CZECH INFRASTRUCTURE ASSOCIATION

January 2021

Future Trends Shaping Rail 2050 and Beyond

A Framework for Strategic Planning of Rail Infrastructure in the Czech Republic

Prof. Andrew McNaughton

ARI

*The **Czech Infrastructure Association** (**ARI**, Asociace pro rozvoj infrastruktury) is a private sector think-tank for the Czech public infrastructure that unites interests and opinions of over 50 major infrastructure contractors and institutions, such as design and engineering advisors, construction companies, consultants, banks and investors.*

***ARI has been promoting clear rules** for planning, public procurement, and transparent contract management **following international good practices** to enable sustainable and efficient long-term development of our public infrastructure. ARI issues opinions and publications, organizes expert discussions and round tables with the participation of foreign experts, ministers and representatives of public organizations in the field of public infrastructure and public procurement.*
Follow us on: www.ceskainfrastruktura.cz

Central Rail Station, Utrecht, Netherlands

Content

Cover: Departure hall of Hong Kong West Kowloon railway station, Hong Kong, China

ARI supports a sector-wide discussion about new challenges and opportunities for the rail development in the Czech Republic for a time horizon to 2050 and beyond.

Author

Prof Andrew G McNaughton FREng FICE FIET FRGS FCILT

Professor McNaughton is the Strategy and Technical Advisor to the British Government on the £80bn HS2 programme to create the British high speed rail network and other major new line and rail upgrade projects. He is a Professorial Fellow at the University of Southampton and Chairman of Network Rail (High Speed) Ltd, the infrastructure operator and manager of the HS1 railway between London and mainland Europe.

As Technical Director between 2009 and 2017 Andrew led the development of HS2 including accountability for strategic design, operational concept, engineering specification and environment assessment, and specific corridor and detailed route optioneering and selection. He was Principal Witness for the Government leading the planning authorisation through Parliament.

Following a role as Special Advisor to the Australian Government, Prof McNaughton chaired the FastRail panel for the Government of New South Wales (2018-20) and since 2017 has acted as Strategic Advisor on high speed rail development in the Czech Republic. Andrew chaired the International Railway Union (UIC) World InterCity and High Speed Rail Committee 2016-2019.

Andrew has been engaged in the management, operation, engineering and strategic development of railways since 1973. His early career culminated in being responsible for the specification and engineering safety of the 30,000 km GB rail network, and evaluation and specification of major upgrade investments such as the £9bn West Coast major route upgrade during this time he chaired both the UIC Infrastructure Forum and the EU European Rail Research Advisory Committee. He also acted as Vice Chair of the EU Transport Advisory Committee.

Andrew is an Honorary Professor of Rail Engineering at Nottingham University and has been a Visiting Professor of Engineering at Imperial College, London. He lectures worldwide on the strategy planning, economics and engineering impacts of major rail transport development and its relationship with land use planning and economic regeneration. He is a Fellow of the Royal Academy of Engineering where he chairs the Transport Sector and is also a Fellow of the Institution of Civil Engineers, the Chartered Institute of Transport and the Royal Geographical Society.

Rail transport infrastructure can play an essential and growing part in the economic and social life of the Czech Republic.

1 Summary

This Report proposes a Framework for developing the Strategic Plan for Rail in the Czech Republic for a time horizon to 2050 and at least a few decades beyond. It considers likely economic and societal influences to establish some guiding principles through which the necessary development of the Czech rail system over the coming decades can be determined.

It has a particular focus on routes between cities for passenger and freight, where the greatest change is going to be necessary given the road and air alternatives. In addition to the current high speed line development programme, a number of other routes between cities will also need major upgrading.

There is the opportunity to increase radically the role of rail in freight distribution including new service offerings to replace much of the current inter-city road haulage.

City rail networks will need to be developed to reflect changes in demand and demographics. Rail will still have a role in serving rural communities if properly integrated with other transport modes.

There needs to be a major programme of station upgrade and rebuilding to meet future user expectation and enhance integration with complimentary transport modes.

In renewing and rebuilding the railway core systems and infrastructure, a focus on standard designs and products, and technologies, will enable greater automation and mechanisation to increase quality of service and reduce cost, making best use of an increasingly scarce but highly skilled workforce.

Given the lead time in new line building and the progressive annual renewal workload, agreeing the priorities of the Strategic Plan and then committing to its delivery is urgent.

2 Context

Rail transport infrastructure can play an essential and growing part in the economic and social life of the Czech Republic. As a mode, the basic infrastructure has a life measured in centuries and the equipment itself several decades between renewal cycles. What was built a century ago has helped shape today's country by promoting places best to live or industries to work in.

> What was built a century ago has helped shape today's country by promoting places best to live or industries to work in.

However, it should not be assumed that the network of the past will be ideal, or indeed even relevant, to the future needs of the nation. At the very least it will require development and adaptation. Upgrading, modifying and modernising existing infrastructure, as well as creating new lines and stations, will consume substantial resources and money.

> But it should not be assumed that the network of the past will be ideal, or indeed even relevant, to the future needs of the nation.

It is essential to plan now for the decades to come, to transition progressively and effectively to the railway of 2050 and beyond. Only a few percent of existing infrastructure is renewed each year and new lines can take decades to develop, authorise and construct. Like other strategically important infrastructure, rail has to be part of a national investment plan based on the future needs and configuration of the country alongside other national strategic infrastructure including health, education and industrial policies, as well as complimentary transport modes.

At the same time, railway equipment like track and power or control systems is being renewed every week and will largely still be in service in 2050. New tunnels or structures, by-pass lines or whole new routes will be in service a century after that. So what is being done now is already shaping the future.

The country sits geographically at the heart of the European network yet its railways are constrained by its history of low speed and capacity railway development. **Even with good current infrastructure management, it is not capable of meeting the needs of 2050** and beyond and will require a programme of sustained and high-quality investment to transform it and realise its potential. The Czech Republic has a good skill base thanks to the tradition of a sound technical education system; but the challenges are significant.

This Framework sets out the wider context of the mega-trends and future passenger and freight demands to demonstrate where major developments and changes will be necessary. It also considers where network-wide technical changes to create a sustainable network will be needed, to be achieved during renewal and upgrade where possible.

3 Mega-trends

As with all such very long-term planning, the detail and priorities will change over time as events occur. However, some global trends are predictable even if their exact timing and extent are not.

The "mega-trends" will affect all developed nations and so are an essential starting point for this Framework for the 10m population of the Czech Republic positioned at the geographical heart of the European Community.

The implications of mega-trends for rail as a viable transport mode are threefold:

1 On the economic and social activity of any society and therefore its transport needs;

2 On the competitiveness and complimentarity of rail as a specific mode; and

3 On the sustainable provision of rail technical systems and infrastructure, and its effective operation.

This is a brief summary of the most significant.

3.1 Rise of Asia

The remainder of the 21st century is likely to be dominated economically by the rise of Asian countries as first manufacturing and then, increasingly, **knowledge industry leaders**. This is as true of India and SE Asia as it is already of South Korea and China.

The established leading economic blocs of America and **Europe will need to compete through investment in research and development, advanced manufacturing and other future technologies** and particularly in knowledge creation. The Czech Republic with its powerful technology tradition and developed technical education system is well placed to play a central role in Europe's initiatives. However, it is most unlikely that the country can stand alone; it will need to work increasingly in an integrated network with its neighbours. Therefore, connectivity not only between knowledge and industrial centres within the country but across its national borders will assume even greater importance than currently.

There are also implications for railway systems and equipment supply chains both through competition for standard products from Asian companies as well as their acquisition of European companies and intellectual property. In turn, the continuing **consolidation of the European players into larger organisations to respond to the market challenge from the East is inevitable**. The building blocks of railways, whether trains, smart systems or infrastructure will become increasingly standardised and available globally. A competitive advantage will exist, however, for those able to design and deliver ways to adapt or extend life of existing (non-standard) infrastructure cost-effectively.

3.2 Urbanisation

Irrespective of short-lived pauses for such as the current health pandemic, the millennia-long **drift towards cities which has been accelerating since the industrial revolution will continue**. The economic efficiency from centralisation of manufacturing continues and has been joined by the recognition of similar efficiencies for "creative production" which happens through teams working closely together more than from individual lone effort.

In any country the centres of excellence will become increasingly concentrated into capital cities and those with good transport connectivity where movement of people and goods is easy both in the city itself and connecting to other cities and the capital. Those with poor links will get left behind economically. As a matter

of public policy, **it will be desirable to ensure excellence centres are spread more widely in the country, not just around the capital itself.** Apart from a very few capitals, no city will have the scale to focus on more than one or two areas of wealth-creating skills and develop them sufficiently to compete in a trans-national or global market. In the European context one exception is probably Frankfurt which has a such a concentration of specialist corporate financiers of international standing that it competes with other global centres such as Singapore, Sydney or New York.

> The rise of the "centre of excellence city" which will, to prosper, need effective connectivity to cities with complementary skills.

Therefore, the consequence of urbanisation is the rise of the "centre of excellence city" which will, to prosper, need effective connectivity to cities with complementary skills. Examples can already be seen in the multiple medium size cities of the Ruhr-Rhine region of northern Germany, the Rondstatt of the Netherlands and the "Northern Powerhouse" region of England. In the latter, Manchester is focussing on the creative industry, Leeds on financing and healthcare, Sheffield on advanced manufacturing and allied research, and Tyneside/Teesside on maritime and offshore applications. **Only collectively will they have the scale of skills to compete globally and so their mutual connectivity, both physically and globally becomes vital.**

The social attraction of urbanisation is founded on the concentration of organised leisure activity from participatory and spectator sport to cultural events and centres. Added to that, secondary and tertiary healthcare is rapidly concentrating similarly on centres of excellence both from an affordability factor of infrastructure provision and the human skills practicality of specialist training and service delivery.

All these factors drive the need for sufficiently good mobility both into and around the city areas and between cities, without which urban decay will be inevitable irrespective of any short-term financial subsidies. Consideration of mobility has to avoid being bounded by current national borders.

3.3 Changing Business and Work Practices

The 2020 pandemic has accelerated the previously very slow trend towards personal computer-based remote working and retail activity by probably two decades in a year. It is most unlikely that at the end of this pandemic office work or physical shopping will revert to the previous state but equally absurd to predict their complete demise.

Leading industrialists and human factors specialists have noted that remote working can be efficient in replacing communal office work for a percentage of the time especially for those with established personal and professional relationships. However, over time those relationships degrade, new personnel are not developed and, vitally, the soft skills of shared endeavour, team spirit and creative team thinking reduce. Therefore, it is likely that while office work will reduce as a Monday to Friday "Nine to Five" activity, it will be **replaced by more flexible working around core hours during a shorter week** – with Monday and especially Friday office attendance greatly reduced.

Only a proportion of employment is in offices, ranging from around 35 % in major financial centres such as Frankfurt or London to more typically 15-20 % in most European cities. It does, however, support a significant number of other service employment roles ranging from office security to sanitation and transport which is less obviously simply switched off.

Business communication is expected to follow trends similar to office work. Routine meetings and contact will continue to be carried out "virtually" perfectly well but activities ranging from more complex group discussion and business development through to development of personal and contractual relationships will continue through physical meeting. So, travel for business will reduce but it will, by definition, be for important reasons and therefore expectation of travel quality and dependability will be high.

> Travel for business will reduce but it will, by definition, be for important reasons and therefore expectation of travel quality and dependability will be high.

Retail activity will divide into two main classes with the major one being the replacement of physical shopping

Digital twins, a virtual world copy of the physical one, will transform the management of consumer services and asset management of system and built infrastructure.
Predictive maintenance, using sensors and artificial intelligence, will allow to detect potential failures before they occur.

for "routine" purposes with on-line purchasing, leaving a smaller more boutique activity of shopping as a leisure experience. Not only will this have a significant impact on the nature and make-up of shopping centres and streets as they change to become leisure "experiences" but it will drive a continuing major expansion in small package distribution logistics.

3.4 Digitalisation

The ability to fit affordable sensors to all types of systems and infrastructure is multiplying rapidly. Coming decades will see similar advances in data management and automated decision-making software. Together they will make possible the **creation of a virtual world copy of the physical one – a digital twin**.

This will transform the management of consumer services and asset management of system and built infrastructure alike as at any moment, a current state could be calculated and from it the impact of any intervention or transaction predicted. For example, the effect of improving, changing or letting deteriorate an asset could be assessed and the optimum economic or service solution determined. Furthermore, the maintenance or change activity itself could be mimicked to identified how it could be improved or risk of error eliminated – so training of staff on any process would be done first in a risk-free virtual environment before being carried out physically.

Smart cities become those where everything from waste management to power distribution to traffic movement can be controlled having first modelled the effect in a digital virtual model. The consequences for rail transport will be far-reaching.

Digitalisation of railway systems will enable the passenger or freight user to plan and control their journey door-to-door requirements independently and individually, going far beyond simply smart ticketing and payment. The railway system will recognise them and to fulfil they journey, with real-time guidance throughout, and especially be capable of real-time re-planning to accommodate either the user's desired changes or any railway disruption. The user will be able to play out the entire journey beforehand to test acceptability, such as a virtual journey through a station between connecting trains and other transport modes, before confirming and paying.

The automated train, already seen in modern metros, will become normal on main line networks because of this control. The human roles of "driver" will change.

For the railway operator, digital control systems will govern traffic movement, controlling the movement of trains to optimise arrival at junctions, replanning real time connections and station use to ensure punctual running. The automated train, already seen in modern metros, will become normal on main line networks because of this control. The human roles of "driver" or "signaller" will change profoundly to becomes supervisors of the automated systems, only intervening in times of system failure. However, because introduction of such systems will be gradual and progressive there will be challenging human factors issues from the new systems and the existing railway co-existing on many train journeys and in control area geographies.

Equipping the railway infrastructure and service trains with affordable smart sensors or inspecting it with autonomous drones or vehicles will enable, like smart cities, the state of the network to be constantly measured and assured. From a digital twin virtual model, **the asset management systems will be able to predict whether a maintenance or replacement activity will become necessary in time to prevent service-affecting failure and then plan it efficiently.** The physical activity can then be either programmed into automated equipment or, if a human activity, practiced in a virtual environment to ensure it can be executed competently and safely.

Put simply, every aspect of railway operation or infrastructure management, and the human activities involved in it will be changed by digitalisation.

Even with growing portion of retired people, when a significant immigration of young people is allowed, a rapid population growth as a consequence will stretch need for all types of established infrastructure.

3.5 Changing Demographics

Through a mixture of medical advances and better health enabled by greater prosperity, the life expectancy of the population will continue to increase. There is some evidence of a limit on this increase, not least due to consumption of less healthy processed dietary choices leading to increased obesity. Simultaneously, the developed world has seen a sustained gradual fall in birth rate, for a number of socio-economic reasons, offsetting the reduction in infant mortality made possible by reduced poverty.

The combination of these factors will continue to lead to a steady increase in the "healthy aged" population; but with a reduction in younger adults in the absence of immigration from the less developed world. Two current extremes are examples. Japan and Great Britain both have rapidly increasing numbers of people over working age; the former with closed borders to immigration is forecasting an overall fall in population and therefore is investing greatly in robotics and automation, the latter has compensated by allowing a significant immigration of young people. Whilst this has stabilised the proportion of working to retired people, **rapid population growth as a consequence is stretching all types of established infrastructure.**

The increasing elderly population can be expected to gravitate to city areas for access to healthcare and social facilities whilst having the time and income to travel widely for leisure. Meanwhile limitations on the acceptable density of urban dwelling, and desire for ready access to public and private open space, have been brought back into focus by the constraints of the current health pandemic. Such access is known to be important to the mental as well as physical wellbeing of the population and it is expected this will see greater focus from future generations. Therefore, cities will tend to expand horizontally more than vertically.

The reduction in the pool of younger people will lead to shortages of skilled labour not only for the wealth-creating industries on which the economy will depend but also in the lower skilled population supporting employment sectors which, as the recent pandemic has reinforced, are vital to urban civilisation. The railway sector will also be competing for talent across all skill ranges.

The conclusion is that all industries will invest in mechanisation and automation to reduce the need for human activity, accelerating the already well established trend of elimination of semi-skilled office or assembly line workers. This will further the reduction in conventional commuting travel. However, the city population is likely to spread over a greater geographical area to limit high density living and will require faster transport to avoid extending acceptable travel time. Meanwhile the railway sector will need further investment ranging from automation of many operational activities to greater mechanisation of infrastructure asset management, given the shortage of skilled workers.

3.6 Rising Consumer Expectation

Increasing prosperity is matched by increasing customer expectation, a trend which is continuing and universal. It is reflected in all aspects of personal retail transaction from response times to orders, availability of choice and action on poor service. Whilst societies value "quality" differently, they all expect improvement to continue over time.

Increasing prosperity is matched by increasing customer expectation.

An aspect of globalisation of travel is that people experience products and services novel to them but normal in other nations and that too raises expectations. One example is that Swiss and German firms now offer Japanese style heated and washing toilets in their home markets to satisfy a demand from consumers who have experienced the standards of hygiene considered normal in the Japanese culture. Similarly, British travellers have experienced the expected quality of "food on the go" in German and Swiss stations or motorway service areas.

Another aspect of rising public expectation comes from recognition of the health limiting impact of poor city air quality driven by a combination of road transport and building heating and cooling. The current pandemic has extended this to other aspects of public space hygiene from air conditioning quality and filtration to cleanliness of surfaces such as seating and handrails.

A short-haul air will continue to perform less well than electric rail from an operational sustainability perspective. In considering door-to-door journeys, rail has the potential to better air travel up to 800 kilometres.

This is as true of public transport provision as every other public experience.

3.7 Environmental Sustainability Including Carbon

The drive to net-zero carbon is but one aspect of a wider sustainability agenda which is at the heart of European policy making. Energy production and usage is particularly problematical. **Whilst focus is currently on carbon emissions at the point of operation, this is expected to spread to a more holistic "whole life" approach to carbon in the coming decades.** Therefore, in the short-term governments will encourage and incentivise cleaner cities through elimination of road transport exhaust carbon emissions but a viable alternative fuel to diesel for heavy road transport has yet to be developed. Widespread electrification will involve accelerated replacement of vehicles which, given the amount of carbon created in their manufacture and the mineral extraction, processing and transport of their constituent materials, will increase global carbon emissions and consumption of rare metals.

Lower energy consumption will, through lower cost of energy, become a competitive advantage.

Harnessing renewable energy in itself involves carbon intensive manufacture of generating equipment as can best be seen in wind or solar farms. Few sources of renewable energy are suitable for providing guaranteed base load electricity other than tidal, nuclear or hydroelectric, two of which are geographically dependent and the other technically and culturally problematical. A universal imperative however will be that the cost of energy, however generated, will rise giving competitive advantage to any company, goods or service which consumes less.

It is likely that alternative fuels will be developed to market. Battery production will continue to develop but will be measured increasingly in terms of its sustainability, not only through the carbon emitted in battery creation but the rapid depletion of finite world resources of key materials. An indicator of the interconnected nature of the global mega-trends is that mineral extraction and battery production is already dominated by Asian governments taking control of the entire supply chain in less developed countries.

Reliance on battery electrification for road transport will require very high-cost investment in charging infrastructure as well as challenging the world's ability to source and manufacture the batteries themselves. Vitally, it will not address many aspects of air quality in cities such as tyre particulates which are already becoming unacceptable. Whole life sustainability, often called the "circular economy" whereby greater value is placed on re-usable rather than single use constituent materials, has implications for every aspect of living and built products. One is reducing the acceptability of frequent replacement of assets rather than their careful upgrade, refurbishment or life extension – whether personally or publicly owned.

Air travel is and will continue to be an innately low capacity but high speed transport mode between regions. Research into net-zero and lower carbon air transport will continue and it is likely that the current carbon footprint of this mode will reduce. The amount of carbon emitted on any air sector is heavily skewed to take-off and this will continue to mean short-haul air will continue to perform less well than electric rail from an operational sustainability perspective.

In considering door-to-door journeys, rail has the potential to be more attractive than air travel up to 800 kilometre especially once generalised journey time of frequency is factored in. This is on the basis of **high speed rail accessing city centres and continuing to avoid some of the time lost in airport passenger processing**. However, airport design will be improved to reduce passenger processing time and hence overall journey time through use of pre-travel and at airport screening technologies. For journeys above this range only political policy change would determine a greater potential for rail.

Meanwhile, because passenger flows are so low it will continue to be inefficient to offer a rail alternative to air unless possible as a by-product of services operating for other reasons.

Long haul air travel will only slowly return to pre-pandemic volumes over the coming decade but thereafter may be expected to continue to expand. If applied to fares, the cost of carbon emissions may reduce the growth in routine leisure travel but the economics of long-haul air travel will remain dominated by high value business and cargo hold "belly" freight. The number of European hubs where significant long-haul networks will be accessed will reduce. Connection to the nearest European long- haul hub, Wien Airport, is achievable by high speed rail but the volume of traffic would not justify such provision were it is not for the major destination of Wien itself. **A greater focus will be necessary on efficient rail connectivity to Prague Airport** both to connect to Europe's business capitals, and to the Gulf States and London to access Asian and North American markets respectively.

> Extreme weather-related events will challenge the standards to which new infrastructure is designed, however, will have greater implications to existing asset base.

Traditionally, the catchment area for an airport is largely from the immediate city region with only a small proportion of passengers from further afield. Even within a city region the volume of airport travellers is small compared to the other daily city flows. However, with air travel likely to be concentrated on fewer locations, **planning should include how best to provide direct rail connectivity from cities within a 2-2.5 hour inter-city journey** time as it will be these rather than remoter ones which will be "visible" to international, especially Asian, markets.

3.8 Climate Adaptation

European central estimates of the effects of global warming, themselves dependent on very challenging major and rapid changes of ways of living in Europe and across the world, demonstrate impacts beyond just heat. As well as changes in temperatures affecting economic sectors as diverse as agriculture and winter sports, the forecasting demonstrates increasingly extreme weather related events – especially both the frequency and power of storms over all seasons. This challenges the standards to which new infrastructure is designed but also has more and greater implications for Europe's existing asset base from housing and utilities to flood defences and transport. It may be anticipated that a sustained effort of **retrofit and upgrade existing assets will absorb much of the funding available for managing the existing built infrastructure.**

4 Implications for Transport Demand

4.1 Passenger

The shape of, and economic relationship between, cities has changed little over centuries and is driven by fundamental human behaviour. **The key human measure of relative geography has always been time rather than physical distance.** This is driven by the concept of personal "travel budgets" whereby individuals calculate how much time is worth committing to travel for the benefit of some event, whether it be for work, shopping, socialising or leisure visit experience. Each individual will have their own view on acceptable daily and less frequent travel time limits. However, in most societies average behaviour coalesces around three or four values.

Any city has, and will continue to act as a distinct entity within, a radius of about 30 minutes door to door travel. This is clear from Ancient Rome through Renaissance Venice to Imperial Vienna and modern day cities. Once a city expands beyond the capacity of its citizens to meet spontaneously or work together, requiring trips of more that this time, it ceases to be a single economic or social entity. Instead, it will break up into a cluster of adjacent but separate communities. In addition, the lower paid unskilled and semi-skilled workforce, on which a city depends for its key services, generally resides within the 30 minute city to limit the cost and timer of its daily work commuting. Beyond this, research increasingly shows the deleterious effect of longer daily journeys in terms of reduced family and other social contact - causing a sense of "live to work rather than work to live".

Given limits on acceptable housing density, **the physical size and therefore population of a city depends fundamentally on its transport system.** Whereas walking limits to around a kilometre at most, and road vehicles to around 5 km given shared use of space and conflicts at junctions, dedicated unconflicted transport corridors can expand the practical limit to 10-15 km door to door.

Economic and social dependency between adjacent cities – **the agglomeration effect** – rarely exists once the time distance extends much beyond **60 minutes**. This is the general limit for daily travel to professional

Economic and social dependency between adjacent cities, the agglomeration effect, rarely exists once the travel-time distance extends much beyond 60 minutes.

or specialised employment, or for business people to have regular contact with associates.

As a consequence, most business-to-business contracts involve entities within this time horizon. In human terms people, where they are reasonably able, do business with those they are in easy regular personal contact with. Likewise, any organisation needing skilled people – from IT and finance through to engineering or health – has found it can attract employees from the pool of skilled people residing within this travel timeframe. Conversely, for that skilled workforce, job opportunities are expanded across places within that time-distance with the ability to advance a career without moving family and breaking educational and social connections.

A similar time horizon exists for non-business or employment activity. In human terms, **an hour journey is an acceptable commitment for regular retail or other leisure activities or evening events.**

The most likely impact of changes in work and business practices accelerated by the health pandemic is to expand the one-hour time horizon to around 90 minutes for some people. This will be driven by the reduced need to work at an office on a daily basis, or to attend every routine business meeting to maintain relationships once established. People are demonstrating the ability to trade within a weekly travel time budget for fewer longer journeys, especially if they can do some productive work whilst travelling. However, this is less likely to affect the time limit on social or leisure contact where the perceived benefit vs. travel time cost is lower.

The last value is around 2 to 2.5 hours for less regular travel. For business activity this represents the practical limit for travel without an overnight stay which otherwise represents a step change in personal commitment. For those specialisms such as corporate financiers and lawyers who often exist in only one main centre within a country, usually but not always its capital, cities which are beyond this travel time are less able to attract timely attention. In effect, they lie below the horizon in terms of business visibility.

This also tends to be true in other spheres such as politics and public policy where national decision makers are clustered in one place and more remote city regions become less visited, less considered, and unattractive for ambitious young skilled people.

The 2-2.5 time horizon also affects personal and family contacts. It represents a reasonable limit for regular weekend visits and special occasions. Beyond this limit physical contact is likely to be only seasonal at best with a duration akin to vacations.

4.2 Freight

The reduction in European competitiveness in basic lower value manufacturing and the shift away from carbon-based fuels will have a very significant impact on the nature and volume of freight flows. Progressively bulk flows such as coal, petroleum and ore will reduce to zero by 2050 although construction materials traffic will continue. An emphasis on sustainable waste management will see bulk movement from cities to recycling centres expand and to landfill sites reduce.

The economics of large ship operation will see containerised movement of finish goods imported into Europe concentrated increasingly on a few deep sea ports – principally Rotterdam, Marseilles and Trieste. It is probable that, assuming effective operational reliability can be achieved, **increasing volumes of Asian origin container traffic will arrive in Europe by transcontinental rail.**

By far the greatest increase in freight logistics movements, fuelled by the rise of internet shopping and movement of high value small volume products, is likely to be in part loads and small package freight. Alongside, will be the continuing trend for foodstuffs and domestic consumables distribution to smaller local outlets throughout cities, being convenient for customers not wishing to do their own private car “bulk road haulage” from out-of-town centres.

The challenge this brings is in melding the need for diverse small volume flexible distribution modes within cities, whilst minimising carbon and other emissions, with the economics of scale for long distance transfer of multiple packages and pallets from points of origin. Whether city local distribution is to retail outlets, serviced pick-up points or individual dwellings, it will

be neither efficient or acceptably sustainably to bring large long-distance vehicles into cities routinely. This implies the expansion of city fringe distribution warehousing to transhipp long-distance loads into local delivery systems.

5 City Passenger Rail

Rail will remain effective at providing high capacity, frequent transport between city suburbs and centres building on the innate capacity and reliability of its dedicated, conflict-free right of way. Wherever possible this should be enhanced by segregation of tracks from other rail traffic sectors and elimination of at-grade road and pedestrian crossing to enhance safety and reduce disruption risks.

The overriding objective will be to achieve the 30 minute city at a frequency which can either be sufficiently high that waiting time can be largely discounted or to a timetable that is reliably adhered to. Given the desire for cities to expand outwards rather than upwards, cost effective ways of accelerating average door to door speeds become most important. **The spacing of stations should be limited to between 2 and 3 kilometre through suburban areas**, with other modes acting as integrated feeders from surrounding areas.

Significant work will be necessary to make stations fit for purpose so that easy and effective access to the rail network can be achieved to a standard that passengers will expect. This is set out in Section 9 Transforming Stations.

6 Inter City Passenger Rail including across national boundaries

6.1 General

Rail will have the advantage of net-zero carbon travel in a more sustainable manner than individually operated electric road vehicles but **only where there will be sufficient traffic flows to achieve this economically** - and where the service provision is sufficiently attractive.

The overriding success parameter will be achievement of the key journey time thresholds for door-to-door travel between cities, and their surrounds, to enable the ready flow of people and capture the economic and social benefits of agglomeration. For each corridor between city pairs it will be necessary to identify the extent and mix of upgrade, new build cut off or completely new route required and the logical stages for delivering the work.

Alongside journey time, **development will need to include capacity enhancement to achieve sufficient frequency of service.** On the 60-90 minute cities links, a base 30 minute service will be necessary to avoid the waiting time between services being disproportionate to the actual journey time given the road vehicle alternative has no such time loss. An hourly frequency may suffice for the longer 2 hour plus connections, especially cross national borders where flows are less, unless services between intermediate “60 minute cities” bridge the gap half hourly.

> Each principal central station should be located and developed in partnership with the city authority.

Additionally, some capacity expansion will be needed at to achieve robust day to day operational performance of both freight and passenger services equally. Given that over time there will be potential to improve capacity on open line through signalling control system advances, **initial focus should be on critical junctions, stations and other pinch-points to eliminate conflicting flows, segregating traffic flows as much as possible.** These will yield the greatest benefits soonest.

Each principal central station should be located and developed in partnership with the city authority based on two principal factors:

1. To maximise its **effectiveness as an interchange** with the city transport systems to provide easy and rapid access to as much of the population as practical; and
2. To maximise **highest value city development** potential which will occur within a 10 minute walking (4-500 m) radius from the inter-city train.

Recognising that in the biggest cities the door-to-door journey time between cities for some of the population will not be attractive if they have to travel via a single central station, **city fringe satellite stations should be provided. These should be located on the inter-city route where ease of rapid interchange with local transport can be maximised.**

Whether such stations are also developed as satellite commercial centres will be a matter of regional planning priority but the potential – given by definition the good connectivity – will always exist and value

City rail networks will need to be developed to reflect changes in demand and demographics.
Rail will still have a role in serving rural communities if properly integrated with other transport modes.

capture of planning gain will contribute to the cost of station provision.

Where new main lines are being developed, for smaller intermediate cities consideration should be given to **provision of stations away from the current immediate centre, albeit well located to interchange well with local transport**. The city will still benefit, the disruption and cost of creating and operating a corridor through the city avoided and the time penalty to the principal passenger flows between more major cities minimised.

The third primary service factor will need to be dependability both in terms of **reliability as a technical system and resilience to external, mainly weather, events**.

The principal routes between cities, both new high speed and existing main lines, should be equipped to be fully interoperable. **The existing main lines should be upgraded as necessary to be capable of accommodating maximum length trans-European freight trains.**

By 2050 the Czech Republic should develop its routes between cities to achieve the following target journey times with a minimum 30 minute frequency through much of the day between the city pairs.

From Prague

City	Target Time (mins)	Key Route Investment
Brno	< 60	New passenger only
Wien	120	New
Bratislava	120	Mix new/upgraded existing
Ostrava	< 100	New passenger only
Hradec Kralove	40	Mix new/upgraded existing
Pardubice	40	Mix new/upgraded existing
Olomouc	90	Upgraded existing
Wroclaw	120	Upgraded existing
Liberec	80	Upgraded existing
Usti nad Labem	30	New
Dresden	60	New
Most	45	Mix new/upgraded existing
Pilsner / Cheb	45 / < 120	Mix new/upgraded existing
Ceske Budejovice	< 90	Upgraded existing

From Brno

City	Target Time (mins)	Key Route Investment
Wien	60	New
Bratislava	60	Mix new/upgraded existing
Ostrava	40	New
Katowice/ Krakow	90	Mix new/upgraded existing

6.2 The Czech Trunk Corridor

The two principal hubs in the Czech Republic will be Prague and Brno. As already planned, by 2050 the link between them should be doubled through the creation of a new main line capable of bringing the passenger journey time to within one hour – preferably under 55 minutes. The new route mid-route intermediate city of Jihlava should receive a special investment as a major growth zone given its proximity to both major cities. City fringe stations should be provided at Prague and Brno to maximise accessibility without the need to travel into the city centres. **The capacity and technical specification of one pair of tracks on the existing main line should then be prioritised for freight and regional passenger services.**

The new line from Prague will be configured for the first few kilometres specifically to allow shared use by fast trains towards Pardubice and Hradec Kralove (see below).

The **route from Prague to Dresden**, as already planned, should be similarly doubled with a new line throughout via Usti nad Labem. From Prague to Litomerice the new line should be passenger only with the existing one optimised for freight. From Litomerice to Dresden will be shared use through long tunnels although it will be important to maintain the existing route for slower trains and as an emergency alternative. It will need to be designed to permit sub one hour passenger journey times half hourly to achieve economic agglomeration benefits.

The **route from Brno to the Austrian border** will, over time, require a new pair of tracks and the opportunity should then be taken to segregate passenger and freight also to maximise reliable capacity and permit a sub 2 hour Prague-Vienna timing half hourly). This **route is part of the other main trans-European rail corridor from Italy to the Czech Republic and Poland hence the need to double capacity to accommodate greater freight flows by 2050.**

Again, as already planned, a new passenger only high speed line should be created between Brno and Ostrava permitting segregation with the existing line upgraded as necessary for freight trains. From Ostrava to the Polish border, the existing route should be upgraded with four tracks throughout.

At Prague the existing network, suitably upgraded, should suffice to **enable freight trains to avoid the city.** At Brno new by-pass lines should be constructed to **permit freight trains from Austria to avoid the city,** both towards Ostrava and Prague. The by-pass lines should also be configured to permit some Prague-

Vienna and Prague-Ostrava high speed services to avoid the city centre.

6.3 Other Major Routes

The industrial region centred on Most will benefit from constructing a faster route direct from Prague branching off the Usti nad Labem new high speed line. This will be a mix of new build and upgrade to achieve as journey time substantially less than 1 hour.

A new Y-shaped line will be needed, branching off the new trunk line outside Prague to serve the cities of **Hradec Kralove and Pardubice**. A mixture of new and upgraded route from the former towards Wroclaw will be a natural extension of this. Selective upgrade of the existing main line towards **Olomouc** and then connecting with the new line towards **Ostrava and Prerov** will string together these mid-size city regions, whilst still allowing the expansion of European and domestic freight on the route to Brno.

A mixture of new tunnelled and existing four-tracked and upgraded route should be created between **Prague and Pilsen** to permit a journey time of no more than 45 minutes. Upgrade of the route to Cheb, already partially completed, should be completed. Upgrade from this line into Bavaria will depend on agreements on freight routes.

Investment to substantially upgrade the route to the Southern Bohemian area centred on **Ceske Budejovice** will be required to ensure that city region can be brought into the central economic area. There may be potential to upgrade the mountain line through to Linz for greater passenger and freight usage but this may not be an early priority.

The northern area including **Turnov and Liberec** is geographically close to the central economic region but current rail routes serve it inadequately. Substantial upgrade work to significantly reduce journey time and increase service frequency will be necessary.

Although it is expected short haul air traffic will reduce, there will remain many European business centres that will only be accessed productively via Prague and Wien airports.

In respect of Prague, a new line from central Prague, which continue west beyond the Airport to bring a greater area within 30 minutes of the city, should be developed. This new route should be configured for combined use by limited stop city rail and by inter city services from the south, east and north east of the country continuing forward from central Prague to terminate at the Airport. This will also relieve platform capacity in Prague central station.

7 Connecting Rural Communities

Like in many developed countries the least prosperous areas will be the rural ones less well served by transport connectivity and tending to depopulation especially by younger people. Older inhabitants in poor health also suffer difficulty accessing the high quality healthcare available in centralised city locations.

Rail has traditionally played a role in connecting rural communities to more major centres and with careful planning will do so in the coming decades with some investment and changes to operational practice to better meet the needs of those served. Costs generally exceed direct revenue by up to an order of magnitude but the **service provided is of high community benefit in providing access to employment and centralised health and cultural facilities.**

In many countries such links have been replaced partially or entirely by public road transport – which is lower cost to provide – and reliance on use of private vehicles. However, **rail remains highly valued by communities still served, even when under-invested, not least because it is seen as a more enduring, permanent link to the city than a road substitute and cuts car dependency.**

Whilst it is unlikely that new-build rural lines could ever be envisaged, a strategy of recovering and upgrading the still existing ones, and consideration or re-opening ones where the right of way has not been lost, is a rational response to rural relative deprivation. The Netherlands has shown that greater value can be obtained from such remaining routes when they receive modest modernisation investment and are fully integrated with rural road transport. This means **using the rail route as the connector to the city and rural bus routes connecting at interchange stations to join to communities away from the railway.**

With integrated timetabling of guaranteed connections, through ticketing and information tools, a more valuable rural network can be created without requiring high frequency - the emphasis being on **dependability combined with an adequate journey time to the city hub at key times of the day**. Given planning of the

The net-zero environmental performance of rail will give it increasing advantage over long distance lorry movement rail has. **Palletised freight** has a major opportunity to carry out the main trunk haulage involved in parcel and small packet delivery.

feeder bus network, rail station interval can avoid being closer than 12-15 km to help reduce journey time.

Rural interchange stations should also be planned with adequate parking and electric charging points to promote mode transfer onto the railway for the main city journey.

Recognising that low density rural communities will continue to depend substantially on personal road transport, even if a measure of shared use is developed, the rural interchange stations should also be planned with adequate parking (with electric charging points) to promote mode transfer onto the railway for the main city-bound journey. Security can be monitored centrally if there is no justification for manned premises. Perceived security whilst changing modes can be effected in large measure by the human presence of bus drivers providing the integrated connecting services.

8 Freight Logistics Serving Industry & Supplying City Regions

Rail will remain strong in bulk construction and waste materials haulage both through economy of scale and public resistance to heavy lorry movements. However as noted previously, most other existing bulk flow will disappear in the medium term.

Rail should be planned to take the opportunity to expand greatly its share of container traffic provided it is given adequate priority in operation. Road haulage will experience two major challenges:

1. With greater prosperity there will be fewer people prepared to endure the life of the long distance truck driver, a trend already well established in several more developed countries; and
2. Substitute fuels to replace diesel have yet to be developed to be economic and practical replacements. Trucks also create a disproportionate amount of noise disturbance as well as air pollution through generation of particulates from tyre wear.

With rail taking most of the long distance containerised traffic, especially to European deep sea ports or overland from Asia, **truck movements can be reduced to regional distribution from container transhipment points** – and the drivers would be a smaller pool of people with more attractive employment being locally based, avoiding their current nomadic existence.

Rail can expand its involvement with time sensitive foodstuffs and domestic consumables distribution in partnership with the major supermarket chains. Whilst examples currently tend to involve very long distance haulage typically over 500 km (eg. Spain to Northern Europe) there are successful examples such as in Switzerland where much shorter distances are successfully operated. **The net-zero environmental performance of rail will give it increasing advantage over long distance lorry movement provided the reliability and journey time requirements of the shippers can be guaranteed.**

Similarly, rail has a major opportunity to carry out the main trunk haulage involved in parcel and small packet delivery. This market area is collectively referred to as **palletised freight**. Today it is largely transported in standardised pallets in large lorries in a similar way to air freight modular containers to distribution centres in major cities then broken down for smaller road vehicle delivery to outlets, pick-up points and individual addresses.

Investment in rail-served distribution centres and modern wagon fleet will be necessary to realise both these opportunities and demonstrate the environmental benefit of trunk rail freight haulage. It will require a different but entirely possible operational approach which will be to schedule and prioritise freight trains as, and equal to, passenger services.

There are three immediate priorities to exploit this major opportunity:

Major priority will need to be the objective assessment of existing stations, determining which need to be replaced, upgraded or eliminated to meet the needs of the 2050 users.
Some locations may have been right a century ago but nowadays, no longer serve much purpose and should be closed.

- to determine, in partnership with the leading freight logistics companies and customers (such as food distribution chains and package and parcels delivery companies) the standards for palletised transport which, similar to air freight, would maximise the use of internal space in rail vehicles. These vehicles could look more like passenger coaches than freight wagons but with easy access for automated transhipment to and from road delivery electric vehicles;
- to develop lower cost, low noise, electrically/battery powered, automated transfer equipment, to allow extended hours of operation in an urban environment; and
- to identify and establish a network of transhipment facilities in each significant city region with good road access for local distribution. Many sites may be established where the freight railway best meets the main city road distributor network but the opportunity should be taken especially to repurpose under used rail facilities which might otherwise remain derelict or be sold off for low value development. In some cities it may be feasible to convert, partially or completely, little used stations which are no longer well located for passengers.

It would almost certainly be necessary to provide some public subsidy for operation of the initial network as well as for the capital cost of depot construction and rail vehicle manufacture. However, this may be set again the value of reduced road freight carbon emission and congestion on existing road networks, possibly following the Swiss model.

Prague and Brno particularly have extensive tram networks. There are some trials elsewhere on using such systems to act as local distributors of parcels and packets especially early morning or late evening. Given the advances in road-based electric local delivery vans which are easily recharged on each visit to a depot, and the potential for these to be autonomous, use of the tram system would seem to have limited value.

9 Transforming Stations

Every city or town should see its rail station as its gateway, the first-place travellers will experience on arrival and the point of departure to the rest of the country. By definition it will be the best connected location and therefore for business the land around it the most desirable. To the city or town concerned the land will be the most valuable both in money terms and opportunity. It will be essential that city and town plans are developed to ensure maximum societal benefit from these key assets and are constrained by current or past use. It should be developed to be not only the mobility hub but also the economic hub and the social hub. This will be reinforced by the increasing importance of rail as a primary transport communications mode.

Station should be developed not only as the mobility hub but also the economic hub and the social hub.

In any journey a passenger may use only one train service but at least two stations. Therefore, in meeting future needs and expectations, a major priority will need to be the objective assessment of existing stations, determining which need to be replaced, upgraded or eliminated to meet the needs of the 2050 users. This should take place against a plan to create new stations to serve new or expanded communities to increase accessibility to the rail network. Some locations may have been right a century ago but no longer serve much purpose and should be closed.

The guiding principle of new or upgraded existing stations will need to be to maximise ease and utility of interchange. Much of this will be achieved through integrated transport planning considering all complementary modes from walking through to light and heavy rail, (potentially autonomous) scheduled and on-demand public and private road vehicles, etc.

Whilst the areas immediately around stations serve a limited pedestrian catchment, each should be regarded as a multi-modal hub and developed accordingly so

that road-based modes act as feeders to avoid gaps between the catchment areas of adjacent stations.

Development should focus on coordinated complementary radial bus routes as well as provision for easy convenient cycle access and storage.

Road vehicle access to stations should include for both "drop off" and parking depending on local needs. Designs will need to reflect changes in the means of road access.

Drop off services whether manned taxi or "kiss and ride" will expand as city **Mobility as a Service** (**MaaS**) concepts are introduced – shared use of electric vehicles "rented" by the minute. These will reduce the extent of private vehicle ownership. Such traditional parking as is still needed should be equipped to provide electric vehicle charging in each parking space.

The station interchange environment will need to be designed around usability standards reflecting the mobility requirements of future passengers and also provide an environment where personal safety throughout operational hours is guaranteed both actually and as perceived by users.

User research, especially amongst the greater proportion of the population which doesn't use rail, or at best doesn't consider it a preferred mode where there is a choice, has shown that **"soft design" will be equally important.**

Soft design is the means of achieving a sufficiently attractive perceived passenger environment and is measured by rating against "ease", "convenience" and "safety" as seen by different sections of the community. As well the increasing proportion of ageing passengers with reduced agility, including mobility impaired wheelchair users, many will have visual, aural or cognitive impairments. Others will have luggage, small children, pushchairs and so forth. The programme will need to include provision for all these sectors of society if it is to achieve its 2050 goals.

Perceived **safety drives** consideration beyond systems such as remote monitoring. Passive safety design standards include lighting and elimination of blind corners in passageways, cleanliness and even avoidance of interaction with vagrants.

Particularly rated is the reassurance of a human presence – whether a rail employee, a connecting bus or taxi driver or, a refreshment stall or convenience shopping outlet. The latter has been shown in countries such as Switzerland to have the added advantage of making a small station more the centre of the community it serves, improving its value and, in turn, use.

Ease and convenience includes readily available whole journey door to door journey planning, through ticketing and guidance, all provided on personal smart devices, including real time changes. Short logical routes physically between connecting modes are equally significant. The ability to access hygienic, secure, public lavatory facilities is of particular importance to many potential passengers; standardised factory-made modules now available should become a normal part of the station development design.

In terms of hard infrastructure "convenience" includes year round shelter from the weather, and step-free access from station to seat on the train. A prioritised programme of station enhancement through provision of ramps and standardised robust and reliably operational escalators and lifts will need to continue.

Convenience can also include the ability to do something else whilst passing through the interchange such as picking up personal internet shopping. So a further aspect of station design is to provide pick up and return points – standard secure modules serviced by the parcels delivery companies.

The greatest challenge then remaining will be the platform-train interface for inter-city and high speed trains. In contrast, regional and urban train design with low floors and small wheels has advanced step-free or at least reduced step travel. The interface is dictated by European interoperability standards for platform heights which are incompatible with minimum practical inter-city train floor level which is around 1200 mm above rail height.

Two approaches are possible. One is to ensure level platform heights where interoperable services are not planned, or at least providing only the minimum number of interoperable platform faces at any location. Innovation in train design could lead to a reduced train floor height, for example the TALGO design philosophy in Spain. However, ultimately, European standards will need to be updated to accept that interoperability cannot be ossified in 19th Century platform designs which are simply unacceptable to 2050 customers.

Civil assets will be vulnerable to increasing extremes of climate change. Any new assets should be designed based on hydrological modelling to withstand worst case flooding events. Climate resilience will become one of major risks.

10 System-Wide Technologies

If rail is to realise its potential then its customers will require, long before 2050, it to achieve:

- the necessary journey times and frequencies described above to attract people and freight customers and unlock the economic and social benefits of agglomeration;
- utterly dependably, at times of the day and week the customers want. Dependability will mean not only individual punctuality and assured connections between modes but also all year round;
- at a cost acceptable to the users (and taxpayers because public benefit will require government financial support); and
- particularly for passenger traffic to provide a passenger experience that is sufficiently secure, clean and easy to access and use comparable with other daily personal expectation.

This will require advances in the design, operation and asset management of the railway system which, given the earlier statement that new build and renewed assets installed today will have an economic life of several decades, should be acted on urgently.

A railway has three states, operational, closed for maintenance, and degraded due to failure. The objective of asset management should be to maximise the first state, reduce the second and eliminate the third. All railway assets degrade with age, some with exposure to climate effects and some with wear. There will be two principal routes to asset and service reliability which are interlinked; **achieving a high initial quality using standardised elements and then implementing smart asset monitoring and management.**

For mechanical, electrical and electronic assets, standardisation on a set of sufficiently robust asset types which are assured defect-free at point of installation will not only reduce propensity to failure but will reduce cost through reduced variety of spares and replacement stocks, and staff competence training. This Japanese approach also encourages a continuous improvement mentality which over time will give further benefit and allows structured obsolescence management. A programme of ensuring assets are protected from vandalism and in appropriately temperature and climate controlled environments, or enhancing weather proofing of those inevitably exposed outdoors, will also be necessary.

By 2050, ETCS and allied traffic management tools and electrification at 25 kV AC will have been delivered principally through asset renewal programmes, simplifying and standardising railway systems and permitting modest improvements in capacity and railway performance with potentially more reliable and less costly to maintain lineside equipment.

Civil assets will be vulnerable to the effects of climate change of which the most destructive will be increased intensity of rainfall and, for some ground foundation types, alternating shrinkage/expansion between seasons because of increased temperature extremes. Any new assets should be designed based on hydrological modelling to withstand worst case flooding events. Re-engineering existing assets to be resilient to these effects of climate change will be a significant and costly activity.

Re-engineering existing assets to be resilient to these effects of climate change will be a significant and costly activity.

It can be accepted that in the most extreme circumstances temporary traffic interruption is appropriate compared with the capital cost or practicality of total protection. An example would be a weather event so extreme that travel generally would be unsafe or impractical. This can be assessed on a location-specific basis. However, a guiding principle should always be that the structural integrity of an asset is not compromised, allowing speedy service restoration once the immediate event has passed.

Most of the railway civils infrastructure in place in 2050 is in service already today and is of variable quality. A **comprehensive survey will be necessary to assess the resilience to weather effects of each built and earthwork structure**, leading to a prioritised 30 year programme of modification upgrade where practical or replacement if necessary.

An Intelligent Infrastructure programme should be progressed, involving installing sensors and condition monitoring systems not only to new assets but retrofitting to those, principally civil, assets that will continue in service long after 2050. Once thus equipped, the safety and performance of critical assets can lead to a fundamental change in asset management practice; henceforth at any given time current condition and serviceability can be remotely assessed, long term degradation predicted and assets servicing or replacement planned and effected before failure. This will have the **twin benefit of increased reliability and greatly improving asset management productivity, reducing cost and disruption of unplanned reactive work.**

Increased initial quality leads to extended periods without maintenance and greatly extends subsequent life.

The 20 year study by Graz University in partnership with OBB has demonstrated the huge benefit from increasing quality of new build and renewed track and supporting track formation. It demonstrates the relationship between installation quality and subsequent degradation rate, intervention frequency and asset life. Summarising, increased initial quality leads to extended periods without maintenance and, given the act of track maintenance is itself a major cause of material degradation, greatly extended subsequent life. By increasing initial quality for a small capital premium, the whole life cost of the track asset can be halved. Other benefits accruing to users include reduced unplanned and planned traffic interruption, and less strain on train running gear.

The direction of train technical design will need to focus on vehicle weight reduction to achieve benefits including to performance, capacity infrastructure maintenance and cost. Primarily it will allow a reduction in energy use. Whilst electrical energy for rail may be net-zero carbon, it will, given other societal demands, be relatively expensive. Reduced weight will assist higher performance though allowing greater acceleration and braking without increasing installed (in turn heavier) power and braking systems - enhancing capacity through reduced station and junction clearance times. **Lighter trains, as shown in Japan, reduce wear and tear on vehicle suspensions and track infrastructure alike, lessening the frequency and cost of maintenance and also improving availability.**

Czech Infrastructure Association

ID: 26671395 I VAT ID: CZ26671395

Tomas Janeba, President of ARI
m: +420 606 640 251 I e: tomas.janeba@ceskainfrastruktura.cz

Gabriela Svancarova, Public Relations
m: +420 724 930 929 I e: pr@ceskainfrastruktura.cz

Address:
Asociace pro rozvoj infrastruktury, z.s.
110 00 Prague 1, Na prikope 583/15, Czech Republic
e: office@ceskainfrastruktura.cz

www.ceskainfrastruktura.cz
www.green-cities.cz