Deloitte.

Transport in the Digital Age
Disruptive Trends for Smart Mobility

March 2015

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Foreword

Change has already arrived in transport. The current wave of digital innovation, which has brought us travel planning on our smartphones and far greater access to customer information, was predicted in our 2012 Deloitte University Press publication and the pace of change is accelerating.

In the last three years digital disruption has become more widespread and companies like Uber have grown to become multi-billion dollar global enterprises. It is now timely to update our research and to examine the trends that we believe will be relevant to the future of the metro, rail, road, air and automotive industries.

Smart mobility strives to integrate all modes of transport to provide the vision of a seamless end to end journey experience. Technology has a major role to play as the transport sector now stands on the brink of great change, where digital innovation will go further to bring about improvements in operations, asset management and the delivery of capital programmes.

As the global population in urban areas reaches four billion, our current research seeks to stimulate debate about the future transport services passengers desire and how digital innovation can support this, and provide a framework for predicting the trends that will shape the transport industry. We hope you find this report interesting and informative.

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Executive summary

Change is coming to transportation, whether we're ready for it or not. You can see it in public sector investment in intelligent streets and digital railways, automakers' focus on next-generation vehicles and smart mobility services, and in the widening recognition that the "information everywhere" world will utterly disrupt the transportation status quo.

The proportion of the global population living in urban areas continues to rise faster than capacity on roads, rail and other types of transport. This pressure on transport infrastructure is driving capital investment estimated at over a trillion dollars a year. However, you can't always create capacity by pouring more concrete, and technology will play a crucial role in changing the way we travel.

The Digital Age has begun, and technology has brought us smart phones, real-time planning, open traffic data, and social customer service. For the first time, the passenger now has more information than the operator. This fundamental shift offers consumers real choice based on a picture of alternative routes, comparative pricing and current network status. As transport operators adapt and new entrants arrive, new business models will transform the use of user information, payments, integration and automation.

These changes will form five disruptive trends for transport and smart mobility services:

User-centred mobility services put travellers in control; public transport will become personal. This changes the approach to operations and planning based on users' choices, priorities, data flows and dynamic response to disruption. Staff will adopt 'digital uniforms', so that they have the information to support customers.

Integrated and intelligent transport networks will sense demand, measure performance, and monitor the health of physical assets. Intelligent systems will respond in real-time to manage capacity and predict and avoid disruption.

Pricing and payments will see a revolution over the next five years. Digitisation of tickets and payments will transform metro services and allow all rail operators to follow airlines by adopting e-tickets. Beyond contactless payments, pay as you travel will be based simply on location.

Automation and safety will benefit from the exponential potential of cognitive technology, with the potential to save millions of lives worldwide, particularly on the roads. Increases in safety and changes to the nature of liability will have a fundamental impact on the insurance industry.

Public and private innovation will work together to meet the mobility challenges of the 21st century. The role of the public sector will be critical to stimulate advances and protect citizens. New private sector entrants will take advantage of peer-to-peer models, digital and mobile technology, and low costs to scale globally.

Looking ahead, the scale and pace of these dramatic changes will vary. The digital age is going to empower the travelling customer and disrupt the way transport providers operate and manage their services. This will put emphasis on the need for varied transport systems to intelligently integrate and facilitate joined up passenger journeys. To achieve this, the public and private sectors – from government to automotive manufacturers – must innovate and think differently, working together to ensure the growth and sustainability of transport for the future.

Rising demand for transport

Demand for transport continues to grow year on year. Europeans, on average, travel around 35,000 passenger kilometres per year, whilst the typical person makes 923 trips or 2 ½ trips each day, with the vast majority of these trips being made by car (64%).[1] However things are changing, rapidly. Since 2002, the number of miles driven per person has fallen by a dramatic 8.5%. At the same time use of public transport has increased.

In 2012, the number of railway journeys made in the UK over the year reached a record 1.509 billion, surpassing, for the first time, the previous record for rail travel set in 1923; if current growth rates persist, then it is likely that we will see 2.5 billion passenger annual rail journeys recorded by 2025.[2] Moreover, the consumer group making this happen is not old. It is not nostalgic for the old days of steam, but young and intrepid. In 2013 17% of all bus tickets sold in Britain were bought by young persons (people in the 17-20 age group).[3] These trends are not just isolated to the UK but reflective of the trend across Europe. In fact, public transport across Europe is enjoying levels of popularity not seen since the 1950s.

The United Nations expects that by 2030, over 60% of the global population will live in urban areas, which "may result in declining automobile ownership as cities may take further actions to promote bicycle and public transport usage to deter usage of conventional automobiles".[4] Vehicles and parking have to be adapted for increasingly dense cities to compete with public transport. Either way, ready or not, the world is changing.

Europe is a hotbed for transport innovation in the public realm and much of the world's investment and existing infrastructure in high speed rail and metro systems can be found here. From buses and bicycles to London's Crossrail and the Manchester Metro, French TGVs to Polish Pendolinos, public transport is becoming an ever more important issue across the continent.

EUROPEANS, ON AVERAGE, TRAVEL AROUND

35,000

PASSENGER KILOMETRES PER YEAR

EVERY YEAR THE TYPICAL PERSON MAKES

923

TRIPS

IN 2012, THE NUMBER OF RAILWAY JOURNEYS MADE OVER THE YEAR REACHED A RECORD

1.509 billion

SURPASSING, FOR THE FIRST TIME, THE PREVIOUS RECORD FOR RAIL TRAVEL SET IN 1923

IN 2013

17%

OF ALL BUS TICKETS SOLD IN THE UNITED KINGDOM, WERE BOUGHT BY YOUNG PERSONS (PEOPLE IN THE 17-20 AGE GROUP).

Trends in digital age transport

Digital is coming

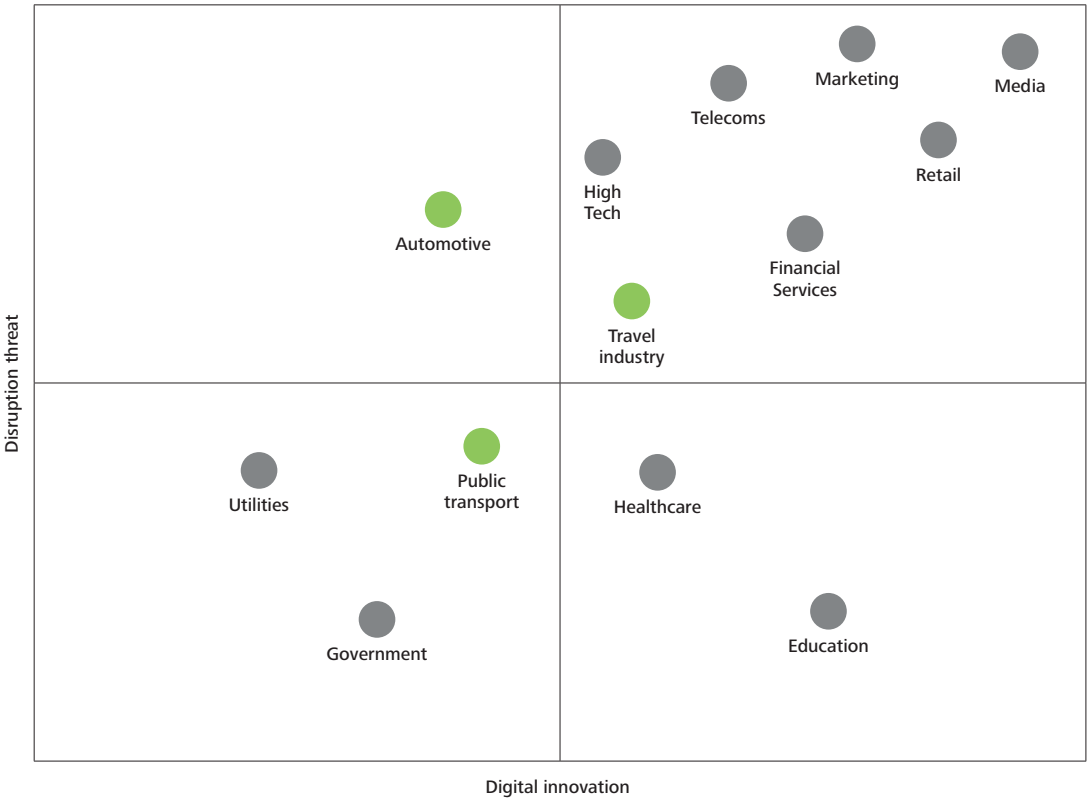
The influence of digital is changing the experience of consumers in all industries and setting expectations that will shape demand for transport services. In other industries, such as media, marketing and retail, technology changes have resulted in significant shifts and disruption to previously well-established businesses. For transport the speed of innovation and threats of disruption will vary. We can already see significant change in airlines, hotels and travel companies. The automotive and public transport sectors will feel the impact next.

Whilst public transport operators may not feel threatened, there is a compelling case to integrate services to empower travellers and give them greater choice.

The adoption of digital will also enable operators to deliver services more safely and efficiently, with intelligent networks and greater automation. Across rail and metro services, changes to ticketing and user information will transform the relationship with the customer.

The automotive industry is also gearing up for potentially dramatic shifts in the ownership and automation of personal vehicles. Connected car technologies have already arrived and the greater use of intelligent traffic management will bring together automotive manufacturers and those responsible for road networks to find new and innovative solutions for smart mobility in the urban environment.

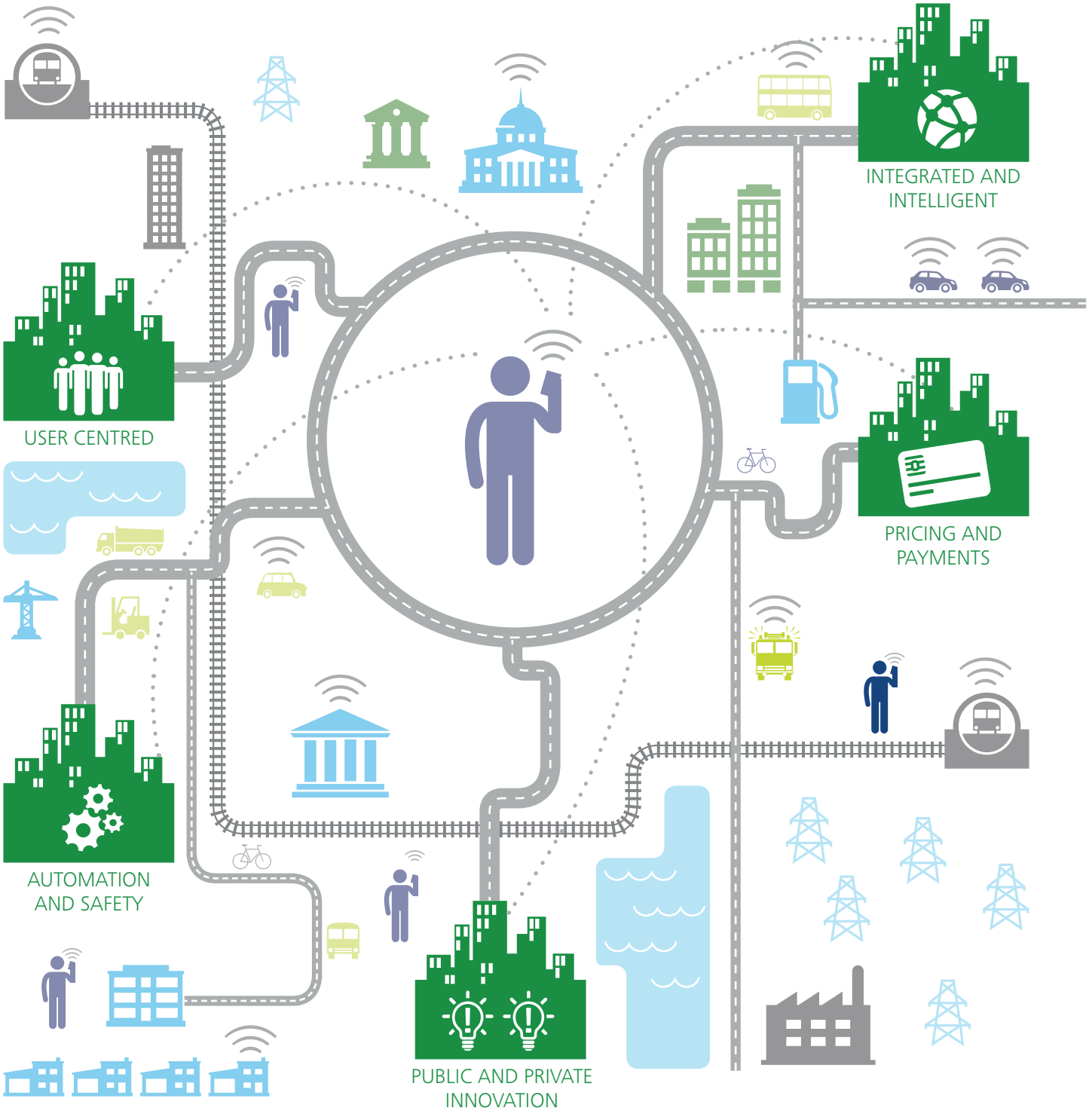
Transport faces increasing innovation and disruption



Enabling smart mobility

Form our research and discussion with clients, academics and the transport industry, we have identified five disruptive trends which we believe will provide the framework to enable smart mobility: user-centred, integrated and intelligent, pricing and payments, automation and safety, and public and private innovation.

Over the following pages these trends are described along with examples and predictions for how they will develop. Each of these five themes can be applied to road, rail, and air transport. The vision is to take advantage of these trends to foster seamless integration between different modes of transport in order to achieve smart mobility and improve the individual's travel experience.



User centred

Digital has changed passengers into people. Individual travellers now have access to information and transport services that put them in control. The digital age has brought the smartphone, giving access to more travel options and real-time status than the control rooms of any transport operator. This has shifted power to users, meaning the choices they make influence the services and business models offered by the market.

The economics of private travel will be disrupted by the choice offered by new business models. Ride-sharing and private mobility services enabled by digital technology are dramatically changing established business models and challenging long-established players. These low cost models, pioneered in the airline industry, simplify the user experience and cut out the middle man to reduce costs.

Public transport is getting personal. "Every journey matters"[5] to users who can dictate what they want from transport and who have increasingly high expectations of operators' reliability and customer service. Travel demand is dynamic and to meet the future challenges for urban mobility, transport operators must offer public services so easy to use that they are preferred to the private car.

Creating choice for passengers

Throughout the digital age people will become less dependent on cars; in fact, the number of young motorists has been decreasing throughout the 2000s. Constituents of Generation Y are more likely to use public transport than any other generation. This is because public transport has become smarter – it is more responsive to its customers than ever before – and mobility is becoming increasingly more user-centred. According to Buzzcar and Zipcar founder Robin Chase, 'The combination of the Internet, which holds the world's knowledge; wireless, which gives us ubiquitous and low-cost access to it; and smartphones that make our interfaces portable and cheap, has been transformational'. This is clearly visible in the taxi market, where smartphone users are now able to hail a cab in advance and secure a fare of their choice thanks to apps like Uber, whose motto is 'choice is a beautiful thing'.

The exponential growth of Uber has been based on a delightful, simple experience for users. This has been enabled by the disruptive forces of the sharing economy, matching passenger and driver locations, digital payments and low incremental costs to scale. In fact, "Uber's CEO says he hoped to take 400,000 cars off European roads this year while creating 50,000 new jobs."[6]

"We must have a wide range of options in transportation" says Chase, "because people go from being 0 years old to being 90; they have different amounts of money, different amounts of ability to move, different amounts of independence, income and social interaction." He goes on to point out that how you move a 2-year-old is not how you would move a 23-year-old, an adult with children, or a senior citizen. To answer transport issues we need to have a variety of possibilities.

An effective transport system offers users choice, adapting to meet demand rather than dictating routine. As Marcus Bowman, founder of 3G Mobility puts it, "We should not modify people's behaviour – the system should be able to accommodate the person. It needs to provide choices for the user."[7] However, others point out that one purpose of dynamic pricing is, in fact, to encourage users to modify their behaviour – to walk or take the train when streets are congested. In the digital age, it will be possible to reward people for making such a decision, enticing them to optimise their travel plans for time, cost and even fitness. According to Martin Tugwell at the UK Transport Catapult, 'the journey now begins well before the ticket is even bought.'

Future smart mobility systems will meet the needs of the disabled, the regular commuter travelling a fixed route, people running errands or rushing to be at last-minute meetings, and an ageing population.

> "My smartphone is my preferred mode of transportation."[8]
>
> **Rt. Hon. Patrick McLoughlin, UK Secretary of State for Transport**

The customer has more information than the operator

Making a dynamic, multi-modal transportation system possible requires a fundamental change in who controls information and how it is shared. Without comprehensive information at their fingertips – whether it involves public or private services – passengers cannot make the best choices for travel. To understand their choices and make quick decisions, users need access to freely shared, up-to-the-minute information.

Within cities, the 'open data' movement is pressing public transit agencies to make their data freely available in a widely used format so that developers can build route, schedule, and other applications on top of it. Success has been mixed, as City-Go-Round, a website that provides access to 'useful' transit apps, makes clear. The website states that as of 2014 only 247 out of 864 transit agencies in the United States had open data, whilst in Estonia none of 32 listed transport operators provided this service.[9] The goal is clear: transportation data needs to be provided in an open format, similar to the way in which London Underground transmits its data.

If you live in an urban area, here's where you want the system to end up: You have a mobile device, and it knows where you are because it is location aware. So you enter where you want to go and it gives you all your options, based on what's going on right now. It knows the best route, the existing traffic conditions and how much parking is available close by to your destination. Moreover, it knows how the trains and buses are running, where the closest bike sharing spots are and whether any bikes are available. Based on this information, your device can process the options and work out which is the best for you at the present time.

The digital age has made this a reality; a whole host of mobile apps like Citymapper are "making cities easier to use". Some, such as Google Maps, can even design routes on a national level. As Google Now is currently proving, the next step will be for our mobile devices to synchronize our calendars, remember our past trips, and understand our daily routines. It will then predictively alert us about the need to set off.

As people become increasingly familiar with real-time information in their hands, this places expectations on transport operators to deliver accurate and timely information in a consistent manner. When this breaks down or in times of disruption, users suffer missed connections and frustration. As transport blogger Craig Nelson experienced when he missed his flight because of an untimely update to the departure board at LAX, "it just underlines that with all the best data and technology in the world, there is always a human involved – and if that human isn't paying attention (both passenger and system provider) bad things happen."

Customer service and the digital uniform

Digitally enabling staff is often just as important as enabling passengers. It ensures that those on the front line of customer service always have the information they need and can respond as quickly as possible to queries from passengers.

In the future, digital uniforms will transform the way members of staff engage with their customers. Building on the traditional staff uniform, digital uniforms will take advantage of advances in mobile devices and wearables to equip staff to respond to passengers and issues as efficiently as possible. This will make staff better informed and more responsive to their customers and transport controllers.

British Airways, for example, deployed 2,000 iPads for its senior cabin crew in 2013 and built an inventory of internal apps to improve staff efficiency and passenger satisfaction on-board its flights. Airlines are even making use of tablets in the cockpit, allowing pilots to perform pre-flight checks in a way that then pushes the results out in real-time, reducing the need to file pre-flight paperwork.

Connecting transport employees has the potential to drive efficiency, whether that's by powering the best digital equipment for engineers, enabling staff to work more flexibly or making it easier for customer service agents to engage with passengers. Connectivity will, and in many cases already is, delivering relevant information right into the hands of those qualified to provide advice. This, in turn, ensures that staff should never be caught off guard, customers are never caught unaware and services can run more intelligently.

Integrated and intelligent

In a hyper-connected world, the exponential power of a network lies in the connections. For transport planners integration is key and making movements as easy as possible means linking transport networks so that the transition from one mode to the next is painless. In the same way, the interconnection of technology and data allows us to create intelligent systems, which can respond in real time to traveller demand and external conditions and start to predict and avoid disruption for passengers.

As noted by Susan Zielinksi of the University of Michigan's SMART (Sustainable Mobility & Accessibility Research & Transformation) programme, "Transportation is not simply one mode that moves a person or object from A to B. It is a system, or rather a 'system of systems', connecting modes, services, technologies and designs according to the best option for the purpose." In these integrated and intelligent systems, as the complexity of connections increases so too does the inherent value and resilience of the network.

Building and operating transport services is capital and asset intensive. Disruptive improvements in computer-aided design, combined with the ability to sense and measure the health of physical assets, will converge, enabling radical new ways of monitoring and maintaining the roads, track and runways.

Integration and open data

Open data is transforming the way we use transport. Information is as much a basic part of the infrastructure of transportation as roads and rails are Open data facilitates the linking of modes of transport, opening up new possibilities for passengers. Enabled by the digital revolution of mobile applications, the sharing of data between operators is helping customers intelligently plan their journeys, often through the use of an application like Citymapper.

Independent from transport operators, Citymapper makes use of open data from a variety of sources to notify its users of services available nearby, compare different routes and prices, and alert of delays or disruption. Citymapper has developed alliances and connections across public and private operators – an example of how open data from multiple sources can be used to provide better linked-up transport solutions.

The same is true of Google Maps, which can show a linked up journey plan, detailing journey times, routes and operators to customers; it can even advise on the best choice of transport mode.

Deutsche Bahn's Qixxit service is a similar solution which has both an intermodal and intramodal approach, because on the one hand it combines several means of transportation in the travel chain, and on the other hand it shows the services of several providers of each means of transportation. The app provides the fastest and cheapest means possible, with the variance presented neutrally, without any preferred means of transport.

The combination or fusion of multiple sources of data also has implications for transport operators, who often have to rely on incomplete data to monitor and predict the state of their network. By fusing data sets they can create a more accurate and richer picture of their operations and correlate the running of services with the interventions they make.

Customers' movements, tweets and messages represent valuable data sources in their own right. They allow transport operators to get to know their customers, communicate with them and understand their preferences and complaints. The potential for transport planners to use customer data to better understand demand for their services is unparalleled. For example, mobile operators are now able to pinpoint customer journeys with a high level of granularity, allowing them to distinguish between walking, cycling, driving and riding a bus. Emer Coleman, director of Transport API, observes that "[Transport planning] is moving from the tyranny of the expert to the wisdom of the crowd."[11]

"A modern transport system which doesn't stream data is inconceivable. He who wants to build the world's most modern infrastructure must envisage, plan and build roads, rails and digital capability all as one."[10]

Alexander Dobrindt, German Minister for Transport and Digital Infrastructure

This will transform the ability of some operators, who are rarely able to collect any information about their passengers, to know their customers better. When customers choose to be identified and contacted by the transport operators whose services they use, they will enjoy a better user experience.

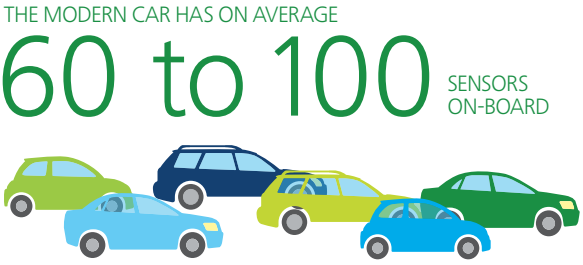
Sensors and telematics

The availability of information underpins smart mobility services. So it should not be a surprise that the movement of networked IT into everyday objects – the so called 'Internet of Things' – creates vast possibilities for reimagining mobility. The true value of these exponential advances lies in their connectedness. As Paul Didier, a manufacturing solutions architect at Cisco, puts it, "the value of devices (and the capabilities they represent) increases exponentially when they can communicate with other devices and systems".[12]

The aerospace industry has led in this area for many years where aircraft telematics relay engine information via satellite to manufacturers and maintenance teams on the ground to minimise time on the tarmac. The newest generation of trains and buses are now networked and capable of sensing their surroundings, and communicating with their drivers and the infrastructure around them. In addition to maintenance of this transport fleet, the benefits also extend to safety, capacity and the comfort of customers.

The potential for harnessing customers' own smartphones as sensors leads to the opportunity for 'crowd sourcing'. Other technologies such as iBeacon location transmitters can work together with customers' phones to provide a better view of passenger flow and network capacity. Crowd-sourcing could become a key method by which operators are able to understand their networks in real time.

The modern car has, on average, 60 to 100 sensors on-board. Given that cars are rapidly getting "smarter", the number of sensors is projected to reach as many as 200 sensors per car. These numbers translate to an estimated 22 billion sensors sold in cars worldwide by 2020.[13] As sensors become ubiquitous and we look to the future of autonomous vehicles, the data collected will be used in different and disruptive ways.



For example, the data on temperature and weather conditions sensed by millions of vehicles every day could be harnessed to drive substantial improvement in weather forecasting. Ultimately, sensors, telematics and hugely increasing computer power will allow us to automate many, if not all, functions of vehicles.

Physical assets merge with the virtual world

The transport industry is particularly susceptible to breakdowns and engineering issues. Transport must innovate to ensure that it can meet its maintenance needs as timely and efficiently as possible.

Maintenance can be improved through the use of asset information systems and networked technology for condition monitoring. This approach will make sure that operators and maintenance staff are well aware of maintenance requirements before they cause failure. In the future it may even be possible for assets to intelligently update their own records and even 'self-heal'.

In the UK Network Rail's ORBIS Programme seeks to improve the acquisition, storage and usage of asset information. With 15,777 km of track, the railways have a lot of assets to map and monitor. The potential to monitor an increasing proportion of this equipment so that it provides real-time data on its condition is huge. The data that could be collected would be transformative, allowing the rail operator to predict and avert equipment failures, and thus eliminate delays on the 24,000 train services run each day in the United Kingdom.[14] The outcome of mapping assets will also allow maintenance teams to find the target asset much quicker than before. This would represent a major improvement for the railways, much of whose infrastructure is over a hundred years old.

"Crossrail is building two railways, one physical and one virtual."[15]

Malcolm Taylor, Head of Technical Information at Crossrail

Imagine if, as a passenger on a metro system, you never again heard that a signal failure at your local station had caused severe delays on the line. Networked infrastructure and analytics has the potential to make this happen. If we can monitor assets in real-time and have a baseline understanding of where issues most commonly occur, we can predict and mediate them. The same is just as true of the roads and airports as it is of the railways. Planning to monitor asset condition and maintaining maps of those assets will ensure that physical infrastructure operates to its optimal level.

The virtual models created with improvements in computer-aided design will merge with information on physical assets to optimise asset lifecycles. Malcolm Taylor, working on Europe's largest transport construction project, alludes to the importance of this for future transport investment programmes. As he puts it, "Crossrail is building two railways, one physical and one virtual."[16]

During the planning of major capital programmes, advanced CAD and sophisticated planning tools will create a complete, hierarchical virtual model of assets. During build or installation, physical data is captured as assets are installed to augment the virtual model. New sensors enable real-time asset condition monitoring, and predictive analytical techniques optimise maintenance cycles and prolong asset lifetimes. The virtual model can be used to accurately simulate how one asset affects the entire system and how to prevent failure. The use of asset information informs future upgrade and planning cycles, with the potential to dramatically reduce the operating costs of transport infrastructure.

Pricing and payments

The next five years will see a revolution in the way transport services are paid for. Digitisation of payments will enable new ways to charge travellers based on a combination of their journey and other factors such as time of day, class of travel, discounts, previous travel patterns and even whether or not it's their birthday.

For nearly all types of transport, effective use of current capacity drives return on investment or profitability. Flat-rate transport pricing is outdated and does not allow for fluctuations in demand. Increased data on customers' travel patterns allows transport operators to both better predict demand and also understand their behaviour. This will enable more intelligent approaches to dynamic pricing to optimise capacity of the transport network.

In the Digital Age, tickets are a thing of the past. This revolution is accelerating across transport, and ticketless travel is now commonplace, not just in the airline industry but increasingly for metro services and road tolls. Exponential change in the digital payments industry will enable more spontaneous travel, where passengers don't need to define their destination before setting off.

Demand and pricing

Demand driven pricing has existed in some aspects of travel for decades, such as aviation. The emergence of internet booking and low cost carriers in the last fifteen years provided the platform for competition based on price.

Whilst physical transport infrastructure often limits competition in rail and urban transport, a more sophisticated approach to pricing can be used to influence demand and make better use of the available transport assets and capacity.

Most transport operators don't know who buys their tickets, but as we move towards online and mobile ticketing, customers will provide their identity when purchasing tickets to simplify the payment process. This customer data will provide rich information to allow operators to both reward customers and offer personalised travel options. This can be used to optimise capacity and drive revenue growth.

By contrast, today's road users do not bear the true costs of mobility, and the consequences of this are profound. As Cisco's Andreas Mai and Dirk Schlesinger observe:[17]

- We consume as much as we can because we perceive [road and traffic services] as 'free'.
- Because the true cost of the inflated demand is not recovered, the public service provider is underfunded.
- The resulting demand/supply imbalance cripples road infrastructure and inflates the cost of mobility.

With the rise of mobile technology and the 'Internet of Things', new dynamic pricing mechanisms that would have been inconceivable just a decade ago are now possible. This enables pricing to be based on variables such as time of day, road congestion, speed, occupancy, and even fuel efficiency and carbon emissions. By pricing different stretches of road or transit routes differently – based on up-to-the-minute conditions – cities can divert drivers and passengers to cheaper routes, as well as collect payment for what it actually costs to maintain a road or system.

While dynamic pricing may still be in the future when it comes to driving, it's fast arriving for parking. Donald Shoup, an urban planning professor at the University of California, Los Angeles, and the author of 'The High Cost of Free Parking', notes that not only do parking space regulations waste valuable urban land, but at any given moment, an average of 30 per cent of the cars in congested downtown traffic are actually just looking for a place to park.

For that reason, several intelligent parking schemes have been established in recent years. San Francisco is garnering great attention for its SFPark programme, which has installed networked meters that can sense the occupancy of each space in real time and communicate it – not just to potential parkers, but to parking managers who can adjust prices based on the overall occupancy of a given block and aim to set a price that keeps one or two spaces free on each block. Similarly, FastPrk in Moscow reduces frustration, saving time and fuel by reducing the searching time by 35%. FastPrk has since partnered to expand its services to Santiago de Chile and Barcelona, where over 500 sensors have been installed.

Digital payment methods

As the world has developed and people have become ever more mobile, methods of payment have had to keep pace. Nowadays people readily expect to be able to pay by card – having exact change is a thing of the past. With the development of applications like Apple Pay, it will become increasingly more important for transport operators to offer a platform that allows for varied methods of payment. In the future, payments may move from our smartphone to our wrists as wearable technology offers secure ways to carry your digital currency.

By 2020 we predict 90% of all transport transactions will not involve the use of a paper ticket.

This is hardly far-fetched, given how ubiquitous this kind of connectivity has become in our lives. Deloitte predicts that 2015 will be an inflection point for the usage of mobile phones for NFC-enabled payments.[18] As customers become more familiar with contactless bank card and mobile payments, this adoption is expected to rise. 46.1 million contactless card transactions were made in the UK in December 2014.[19]

Transport actually pioneered contactless technologies in the 1990s. Speedpass, the first contactless payment device (a key fob for use in gas stations), was launched in 1997, and in the same year, the Hong Kong metro system introduced a contactless pre-paid fare collection system. However the transport sector has failed to capitalise on these innovations and now lags behind banking and retail in terms of global integration.

46.1 million

CONTACTLESS CARD TRANSACTIONS
WERE MADE IN THE UK IN DECEMBER 2014

As former IBM chairman and CEO Sam Palmisano, points out, "We take it for granted that we can transfer funds and make payments amongst institutions; that we can use the same payment and billing systems, regardless of store, website or industry".[20] All these systems have standards and interfaces that permit information to flow. Transportation, he argues, isn't even close. The connections simply don't exist among vehicles, pathways, government agencies, regulators, providers and carriers, let alone for the goods and people being moved.

This technology has actually existed for a number of years, exemplified by Transport for London's Oyster Card programme (in operation since 2003) and the recent installation of contactless payment technology in 2014. Greater London now has a fully integrated payment system for all modes of transport that come under the responsibility of TfL. This technology could easily see an expanded role in the wider national rail and public transport network. There is even potential for it to be implemented in taxi cabs and various other modes of transport, particularly buses. Since the introduction of contactless technology to London's transport, over 40 million payments have been made in just five months.[21]

Establishing a well-connected system of systems will take work. It means making sure that a number of capabilities are in place: roadways, parking spaces, cars and transit vehicles that are all equipped with sensors. Payment systems will have to be integrated so that regardless of whether you're using a bicycle, taking the metro or paying road tolls in three different regions, you can do so electronically using just a single card or device. And the agencies – public or private – that run the various systems must make their data available so that others can use the data to build the applications that make it possible for ordinary users to travel easily, fully aware of their options.

Pay as you travel

Pay as you travel has the potential to transform the transportation sector. In the rail industry there is the potential to make use of digital technology and modern payment solutions, such as contactless card technology, to make this happen. The sector could make great use of location monitoring and iBeacon technology to track customers and their level of payments. The scenario below presents a possible framework for the way this might work.

Imagine you are a rail passenger. You touch your payment-enabled phone to the access barriers at your local station. You board a train north but don't yet know your destination. As you travel your phone monitors your position, it logs your progress and it sends that data to the train company, which then calculates your fare. Suddenly your colleague calls and tells you to get off at the next stop. Upon exit from the station, the system recognises you have completed your journey and charges the cost of the trip to your account; your phone then notifies you of the charge. When you return home, the system again tracks your movements and only charges you the additional cost of a return fare. In this scenario, thanks to iBeacon technology, the system knows the class travelled and can apply a discount based on whether the journey has been made during peak or off peak travel times.

The automotive industry also has the potential to be transformed by pay as you travel. Drivers could be charged by the mile, ensuring that they only pay for what they use. Furthermore, in the Digital Age, your style and quality of driving would also feed into the system (as discussed later in telematics).

This could revolutionise pricing, meaning that a good driver would pay less per kilometre, whilst a poor driver would pay more. The technology to implement this already exists and is used on an opt-in basis by a number of major insurers, all of which offer discounts for good driving standards.

In the future of smart mobility services the boundaries between automotive manufacturers, leasing companies, rental providers and even taxis will blur. Car ownership may be replaced by access to mobility services that offer a vehicle to suit your needs when you need it. The choice offered by services such as Uber, Zipcar and other providers will give rise to new business models where pricing adapts to demand. The emergence of autonomous vehicles may be accompanied by a shift from buying assets to paying as you go.

Automation and safety

The majority of people we interviewed thought driverless cars would be in everyday use by 2030.

Automation – to some degree – is not new to transport. Human error is the single greatest cause of injury and death in every transport system, and advances in technology have been applied to increase safety in signalling systems, avionics, and automotive applications. The biggest transformation to transport over the next twenty years could be the saving of millions of lives worldwide.

Today's automation is based on the foundation of science and engineering. However, as we progress towards greater degrees of automation the logic of engineering may be disrupted by the exponential potential offered by cognitive technologies. The ability for transport systems to continuously learn, take decisions in real time based on vast quantities of information, and also predict and anticipate ahead will lead us into the autonomous age.

These disruptive changes will reshape the transport sector and workforce. According to Frey and Osborne's research for the 2014 Deloitte London Futures Report, greater automation will put jobs in the transport sector at high risk of becoming obsolete.[22] Massive increases in safety and changes in the nature of liability will also have a fundamental impact on the insurance industry.

Degrees of automation

Technological advances are reshaping the travel experience. In the automotive world drivers are, in effect, being turned into passengers and other modes of transport are more frequently automatically controlled. The Dubai Metro is an example of this trend – 75 km of track and all the trains are operated centrally without the need for drivers. Dubai is not alone – both Copenhagen and Madrid's metro systems are also fully automated.

Metro systems, in particular, are clear candidates for investment in automation due to the limited scale of the network, high density of passengers, and the high frequency of service. These technology solutions allow metro operators to run trains at shorter intervals, decreasing the amount of time passengers spend waiting for a train and crowding on platforms.

Automatic operation undoubtedly represents the future for railway operations. In the heavy rail sector, the Czech rail operator – České Dráhy – has been pioneering Automatic Train Operation (ATO) for its operations since 1993. It now has over 200 vehicles equipped with basic ATO technology and is working to transform its entire network. The European Train Control System (ETCS) is a further development which will revolutionise the way our railways operate. Basic ETCS uses a mix of electronic tracking and GPS location information to make line-side signals obsolete. The potential this has for ultimately taking over train control from the driver is evident. However it will take many decades for the automation of mainline services to be adopted due to network complexity.

Aeroplanes have been heavily automated for a long time now, with pilots often only required to take control during taxi operations. Imagine an airport, where apron operations are increasingly being centrally controlled to improve safety and efficiency. In fact in Sweden a study is already underway to relocate air traffic controllers from towers to a centralised control centre. In the words of Paul Jones, Operations Manager at NATS, which provides air navigation services in the UK, "I have little doubt that this is the next big thing for our industry".[23]

Automation on our roads is an altogether different challenge. Modern cars can now identify lanes and track the car in front, enabling new safety features, such as automatic braking and steering. However, there is tremendous opportunity for road transport to become more intelligent.

In the Digital Age we are likely to see cars that communicate with infrastructure (V2I) and each other (V2V). As US Transport Secretary Anthony Foxx announced, "safety is our top priority, and V2V technology represents the next great advance in saving lives". With the support of the Obama Administration these new standards may become law as early as 2017.

Ultimately the biggest challenge in moving to the highest degree of automation is the almost unlimited complexity of mixed operation, with autonomous and traditional vehicles, and other road users, all sharing the same road space.

Cognitive technology

Traditional engineering solutions and vehicle to vehicle communication will never be enough to solve the problem of mixed mode operation. Instead, the exponential rise of cognitive technology will offer a new type of car, one that thinks and drives like a human, but with the collective knowledge to anticipate and avoid accidents.

Cognitive ability will also transform the way autonomous vehicles anticipate and react to hazards and traffic scenarios. Arrays of sensors and cameras will give the car 360-degree vision and allow it to judge range. This information will allow cars to see and sense in ways that humans never could when driving. This will allow vehicles to make intelligent decisions about every issue they encounter.

A number of traditional automotive manufacturers are now investing significant sums in the technology, including Volvo, Audi, Nissan, Tesla, BMW and Mercedes Benz. However, the most famous of these is Google's self-driving car, of which over 100 are expected to be on the road during 2015. Google vehicles alone have already travelled over 1,000,000 miles. The cognitive power of the combined knowledge of all the miles driven will equip vehicles with the experience to anticipate almost any scenario. As the number of vehicles and distance driven grows, the captured data and accumulated experience will increase exponentially.

Imagine, soon you may be driving down the motorway, overtaking a large group of lorries that are all sticking together in convoy. Looking in your rear view mirror you then realise that none of the lorries have a driver. Indeed, this could well be the case. Goods vehicles of the future will be autonomous; they will learn to travel in convoys to cause the least disruption possible on the road. They will be capable of travelling throughout the day and night, no longer concerned about driver hours.

In the digital age, the connected car will benefit from the next generation of infotainment systems, with Apple Car Play and Android Auto vying to replace decades of in-house development by automotive manufacturers. This will bring the world of mobile apps into the context of the connected car. Ultimately, the future of cognitive and autonomous vehicles will revolutionise the experience for the driver who will now be able to use the time to work, relax or even sleep as their car takes control.

It's hard to imagine, but children born today may never have to take a driving test.

"I can't believe they still let humans drive cars."

Whilst most mass modes of transport have adopted levels of automation to increase safety, in the air, on the railway and at sea, cars have the most to gain from catching up with the increases offered by automation.

Liability and insurance

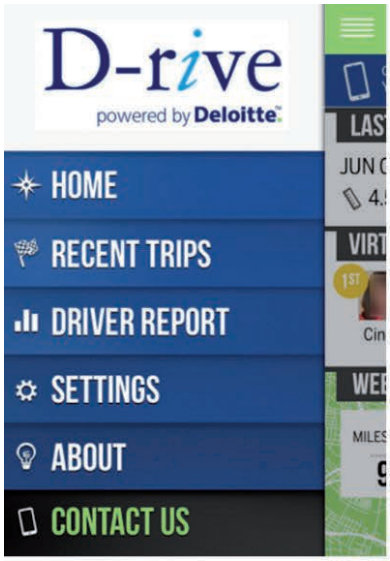
Currently most accidents happen because of human error. Whether that be driver, operator or pilot, error is irrelevant – humans are the single greatest reason for transport accidents. Greater automation of vehicles will reduce accidents; autonomous vehicles will eliminate them. The emergence of advanced sensors will allow vehicles to maintain optimum breaking distance, speed and course, whilst also monitoring external conditions in real-time. We can be sure that digital age transport will be safer than ever before.

Whilst most mass modes of transport have adopted levels of automation to increase safety, in the air, on the railway and at sea, cars have the most to gain from catching up with the increases offered by automation. This is because of all the transport modes, automotive is the most likely to suffer from driver failure. This is due to the high level of human involvement in vehicle control. With increased automation insurance premiums would either fall dramatically or disappear altogether, impacting the ca. 617 billion dollar automotive insurance industry.[24] Furthermore, the technological shift would move liability for accidents from the driver to the car manufacturer.

Such technology is already used by a number of insurers to monitor in real-time the movements of their policy-holders as part of a scheme to link policy prices to driving standards. This group of insurers includes Aviva, the AA, Direct Line and InsureTheBox.

Telematics have the potential to help reduce accident and injury on the roads, or at the very least aid in providing medical response. In the case of insurer-installed telematics devices, should the covered driver have a serious accident, the trackers can aid rescue by setting off a series of alarms, allowing the insurer to alert the medical/rescue services. Indeed, Charlotte Halkett of 'InsureTheBox' alludes to an incident when they 'had a driver upside down in a ditch in a remote country lane in the middle of the night' and were 'able to get the emergency services there quickly, [but] without the alarm, the driver would have been left there for hours, and the outcome could have been much worse'.[25]

Other advances are represented by the Deloitte HexScore, which assigns a level of potential accident risk to every 500 metre stretch of road in the UK by assessing the spatial, temporal and environmental dimensions of people driving on that road. The Deloitte D-RIVE app, also uses driver performance data to make similar judgements about the way they are handling their car. Both figures have great potential to transform the way individuals' insurance premiums are calculated.[26]



Public and private innovation

"I have never seen anything like the pace of change we're seeing today," says Larry Keeley, founder of Doblin Group, a business that focuses on helping create innovation within its clients' businesses. In the Digital Age such innovation is quickly changing the way we travel, how operators deliver services, and how governments invest for the future. Business models invented in the media and retail sectors are being adapted to change travel and transport. Technology is shaking up the value chain, enabling new types of mobility services.

However, the role of the public sector will be critical in both stimulating these advances and protecting citizens. Working together with the private sector, they will need to build integrated transport networks to prepare the world's urban areas for the growth in population and business investment in the coming decades. Globalisation will enable new transport business models to be transferable between countries and grow exponentially, whilst cities will compete on a global stage to offer the best business environment and quality of life.

Future roles of the public and private sectors

In essence, the core role of government is to set policy, maintain the safety of citizens and support the delivery of universal and inclusive transport services. However, one of the hardest questions to answer when looking at the future of transportation is how change is going to be organised and paid for.

One of the key assumptions about most roads, railways and other transport infrastructure has always been that they are a public good, and therefore should be funded partially through public subsidies, ultimately paid for by the general tax base. Financing has been largely provided by the private sector in the bond markets. However, in recent years the gap between available public funds and infrastructure needs has grown ever wider.

> "I have never seen anything like the pace of change we're seeing today."[27]
>
> **Larry Keeley, Founder of Doblin**

If a new transportation system is going to come into being, government will neither be in a position to fully fund it, nor take primary responsibility for it, given the current taxing or toll levels, particularly against the backdrop of austerity in Europe. This may need radical new thinking about taxation for transport infrastructure as the income from fuel duties falls with the increasing adoption of hybrid and electric vehicles. For most transport modes, revenue is raised at point of use, e.g. airport taxes and rail charges. For roads there will be an increased focus on future models for tolls and road user charging.

There are clearly challenges for the transport sector and these need to be met without spending extra public money. The government is asking private sector providers to address this need and in doing so it is, by default, asking them to devise creative new approaches. The UK Department for Transport has taken on this challenge with the establishment of the UK Transport Catapult, which has the task of encouraging innovation in the transport industry. It was the Catapult that developed the new rail franchise innovation fund, a mechanism designed to incentivise new types of change in the rail industry.

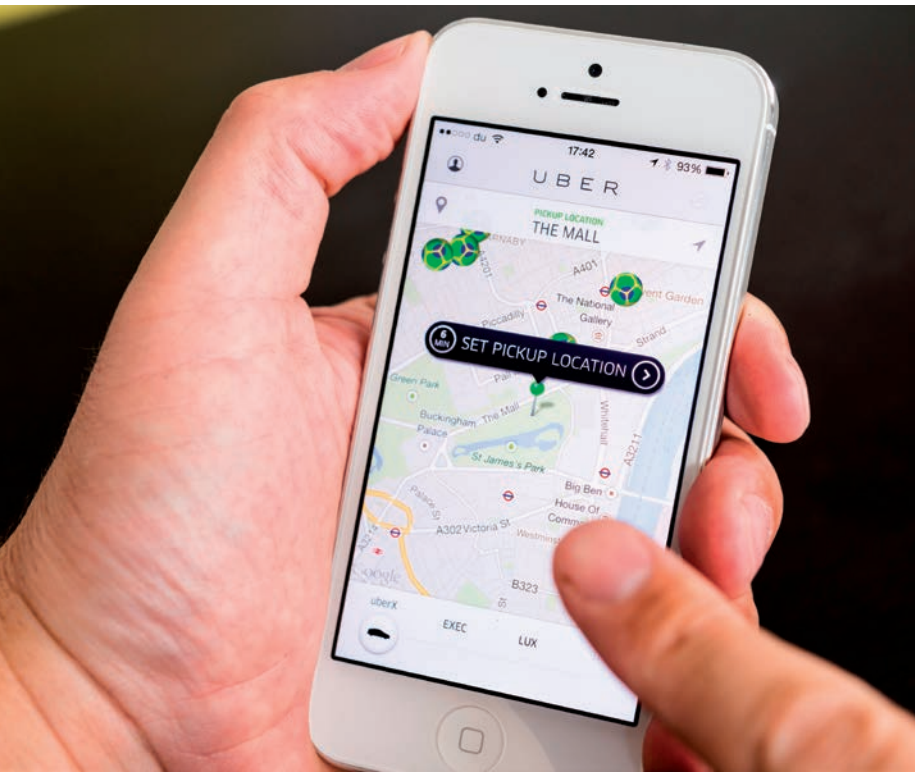
The rail innovation fund embraces public-private partnership as a basis for revolutionising the rail industry. With government matching the funding provided by train operators, the fund is a unique example of how government and commercial entities can work together to promote innovation.

Building for the future

To meet the growing urban needs of the global population, billions will be spent on infrastructure in the next ten years. However, in dense urban environments you can't always create capacity by pouring more concrete. New capital programmes will need to involve investment in technology, both to ensure effective construction of new systems and to build intelligence to get the most out of the new assets. Whilst capital programmes are often built with an investment time frame of twenty or thirty years or more, it is increasingly hard to build in flexibility when private sector innovation cycles are accelerating.

Capital programmes should become smarter in the way that they use technology to understand how planning should go ahead. The use of technology has revolutionised the way in which we build and maintain complex transport networks. As with the maintenance of assets, if we know where existing structures lie and their exact physical make up, we can plan to integrate them into new improvement projects. It is this planning which will enable the kind of future-proofed capital programmes we want to deliver.

User-centricity and automation will come together to deliver a more enjoyable travel experience. With old constraints removed and new possibilities, architects and designers will be able to radically reinvent and simplify our urban environment. Imagine building an airport, for example. In the future, airports are likely to be even more automated than they are nowadays; planning will take into account the decreased need for physical presence in the airport terminal. All the airport's functionality, from check-in to security procedures, will be planned from the outset, allowing for a smoother, more personalised journey.



Going forward crowd-sourcing may help determine where there is a need for investment in asset building. Crowd-sourcing could present us with real-time data about the state of the network and the areas of network/business that passengers are most unhappy with.

Transport companies often respond too slowly to the capital requirements of their networks, but digital monitoring will transform the way in which they respond to capacity limitations, customer dissatisfaction and the need to upgrade infrastructure.

Disruptive business models

New business models are emerging based on a number of disruptive innovations that enable them to grow dramatically. New entrants, such as Uber and AirBnB, are taking advantage of excess capacity and a sharing economy to bring together customers and independent suppliers using digital and mobile. These new businesses have simplified the value chain using a peer to peer model, with little incremental costs to scale globally.

Traveller convenience drives loyalty and in this sector everything is mobile. Building a delightful business model requires the seamless integration of several or all of the five key disruptive trends for transport in the Digital Age: a user-centric experience, integrated data, simple payment transactions, some magic automation and a visionary business.

It's easy to think that the best digital business models have now been claimed, but the reality is that we're just getting started. Hundreds more innovative ideas will transform the way we travel and there has never been a better time to change your business or invent a completely new one.

Looking ahead

Transport in the Digital Age will be autonomous, intelligent and suited to users' needs. We can look forward to self-driving cars and trains, autonomously controlled aircraft and vehicles that learn to adapt to our needs and preferences. Ultimately, the hassle of using public and private transport will be eliminated by the advances we will see over the next few decades. This, however, gives rise to another question; what can we expect from transport in the next five, ten, twenty years?

Five years from now

In the next five years, contactless payment will no doubt become the norm; gone will be the days of using a ticket machine and carrying a paper ticket. Certainly in modern metro systems paper tickets will cease to exist – you simply won't even be given the option to buy one. At the same time, our phones will be syncing travel plans with our calendars, telling us, step by step, what to do next and exactly when to do it. Transport agencies will be monitoring traffic flow and passenger numbers in real time, pre-empting congestion and working to avoid it. None of these changes are far away. In fact, a number of operators are already way ahead of the curve, moving their staff out of ticket offices and onto platforms, equipped with technology and ready to help any traveller in need. Millions of sensors will start creating a private network of things.

Ten years down the line

Within ten years we should see the beginnings of fully automated transport. Most of the world's metro systems will be driverless and automation of mainline rail services will be in the testing phases. Signals will disappear from the line-side, trains will be automatically controlled, and track assets will communicate status data in real-time to a manned control centre. Further still, the public and private sectors will be working together to push the integrated transport agenda, thereby delivering tangible improvements in user experience and operator efficiency. Your car will be connected to a network of other vehicles and infrastructure which inform it of impending delays and accidents; the beginnings of driverless technology will have arrived. What is more, regardless of how you travel, you will do so in comfort and with ease.

The airline industry will have removed manned check-in desks and security points will be increasingly automated. The need for a boarding pass will have been superseded by contactless technology – your payment card will also act as your boarding pass. Moreover, the days of inaccurate airport delay predictions will be gone – from now on, your contact details will be used by the airlines to push information relevant to your flight straight to your mobile device, helping you to make a decision about whether to stay and wait or fly the next day.

Twenty years on

Twenty years from now we can expect the transport sector to have been completely transformed. Most transport systems will be intelligent, vehicles will be fully automated, and users' travel plans will be facilitated by their mobile devices. Transport staff will devote all their time to customer service and will never be caught off guard by a customer who has more information than they do. We will see a revolution in public-private partnership, with governments promoting and facilitating the integration of transport modes globally. Payment systems will be standardised and available to all. The days of the autonomous personal vehicle will have arrived and the driver will become the passenger – enjoying a nap on the way to work!

Ultimately, the hassle of using public and private transport will be eliminated by the advances we will see over the next few decades.

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