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DECARBONISING TRANSPORT: THE CASE FOR RAILWAYS

THALES WHITE PAPER

01

INTRODUCTION

Climate change is a real and growing threat. New temperature records are broken every year. Extreme weather conditions, from flooding to droughts, are becoming more frequent. Nations and businesses need to act urgently to protect the planet for future generations.

Railways play a vital role in countering the dangers of climate change while supporting the economy and connecting communities. Indeed, what makes railway so important, and so attractive, is that they enable economic growth while simultaneously reducing carbon emissions.

The need for action is increasingly urgent as economies struggle to recover from the Covid crisis. A business-as-usual scenario, with emissions climbing hand in hand with growth, is not feasible if the widely held goal of net zero emissions by 2050 is to be achieved.

Transport is the only sector where emissions are still rising. On the eve of the Covid crisis, the transport sector was responsible for greenhouse gas emissions totalling more than one billion tonnes a year in Europe[1] and eight billion tonnes per year globally.[2] Road transport, shipping and other means of transportation were responsible for the bulk of these emissions.

Rail stands out as an exception. While overall transport emissions in Europe have increased 29% over the past three decades[3], rail emissions have fallen dramatically – despite rising passenger numbers and freight volumes.

Freight moved by rail is nearly nine times less polluting than freight moved by road. Passenger journeys by rail also produce much lower emissions than equivalent journeys by other means of transport.

Rail has two key advantages in the race to deliver net zero emissions by 2050:

First Rail offers quick wins

Railways have the potential to deliver rapid results. The assets required – track and trains – already exist. This is not the case with other means of transport, which will require massive long-term investment in new types of assets (some yet to be invented) if emissions are to be reversed.

Second Rail is on track to net zero

Rail operations are already heading towards zero emissions by default as electricity grids transition from fossil fuels to renewables. Every time a new wind or solar farm is deployed, passenger and freight emissions fall.

This white paper has three purposes. First, it outlines the position of railways in the current transport landscape. Second, it considers how railways can attract and absorb additional traffic. Finally, it examines how digitalisation can be used to enable expansion of the rail sector.

[1] Transport: increasing oil consumption and greenhouse gas emissions hamper EU progress towards environment and climate objectives. EEA. 3 February 2020, https://www.eea.europa.eu/themes/transport/term/increasing-oil-consumption-and-ghg

[2] Greenhouse gas emissions from transport in Europe. EEA. Modified 19 December 2019, https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12

[3] Tracking Transport 2020. IEA. May 2020, https://www.iea.org/reports/tracking-transport-2020

02

CURRENT SITUATION

RAIL EFFICIENCY CONTINUES TO RISE

RAILWAYS: THE GATEWAY TO THE FUTURE OF TRANSPORT

Rail has the potential to cater for the increased mobility demands generated by economic growth. And most important of all, this can be achieved without adding to emissions. Indeed, the effect of modal shift to rail will be to reduce emissions.

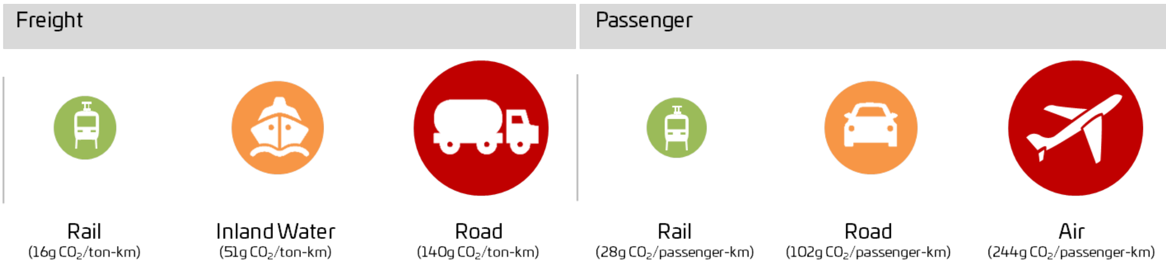

Figure 1. Specific CO2 emissions per transport mode, Source: European Environment Agency, 2017

Railways have made many major breakthroughs over the past 25 years. In Europe, these include a near fourfold expansion of the high-speed rail network, the construction of three major Alpine tunnels and the expansion of interoperable European Train Control System (ETCS) signalling.

Equally important has been the transformation of rail's environmental performance in terms of greenhouse gas emissions.

To put this in context, Europe's railways were responsible for CO2 equivalent emissions of 11.3 million tonnes in 1995. By 2017, that figure had dropped more than 41% to just 6.6 million tonnes – a huge achievement.[4]

What makes this reduction even more remarkable is that it has taken place against a background of growth in rail traffic over the same period. In 1995, Europe's rail network handled 388 billion tonne-kilometres of freight traffic. By 2017, this figure had risen to 421 billion tonne-kilometres, an increase of 8.5%.[5] Passenger journeys also grew over the same period, rising from 343 billion passenger-kilometres in 1995 to 470 billion passenger-kilometres in 2017 – up more than a third (37%) compared with 1995.[6]

In short, the improvement in rail's environmental performance has been remarkable. Today, Europe's railways handle more than 11% of total goods transport and more than 8% of passenger traffic. All of this is achieved with just half of one per cent of overall transport greenhouse gas emissions.[7]

[4] EU transport in figures. Statistical pocketbook 2019. European Commission. [p134], https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1

[5] EU transport in figures. Statistical pocketbook 2019. European Commission. [p36], https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1

[6] EU transport in figures. Statistical pocketbook 2019. European Commission. [p48], https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1

[7] EU transport in figures. Statistical pocketbook 2019. European Commission. [Page 136] https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1

CAN RAILWAY PERFORMANCE BE IMPROVED?

The physics of rail transport determine its energy efficiency. A steel wheel on a steel rail generates less rolling resistance than a rubber tyre on asphalt. Air resistance is also lower in rail than it is in road. In addition, there are scale efficiencies: large machines (such as trains) are more efficient than small ones (such as cars and lorries). Electric trains do not need to carry fuel, further contributing to their efficiency. And when trains use electricity generated by renewables, direct emissions are zero.

Yet there is still scope to improve the environmental performance of rail. Europe's railway network stretches for 217,200km. Of this, 117,300km (54%) is electrified.[8] Most current traffic (approximately 80% of trains) operates on the electrified part of the network.

Policies that encourage modal shift to rail are likely to result in greater utilisation of the 100,000km of routes that are currently not electrified and which depend on diesel traction.

While any modal shift from road to rail has the effect of reducing net emissions, increasing rail's reliance on fossil fuels is clearly not desirable. There is therefore a strong case for extending electrification in places where carbon reductions are likely to be the greatest.

On routes where the economic and environmental case for electrification is marginal, there is increasing scope for deployment of clean forms of motive power which do not depend on overhead line infrastructure. Among these are battery and hydrogen powered trains. In the case of hydrogen technology – already deployed in revenue service in Germany – rail is arguably better placed to benefit than roads thanks to the more concentrated nature of rail refuelling infrastructure.

Signalling and supervision technologies also have the potential to deliver significant improvements in rail's environmental performance. Systems that allow infrastructure managers to predict and minimise conflicting movements, and to optimise traffic flows at network level, already contribute to the efficiency of rail systems and will do so even more in the future. This technology is considered in section 04.

EFFICIENCY COMPARISON

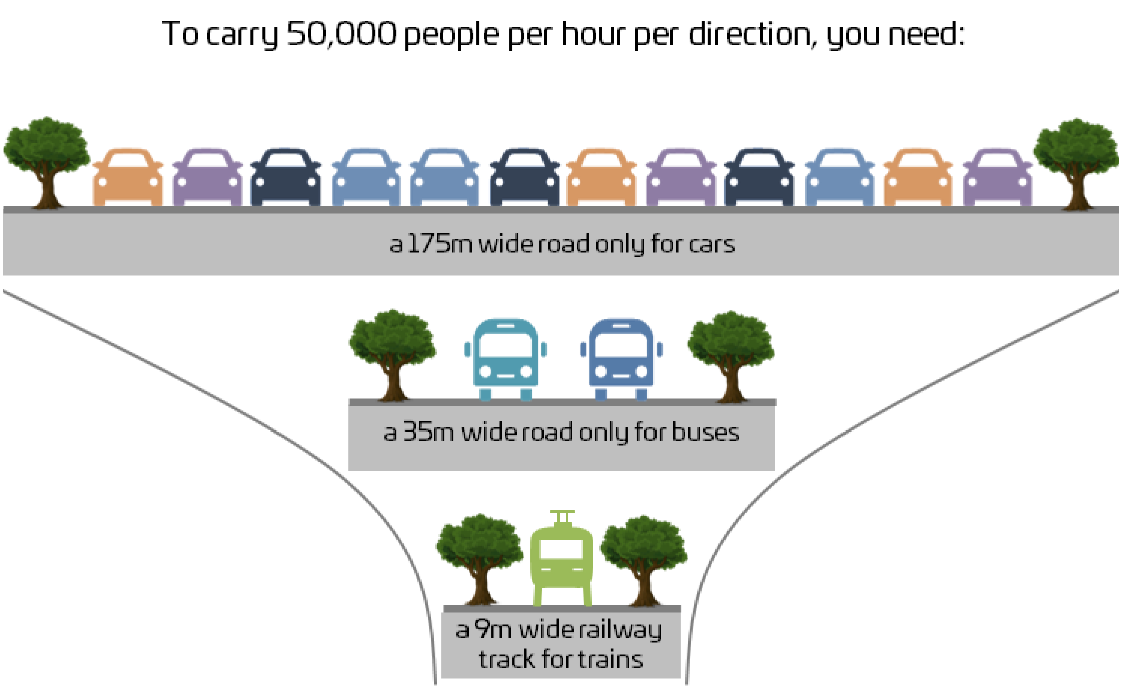

Figure 2. Efficiency of urban rail in relation to land use (Source: EU Strategy for long-term greenhouse gas emissions reductions The crucial role of rail)

[8] EU transport in figures. Statistical pocketbook 2019. European Commission. [Page 33] https://op.europa.eu/en/publication-detail/-/publication/f0f3e1b7-ee2b-11e9-a32c-01aa75ed71a1

Rail does not exist in a vacuum. The use of railways is influenced, both directly and indirectly, by wider economic and social trends. The ability of transport authorities and infrastructure managers to identify new patterns of transport consumption and shifts in public preferences will therefore play a decisive role in the success with which new traffic can be captured.

URBAN AND SUBURBAN MOBILITY

Populations are increasingly urban. While the spread of Covid has raised questions about the sustainability of cities, history suggests that concerns about urbanisation are likely to subside in the long term. Globally, the trend towards urbanisation is firmly established with city populations swelling by more than one million per week. Even in Europe, the proportion of people living in cities is expected to rise.

However, patterns of transport demand in developed economies are undergoing significant change. While much of the focus over the past 30 years has been on improving rail capacity within cities, attention is increasingly turning to improving mobility at the urban fringe and beyond.

There are two dimensions to this. First, the suburban fringes of cities are generating increasing volumes of passenger traffic – even at distances of up to 80km from city centres. One of the consequences of this is that rail services between outer suburbs and city centres are becoming more metro-like in character in terms of passenger loading and frequency. To accommodate this shift, infrastructure managers and operators need to be able to improve headways and boost reliability.

Second, there is an increasing need for low-carbon transport within and between suburban areas. These have traditionally been poorly served by rail and reliance on road transport is growing.

Light Rail Transit (LRT) is increasingly seen as a way to meet the need for easy mobility while combating the negative environmental impacts of increasing car dependency. Within cities, new rail infrastructure has the advantage of making the most of limited land resources, with up to 20 times less land take than equivalent road infrastructure for the same number of passengers.

MULTIMODAL JOURNEYS

Anybody who rides an electric scooter to a railway station to catch a train is embarking on a multimodal journey, whether they realise it or not. The constellation of modes of transport used by travellers is constantly expanding and increasingly diverse. Indeed, the past five years has witnessed an explosion in new modes of shared mobility and micromobility, spanning everything from e-scooters and electric bikes to ride hailing and electric vehicles.

New forms of electric mobility are interesting because, in conjunction with railways, they bring the vision of full electrification of door-to-door journeys a step closer to reality. For the rail industry, the challenge and opportunity is to accommodate and integrate these different modes of transport. Aside from docking and charging facilities at stations, passengers need Mobility as a Service (MaaS) apps to plan and pay for their journeys – and to ensure that rail forms the backbone of multimodal travel.

03

THE FUTURE

CAN RAILWAYS ATTRACT AND ABSORB ADDITIONAL TRAFFIC?

Railways will need to expand their share of passenger and freight traffic dramatically in the coming years if net-zero emissions are to be achieved. Their ability to attract and absorb additional traffic is governed by three factors: capacity, attractiveness and integration with other modes of transport.

CAPACITY

In broad terms, capacity is about how many people or how many tonnes of goods can be transported in a defined timeframe.

However, there is no single metric for measuring the carrying power of a railway network. To a great extent, the capacity of a railway is determined by the way the network is used. This, in turn, is determined by more than a dozen different factors. These range from the length, acceleration and braking characteristics of trains, to timetabling, signalling and traffic management. Whatever the questions associated with measuring capacity – and a variety of mathematical techniques can be used – policymakers are interested in gaining a broad idea of how much extra traffic existing railways might be capable of absorbing.

While there is no simple answer to this question, one fact that is not disputed is that one of the main barriers to capacity increases on main lines is fixed-block signalling. This has existed in various forms for more than 150 years and is based on the principle of maintaining fixed spacing between trains, irrespective of their speed. Fixed-block signalling is used almost universally on main line railways.

Given current levels of route utilisation, fixed block does not – yet – impose a significant constraint in many places. But on congested routes, particularly around junctions and stations, fixed block already creates bottlenecks. As main lines absorb expected increases in traffic, widespread congestion will become increasingly likely unless action is taken.

Metros provide an insight into the potential for creating extra capacity when modern digital signalling is used. Communications-based train control (CBTC) signalling is based on the principle of moving block: safe separation between trains is governed by speed rather than fixed geographical blocks.

Converting a metro line to CBTC can deliver capacity gains of 20-40%. Given that CBTC systems are typically implemented on routes that are already operating at or near their maximum capacity under conventional signalling, these gains are highly significant.

Section 04 considers some of the ways that moving block can be implemented on mixed mode main line railways. The role of traffic management in delivering efficiency improvements is also examined.

The topic of capacity also embraces interoperability. National variants of conventional train control systems typically make cross-border rail passenger and freight movements impossible without a change of train or locomotive. While ETCS has gone a long way in enabling seamless cross-border train movements, the vision of full operational harmonisation has yet to be realised.

ATTRACTIVENESS

Encouraging modal shift not only depends on providing capacity, but also on offering services passenger and freight customers want to use – and keep using.

Creating an attractive environment for rail customers encompasses a number of operational areas. Punctuality, availability and reliability are major concerns for both passengers and rail freight customers, so the ability to predict and prevent equipment failure will become increasingly important.

Safety is another concern, particularly with regard to the threats posed to railway infrastructure by climate change. The ability to monitor the trackside, including cuttings and embankments, is likely to become increasingly important.[9]

MULTIMODAL INTEGRATION

Greener journeys are typically multimodal in character. As travellers become less reliant on a single mode of transport, the ability to enable integrated journeys using multiple modes is going to become increasingly important. Rail provides a natural focal point for mobility in its widest sense: stations have the capacity to serve as hubs for multiple modes of transport, including buses and trams, as well as offering facilities to support e-mobility, from vehicle charging to bike sharing.

Figure 3. Multimodal Environment-Friendly Transport

[9] Resilience of rail infrastructure Interim report to the Secretary of State for Transport following the derailment at Carmont, near Stonehaven. UK Department for Transport. 1 September 2020, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/915898/resilience-of-rail-infrastructure-interim-report.pdf

04

THE THALES WAY

CONTRIBUTING TO THE DECARBONISATION OF RAIL

Innovative digital technologies play a critical role in expanding capacity, boosting performance and cutting emissions. Crucially, digitalisation makes it possible to do more with existing networks, reducing the need for new infrastructure.

Infrastructure managers need ways to run more trains, enable cross-border operations and provide a level playing field for multiple operators. On top of this, they need to minimise the cost of operations and maintenance, while improving the reliability of their networks. Digital technologies help to achieve all of these goals.

SMART TRACKSIDE

Conventional signalling is expensive to maintain. It also uses a lot of electrical energy. Digital signalling solves both of these problems. Intelligent LED signals and digital train detection reduce power consumption and boost reliability, while decentralised architecture means fewer buildings (and less air conditioning) are needed. The savings are significant: on a 500km line, switching from conventional to digital signalling can reduce CO2 emissions by as much as 10,000 tonnes over the lifetime of the system.

TRAFFIC MANAGEMENT

Main line infrastructure managers are under growing pressure to boost the performance of their existing networks. While command and control signalling plays a critical part in achieving this, there is also a need to optimise traffic flows and to predict, prevent and resolve conflicts automatically.

Digital Traffic Management Systems (TMS) fulfil these needs. In situations where the underlying signalling systems are digital, Traffic Management Systems can be integrated to provide automatic route setting for trains. But they can also be used in standalone mode to supervise and optimise traffic flows on any type of network – irrespective of the mix of signalling technologies.

Aside from improved reliability and punctuality, the ability to supervise networks at system level delivers specific environmental benefits. One of these is the ability to keep trains moving by minimising wasteful stop-start cycles at signals and junctions – saving energy and cutting emissions.

Better use of advanced ETCS solutions also has huge potential to increase operational performance and energy efficiency. Based on position and speed information of all ETCS equipped trains in the TMS control area, and the possibility to command the trains via an overlay Automatic Train Operation (ATO) system, the TMS could monitor and control trains closely and in an optimised way. As the ATO system consists of a trackside (TMS) part and an on-board subsystem, interoperability is a key requirement, enabled by a standardised architecture.

A capacity increase of 20% on a 500km line can generate a reduction of indirect CO2 emissions of 200,000 tonnes per year.

The way trains are driven has a dramatic impact on energy consumption. To achieve energy savings and reduce emissions, train drivers need better information in the cab.

Driver Advisory Systems use algorithms and data about the route to provide real-time assistance, including the optimal speed for saving energy. In addition, they help to boost punctuality, improve headways and reduce wear and tear. Driver Advisory Systems can be integrated with Traffic Management Systems, so information about schedule changes and speed restrictions are immediately available in the driver's cab of the train. These systems offer a quick win for operators and infrastructure managers, because no integration with signalling or train control is required.

In addition, Driver Advisory Systems are a good starting point for the introduction of an ATO solution, because of common features on trackside and on-board subsystems.

A 15% reduction in traction energy consumption on a 500km line can cut CO2 emissions by 20,000 tonnes per year.

INTERLOCKING AND TRAIN CONTROL

Digital modular interlocking is a key element of future safety solutions. Combining the features of modern telecommunications networks, cybersecurity solutions and high-performance software platforms, digital interlocking enables efficient operations and the highest level of availability.

Interoperable train control plays an equally important role in transforming the performance of railways. The European Train Control System (ETCS) provides the basis to answer market needs. ETCS is a digital signalling system that is based on radio technology, so reliability and availability are dramatically increased.

Crucially, ETCS paves the way to implementing high-capacity moving block technology in complex main line environments where passenger trains and freight traffic share the same infrastructure. This can be achieved using ETCS Level 3 (L3). Implementing ETCS L3 on a 500km line can reduce CO_2 emissions by 25,000 tonnes over the lifetime of the system, thanks to the elimination of some trackside equipment.

One particular version of ETCS L3 is L3 hybrid – a cost-effective solution that allows trains with on-board train integrity supervision (typically passenger trains) to proceed under short blocks, while trains without train integrity supervision (typically freight trains) continue to operate under longer blocks.

ETCS L3 with moving block achieves an even higher level of performance. The space between trains is no longer fixed, but variable and dependent on track and train characteristics.

INFRASTRUCTURE MONITORING

In order to improve efficiency and reliability, infrastructure managers need ways to prevent delays and minimise the safety impacts of asset failure.

Intelligent infrastructure monitoring tools use an Internet of Things (IoT) platform to monitor the performance of high value, high impact assets such as points and axle counters. Early warnings of failure are detected and alarms raised automatically, allowing maintenance teams to fix assets before they fail in service.

The principle of infrastructure monitoring can be extended to monitor civil assets, such as cuttings and embankments, which are increasingly threatened by extreme weather events. Predictive maintenance increases the operational availability of the railway system, avoiding alternative transport via road in case of non-availability.

MULTIMODAL JOURNEY TOOLS

Convenience holds the key to attracting new passengers and retaining existing ones. To achieve these goals, planning and paying for multimodal journeys needs to be made as easy as possible.

Mobility as a Service (MaaS) holds the key. MaaS provides a single digital platform for multiple transport services, including rail, metro, buses, ride sharing, taxis, ride hailing, shared bicycles and scooters. Any mode of transport can be included. Access to MaaS is provided via a smartphone app which offers route planning, booking, ticketing, customer services and payment.

Rail operators are uniquely positioned to participate in MaaS platforms thanks to their access to real-time operational data and passenger journey data.

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