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Next Stop: the 'Digital Railway'

The evolution of Rail: Past, Present and Future

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Executive summary

Railway organisations historically ran very engineering and operationally focussed business models. Market liberalisation and competition ultimately drove a greater focus on customers and railways, like many contemporary service organisations, underwent key reforms to make them more efficient and customer centric.

With railway executives and governments now having gone a long way to embedding greater customer focus within their organisations, the question is – what comes next?

Enter the digital railway.

To thrive in the future, railway organisations will need to embrace digital technology to meet growing demand and higher customer expectations amid sustained funding pressures.

This paper aims to provide some thought provoking ideas about how digital technology can be leveraged to deliver a proposition that achieves this ambition and what railway executives will need to focus on to bring 'The Digital Railway' to life.

01

The Journey to Customer Centricity

The early years – ‘We run trains’

Railway organisations historically ran engineering and operationally led business models. Technical capabilities were valued above all else. Culturally, it was all about the operations, with an overarching ‘we run trains’ mindset.

Organisations were typically functionally siloed, with bureaucracy often constraining the speed and efficiency of decision-making. A high degree of dependence on manual processes and information flows led to imperfect data and lack of a ‘single source of truth’, further constraining management’s ability to make fully informed and timely decisions.

Infrastructure was not built for scalability and maintenance regimes were reactive in nature and challenged by complex industrial demarcations. This often led to uncoordinated shut downs. Consideration of operational / customer trade-offs in times of network failure were rarely coordinated, with operational recovery and “returning to schedule” overpowering more nuanced decisions that might be in the best interests of customer.

The customer service model was inefficient and labour intensive, based on human interaction at almost every touchpoint. The focus of the rail organisation was almost exclusively on the station-to-station leg of a customer’s journey, with limited consideration given to interchange or cross-modal integration.

While the system worked, passenger numbers continued to grow, and with it so did the challenges. As new infrastructure and services were brought online to meet increased demand, funding pressures began to be felt. Farebox recovery (on average less than 30% in Australia)[1], failed to keep pace with the increased operating and maintenance costs from expanded networks. Consequently, operating deficits widened.

Simultaneously, customer expectations were rising, with improving service standards in adjacent industries and amongst Global peers, particularly in Asia. Australia was playing catch-up.

Rail needed to become more efficient and customer focused.

[1] NSW Auditor-General (2017) Report on Transport 2017

The new millennium – 'We move customers'

Facing dual challenges of funding constraints and evolving customer needs, railway organisations began to pursue reform in a bid to transition to more efficient, customer centric operations. Reform agendas were wide ranging, but at the core was a focus on the customer and aligning service delivery, infrastructure, people, culture and competency to service customer interests.

More customer centric operating models rose to prominence, with customer focused executive roles and directorates focused purely on 'the customer' signalling the broader strategic intent.

Technology was embraced. Provision of real time information became the norm and blended human interaction/self-service models took flight, driven by electronic ticketing and the onset of smart devices. Real-time apps and journey planners were launched, and journey integration became common place, with railways recognising they are only one 'cog in the wheel' across customers' end to end journeys.

At a more operational level, manual processes very slowly began to give way to more web-based, digitised processes. This improved the magnitude and quality of data available for management decision making and helped to reduce organisational bureaucracy.

Centralised control centres were established, with more rules based control room decision making that took account of the 'customer' when considering trade-offs. Outsourcing of certain non-core activities of the organisation to more efficient and technically capable suppliers became more commonplace. Reactive maintenance regimes began to give way to more proactive maintenance regimes. Signalling and train radio systems were upgraded and rollingstock modernised to meet growing demand and changing customer needs.

At a people level, value began to be placed on a blend of technical, customer and technological skills sets. Workforces began to become more mobile and flexible, and digital toolkits began to enable more modernised 'ways of working'. Culturally, the operational bias began to decline. Ask a typical railway employee what their company does, and they just as likely reply with 'we move customers'. The customer was no longer an afterthought. Exhibit 1 summarises key areas of rail reform since the 2000s.

EXHIBIT 1 KEY AREAS OF RAIL REFORM, 2000 - PRESENT

	Where we were	Where we are today
	"Operationally focused"	"Customer centric solutions"
Customer Experience	• Vanilla, non-differentiated services • Labor intensive customer service, based on human interaction	• Clear customer identity and differentiated products • Blended self service / human interaction models • Enhanced cross-modal journey integration
Operations & Service Delivery	• Manual process and information flows • Low frequency services	• Centralised, rules based control room decision making • Access to private sector innovation • Improved network capacity and frequency of services
Infrastructure & Maintenance	• Decision making based on census datasets • Non-scalable, fixed assets • High on-going maintenance cost	• More modular infrastructure designs • Enhanced technologies increasing track capacity (e.g. ATP, Signalling) • Modernised rolling stock • Emerging condition based maintenance
People & Competency	• Operations focused technical workforce • Strong industrial demarcations • Manual ticketing	• Multi-skilled workforce with emerging flexibility • Blended customer service and technical capabilities • Digital ticketing changing role of station staff towards customer service

Source: Strategy& analysis

While dramatic improvements in how railway organisations operate and serve their customers are apparent – challenges persist.

Cost recovery remains an issue. Productivity challenges continue to inhibit railways financial performance. Legacy infrastructure constraints are impacting the ability to optimally scale networks in line with expected passenger growth. Funding constraints continue, as governments try to balance a set of competing social priorities.

All the while, technology continues to rapidly evolve and with it, customer preferences also continue to shift.

With railway executives and governments now having gone a long way to embedding greater customer focus within their organisations, the question is – what comes next?

02

The Rise of the Digital Railway

The future of transport will be shaped by a set of key macro trends, including rapid urbanisation, societal focus on sustainability and the changing nature of the car market (influenced by the rise of the ‘shared economy’). But none are likely to have as much impact around the way railways operate than the world’s rapidly changing digital and technological landscape.

The digital revolution

Emerging technology trends are reshaping the way in which business is conducted and services provided across both private and public sectors. The good news is that the emergence of these new technologies will present railway organisations with an opportunity to both modernise and optimise the way they provide services to their customers.

Artificial intelligence and neural networks are increasing automation in customer service and control systems, simultaneously reducing labour requirements and improving outcomes. Advancements in robotics and IoT sensors are driving down costs of traditionally labour intense functions, including maintenance, repair, survey and heavy lifting. PwC estimates that 45% of organisational work activities can typically be automated.[2]

The ability to generate insight from big data is improving with continued development of predictive analytics, coupled with exponential increases in computing power and decreases in data storage costs from cloud based storage. This is expected to continue to improve as we move towards Web 3.0. This presents opportunities to leverage existing large data sets to uplift organisational customer experience, increase efficiency and identify new commercial opportunities.

The prevalence of mobile devices, coupled with AI and predictive analytics, is enabling the provision of more tailored, personalised information. Increasing exposure to technology is also making consumers more comfortable and aware of its benefits (e.g. Amazon delivering voice activation assistance with Alexa, face recognition on the iPhone).

According to a recent PwC study, global GDP will be up to 14% higher in 2030 as a result of the accelerating development and take-up of AI and automation – the equivalent of an additional $15.7 trillion. Labour productivity improvements are expected to account for over 55% of all GDP gains from AI over the period 2017 – 2030[3].

Funding pressures

Yet this is occurring in the context of Government budgets facing twin dilemmas. A huge call on capital for new railway construction, and a tail of operating deficits almost as large.

$100b

Value of Greenfield Rail Projects in Australia & NZ, 2019[4]

Dominated by Victoria and New South Wales, there is an unprecedented investment in new railways across the country.

$72b

Estimated Cumulative Rail Operating Deficit, 2018-2030[5]

Expansion of the networks, combined with poor cost recovery is forecast to double annual operating deficits. To 2030, the cumulative operating deficit is $72b for railways, or $114b when all urban public transport modes are included.

With governments investing unprecedented amounts in expanding the network, what space is there to fund innovation and digitisation?

As it turns out, plenty – because (delivered well) digitisation enables us to deliver much more with much less by changing railway business models. Historically there had been a trade-off between enhancing the customer experience by adding cost. Now, we can improve experience by lowering cost.

Where customer needs previously added cost with upgraded seating, air-conditioning and in-person wayfinding, we can now reduce cost with proactive information delivery, load balancing across carriages and less labour intensive maintenance.

[2] https://www.pwc.com.au/operations/robotic-processing-automation/digital-operations.html
[3] https://www.pwc.com.au/government/pwc-ai-analysis-sizing-the-prize-report.pdf
[4] Infrastructure Partnerships Australia, Australia & New Zealand Infrastructure Pipeline
[5] Strategy& analysis

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Digital is a key strategic pillar for moving Deutsche Bahn into the future.

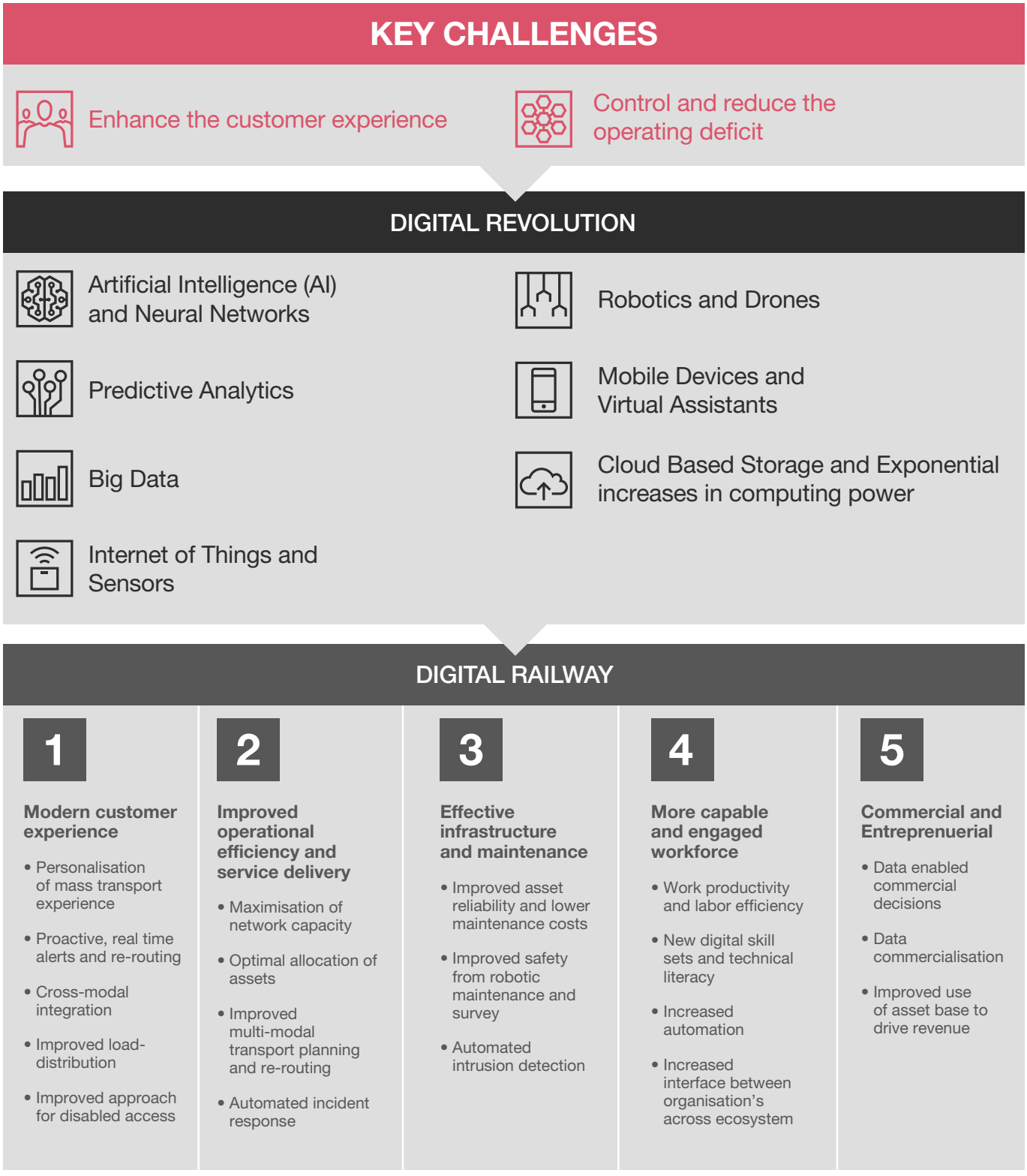
We are using digital technology to significantly improve our core operations in terms of customer experience and operational efficiency and effectiveness.

Stefan Stroh
Chief Digital Officer, Deutsche Bahn

What it means for railways

Leveraging a portfolio of digital technologies holds the key to meeting railway efficiency challenges head-on, without compromising on the customer experience. The range of opportunities presented by digital technology will help to redefine the way railway organisations operate well into the next decade.

We see the Digital Railway leveraging digital assets across 5 business areas as summarised in Figure 2 and discussed in further detail below.



Source: Strategy& analysis

1. Modern Customer Experience

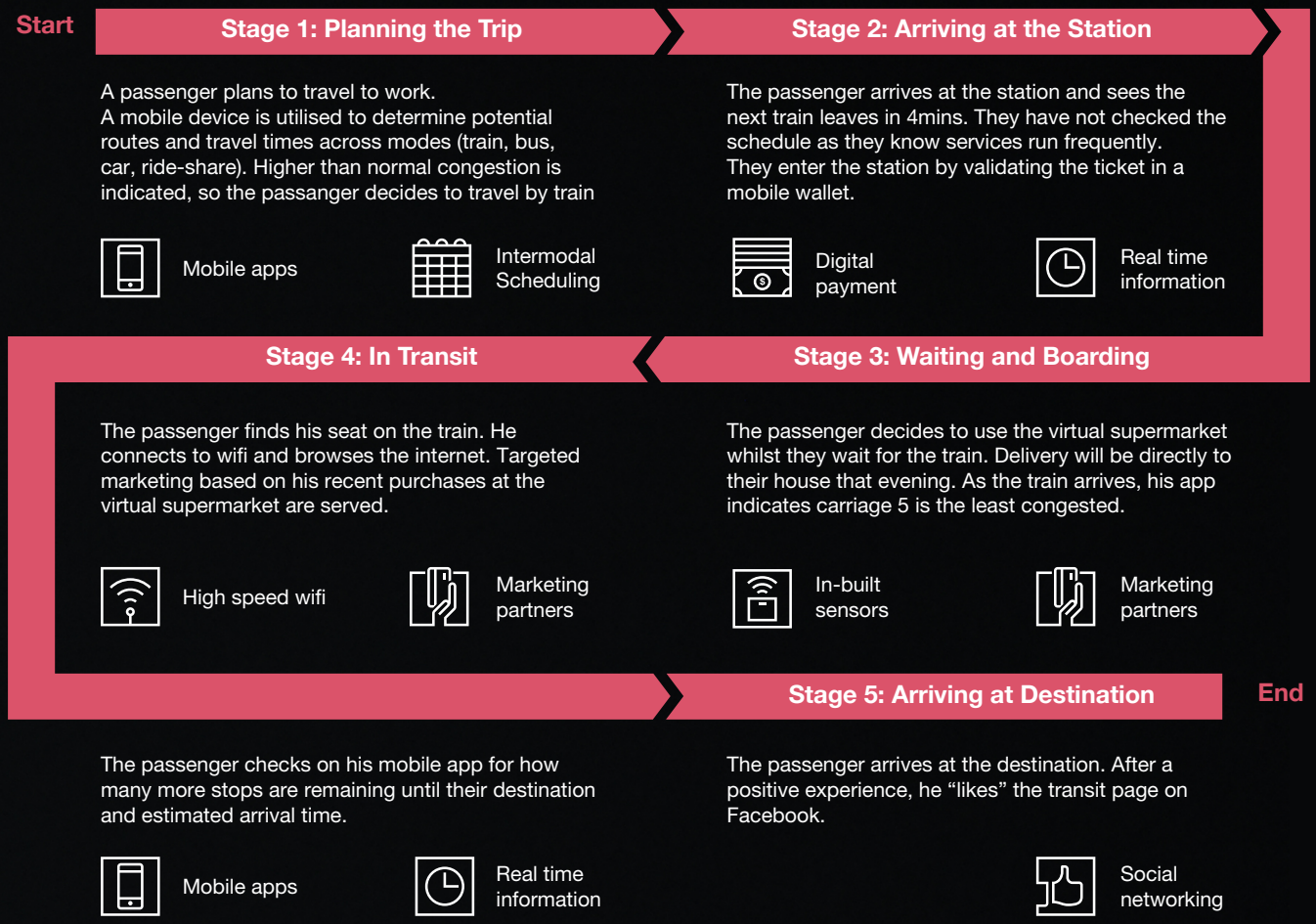
As expectations grow, **digital will become key** to personalising the mass transport experience and seamlessly coordinating end-to-end journey's across transport modes.

Intelligent systems, connected with real-time data across transport modes from **IoT sensors,** will deliver proactive and real time information on multi-modal transport options to customers.

Coupling real-time data with **predictive analytics,** potential delays can be identified prior to occurring, facilitating improved re-routing of customers. For example, with the forecast of inclement weather, an alert would be sent to a customer's smart device indicating an estimated 20 minute delay on their regular bus service due to anticipated congestion. The customer is recommended to take a nearby train which is expected to be less affected and would deliver a superior journey. In Sydney, 28% of customers have more than one feasible itinerary[6] to reach their destination, suggesting that simple nudges in one direction or another could considerably improve performance during times of disruption.

[6] Ho and Ho, Crowding on Trains and Platforms: A New Approach to Big Data, Institute of Transport & Logistics Studies, University of Sydney

EXAMPLE CUSTOMER JOURNEY USE CASE



Digitally enabled **real time load distribution** (via capacity sensors on carriages linked to apps or visuals queues) directing passengers to least crowded carriages, will improve the on-board experience and – crucially – delay the need to invest in costly peak capacity such as new trains and track in congested urban areas. AI enabled customer services will increase accessibility for customers and digital channels will similarly improve outcomes for passengers requiring assistance with disabled access route planning.

The ongoing development of **virtual assistants** (e.g. Siri, Alexa) will increase the use of voice activation to obtain information. When a passenger asks Alexa about potential disruptions on their journey to work, accurate real-time information will be accessible to communicate back and can enable customers to make different decisions about their travel patterns at a time of convenience (e.g. choosing to work from home if there are major disruptions, which is a more difficult choice to make once the customer has arrived at the platform).

Precedence for **digital ticketing,** accessed by smart device, has already been established by airlines, whilst growing use of digital wallets is demonstrating increasing comfort with contactless mobile payments. These will apply in the rail environment, as is demonstrated in the roll out of contactless ticketing in Sydney.

Station precincts will be designed to include **digital supermarkets, supermarket click and collect, parcel lockers** at stations to improve the value proposition for the customer. Advertisements will be tailored to individual customers, and individual passenger preferences will be tracked and actioned. Digital tracking of passenger movements drives improved yield on advertising space by allowing dynamic trading and better realisation of asset value. Transport for London is generating an additional £322m over 8 years through this technology.[7]

2. Agile Operations & Service Delivery

Optimal allocation of finite network capacity will remain a central challenge. Whilst new infrastructure will inevitably be required, railway organisations, enabled by digital, will be able to get more out of their existing assets.

Continued rollout of **Communication Based Train Control,** utilising wireless communication and sensors, will increase the precision of train locations, increasing the allowable number of trains on the track. This will increase the capacity of existing below rail infrastructure, typically constrained by non-modular design, whilst improving frequency of services and aiding on-time performance. Hybrid rollingstock with **regenerative braking** will reduce power consumption and improve the efficiency and environmental performance of rail.

Predictive analytics and **AI,** leveraging real-time network and operational data, will dynamically support complex routing decisions to optimise transport planning, schedules and rolling stock utilisation. Dynamic adjustment of the transport value proposition would also be possible. For example, if an incident has occurred on a key arterial road, an alert for discounted rail travel can be sent direct to mobile devices to encourage mass transport use.

Similarly, enhanced **data analytics** will utilise the increasing richness of digital ticketing data to provide clarity around usage, peak demand and after peak tapering to inform infrastructure and service schedule decisions.

EXAMPLE AGILE OPERATIONS USE CASE

Start

Stage 1: Asset Management

Rail assets are monitored using an asset management system. Asset maintenance is scheduled using the predictive maintenance algorithm to ensure maximum availability and minimal cost.


Asset management


Predictive maintenance

Stage 2: Planning the Schedule

Past demand and predicitive analytics, using mulit-modal data, estimates demand on each lines. Available rolling stock is allocated to maximise utilisation.


Integrated networking planning & optimization


Predictive operations

Stage 3: Arrive at Station

The rail vehicle arrives at station. Sensors have alerted passengers of least congested compartments. Real time information is provided to workers and passengers on any potential delays or issues.


In-built sensors


Interactive / intermodal scheduling

Stage 4: In Transit

The train is in constant communication with trains on the track, altering its speed to maintain safety and timing. Automated intrusion detection aids identification of persons on the tracks.


Communication Based Train Control


Driver assistance & collison avoidance

Stage 5: Arriving at Destination

As conditions change, operations are dynamically managed and re-routed. An incident ahead has halted services. Replacement bus services are organised and customers alerted.


Weather and rerouting & predictive operations


Real-time traffic management

The rail car arrives at its destination. The operator is informed of its next transit. Carriages are removed as demand is expected to be lower.


Predictive operations

End

[7] Tfl Wifi data connectivity pilot Customer Experience Analytics Operational Research

Automated and rapid incident response, enabled through hybrid **drones** and human channels, will improve response times and reduce network delays, whilst the widespread emergence of **driverless trains** (already observed globally, in the mining industry and introduced to Sydney in 2019), monitored and managed through central centres, will reduce human error improving safety and increasing efficiency.

The abundance of data will also allow for more disciplined continuous improvement practices across all elements of operations.

3. Scalable Infrastructure & Predictive Maintenance

While existing infrastructure remains a major constraint to system capacity, future infrastructure will be **modular** and **scalable.** Automatic Train Protection (ATP) and Automatic Train Operation (ATO) systems will be standard, with modernised signalling systems supporting an uplift in network capacity through reduced headways (increased frequencies).

Maintenance practices will evolve to ensure the network is on line as often as possible. **Predictive maintenance,** using data from interconnected **IoT sensors,** will enable improved asset reliability and reduce maintenance costs (as illustrated in Figure 3). Predictive maintenance utilises algorithms coupled with operational and sensor data to predict likely failure, providing an optimal maintenance window that takes into account demand and availability of other assets. Evidence suggests overall maintenance cost can be reduced by up to 30% and breakdowns by almost 70%[8]

[8] World Economic Forum, Industrial Internet of Things: Unleashing the Potential of Connected Products and Services http://reports.weforum.org/industrial-internet-of-things/

EXAMPLE CASE STUDY

Robotic Survey

A 1km section of track requires immediate inspection by rail workers. The inspection presents dangers to the workers and to ensure their safety, 3 other parallel rail tracks are closed. With 4 tracks closed, the ability to deliver services to commuters is affected.

With the development of robotic technology, a robot has been designed to run along a rail track and survey the infrastructure.

The survey robot:

- Eliminates a dangerous situation by removing the need for workers on the track
- Improves asset availability. As there is no human exposure, only a single track (or possibly no tracks if done between services) is required to be closed during the survey
- Improves response time as the robot can be deployed at any time during the day or night

This technology – Mechanised Track Patrol – has been deployed in NSW as a dedicated vehicle, but will become increasingly smaller scale and will likely be fitted on passenger vehicles in next generation rollingstock.

Source: Strategy& analysis

Automated Intrusion Detection, facilitated by railside sensors and cameras, provides real time monitoring of tracks. This increases safety through automatic identification of objects or persons and acts as a deterrent to reduce asset damage and vandalism, lowering rectification costs.

3d printing technology will also facilitate reduced inventory holdings and improved part longevity. Items and parts will simply be "printed" on-site when required, reducing the need for large orders from centralised, mass-producing manufacturers. General Electric has already demonstrated this benefit in the transport industry, with some 3D printed parts lasting up to 5 times longer, and can be manufactured for 60% lower cost.

4. Capable, Flexible & Enabled Workforce

People and the surrounding organisation will need to **adapt to new ways of working** brought on by the onset of digital systems and technology.

Digital systems will turbocharge **labour productivity** within the rail industry as automation, AI and **predictive analytics** dramatically increase the output per employee. Consequently, this will impact the composition of the workforce, with transactional, manual roles expected to decrease while knowledge based and customer facing roles may increase.

New **digital skill sets** and **technical literacy** will be required to manage technology interfaces. Adaptable and **agile** ways of working, along with more **mobile** and **flexible** workforces, will enable more dynamic operations, facilitated by predictive analytics.

Opportunities to improve identification of training and development needs will be facilitated by **IoT** sensors. Sensors, installed on-board, will be able to recognize improper driving techniques and allow for personalisation of driver training.

Digital tools will also be utilised to improve the efficiency and effectiveness of back-office functions. Improved management of complex IR awards through digital tracking will improve payroll integrity and ensure each employee gets the correct allowances. **Data analytic backed algorithms** will be able to optimise employee rosters and forecast likely absenteeism, allowing reduced stand-by labour and lowering costs. More abundant, real time data, combined with powerful analytics tools, will help increase the efficiency and accuracy of management decision making.

[9] https://www.ge.com/reports/epiphany-disruption-ge-additive-chief-explains-3d-printing-will-upend-manufacturing/

5. Commercial & Entrepreneurial

To prosper, railway organisations will need to become more **commercial** and **entrepreneurial.** Railway organisations will begin to **monetise** customer data, and make better use of the fact they have access to large "captive" audiences for significant periods of the day. On station and on board space will be better utilised, **targeted** marketing will be pursued through a multitude of channels.

Their land based assets will also be put to better use (e.g. using large land bases to facilitate telecommunications need for distributed small cell sites when rolling out 5g) while digital twins of the asset base will enable more detailed examination of potential property development opportunities. Advances in material development (e.g. carbon fibre) will potentially enable decking of previously uneconomic land for residential and commercial property development.

The air space above existing rail corridors – which are typically already equipped with sophisticated communications equipment – may also be appropriate for UAV flight navigation which existing control centres could facilitate.

Demonstrating the scope for **innovative commercialisation,** Paris Metro recently worked with Ikea to place a selection of sofas at stations, allowing passengers to try and buy whilst in transit. The potential opportunities are limitless.

THE RAIL NETWORK ADVERTISING OPPORTUNITY

12 minutes is the amount of time the average traveller on public transport spends waiting per trip

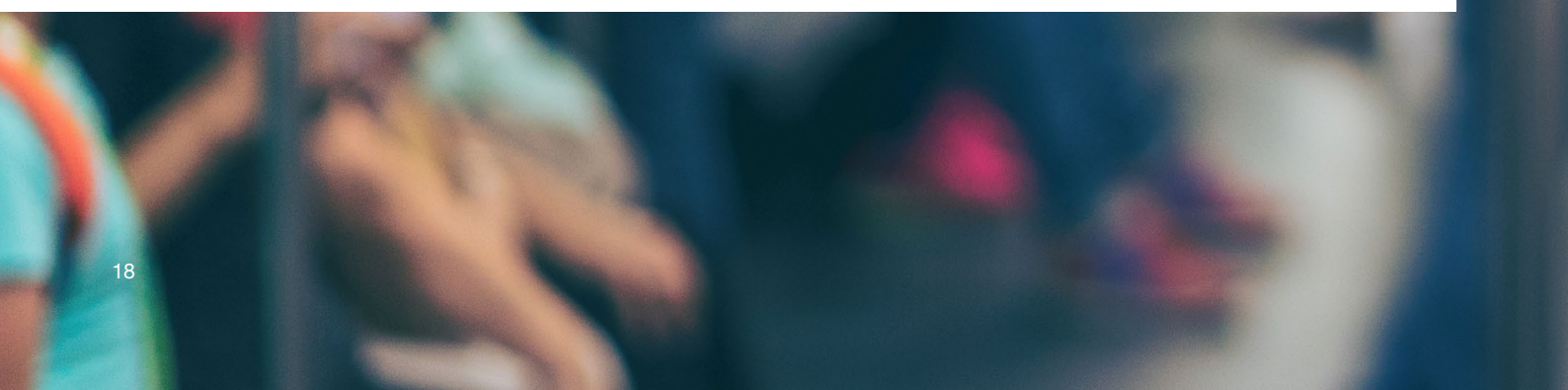
70% of CBD workers notice advertising on public transport – typically a difficult audience for advertisers to reach

69% of commuters claim they pay more attention to advertising in the rail environment than elsewhere

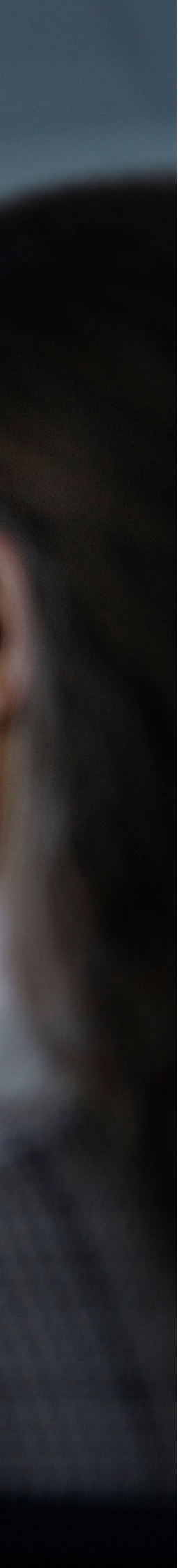
Source: APN Outdoor, Roy Morgan

Who are the biggest beneficiaries?

The best thing about the digital revolution is that all stakeholders have much to gain. The customer gets a more personalised and modern travel experience, the frontline workforce get access to modern 'tools of the trade', management get access to more and better quality data to inform decision making and government get improved cost recovery that doesn't come at the expense of the customer satisfaction.



Ensuring a successful transition



The opportunities presented by digital technology will significantly shape the future of rail. However, the introduction of technology alone will not ensure the digital railway of the future will fulfil the potential and promise of today. Our experience suggests railway executives need to focus on six key factors to ensure they appropriately position their organisations for success in the digital future:

1. **Align on the railway's digital vision:** railway organisations must provide stakeholders, employees and customers with clarity around their digital aspirations. By providing a clear vision, the organisation can excite the customer base and ensure employees have an appreciation of the benefits and nature of the inevitable change journey about to be embarked upon.

2. **Have a clear roadmap (and the funding) to get there:** technology will require significant investment. Having provided clarity around the digital aspiration, it will be important to boil the vision down into manageable chunks of key investment, against which business cases can be built and decisions can be taken. This is particularly important in the capital constrained environment within which railways typically operate. Ensuring clear, viable business cases, linked to an overall vision that has been already been endorsed by key stakeholders will maximise the chances of being afforded the capital required to bring the vision to life.

3. **Build cohesive, aligned capabilities:** ensuring sustainable and successful change will require organisational capabilities and digital tools that are fit for purpose. In this instance, digital and commercial capabilities in particular rise to the fore. Capability cannot be built overnight. A clear plan is required to ensure capability build lines up with proposed investment plans and rollouts and lead times are appropriately managed. With digital tools, it is often a case of too many with little cohesion resulting in sub-scale capabilities that do not complement each other, or which have unclear use cases. The right roadmap, and a portfolio of cohesive capabilities is needed.

4. **Evolve your organisational culture:** significant effort was put into shifting the organisational culture towards customer centricity. This was a journey that spanned many years, and the shift towards digital, commerciality and innovation will be no different. Understand that this will be a journey, but an important one if you are to fully maximise the benefits realised from application of the digital technology at your disposal. For the digital railway, the technology itself will be a small part of the change. New ways of working, transformed skillsets and different behaviours will be required to fully capture the benefits of digitisation.

5. **Manage the industrial environment:** working jointly with the workforce and unions to embed and manage the change will be important to ensure its success. This includes being transparent around your digital ambition and maintaining open lines of communication between all parties. Development of a digital roadmap and establishment of a supporting change program will be important first steps.

6. **Reorganise for success:** too often, while the right tools, technologies and intent may exist, successful change fails to materialise because the organisational operating model is not setup in a way that provides the necessary enabling support. This is particularly critical to ensure sustained success of railway organisations into the future.

Concluding thoughts

The future for railway customers is filled with promise. The onus has always been on railway executives to deliver a proposition that balances the seemingly competing needs of customers with the need for a prudent efficiency and productivity focus in a constrained funding environment. The ‘Digital Railway’ may just be the solution

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