable significant improvements for network capacity and offer greater flexibility to meet customer demands, resolve perturbations and reduce operational costs.

4.24 Automation of a wider range of maintenance operations lowers the risk to maintenance personnel. Automated asset data provision would improve asset management and maintenance schedules. Better predictability subsequently increases the flexibility to respond to unpredictable events more efficiently.

### SIMPLICITY

4.25 Many of the strategies in the themes offer concepts supporting a simple railway.

4.26 A whole-system approach for rolling stock and infrastructure should reduce asset failures and maintenance requirements.

4.27 Standard modular systems architectures would reduce the unnecessary complexity of working with bespoke systems and requirements.
Similarly, standard assets and interfaces simplify maintenance requirements and reduce costs.

4.28 Standard language and glossaries such as a common data dictionary would simplify data flows and be easier to use if unnecessary jargon were removed. Misunderstandings that arise from different terminologies would also be avoided.

4.29 Simplified procedures, where possible, would give clear, unambiguous instructions to assist personnel to carry out tasks more efficiently.

4.30 Virtual and mathematical modelling should test the impacts of change to the system before implementation. Risks would be reduced when the potential complexities are understood before the event.

FLEXIBILITY

4.31 Flexibility means that the railway can adapt to circumstances quickly and efficiently in operating and planning contexts to meet the needs of passengers and freight customers.

4.32 Intelligent control systems would be able to re-route trains in real-time in the (increasingly rare) case of a perturbation.

4.33 Flexible rolling stock designs allow trains to have wider access to the network than is currently the case.

SUSTAINABILITY

4.34 Passengers may be more attracted to an environmentally-friendly railway and make it their preferred choice of transport, especially if environmental factors become increasingly important in the future. Other sectors are already researching and promoting ‘green’ initiatives.

4.35 The industry has identified the environmental impacts that can be reduced. These include: noise and vibration, waste and pollution, sustainable consumption and production, air pollutant emission and biodiversity\(^\text{33}\). Improvements can be achieved with the application of a whole-life, whole-system approach towards decision-making, considering both cost and environmental impacts.

4.36 Large quantities of steel, concrete, aggregates and other materials are used for maintenance, renewal and enhancement. Lower carbon options which do not adversely affect performance or cost could replace many of these materials. For example, using low carbon concrete which contains fly ash, a waste product from electricity generation and slag, a waste product from the steel industry, can reduce carbon life-cycle impacts by up to 80%.

\(^\text{33}\) The Rail Industry Sustainable Development Principles, February 2009
### ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>4Cs</td>
<td>Cost, carbon, capacity and customer satisfaction</td>
</tr>
<tr>
<td>4G</td>
<td>Fourth generation of mobile communications standards</td>
</tr>
<tr>
<td>AC</td>
<td>Alternating current</td>
</tr>
<tr>
<td>ATO</td>
<td>Automatic train operation</td>
</tr>
<tr>
<td>ATOC</td>
<td>Association of Train Operating Companies</td>
</tr>
<tr>
<td>bn</td>
<td>Billion</td>
</tr>
<tr>
<td>CCS</td>
<td>Control and Command Systems</td>
</tr>
<tr>
<td>CCC</td>
<td>Control, command and communication</td>
</tr>
<tr>
<td>COTS</td>
<td>Commercial off-the-shelf</td>
</tr>
<tr>
<td>CP</td>
<td>Control period</td>
</tr>
<tr>
<td>CPD</td>
<td>Continuing professional development</td>
</tr>
<tr>
<td>DAS</td>
<td>Driver advisory systems</td>
</tr>
<tr>
<td>DC</td>
<td>Direct current</td>
</tr>
<tr>
<td>DfT</td>
<td>Department for Transport</td>
</tr>
<tr>
<td>DMU</td>
<td>Diesel multiple units</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>EMU</td>
<td>Electrical multiple units</td>
</tr>
<tr>
<td>ERTMS</td>
<td>European Rail Traffic Management System</td>
</tr>
<tr>
<td>ETCS</td>
<td>European Train Control System</td>
</tr>
<tr>
<td>FuTRO</td>
<td>Future Traffic Regulation Optimisation</td>
</tr>
<tr>
<td>GPS</td>
<td>Global positioning system</td>
</tr>
<tr>
<td>GSM-R</td>
<td>Global System for Mobile Communications - Rail</td>
</tr>
<tr>
<td>HLOS</td>
<td>High Level Output Specification</td>
</tr>
<tr>
<td>HS</td>
<td>High-speed</td>
</tr>
<tr>
<td>ICMM</td>
<td>Innovation Capability Maturity Model</td>
</tr>
<tr>
<td>IEP</td>
<td>Intercity Express Programme</td>
</tr>
<tr>
<td>IP</td>
<td>Intellectual property; internet protocol</td>
</tr>
<tr>
<td>IT</td>
<td>Information technology</td>
</tr>
<tr>
<td>KTN</td>
<td>Knowledge Transfer Network</td>
</tr>
<tr>
<td>kV</td>
<td>Kilovolt</td>
</tr>
<tr>
<td>m</td>
<td>Million</td>
</tr>
<tr>
<td>mph</td>
<td>Miles per hour</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>LTE</td>
<td>Long-term evolution</td>
</tr>
<tr>
<td>NDT</td>
<td>Non Destructive Testing</td>
</tr>
<tr>
<td>NISC</td>
<td>National Information Systems Catalogue</td>
</tr>
<tr>
<td>NR</td>
<td>Network Rail</td>
</tr>
<tr>
<td>NSARE</td>
<td>National Skills Academy for Railway Engineering</td>
</tr>
<tr>
<td>OLE</td>
<td>Overhead line equipment</td>
</tr>
<tr>
<td>ORBIS</td>
<td>Offering Rail Better Information Services</td>
</tr>
<tr>
<td>ORR</td>
<td>Office of Rail Regulation</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
<tr>
<td>RAMS</td>
<td>Reliability, availability, maintainability, safety</td>
</tr>
<tr>
<td>RCF</td>
<td>Rolling contact fatigue</td>
</tr>
<tr>
<td>RCM</td>
<td>Remote condition monitoring</td>
</tr>
<tr>
<td>RDG</td>
<td>Rail Delivery Group</td>
</tr>
<tr>
<td>RoSCo</td>
<td>Rolling stock companies</td>
</tr>
<tr>
<td>RSSB</td>
<td>Rail Safety and Standards Board</td>
</tr>
<tr>
<td>RTS</td>
<td>Rail Technical Strategy</td>
</tr>
<tr>
<td>RUS</td>
<td>Route Utilisation Strategies</td>
</tr>
<tr>
<td>RVfM</td>
<td>Rail Value for Money</td>
</tr>
<tr>
<td>SIC</td>
<td>Systems Interface Committees</td>
</tr>
<tr>
<td>SME</td>
<td>Subject matter expert; small and medium enterprises</td>
</tr>
<tr>
<td>TAF</td>
<td>Telematics applications for freight services</td>
</tr>
<tr>
<td>TAP</td>
<td>Telematics applications for passenger services</td>
</tr>
<tr>
<td>TOC</td>
<td>Train operating companies</td>
</tr>
<tr>
<td>TRaCCA</td>
<td>Tomorrow’s Railway and Climate Change Adaption</td>
</tr>
<tr>
<td>TRL</td>
<td>Technology readiness level</td>
</tr>
<tr>
<td>TSAG</td>
<td>Technical Strategy Advisory Group</td>
</tr>
<tr>
<td>TSLG</td>
<td>Technical Strategy Leadership Group</td>
</tr>
<tr>
<td>TSI</td>
<td>Technical Specifications for Interoperability</td>
</tr>
<tr>
<td>VOSE</td>
<td>Vision, Objectives, Strategy and Enablers</td>
</tr>
<tr>
<td>VTISM</td>
<td>Vehicle-Track Interaction Strategic Model</td>
</tr>
<tr>
<td>XIRCM</td>
<td>Cross-interface RCM</td>
</tr>
<tr>
<td>XIIS</td>
<td>Cross-industry information systems</td>
</tr>
</tbody>
</table>
GLOSSARY

4Cs
The rail industry’s key strategic challenges: cost and carbon reduction, increased capacity and improved customer satisfaction.

Automatic train operation (ATO)
Control of train propulsion and braking without intervention of a driver.

Axle counter
An alternative to track circuits for track-based train detection.

Axle load
Axle load refers to the maximum weight permitted on a single axle. A four-axle vehicle weighing 60 t (metric tonnes) would have an axle load of approximately 15 t depending on how the weight was distributed. In the UK the maximum axle load is 25 t on most main lines. The European maximum is 22.5 t.

Balise
A track-mounted device for communicating with passing trains. Balises have six different types: inductive, radio-based, active, passive, intelligent and dumb.

Ballast
Selected material place on the sub-grade to support and hold the track with respect to its alignment within the bounds of specified top (vertical) and line (horizontal).

Cab signalling
Display of signal indications or other movement authorities within the cab.

Communication-based train control (CBTC)
A continuous automatic train control system also known in the UK as transmission-based signalling (TBS) and in Europe as ERTMS Level 3. The characteristics are: high-resolution train location measurement, independent of track circuits; continuous high-capacity bi-directional train-to-track radio frequency data communications; trainborne and wayside processors capable of implementing vital functions.

Dwell time
The interval between when a vehicle comes to a stand at a station and restarts.

Sources: Rail Lexicon Mark 24, University of Birmingham and Network Rail, 2011
**Eddy current**

A localised electric current induced in a conductor by a varying magnetic field. Eddy current technology offers the potential for frictionless braking at high speeds but in practice relies on external factors such as signalling and train control systems and track structure.

**Electric multiple unit (EMU)**

The generic term for an electrically-powered train where traction drive and control system is contained under or in the roof space of various carriages.

**Electrification**

The installation of overhead wire or third (or fourth) rail power distribution facilities to enable operation of EMU trains, or trains hauled by electric locomotives.

**European Integrated Railways Radio Enhanced Network (EIRENE)**

An International Union of Railway’s project to develop GSM-R specifications for a train radio system suitable for transmitting the information required by ERTMS and facilitate its standardisation. It uses GSM in the 900 MHz band for railways.

**European Rail Traffic Management System (ERTMS)**

Signalling and operation management system using ETCS for cab-based speed control and GSM-R for voice and data transmission. There are three levels of ERTMS: Levels 1 and 2 use track-based equipment for train detection and Level 3 uses onboard equipment in the cab.

**European Train Control System (ETCS)**

A train-based computer which provides the signalling aspect of ERTMS. There are three levels of train control: Level 1 is a standardised ATP system with lineside signals. Levels 2 and 3 require output from project EIRENE to assure transmission of movement authority by radio.

**GSM-R**

Specialised global system for mobile communications with cellular personal mobile radio (PMR) for railways using 900 MHz band with higher reliability and safety and more features than GSM.

**Headway**

Minimum interval between trains on the same line in the same direction allowed by the signalling system.

**Hotel power**

The part of a train’s power consumption used for air-conditioning, lighting, heating and kitchen facilities. It is often greater than 10-20% of the total energy requirement.

**Hybrids**

Hybrid technology combines a diesel engine/generator and batteries to produce a more efficient means of powering trains, using electric power to move a train at low speed, with the engine cutting in to provide extra power for acceleration. The kinetic energy from braking would be converted into electrical energy to recharge the batteries.
Interlocking
A system of logically linking points and signal operation to prevent route conflict. Interlockings are now largely computerised using a two-in-three voting system, diverse hardware and software or protocols.

Intermodal
Descriptive term for freight traffic involving transfer of containers to and from road and rail vehicles. Sometimes referred to as container traffic.

Interoperability
The ability of the trans-European conventional rail system to allow the safe and uninterrupted movement of trains which accomplish the required levels of performance for these lines. This ability rests on all the regulatory, technical and operational conditions which must be met to satisfy the essential requirements.

Metro
An urban railway running exclusively on its own right of way, often underground.

Movement authority
Information given by the signalling system as to how far a train can proceed.

Multiple unit (MU)
The practice of distributing traction power to units along the length of the train and for coupling two or more power units. MUs can be EMU (electrical) or DMU (diesel).

Network capacity
The Institution of Railway Operators define network capacity as: The number of trains that can be incorporated into a timetable that is conflict-free, commercially attractive, compliant with regulatory requirements and can be operated whilst meeting agreed performance targets in the face of anticipated levels of primary delay.

Network modelling framework
A comprehensive set of models developed by the industry under the leadership of the DfT to predict the impact of changes to the network and services operated on cost, performance, safety and crowding.

Passenger capacity
The number of passengers that can be accommodated in a passenger vehicle. The network modelling framework defines the capacity of a vehicle as the number of seats plus the number of passengers who can be accommodated in the available standing space at a given allocation of space per standing passenger. The total capacity of the railway system to carry passengers is then the resultant of the passenger capacity of each vehicle, the number of vehicles on each train and the network capacity.
Path
A possible schedule for a train along its route that reflects the achievable sectional running times and does not infringe the permitted planning separations from schedules of other trains.

Primary delay
Delay to trains arising directly from an incident such as a technical failure or line blockage through an external cause, as opposed to a secondary delay.

Regenerative braking
A way of slowing an electrically-powered train by using the motors as brakes. The motors act as generators and return the surplus energy as electricity into the supply rail or overhead wire.

Remote condition monitoring
The use of telemetry and complex algorithms to assess the state of railway infrastructure and rolling stock remotely and manage maintenance effort so that assets cannot deteriorate to the point that affects safety and reliability.

Robustness
The ability of a timetable and network to experience primary delay without introducing a secondary delay.

Route availability (RA)
A code to indicate which rolling stock can use which routes; must be used in conjunction with loading gauge availability and axle load.

Secondary delay
Delay caused by one train to another, remote from the incident location, which itself would not have delayed the other train.

Slab track
Rails secured to or cast into a continuous concrete slab instead of intermittent sleepers.

Smart grid
An electric grid that analyses consumption and automatically makes adjustments according to demand to improve the efficiency, reliability, economics and sustainability of the production and distribution of electricity.

Switches
Movable rails that direct trains from one line to another at junctions.

System capacity
The total capacity of the railway system to carry passengers or freight. This is the resultant of the passenger capacity of each vehicle or payload of each freight wagon, the number of vehicles on each train and the network capacity, or that part of it allocated to either passenger or freight traffic. Unless line, network or passenger capacity is specified, capacity can be understood to denote system capacity.
System Interface Committees (SICs)

The five cross-industry groups whose purpose is to identify opportunities for improving efficiency at the interface between vehicles and infrastructure and to consider ways to develop and implement these solutions. The SICs are: Vehicle/Structures SIC, Vehicle/Track SIC, Vehicle/Train Energy SIC, Vehicle/Train Control and Command SIC and Vehicle/Vehicle SIC.

Tamping

The process that pushes ballast under sleepers to fill voids so as to maintain the correct geometry of the track. Tamping can damage the ballast and may not be effective due to ‘ballast memory’, that is, the tendency for ballast to return to the mutual positions existing before tamping.

Through ticketing

The ability to buy a ticket in one transaction for a journey using more than one operator.

Train detection

The function of the signalling system that identifies train location on the network to ensure physical separation from other trains.

Whole-system approach

A whole-system approach considers all parts within an integral whole. Decisions are reached by evaluating the impact of any change on all aspects in the system and with the recognition that isolated changes to parts may have negative effects on other parts.
TSLG would like to thank the following bodies, who have contributed their expertise and supported the development of RTS 2012:

Association of Train Operating Companies (ATOC)
ATOC Engineering Council
ATOC Operations Council
ATOC Technical Strategy Group
DB Schenker Rail (UK) Ltd
Department for Transport
Freightliner Ltd
Institute of Asset Management
Institute of Logistics and Transport
National Skills Academy for Railway Engineering
National Task Force
Network Rail
Office of Rail Regulation
Passenger Focus
Passenger train operators
Planning Oversight Group
Rail Delivery Group
Rail Freight Group
Rail Freight Operations Managers Group
Railway Industry Association (RIA)
RIA Electrification Technical Interest Group
RIA Engineering Committee
RIA Signalling and Telecommunications Technical Interest Group
RIA Traction and Rolling Stock Standards Group
RIA Traction and Rolling Stock Technical Interest Group
RoSCo Technical Liaison Group
Rail Research UK Association (RRUKA)
RSSB
The five System Interface Committees
Transport Scotland
Welsh Assembly Government

TSLG would also like to thank all the individuals who have participated in, or responded to the industry workshops and all who served as members of the Steering Group for the RTS 2012 project.