

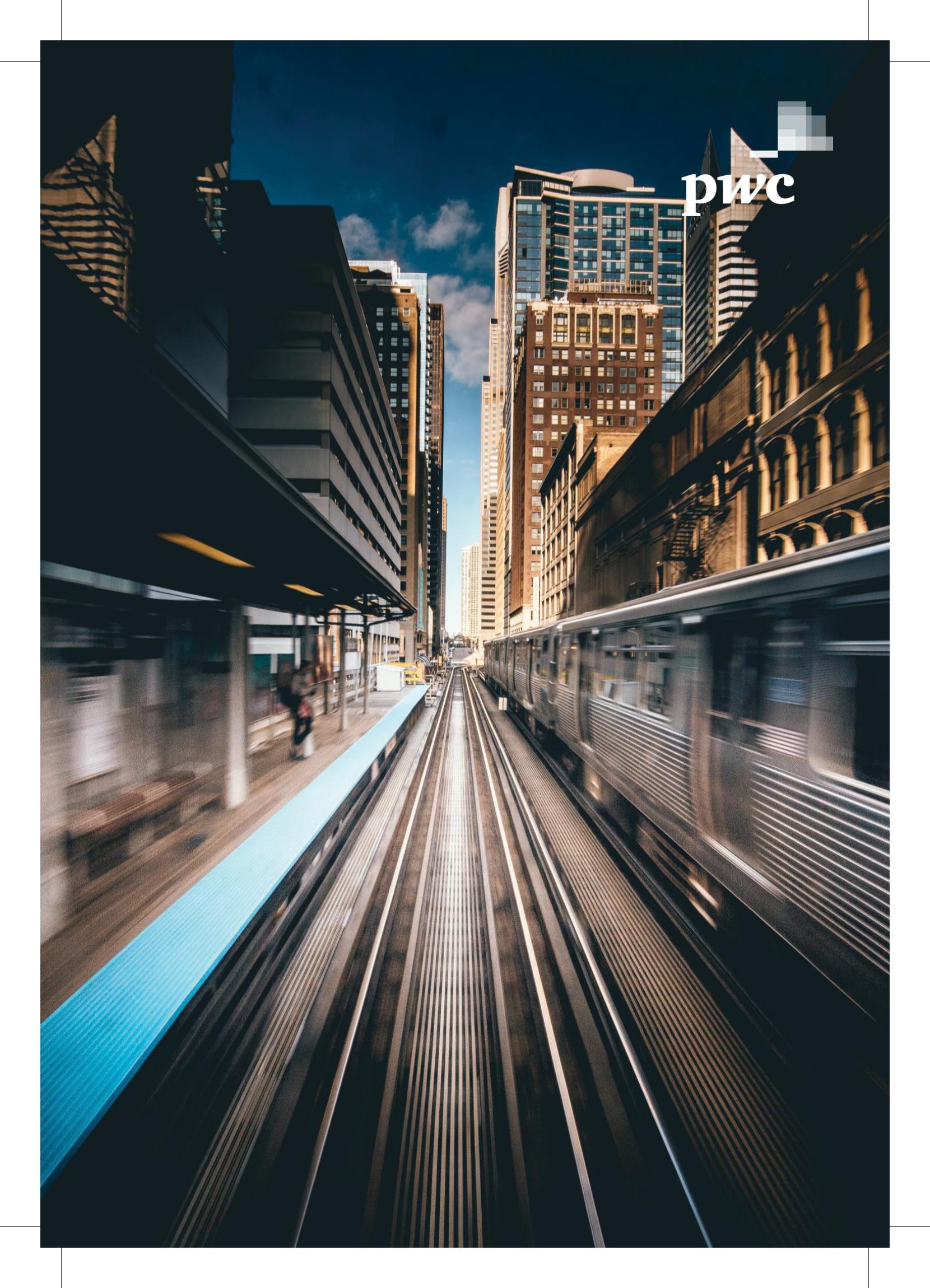


pwc



PwC

Innovation for railways



РИС

PwC does not shy away from the most complex issues affecting the industry.

We take a holistic approach, examining the root cause and full scope of any given set of challenges, and recommend sustainable, long-term solutions that can be adopted. This approach can help to save time, create greater efficiencies, and enable transportation and logistics companies to apply more strategic investments in support of profitable growth



Our global network of transportation and logistics specialists not only understands the challenges that air, rail, shipping and logistics companies face, we know the businesses with which these companies most frequently interact. This big-picture perspective provides us a unique vantage point that benefits our clients.

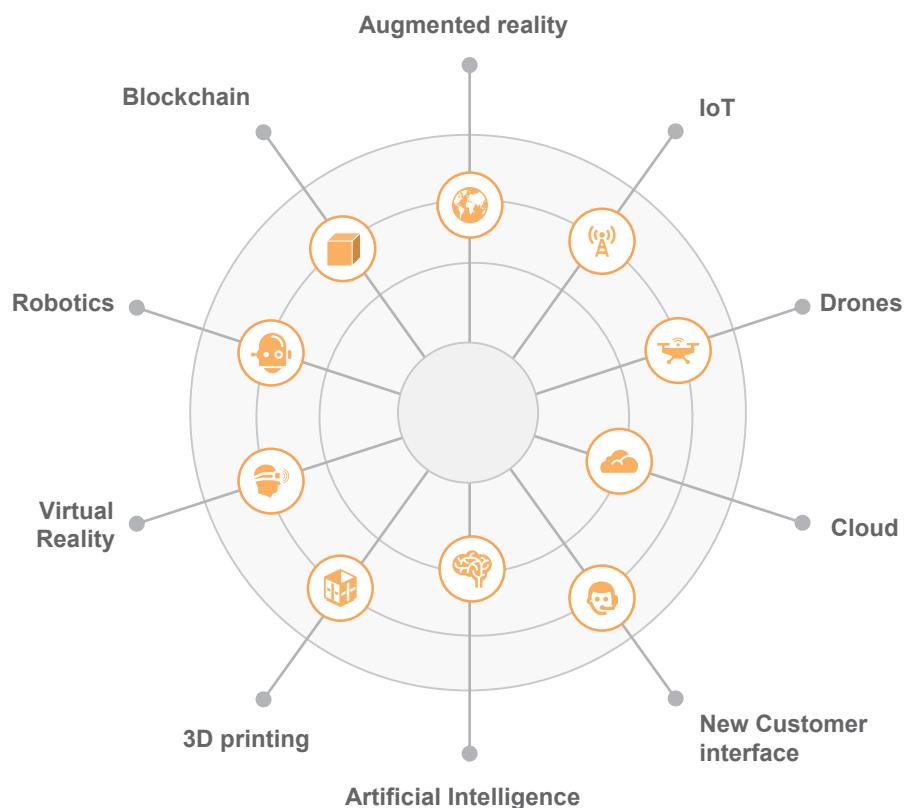
Our transportation and logistics team consists of over 5,800 experts

 Antony Cook Partner responsible for relations with: 	 Rainer Kroker Partner responsible for relations with: 	 Dr. Harald Dutzler Partner responsible for relations with: 	 Michał Mazur Partner responsible for relations with: 
 Paolo Guglielminetti Global Rail Leader responsible for: 	 Eric Bertier Partner responsible for relations with: 	 Mariano Cortés Redín Partner responsible for relations with: 	 Matthias Reyntjens Partner responsible for relations with: 
 Elizaveta Filipowa Partner responsible for relations with: 	 Olena Volkova Partner responsible for relations with: 	 Torsten Thieme Director responsible for relations with: 	 John F. Gibson Partner responsible for relations with: 
 Baiba Apine Partner responsible for relations with: 			

The future is digital. Let's **shape** that future. Together. Reimagine the possible.

New digital trends and emerging technologies are changing the way we engage with the world around us.

PwC brings an insight of intersection between business, experience, and technology in order to help enterprises to keep up with the constantly moving cycle of creation and adoption.



In our experience, digital leaders embrace six key principles to capture digital opportunities



1 Digital to serve business needs

Digital not for its own sake, but to build commercial engines

2 Anticipate the future

Design for 3 years out, build for today

3 Think end customer

Leveraging human centred design – putting the consumer benefit at the core

Key Principles to Capture Digital Opportunities



4 Agile

Produce a lot to learn a lot (i.e. divergence and convergence)

5 Transversal

Leverage digital across functional boundaries

6 Open

Leverage best solutions from third parties

Emerging technologies have a potential to redefine the railway industry.

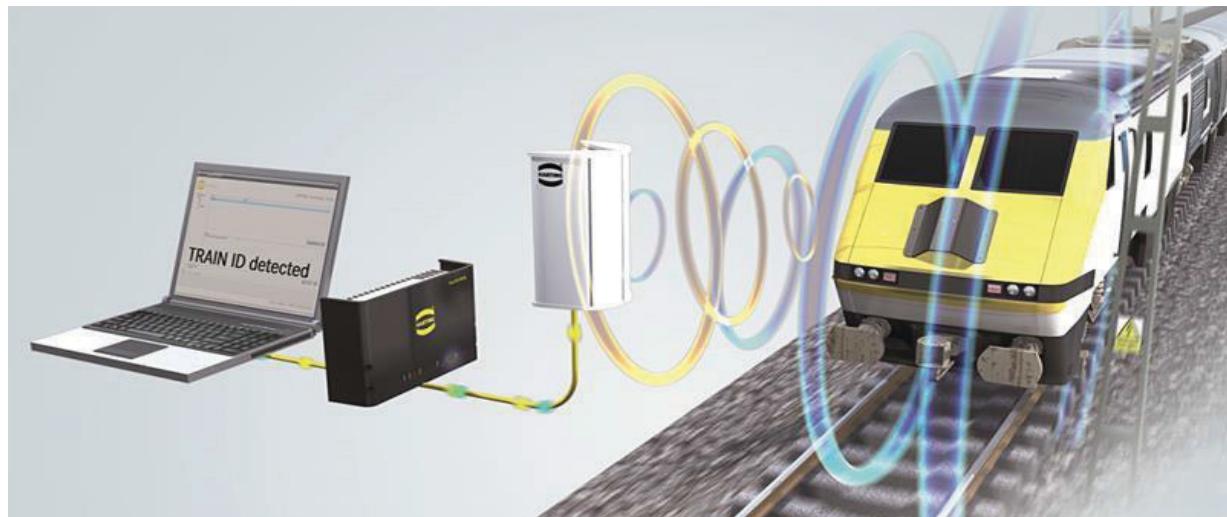
	Predictive Maintenance	Predictive maintenance (PM) is an MRO strategy that uses sensors and data to predict maintenance requirements before they occur, thus significantly decreasing stoppage times and costs. The efficiency gains from PM are expected to be between 15% and 25% for rail operators.
	Smart ticketing	Smart ticketing is the use of contactless debit/credit cards instead of traditional paper tickets. In London, the leading city for the use of smart ticketing, only 56% of all passengers use a dedicated smart card as of 2017.
	Drones	Aerial data acquisition conducted by specialized drones equipped with sensors followed by data processing and analytics by PwC Drone Powered Solutions Centre can decrease capital projects costs by up to 12% and maintenance costs by 17% .
	Customer experience	AI and facial recognition can revolutionize the rail industry. Already operating in China's Wuhan Railway Station, the facial recognition device identifies passengers before boarding a train and has a potential to end railway ticket barriers and rush-hour queues.
	The internet of trains	Spanish train operator RENFE uses a Siemens IoT system that allows 300 sensors of train components to continuously communicate. This has helped services become incredibly reliable – only one of 2,300 journeys has been noticeably delayed (by 5 minutes or more).
	Big Data	Big-data is the new frontier for collecting and analysing data and for turning it into usable information. A Swedish train operator developed a predictive algorithm from big data allowing to forecast delays. Traffic controllers can be alerted to possible delays, 2 hours before they occur.
	Simulations	Digital Twin technology allows railway manufacturers and operators to maintain an exact digital copy of their rolling stock on computers. Simulations carried out with these twins can indicate how equipment may act in certain scenarios. GE is implementing it in nearly all their products
	Creative disruptions	The current trend in disrupting innovations is an ability to leverage spare capacity, monetize it and then expand quickly without large investment. Digital lies at the forefront of disruptions in railway.
	Automation	GPS, LIDAR technology, AI (alternative intelligence) and Big Data will work together to automate rail traffic and increase safety and reliability. In Kuala Lumpur, Dubai, Tokyo and Copenhagen, fully automated metros have been running for several years, Others will follow as the scope and reach of automation increases.

Predictive maintenance and remote diagnostics....

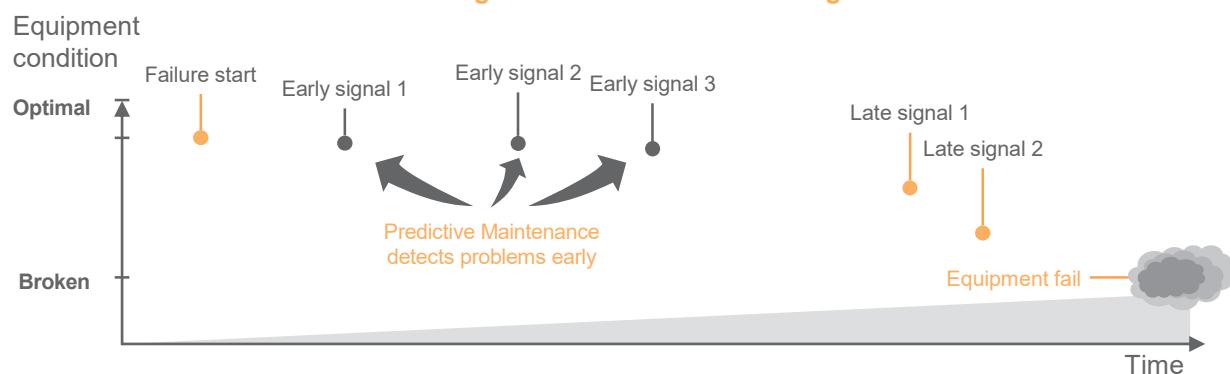
Predictive Maintenance is not only about collecting data (telemetry) but also about linking them to other events such as disruption in operation or repair activities so that you predict the delay or the required repair actions.

Our statistical analyses show:

- Some trains are more sensitive to failures than others.
- Interactions between different diagnostics are important, one-dimensional monitoring of the systems yields an inferior predictor;
- Trains that are riding in combination with other trains have a higher likelihood of failing



Predicting Maintenance is a balancing act



Predicting Maintenance involves minimization of a false conclusion:

- False positive: Predict train failure where it won't fail
- False negative: Predict no train failure where it will fail

Our client solution

- The specific model **correctly predicts 40%** of the trains that will break down
- The model is able to **predict at least 30 minutes up front** whether a train will fail or not

... is a matter of data. Our solutions are proved in different industries and ready for railways.

How can we derive value out of a predictive maintenance solution?

THE CHALLENGE TODAY

Existing maintenance tools lack the capabilities to predict maintenance-related delays, resulting in high operational costs due to delays or cancellations

THE IMPACT OF ANALYTICS

PwC designed an analytical approach, which filters and prepares data to assess values gained from model development, and develops and calibrates system-specific event models for predicting delays

THE BOTTOM LINE

Potential cost savings from avoided delays or cancellations directly improve the financial bottom line

Our Approach

- 1 Collect client data covering a range of performance-relevant metrics in three key dimensions: cost, service, and risk
- 2 Apply filter to shortlist messages and logs data and prepare key insights to present
- 3 Leverage proprietary approach to create scores on a scale across metrics and dimensions; create intuitive, interactive visuals to enhance understanding
- 4 Incorporate model outputs into field test tool, which can alert clients to dispatch maintenance tasks according to outputs

An aircraft operator seeks to utilize large volumes of data collected to predict maintenance needs and **avoid delay or cancellation, ultimately reducing operational costs**



The Predictive Maintenance App accelerated the selection of key data, sifting out huge volume of irrelevant data that would interfere with predictive model development

Based on shortlisted data, PwC can develop predictive models, yielding a potential net benefit of general field test



How can maintenance problems be predicted earlier to reduce costs?

THE CHALLENGE TODAY

Increased regulatory pressure, customer expectations and potential high costs are pressuring companies to lessen maintenance issues. Current sources for understanding maintenance often go under utilized and are not integrated

THE IMPACT OF ANALYTICS

Predictive Maintenance uses diagnostic, warranty, survey, federal and social data sources with advanced analytics to detect and predict which parts, or combination of parts, are potential issue points

THE BOTTOM LINE

Cost savings from avoiding major repair, recall or warranty work directly improves the bottom line

Our Approach

- 1 Gather, prepare, and refine client data for statistical workflow
- 2 Confirm data source consolidation results and ability to fit into the model
- 3 Refine thresholds limits for model results
- 4 Perform client-determined action on parts that reach thresholds

An auto manufacturer wants to **detect potential part issues earlier to avoid large scale costs or impact to the brand image**



The Predictive Maintenance App shows a sedan has two engine parts often appearing in warranty work, as well as social frustration for the engine in general



Pre-emptively fixing the parts during routine maintenance in the first year of purchase saves the auto manufacturer millions by avoiding a future engine replacement recall



The medium of ticketing is about to change, but many questions need to be addressed

Smart ticketing is an alternative to the traditional paper or cardboard ticket. Smart ticketing has the potential to make it quicker and simpler to buy and use tickets. However, our research highlights that it is not enough for a significant behavioural change without other incentives. This is important because it is only when a significant proportion of passengers have switched that the full benefits of smart ticketing really kick in. So smart ticketing will most likely need to be linked to offering passengers material benefit.



Key considerations

Do we need to design for multiple ticketing solutions to cater for changing consumer preferences – ranging from traditional forms of cash payment to mobile or contactless bank cards?

What are the cost implications and how can investments be effectively managed to maximize return?

How can we take advantage of smart ticketing as a platform for new marketing campaigns and pricing models to attract new customers and drive demand?

How should any smart ticketing offering link to other types of services provided to consumers?

Conclusions

- Convenience is paramount
- Better information can encourage modal shift
- The appetite for smart ticketing is growing
- Price is a key driver for passengers to change to smart
- Fare commitments provide a compelling case to switch to smart
- Additional products and services on transport services and in stations can improve the attraction of public transport

The adoption of smart ticketing might provide far-reaching solutions to tough problems

How can information obtained through smart ticketing be monetized?

THE CHALLENGE TODAY

Due to dynamic nature of today's transport networks, obtaining appropriate data is key to ensuring the provision of the best service

THE BENEFIT OF SMART TICKETING

Smart ticketing can give operators an insight into their passengers' travel patterns. This information can be used in order to better cope with demand, such as adopting new price mechanisms

THE BOTTOM LINE

Smart ticketing can facilitate the collection of big data and help enterprises to tailor their services appropriately

Our Approach

1
Breakdown of an operator's customer base and identification of major customer segments

2
Identification of customers' behaviour patterns and formulation of most effective methods to incentivize the adoption of smart ticketing

3
Formulation of recommendations for customer incentivisation and procedures for price optimization according to data obtained

A railway services operator is struggling to cope with demand at peak time for a number of its routes and requires more data on its passengers' behaviour to properly manage its pricing



PwC analyses key passenger's segments and identifies the most appropriate ways of incentivisation to switch to smart ticketing

When a significant proportion of passengers have switched, the operator is able to utilize acquired information to design shoulder pricing where there is a mid-price between peak and off-peak travel periods to better cope with demand



How can we cope with demand on transport networks through the use of smart ticketing?

THE CHALLENGE TODAY

With a growing population and economy, demand on the transport networks is continuing to rise. The challenge for governments is to ensure that transport is crucial for this continued growth

THE BENEFIT OF SMART TICKETING

The convenience of smart ticketing has a potential to boost the usage of public transport and thus to reduce the stress on local, regional and national infrastructure networks

THE BOTTOM LINE

Increased public transport usage, reduced road traffic congestion and boosted economic activity due to improved connectivity to places of work

Our Approach

1
Market segmentation analysis is performed to identify key customer segments and quantify the size of the segments

2
A market impact assessment is undertaken to establish the barriers to use of smart ticketing for various segments

3
A set of strategic recommendations is developed to bridge the gaps in the baseline ETS channel strategy

A city council wants to accelerate the adoption of smart ticketing in order to potentially increase the usage of public transport and reduce traffic congestion

Convenience of acquiring and reloading smartcards are key to enabling the switch to smart ticketing. PwC identifies the density of the reseller network and makes recommendations to bridge the gaps in displacement to key market segments



The switch to smart ticketing encourages customers to utilize public transport more, thus enabling the council to achieve its targets for congestion and emission reductions targets



Smart ticketing is a solution for numerous stakeholders



Transport operations

For public transport operators, the immediate advantage in moving to smart is in the potential to reduce costs. Fewer ticket printing machines and fewer mechanical breakdowns of ticket readers, for example. Later, savings will also come from completely eliminating some of the older style ticket formats. Big benefits also come from the insight that smart ticketing can give operators into their passengers' travel patterns. Smart ticketing facilitates the adoption of new pricing mechanisms, such as shoulder pricing where there is a mid-price between peak and off-peak travel periods to better cope with demand



Network operations

For network operators there are benefit too. Changes to smart ticketing radically change the facilities required at stations and at travel centers. As a consequence, some of the space currently used for ticketing could be freed up for increased retail or other purposes.



Mobile phone operators

Mobile network or device operators have an opportunity with smart ticketing to provide additional services to their customers, thereby making the smart phone or other device more intertwined with their travel. This should lead to increased sales of product or related services. Part of the offer from a mobile network or device operator could be improved provision of travel information, including real time, advice on journey planning options, tailored offers, and provision of targeted advertising



Card service providers

The introduction of contactless bank cards into transport smart ticketing brings bank card issuers more directly into this market. They already provide the payment means behind many conventional ticket and smart card product purchases. But the new model, being promoted by Transport for London in particular, brings them closer to the individual transaction. There is an incentive for their involvement in smart ticketing to increase their transaction fees. More significantly, using a contactless bank card as a form of smart ticket provides a potential catalyst for increased take-up of contactless card use in other sectors



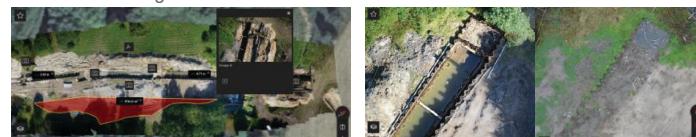
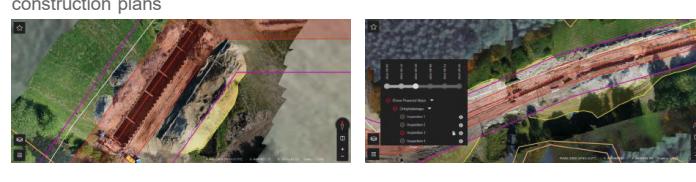
Government

Smart ticketing is not just about the benefits for individual passengers and the savings for operators. From a government perspective, efficiencies can translate into reduced subsidies or grants for rail or bus operations. But the bigger benefit is in the increase in use of public transport, which reduces road traffic congestion and by improving the connectivity of people to place of work and boosts economic activity.

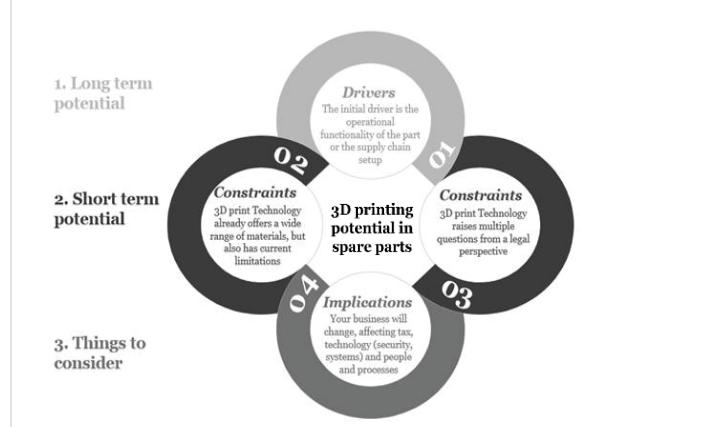
Getting SMART is not technology implementation only, it is about a better way of living together!

We make clever use of emerging technologies to help our clients achieve their goals

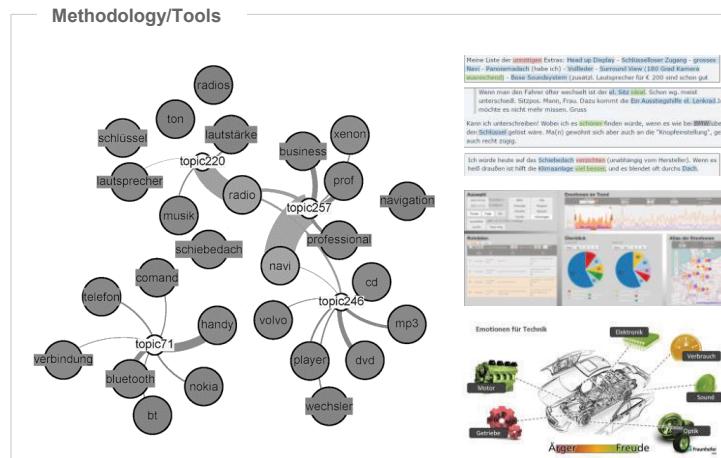
Our Drone Solutions improve reliability of construction surveillance and allow for a systematic collection of information

	Client needs	Methodology/Tools
	<ul style="list-style-type: none"> Plans to build ~2000 km of linear infrastructure throughout the country Over 60 separate construction sites spread all over the country Financing institutions expect reliable progress reporting monitoring process 	<p>Images, 3D models and reports available to the client through web browser</p> 
	PwC Approach	Construction progress monitoring
	<ul style="list-style-type: none"> Replacing in-person surveillance with drone supported end-to-end investment Weekly investment sites HD images capture from drones 	
	Value Delivered	Verification of conformity with construction plans
	<ul style="list-style-type: none"> Full view of the construction site and real time progress monitoring Systematic information about number of working employees, machinery and used materials 	

We help to integrate 3D printing in spare part supply chains in order to drastically reduce operational costs

	Client needs	Methodology/Tools
	<ul style="list-style-type: none"> Our client has a portfolio of >46.000 sku's to keep the manufacturing site operational As the long term volumes on the machines will be reduced, obsolete costs need to be managed properly 	<p>1. Long term potential</p> 
	PwC Approach	2. Short term potential
	<ul style="list-style-type: none"> Investigate the business potential of 3D printing in the overall spare part supply chain 	<p>02 Constraints 3D print Technology already offers a wide range of materials, but also has current limitations</p>
	Value Delivered	3. Things to consider
	<ul style="list-style-type: none"> Long-term potential: We identified 9% of the total spare part portfolio to have beneficial characteristics to consider 3D printing, representing 18% of inventory value Short-term potential: For the selected parts, we were able to reduce yearly OPEX costs by 30%, as a result of 3D printing (improved design – SC benefits) 	<p>01 Drivers The initial driver is the operational functionality of the part or the supply chain setup</p> <p>03 Implications Your business will change, affecting tax, technology (security, systems) and people and processes</p>

Our analytical approach to social media helps to identify systematic failures and prevent brand damage

	Client needs	Methodology/Tools
	<ul style="list-style-type: none"> Systematic failures can only be identified after a critical number of consumers have reported a similar issue in a service shop. Consumer complaints on social media bear the risk of evolving viral which impacts the company's brand. 	
	PwC Approach	
	<ul style="list-style-type: none"> Automated monitoring of social media platforms to extract relevant posts using APIs and web crawlers Sentiment analysis to understand consumer's opinion and feelings Visualizations for share of voice, trending topics, top influencers, geographic, drill-down in to actual posts. 	
	Value Delivered	
	<ul style="list-style-type: none"> Systematic errors can be identified earlier Customer complaints can be monitored in near real time at lower cost Alert system can be connected to workflows for quickly reacting to errors and complaints 	

PwC has substantial experience in integrating digital technologies for railway industry operators

We support Railways in the digitization of the customer experience extended to multimodal travelling



Client needs

- Providing integrated mobility services to existing and potential customer
- Improved customer experience



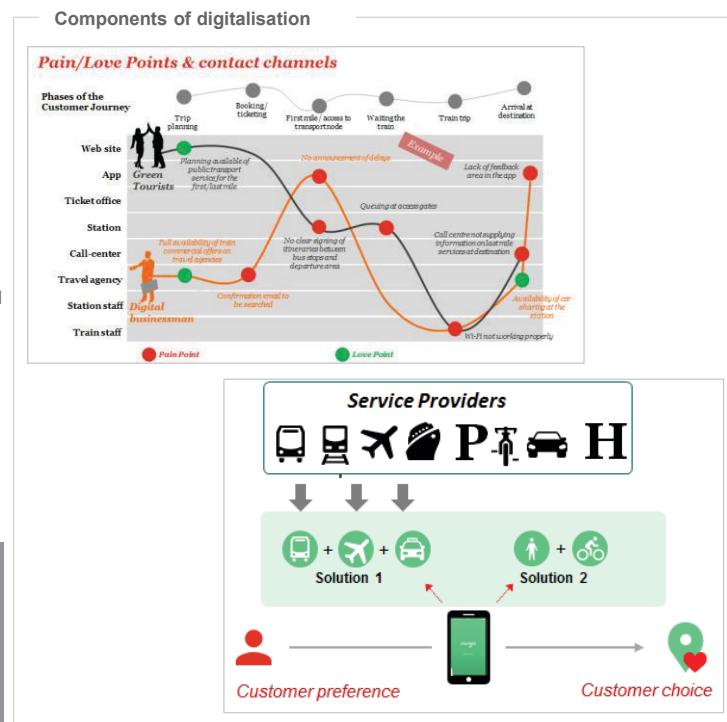
PwC Approach

- Detailed analysis of the pain & love points along the customer journey on high speed train services
- Identification of key actions to improve the customer experience
- Business Intelligence on customer behavior and preferences focused on the Trenitalia Loyalty scheme members, & support to launch and monitor commercial campaigns (precision marketing)
- Development of consistent business and operating models to support the new multimodal platform
- Estimate of the demand for the new multimodal platform and development of business case of the initiative
- Support to develop commercial agreements with other transport operators
- PMO for the new multimodal platform



Value Delivered

- Better passenger segmentation
- Revision of the loyalty scheme
- Additional revenue from precision marketing
- Development of the new multimodal planning & ticketing platform



We support rail infrastructure manager in automating rail timetabling and traffic management



Client needs

- Automatize the railway timetabling design and traffic management, under coherent network utilization strategy based on optimization techniques
- Allow timetable quality analysis through the new tool
- Integrate network and node / station utilization plans in the definition of the timetable



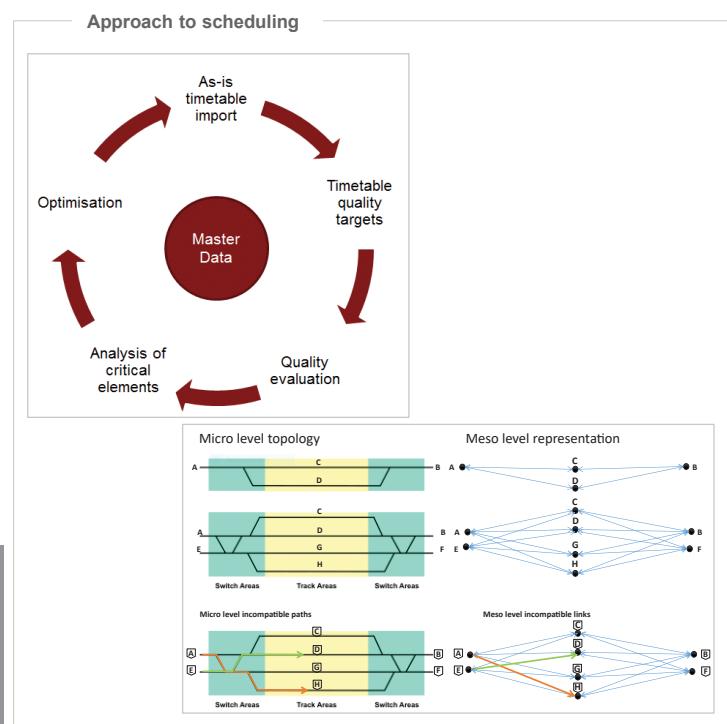
PwC Approach

- Support to the definition of the system's functional requirement
- Comparison through a Beauty Context of suppliers of optimized and integrated timetabling and traffic management solution
- Support for data gathering & pilot case
- PMO for the development of the project



Value Delivered

- Selection of the suitable solution provider
- Launch and completion of the pilot tool



PwC T&L team have extensive experience in the implementation of projects for railway companies

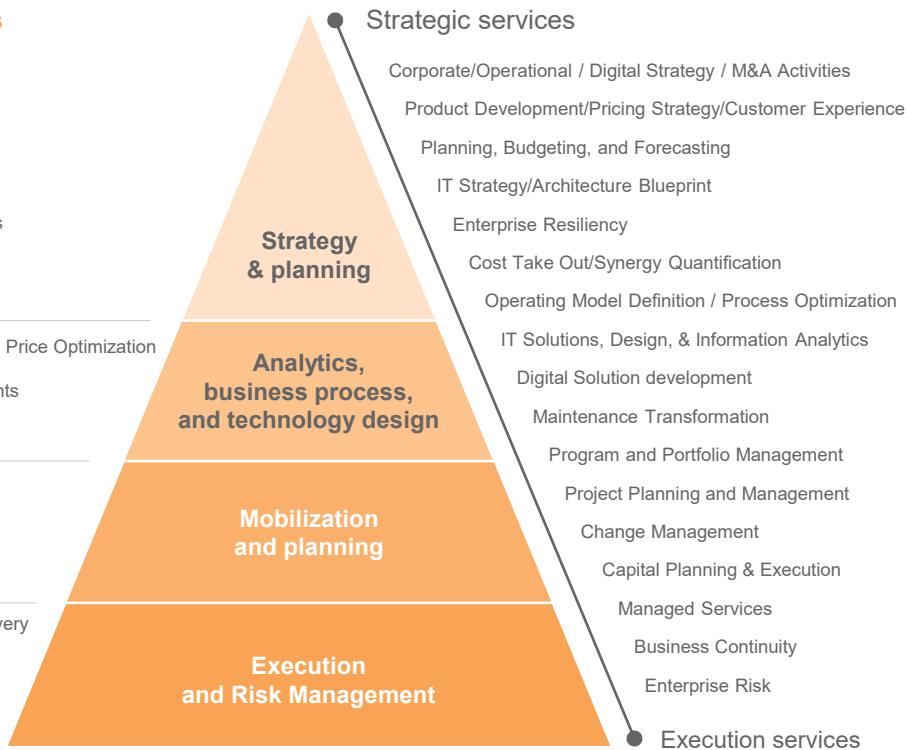
Sample T&L engagements

- M&A Strategies & Deal Structuring
- Procurement Transformation
- Category Management
- Network Optimization
- Operations & Maintenance Strategies
- Post Merge Integration
- Mobile Strategy
- Value chain transformation

- Pricing, Revenue Management, O&D Price Optimization
- Ancillary/Brand Impact Analysis
- Customer Analytics, Cost Assessments
- Preventive/Predictive Maintenance
- Multi-modal Alliances

- Service Design
- Yard Planning, PMI-PMO
- Mobile and IT Planning & Execution
- Operating Systems Integration

- E-commerce/Mobile Platform(s) Delivery
- Crew scheduling systems
- Locomotive Scheduling
- Locomotive Maintenance Optimization
- Safety Systems Management



Selected PwC clients from the Transport and Logistic sector



PKN ORLEN



ArcelorMittal

ČESKÉ DRÁHY, a.s.

LCR

Russian Railways

transpennine express

Raben
your partner
in logistics



DB BAHN



DB SCHENKER

CSCARGO

UIC
INTERNATIONAL UNION
OF RAILWAYS



PKP LINIE KOLEJOWE

PKP ENERGETYKA



Rail Baltica
Linking nations, people places

AEROFLOT

LHS
PKP Linia Hutnicza Szektorowa sp. z o.o.

LOT
AUSTRIAN AIRLINES

Rīgas satiksme
Latvijas Dzelzceļš



NetworkRail

TP Ferro

Docklands
Light Railway

OBB

LDZ

EESTI Raudtee
PIDEVUS, TULEVUS

SBB CFF FFS

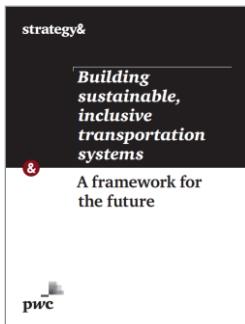
CTL LOGISTICS

INTERNATIONAL AIRPORT
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Follow us in order to keep up with emerging industry trends



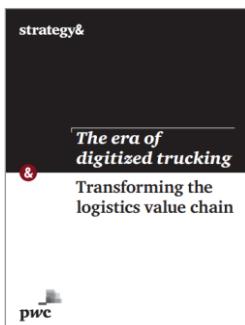
Building sustainable, inclusive transportation Systems

A framework for the future



2017 Commercial Transportation Trends

Incumbents must adapt to keep up with their customers



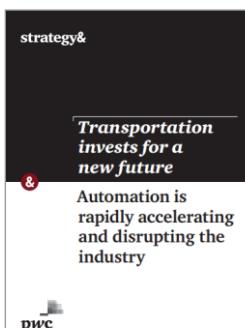
The era of digitized trucking

Transforming the logistics value chain



Investing in transportation

The role of Value for Money analysis



Transportation invests for a new future

Automation is rapidly accelerating and disrupting the industry



Clarity from above: transport infrastructure

The commercial applications of drone technology in the road and rail sectors

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