Resilience – more than just Technology

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SUMMARY

When we think of resilience within the railway most of us will almost certainly relate it back to technology. Technology is one element of resilience within the railway industry but there are many other elements that contribute to it being a successful means of transport. Throughout this paper I will highlight some of these elements that contribute to making the railway more reliable, seamless and accessible, as well as future proofing the railway with respect to unknown factors and trends.

1 INTRODUCTION

Maintaining the safety of the railway when systems fail is only one aspect of resilience, when considered in the context of future command, control and signalling systems. Other factors against which the resilience of future solutions will be tested are changing environments, both natural and man-made, changes in passenger habits and human resource management as well as in the industry landscape, trends and transport market. The train network is like a giant living organism - what happens to one part will have an effect, no matter how small, on other parts.

2 NON-TECHNOLOGY RESILIENCE

2.1 Climate Change

One major threat to the resilience of the railway comes from the ultimate non-technological source – nature! Climate change is a well understood phenomenon, and in recent years the impact of climatic events on the railway have been very well publicised.

It is predicted that the overall trends in climate change will be towards longer and warmer summers, increased rain and flooding, and colder winter periods, all of which impact the railway in different ways, whether that be through more lightning strikes on trackside equipment or wet weather causing train detection failures. It may become necessary to incorporate means of proactively predicting and detect such phenomena into the overall control system so that trains are prevented from running on compromised sections of track and appropriate counter measures can be put in place for example; portable flood defences or spare parts for lightning struck equipment.

2.1.1 Wet Conditions

In wet conditions trains act very similarly to the way automobiles react on wet roads, they need a longer braking distance when it rains to ensure safe train separation. This reduced adhesion also happens when it gets cold and ice forms, or the ice can cause equipment to not function properly. This is particularly true with switches, crossovers and point operating equipment. The industry must be prepared for such occurrences, especially if this will be something that will be experienced more frequently as a direct effect of climate change. Technology has advanced enough that even our watches can let us know what the weather will be like tomorrow. The industry will need to have the right contingency plans in place and adapted timetables and services to handle a degraded service in these extreme circumstances, making sure people can still travel safely.

2.1.2 Hot Conditions

Hot weather conditions have as severe an effect on the railway as cold conditions do. The railway and a lot of its equipment is designed and set up to operate in a certain temperature range, if the weather gets too hot, for example, the rails can buckle. In recent years this has resulted in much newspaper coverage when speed restrictions have had to be put onto the railway in hot weather for safety reasons. If these ambient temperatures are expected to rise year on year, we need to consider the operating temperatures of railway equipment when operating in full sun. From a signalling point of view we could use data from trackside equipment to monitor that change, bringing it together with all the other data, predicting problems before they occur. Some routes will be more susceptible and exposed to direct sunlight than others, so we could explore re-routing in the traffic management system (TMS) to minimise the impact of equipment failing due to temperature increases. Research

into location cases needs to be conducted to understand whether equipment within big metal boxes can operate reliably in extremely hot conditions. Options of other materials that could be used to house the equipment could be explored; material that would not get as hot as metal and hence provide increased reliability during periods of high temperatures. Of course, if the world is getting warmer, then perhaps there is a related benefit in being able to harvest energy in a different way to today.

2.1.3 How Climate Change Affects Journeys

As well as affecting the railway the hot weather affects passengers and commuters. Several commuters have reported that temperature on certain London Underground Lines last year reached 35-40°C. Starting a journey fresh and reaching the destination sweating and tired is not the right start or end to anyone's day. Transport for London has been constantly exploring new ways to keep the temperature down on the Tube and have doubled the number of cooling fans on the network since 2012 as well as installing chiller units to pump in cold air. There are also 192 air-conditioned trains serving 40% of the network, with this number set to increase once the new Siemens trains are rolled out on the Piccadilly line in 2023. All the buses have opening windows and all new double-deck buses use air cooling systems. It must also be noted that the heat being released from the trains is heating the tunnels. The biggest source of all this heat is from friction due to braking, which causes temperatures to rise. Having modern rolling stock with regenerative braking on the network can feed the energy from the braking into the power supply, minimising heat generation. This also reduces the amount of brake dust produced by trains.

Other opportunities to reduce temperatures in closed environments such as metro railways should be explored, for example platform screen doors. Platform screen doors come at a significant cost but would help tackle the heating in the tunnel, health and safety of commuters as well as could be a good opportunity to increase capacity and reduce dwell time on that line. If passengers are experiencing a bad service on specific lines due to adverse conditions, such as heat, they will find other ways to commute and avoid their usual pattern, hence not investing to tackle this will result in less revenue for that line or operator.

Having longer and warmer summers might also have an impact on ridership on trains which are not air-conditioned, especially on the underground. With nicer weather and warmer temperatures, other modes of transport such as cycling, or walking might take precedence over travelling via train or underground. The above graphs, in figure 1 and 2, from Transport for London Santander (hire bikes in London) casual and member cycle Hires show an increase between July 2017 and July 2018. It is evident that the number of cycle hires increases during the Summer months of May, June, July and August with almost a million hires per month. The hottest temperature recorded in July 2017 in London was that of 31°C. This peaked to 34°C in July of 2018 contributing to a higher number of

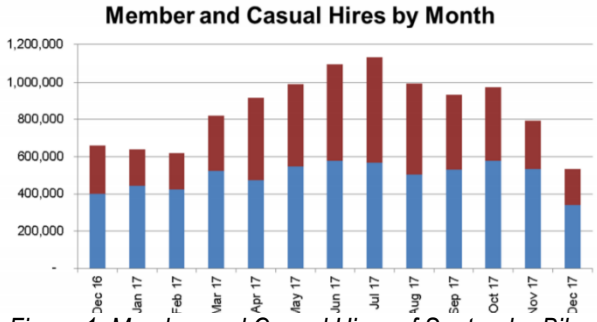

Figure 1: Member and Casual Hires of Santander Bikes 2017

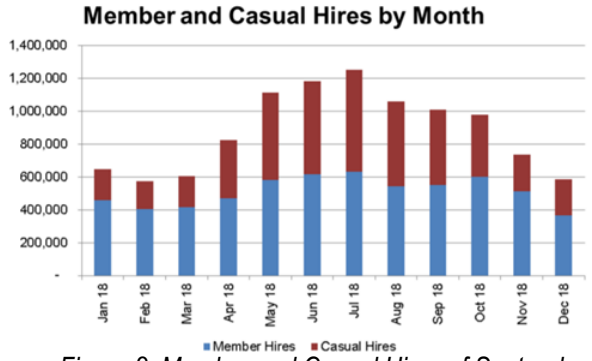

Figure 2: Member and Casual Hires of Santander bikes 2018

Month	Member Hires	Casual Hires	Total Hires	Year on year difference
Jan 18	459,261	186,719	645,980	7,489
Feb 18	403,685	172,867	576,552	- 41,998
Mar 18	415,483	189,593	605,076	- 214,676
Apr 18	470,165	354,723	824,888	- 92,688
May 18	584,070	528,828	1,112,898	120,297
Jun 18	615,764	566,220	1,181,984	83,690
Jul 18	633,671	620,134	1,253,805	121,967
Aug 18	544,132	514,271	1,058,403	64,204
Sep 18	552,580	455,807	1,008,387	73,636
Oct 18	602,657	375,873	978,530	4,848
Nov 18	514,266	223,913	738,179	- 53,903
Dec 18	364,829	220,601	585,430	51,342

Figure 3: Year on Year Monthly Difference

cycles hire especially during the warmer months highlighted above. It is interesting to notice that during the summer months the number of casual hires almost equals that of member hires.

Figure 4: Deep Tube Upgrade new Siemens Rolling Stock

Apart from disruptions on the network, high temperatures can also create health hazards. Since 2016, 825 people have fainted or felt faint/ill while travelling on the Tube during morning rush hours due to overcrowding and hot temperatures. Apart from this being a health issue it also disrupts services where a train must stop at a particular station for more than the scheduled time, holding up following services. This issue is common in metro style operations all over the world such as Singapore, Hong Kong, Bangkok etc. Aside from health conditions it also starts causing unnecessary stress and other issues when passengers are in a tightly packed and stalled train. Unreliable services can also cause passengers to become impatient, which can result in self-evacuating from a train when it is not necessarily safe to do so. This was evident in an incident on the 2nd of March in 2018 when a passenger got out of a Southeastern train and went on the track near Lewisham station where adjacent lines were still open to traffic and the electric third rail traction power system was live. Ways of avoiding something like this from happening include:

- Better provision of information of what is happening to passengers.
- Providing information about how long it might take to resolve the issue and resume normal service
- Alternate routes to reach the end destination (especially for connecting services)
- How to safely evacuate the train and repercussions of what might happen if the procedure is not executed safely

2.1.4 Resilience To Climate Change

Some weather conditions can be predicted, steps are already being taken on the Great Eastern overhead wiring, where spring tensioners are used to make sure it is kept taut in all weather conditions and does not sag in hot temperatures. Other mitigations, such as painting the rails white to keep cool and prevent buckling can be seen on complex crossovers and junctions. White paint can reduce the temperatures of steel rails by up to 10 degrees.


Figure 5: Trees on the line at Barnehurst 2019

Windy conditions and landslips can also cause major disruption to the railway. In 2019 there was such an occurrence of trees on the line at Barnehurst. An intelligent monitoring system consisting of 250 triaxial tilt sensors, communicating continuously with ten solar-powered infra-red cameras, to give early warning of any failure. At 03:30 on Monday 11 February, just such a warning was given. A tilt sensor had detected significant movement and alerted a rail surveying and monitoring engineer who was sent automatic text alerts and infra-red-illuminated camera images. The landslip had caused a tree to fall on the tracks, blocking the line. The line was closed, and trains cancelled. This was the fourth time this cutting face had slipped since 2010, hence all the monitoring arrangements. 300 tonnes of earth and trees were removed and then work could start on the 30 metres of wall. Piling was finished by Friday 15 February and the wall infill panels completed over the weekend. Prior to reopening the railway, work was undertaken to ensure the track was safe, replacing and replenishing contaminated ballast, and after test trains ran through on Sunday evening to check the repairs and test the signalling. The line was open again on Monday 18 February, one week after the landslip had occurred.

Floods can also cause service disruption by leaving the railway under water and shorting out track circuits, damaging signalling equipment and contaminating ballast. This is what happened recently on the Conwy Valley line in Wales due to damage caused by storm Gareth in March. At least nine sections of track between Llandudno Junction and Blaenau Ffestiniog require significant repairs which will keep the line closed for a few months. This also includes embankments, bridges, signalling equipment and level crossings.

Figure 6: Conwy Valley line, March 2019

It is very difficult to proactively predict and prevent these incidents occurring on the railway. There are projects underway to move fifty thousand tonnes of soil using specialist diggers to protect the railway in West Cumbria from landslips. This will help keep 2,500 railway locations across the north safe and reliable. £8 million is being spent on the Cumbrian Coast line, following a £3 million overhaul of three miles of track between Millom and Bootle in February and with the line between Whitehaven and Bootle to be renewed in the summer.

It is evident that while we cannot change the effects of climate changes, we can improve on how we detect and predict these occurrences. The use of Remote conditioning Monitoring will be essential to pool data from all over the network to understand what is happening during these circumstances and how we can predict it in the future with the use of smart data and machine learning. Infra-red lights provide visual verification to validate data readings from sensors without having to send an engineer to site. Not sending engineers to site has several benefits, including improving health and safety as manual checks at night and during extreme weather are no longer required, reducing cost and carbon footprint. Predictive Information will be essential to ensure services running as smoothly as possible and safety is not jeopardized in such extreme weather circumstances.

2.2 Ridership Changes

As train ridership continues to increase, passengers expect shorter waiting and journey times; Yet much of the ageing infrastructure is becoming increasingly unable to support the higher capacity.

Rail demand has more than doubled over the past 20 years in the UK.

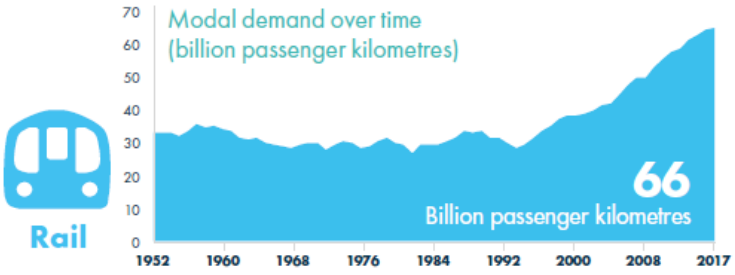

Figure 7: Rail demand in the last 65 years

Data shows that this is expected to continue to increase over the next few years. This will put extra pressure on the network and solutions to be more resilient and reliable. Passengers expect higher rates of reliability especially as fares increase . A Traffic Management System (TMS) can serve as a single source of data for train timetabling, rolling stock allocation and train crew deployment. This data will be vital in planning accurate operations and provide accurate simulation of real time events. TMS can detect potential conflicts in the timetable and allow signallers to select the best resolution for this conflict. With more services running on the network; this will be vital to providing passengers with higher frequency trains and shorter waiting times. Around 22,500 trains run every day in Britain with almost 1.7 Billion passenger journeys each year, another 400 Million rail journeys will be made

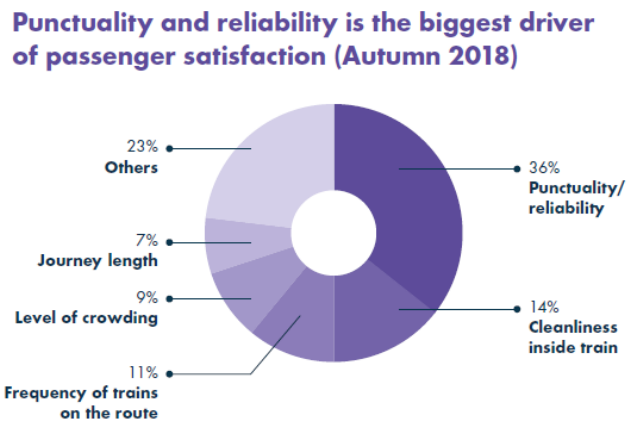

Figure 8: Punctuality and Reliability Chart

every year by 2020. More traffic on the network would inevitably increase the number of conflicts. This is especially true with the higher demand for rail freight in the UK, which has seen a 70% increase since the 1990s. TMS is the glue that links and connects systems such as European Train Control system (ETCS), GSM-R, Connected Driver Advisory Systems (C-DAS) and Stock and Crew solutions to create a "system of systems".

A limiting factor is the dependency on train crew and station staff. Recovering after a disruption is driven by the availability of skilled and qualified personnel, the management of which is complicated by considerations such as logistics around where each person will end their shift and how many rostered hours, they will have remaining. Stock and Crew solutions aid in making sure to improve recovery time from disruption and automating processes and current practices that still use manual techniques to implement this complicated logistics. An integrated "System of Systems" environment would help normal current multiple processes and procedures to align with one source of truth.

TMS enabled with the other mentioned tools would help provide more accurate data and timetable information for passengers, especially during disturbances and major disruptions. This data could be fed to open data applications that could then redirect passengers to other routes or modes of transport to complete their journeys. Better information, punctuality and reliability will help improve passenger satisfaction. Passenger satisfaction was at its lowest in 10 years in 2018 as stated in the Williams Rail Review (a root and branch review of Britain's railway, independently chaired by Keith Williams).

Although the trend shows rail demand increasing in the upcoming years due to the population growth, 2018 was the first year that London Underground passenger journeys dipped as opposed to the previous 4 years. Rail Passenger Journeys also fell by 1.4% in 2017-2018 compared to the previous year as journeys on Season tickets in the London and south East Sector dropped for the second consecutive year.

London Underground	2013/14	2014/15	2015/16	2016/17	2017/18
Passenger journeys (millions)	1,265	1,305	1,349	1,378	**1,357**

Figure 9: Passenger Journeys on London Underground Network in the past 5 years

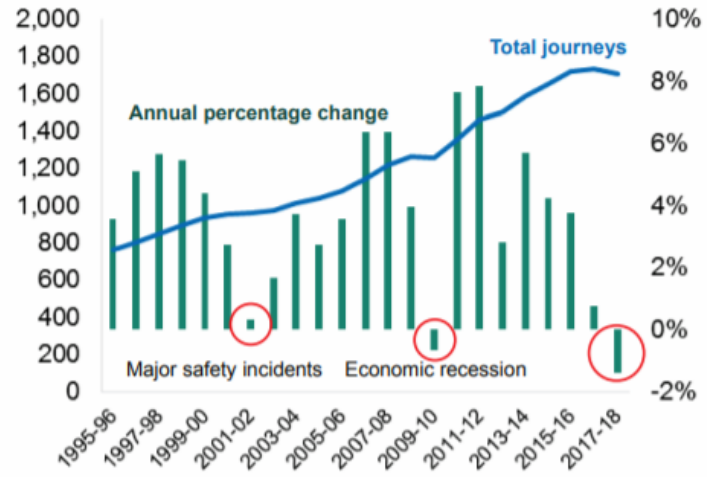

Figure 10: Rail passenger journeys for franchised train operators in Great Britain

The dip in passenger journeys both on main line and mass transit service could be due to several things. As mentioned above, the increased cycle hires have a part to play for this dip. Lifestyle changes could also be another component of this sudden decrease. More companies, especially in the capital are always looking at better and leaner ways of working, with the introduction of remote or working from home options becoming more and more popular. This is very evident on Mondays and Fridays when the services in London are not as busy as the remaining weekdays. Figure 11 right shows the main activities that they use public transport for. Over 55% of rail journeys are done for work and education commuting purposes. It is clear to see that with improvements in online shopping and same or next day delivery services, only 6% of rail journeys are done for retail and shopping purposes. With different trends in media and streaming services such as Netflix and others, as well as food delivery services such as Deliveroo and Uber Eats it's no surprise that the number of people that use rail services for leisure is only 25%. These trends will continue to emerge to make tasks such as shopping and dining out more comfortable and simpler by allowing the end-user to time, track and compare deliveries and services form the comfort of one's home.

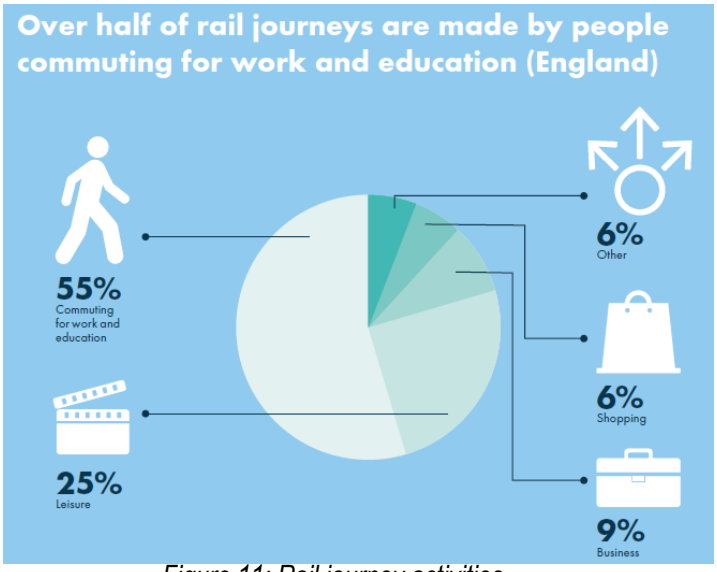

Figure 11: Rail journey activities

2.2.1 Resilience to maintain a sustainable Railway

As mentioned in section 2.2 there is still a huge demand for commuters to use the railway as their preferred mode of travelling and trends show this will be increasing. Apart from focusing to improve technology and upgrade solutions to handle this demand we must also ensure the surrounding infrastructure can handle this added capacity.

One clear example of this is on the Victoria line, where London Underground operate a service of 36 trains per hour at peak times. This means a train every 100 seconds, which is quite fascinating as one train leaves the station the lights from the next train immediately appear. Meaning that by the time you walk the full length of the platform a new train will have arrived. This also highlights that the platform should be cleared fairly quickly to make way for new people that want to get off or board the next train. If one of the escalators stops working (especially during peak) this will cause significant stagnation at the platform and station, causing the operator to regulate the service or operate at lower frequency. This is also the case when there are only a few ticket gates or a few are faulty, making the flow of passengers in and out of a station slower. This echoes the point mentioned in earlier sections, that all parts of the network must work in harmony. One small component failing to co-operate such as an escalator or ticket gate will slow down the flow of operations. This could be quite chaotic at key stations with interchanges to main line trains which might cause missing connections or during events such as football games where the demand is high and particular to a specific day or time.

The railway is dependent on passenger demand for services hence it must adapt to what the passenger needs and their lifestyle changes. As highlighted in figure 11, most people aren't using the network for leisure activities. New methods and incentives could be identified to promote using the railway for such activities. The industry is already keen on having one ticket for multiple modes of transport, we could perhaps integrate other forms of activities as well as travelling. This is quite common on website that offer flight booking services, that offer customers the opportunity to procure tickets for accommodation and car rental. One example could be booking cinema tickets; when the customer is booking cinema tickets, he could be promoted to book train tickets (if needed) to get to the venue. On purchase of both activities, the train ticket is bought at a reduced price as it is related to a leisurely activity. That is one example that could be used where other industries have managed to incorporate single transactions for multiple activities, making it more user friendly for the consumer and allowing to offer discounts and promotions.

2.3 Skills Mitigation

Some of the infrastructure on the current British railway network has been there for over 70 years. We are now living in a world of rapid technology advancements and integration to pool smart data for more accurate predictions. With this change comes the need to nurture legacy skills and retain knowledge retention whilst still being able to support new technologies. It also brings about the need to train and cross skill existing workforce on new emerging skills.

Engineering UK estimates the need to recruit around 186,000 skilled engineers each year between 2018 till 2024 in order to gain enough candidates to reduce the skills gap that currently exists. With the introduction of new digital technologies being implemented on our railways there is an opportunity to shine a light on the railway industry and make it attractive to a new generation of potential talent. This is highly important especially when the rail industry faces tough competition from other industries and new emerging careers such as blogging and gaming. To make sure that we have the right skillset and diverse talent to deliver future projects such as HS2, Northern Powerhouse and Crossrail 2 we need to attract young and diverse talent to the rail industry. New and additional skills profiles for such talent is yet to be defined as we are constantly seeing new trends emerging such as the need for Cyber security specialists and data engineers. These new skills will need to be analysed and developed along the more conventional roles and profiles such as signal designers, systems engineers and commercial and project managers. It is estimated that a minimum of at least 3,000 Level 3 rail graduates are required to maintain the current skills levels with at least another 7,000 required for level 4 advanced technicians graduates across the sectors. Specific projects such as HS2 will require 600 advanced rail engineering technicians each year from 2019 onwards. The cost of this skills shortages and gaps in the rail industry employers equated to £206m per year (£110m to the direct rail industry and £96m to the supply chain) with the prospect of increasing to £316m per year by 2024 without intervention from industry and the government. This includes a cost to the government of £358m per year. Therefore, it is essential to have colleges and training academies that can help open doors for careers in the rail industry such as the National Training Academy (NTAR) in Northampton and the National College for High Speed campuses in both Birmingham and Doncaster. The rail industry and its supply chain contribute to the employment of approximately 212,000 individuals and generates £9.3Bn in Gross Value Added (GVA) each year.

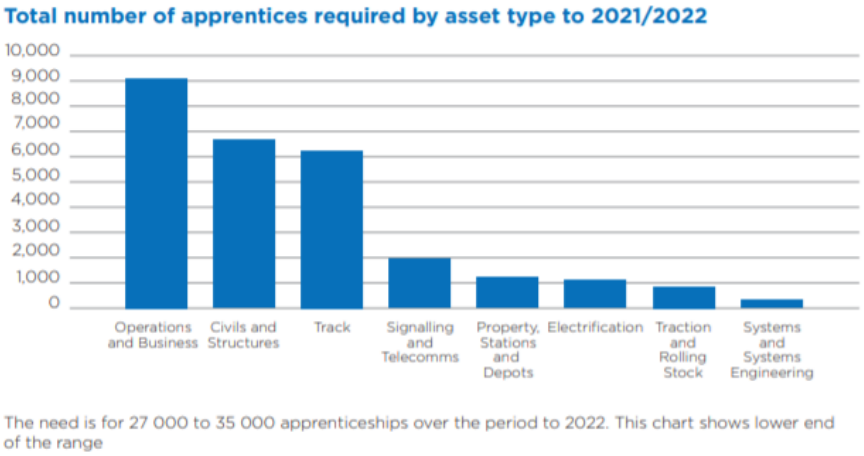

Figure 12: Apprenticeships types required by 2022

Figure 13: NTAR Apprentices

Figure 14: NCHSR apprentices

2.3.1 Focused Engineering Campaigns

Recognising the importance of investing to ensure resilience in terms of skills, last year the government launched the "Year of Engineering" Campaign to raise awareness around the engineering industry and attract young future talent to the industry to help bridge the skills gap. The campaign gained support from more than 1,500 partners that played an influential role to highlight the wonders of engineering at the workplace and how it can lead to successful and innovative career.

> In 2018, more than 1,500 Year of Engineering partners and supporters played a huge role in bringing engineering to life for thousands of young people, teachers and parents. Here are just some of the successes of a year that saw Government and industry work together more closely than ever to tackle the engineering skills gap.
>
> **More than 1 million direct experiences** of engineering for young people
> **85,000 unique users** supported through our website
> **30,000 views of lesson plans** on our teachers hub
> **50% increase in STEM Ambassadors** from 2017 to 2018

Figure 15: Year of Engineering Newsletter

Engineering helps us shape societies, improve lifestyles and pioneer new innovations. The apprenticeship levy on UK employers is also another great initiative to help development and delivery of apprenticeships with the aim of improving the quality and amount of those available. The levy will help increase industry-wide apprenticeships by 20,000 by 2020 to meet the Transport Infrastructure Skills strategy target and assist the industry in exploiting the apprenticeship levy to gain maximum benefit. The Rail Sector deal also highlighted several initiatives that would help close the gap. An implementation of a "shared apprenticeship" programme and a schools engagement programme are both mentioned, with a pilot in the Midlands to help deliver:

- Increase in number of Small Medium Enterprises (SMEs) recruiting apprentices
- Increase in number of apprenticeships offered
- Increased impact and co-ordination of regional school's engagement activities

The sector deal also highlights the need for skills development encouragement to come through public procurement using skills score cards and a visible pipeline to enable skills investment. The Skills Sector strategy also needs to encompass shifts into a digitally enabled mobility industry and the skills required to develop rail/mobility specific technologies, capabilities and expertise. The rail industry offers a wide variety of interesting and well-paid careers spanning numerous disciplines. However, it also recognises that rail is in competition for talent with other sectors who have historically been better at promoting themselves and their job opportunities. To make our attraction rates more successful the rail industry has to be more diverse and representative of the communities it serves. As of 2019, 87% of people employed by public sector bodies in the UK are men (i.e. Network Rail, ORR, DfT). Across the whole industry its 84% male and 95% when it comes to suppliers. The percentage of women working in the rail industry are in junior positions with only 0.6% of them working at director or executive level. This gender gap must reduce significantly if we want the skills gap to reduce and attract more diverse talent to the industry. Gender is one of the most striking characteristics that needs to improve in the rail industry but others such as race, religion, colour, sexual orientation to name a few are also highly underrepresented. As stated in the McKinsey Report "Why Diversity Matters" companies with more diverse workforces perform better financially. This benefits not only in

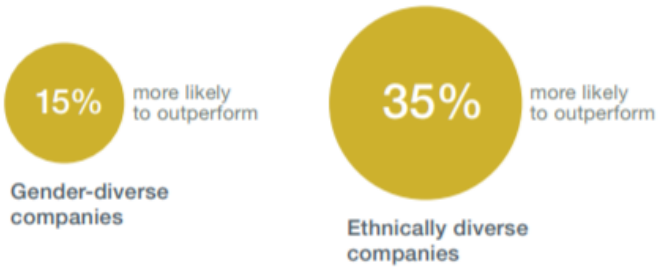

Figure 16: Companies with more diverse workforces perform better financially (source: McKinsey's Why Diversity Matters 2015 Report

managing to attract top talent but also aids in improving customer orientation, employee satisfaction, retention rates and better decision making. The more diverse the workforce is, the more innovative and inclusive our solutions become, making it a more attractive career and means of transport.

2.3.2 Resilience to address skills gap

Resilience to the changing industry will require people with knowledge on all the legacy systems in use, but also on the more recent and upcoming technologies of network systems, software, and safety electronics. Attracting young professionals into the industry through early career schemes such as apprenticeships and graduate schemes is necessary if the demographic issue of maintaining the railway while the older experts retire is to be solved. The experience and perspectives of people from other industries are also very relevant to maintaining resilience against new threats and seizing opportunities for innovation.

2.4 Innovation

New technologies in the wider context of mobility, like automated road vehicles and mobility-as-a-service, will influence the rail market and will necessitate understanding global changes such as evolving work patterns, remote diagnostics and other connected services. The use of digital twins at present seems to offer the best hope of modelling the world as it allows us to design for resilience in all its forms, raising the question of whether as an industry and as a country we are investing sufficiently in the right technology.

The railway industry must continue to draw on the UK's position as a global leader in science and research. The UK is home to four of the top ten universities in the world and performs well in research excellence. There needs to be a shift in how we embrace R&D and deploy new and emerging technologies on the network. The Rail Supply group published the "Fast Track to the future" in 2016 and highlighted five key areas of technology where the UK has the potential to be a world leader:

- Advanced control
- Energy management
- High value rolling stock systems
- Whole life asset optimisation and through life management
- Customer experience.

The government is keen to accelerate the growth of innovation in the UK and is keen to secure this through investments. This has included £40m invested in a three-year programme of rail innovation competitions via Innovate UK targeted at UK-based business and SMEs. The DfT is also collaborating with the Department for Digital, Culture, Media and Sport of innovative telecoms technology for the railways comprising of £35m allocated for trials and installations of trackside 5G infrastructure along the Trans-Pennine Route. The UK Rail Research and Innovation Network (UKRRIN), formed in 2017, is a partnership between the rail supply industry and a consortium of eight universities. It has secured funding of £92m for research aimed at establishing the UK as a world-leading centre of railway excellence. This includes £64m of private sector investment into innovation, in addition to £28m from the government, thereby accelerating supplier-driven industrialisation through pooling and co-ordinating academic, industrial, train operator and infrastructure manager resources. Innovation in the IIoT revolution means using readily available data to drive analysis and better decision making. Open and data sharing will be essential for innovation to thrive in the digitally connected mobility world. The rail sector Deal mentions an established data platform to securely share rail industry data. This will enable multiple modes of transport to effectively communicate and share data on different infrastructure systems. A common data platform would ease integration of different infrastructure solutions and adverse risk. From a passenger experience point of view this will take the stress out of journey planning as the passenger can plan and improvise their door-to-door journey in real time. Mobility as a service (MaaS) will provide passengers seamless travelling by allowing them to create, manage and pay for their single trip combining both public and private modes of transport. Making traveling simpler and giving the passenger more authority to plan and manage will help promote public transport as the preferred, reliable and convenient choice. Offering people easier access to different but seamlessly connected ways of travelling will not only have a positive impact on economic potential but help improve mobility for those less able

to travel. The Data sharing platform would make it possible to share and co-ordinate timetables for different transport modes.

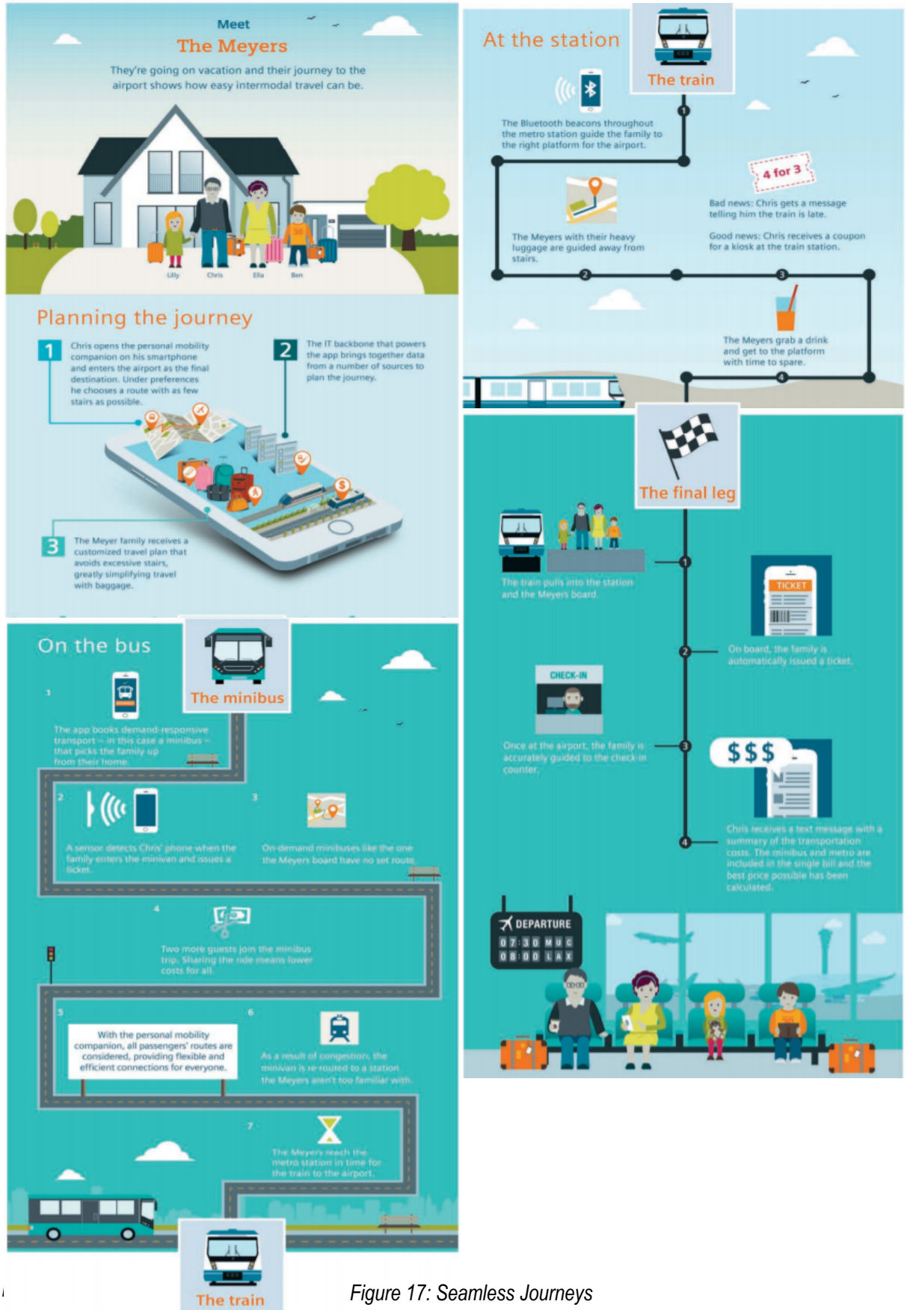

Figure 17: Seamless Journeys

3 CONCLUSION

Resilience in the railway is not just about technology, it is about the need that drives its investment and revenue, the skills to maintain it and innovate it into the 21st century and not least it is understanding and predicting the elements we have no control over such as climate change and new emerging trends.

Having a more diverse and inclusive workforce on the railway will contribute to having a railway that is representative of the communities it serves. Diversity will break down barriers and bring about challenges to the norms with fresh perspectives and inclusivity at the heart of everything we do stemming from design. This will help in closing the skills gap by widening the talent pool and enriching the railway with more ideas. The industry must ensure it is providing a reliable, seamless and accurate service making it good value for money for the customers and improving overall experience. We cannot focus solely on one aspect of the railway as all aspects are intertwined. One struggling element will have a ripple effect on other parts of a customer's journey hence we must ensure this is kept in mind especially when upgrades or works are being planned.

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