Impact of Digitalisation on the Public Transport Industry

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A common definition of digitalisation (or digital transformation) is the integration of digital technologies into everyday physical life. In business, we can define digitalisation as the integration of digital technologies to change our business model, provide new revenue, or to achieve an improvement in resources productivity and cost savings. It is, in any case, the process of adapting traditional businesses through the use of computer-based technologies.

Digitalisation is not new. Those first IBM home computers of the early eighties were already used for digitalisation. Before them, my uncle, a sociologist lecturer, would pay me some good pocket money to do calculations for statistical tables on paper. Soon, my 'job' was replaced by a very efficient IBM model 5150 with Lotus-123 on it. You could argue that back in the early eighties my young me was one of the first victims of digital disruption. However, the industrial use of digital tools to change our business models were heavily dependent on fast internet. Dial-up would not cut it, and digital disruption 'proper' didn't start until fast fibre optic networks and 4G mobile technology became a reality around 2010.

Digitalisation has brought a significant amount of disruption to traditional businesses. Amazon or AirBnB to quote just the cliché examples. There are however, hundreds of other examples, a few of them quoted in this white paper. At the heart of their disruption is the **Value Proposition** to the customer. Digital disruptors have managed to capture the essence of this value proposition, but they have changed how it is delivered, increasing the value for the customer.

In this white paper, we look into the digitalisation of Public Transport. How disruptive technology affects a somehow traditional sector, and how it needs to adapt to it for survival. We cover the threats. And we cover the opportunities. From geo-fencing to open-loop ticketing, to autonomous vehicles, everything is up for grabs. And the COVID-19 pandemic has made the need for change even more acute, highlighting the need for fast digitalisation.

This is a public and free white paper. Please feel free to forward it to those in your network that may benefit from reading it.

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Digitalisation and Disruption

Digitalisation is not a new phenomenon. We have been digitalising our society since the early computers of the 60s and 70s. This process accelerated in the 80s, with the first personal computers, Apple and IBM. And it was accelerated again in the 2010s, with the arrival of Apple's first iPhone in 2007 and 4G technologies (EE October 2012). However, the 2020 COVID-19 epidemic has accelerated the need for digital transformation exponentially. In the last few months, we have seen an explosion in digital solutions for human problems. From having to work remotely from home through the months of lockdown to fast implementations of e-commerce solutions for takeaway food and drinks, to the need to tell passengers about the volumes of passengers on public transport in real-time, the world is changing rapidly through a digital revolution.

At the heart of this disruption is the Value Proposition to the customer and how different digital disruptors have managed to capture the essence of this value proposition, only changing the means to achieve the same value for the customer.

Digitalisation has brought a significant amount of disruption to traditional businesses. And just like the Richter scale measures earthquakes, we can distinguish between three categories of disruption, ranging from most extreme to least:

- New Digital Business, that completely replaces a current traditional business.
- New Digital Models and Value Propositions resembling traditional competitors are created, increasing market competition.
- New Digital Tools, used to improve current value propositions, products and services, and productivity.

The level of disruption of each of these categories on our organisations and businesses will be very different depending on individual circumstances.

New Digital Business

A New Digital Business is a destructive force that affects current businesses, traditionally built around physical products and services. The disruptor captures the very essence of the Value Proposition (e.g. listening to music that we like or watching films that we enjoy). And it replaces the traditional means of achieving the customer value (purchasing music on a high street outlet or buying a DVD) with an equivalent digital version of the value proposition (purchasing an online music subscription like Spotify or a digital video solution like Netflix).

A New Digital Business have the disruptive power of a level 10 Richter scale earthquake. The incomer is very light on cost, typically a few developers and some cheap ($30 a month cheap) rented space in AWS or Azure, while incumbents are left holding expensive physical assets, like high street shops. The assets move from competitive advantage to liability because they become empty and a burden to the P&L account.

To counter new incomers, incumbents must give up their core businesses and find new value propositions, or alternative digital ways to serve the same value proposition. This could lead to 'cannibalisation' of their own physical business, but it could be the difference between life or death for the business.

A New Digital Business is unusual. They are called 'unicorns' for a reason. However, like a category 5 hurricane, their path of destruction comes quickly, with focus, determination and intent, and without any apology.

New Digital Models

Unlike a New Digital Business, New Digital Models do not replace traditional ones. Not initially anyway. New Digital Models do not aim to replace traditional ones but to complement them and enhance them. In time, however, they may replace the traditional ones. The best and most familiar example is Amazon. The value proposition is still the same (purchase of goods). However, customer experience and logistics are completely different.

Initially, Amazon was born as a New Digital Model, using the internet to buy books. However, it is now threatening traditional retail's very existence, and it is edging rapidly towards a hugely disruptive New Digital Business, including food stores.

In transport, the best example of New Digital Model is Uber. The world of taxis was ripe for a new digital model. The value proposition for taxis is simple: for a customer to be transported from A to B, with minimum possible wait and cost. The traditional taxi (e.g. black cabs in London or yellow ones in New York) is not always there when required. And regional taxi business (mini-cabs) often offer poor service levels and a slow physical dispatch process, with frequent queueing under the rain after a train trip. Uber recognised the flaw in the value proposition (the customer needs to wait and be uncertain about timings and costs, the taxi being that 'god of the transport') and offered a new digital model where the passenger became the 'god of the transport', with taxis waiting for them instead. Taxis are now fighting back with ride-hailing apps, such as Gett, which have improved efficiency and reduced waiting times.

Imitating the disruptor is possible, but it requires a fundamental change in approach, often riddled with failure (e.g. Tesco Direct Vs Amazon).

The response of traditional businesses to New Digital Models should be to build their alternative digital model as a complement to their traditional one (e.g. on-line branches of a traditional retailer or Estate Agent), or to find complementary value propositions for the customer (e.g. coffee shops/book shops opened recently by Waterstones in the UK).

New Digital Tools

New Digital Tools are the most common use of digital for competition, as, instead of disrupting a business, they help competition among established businesses by applying digital technology to enhance their products or services. New Digital Tools augment or enhance the value proposition but do not fundamentally change it.

There are many different new digital technologies that we could use to enhance our value proposition. **In this white paper, we cover the most relevant ones for the Public Transport sector.**

Digitalisation – New Digital Businesses

At the heart of any potential disruption (or opportunity) in transport, we will have the Value Proposition: moving a customer from A to B in the most efficient, and cheap way, frictionless.

New Digital Businesses

A New Digital Business is probably not a significant threat to Public Transport. A Digital Disruption in transport would mean substituting a physical way of moving customers from A to B in the most efficient, cheap and frictionless way, to a digital form of doing it. Or, in other words, teleportation. Which, in 2021, is difficult to imagine as a new digital business.

However, in a post-COVID era, we need to be mindful of people not leaving their houses and the impact this shift will have on public transport. An indirect form of digital disruption to the transport industry introduced by employee tools like Office 365 Teams or Zoom video conferencing.

Digital Layering and Digital 'Slavery'

Although digital substitution as such would be conceptually difficult to imagine, there is a form of digital substitution much easier to imagine. I have called it 'Digital Layering', and it refers to the likes of Google Transit, Moovit or Citimapper. The transport itself does not change. However, the link with the customer does change. Significantly.

These digital giants are tempting transport operators to join their Transit offer, for example: "If you provide a transportation service that is open to the public, and operates with fixed schedules and routes, we welcome your participation - it is simple and free".

https://maps.google.com/landing/transit/index.html

The case for participating is obvious: "everybody uses Google maps, so, let's get our services in them, and we will get more customers". This is could be true in the short-term. However, the creation of this extra 'layer' between customer and operator may have several severe risks:

- It will very likely add cost. These layers may tempt operators with a 'free' service. Although Google may not be in a hurry to charge for it initially (as with Google Maps for web sites and mobiles apps,) when the critical mass is there, it may be a different story…
- In this exchange, the operator could risk losing the relationship with the customer. Remember: the person 'talking' with the customer will be the 'digital layer', and not the operator. This could be step one on a digital 'slavery' journey, where the digital giants start demanding over and above a simple fee, as happened with Uber. The relationship with the customer may compel them to dictate the rules on routing, frequency or even terms and conditions.

Between a simple innocuous customer layer and digital 'slavery' there is only a paper-thin boundary.

Digitalisation – New Digital Models

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New Digital Models

New Digital Models now have a significant presence in public transport, and are very likely to grow further. Several potential disruptions will require adaptation from the traditional methods of providing public transport.

1 App-based private hire. This is now a common approach to taxi hire, started by the revolutionary Uber, connecting passengers with willing drivers.

Two different approaches:

- A passenger requests a car through a mobile app. A driver accepts the run with the same app and takes the customer to their destination. Payment is taken automatically from the passenger's debit or credit card, previously registered with the platform. Uber and Gett being probably the best examples.
- Several passengers share a cab or mini cab by booking through a mobile app or web site where artificial intelligence calculates the best routing and assigns the jobs and the payments. A good example would be Splitcab in London.

2 Shared cars, pool cars. Traditionally, car-pooling was an arrangement between people to make a regular journey in a single vehicle, typically with each person taking turns to drive the others. Normally friends, work colleagues or family.

However, technology has allowed several different new models for sharing a ride:

- Using a mobile app to find people wanting to share a car ride on a private car. One of the first ones was BlaBlaCar in France. Other good examples are Waze (not in the UK), Gocarshare or Liftshare.
- Using a mobile app to find both a rental car and people wanting to share the ride. A good example would be Turo.
- Offering your car as a pool car when not used (also called 'peer to peer car sharing'). Typically, the scheme (Turo also offer these services) would insure the car.
- Car clubs, where you pay a subscription and can use cars and vans as often as you want, booking the car through an app, and opening the car with that same app. Good examples would be Enterprise Car Club, Zip car, Co-wheels, or Ubeeqo.

Car or pool share is a growing trend in big cities, where people often don't own a car. Instead, they prefer to rent it and only pay for the time used and work on the bus or tube. But need to go to Ikea Wembley? Rent (and only pay for) three hours of a large size car or small van.

Digitalisation – New Digital Models

At the heart of any potential disruption (or opportunity) in transport, we will have the Value Proposition: moving a customer from A to B in the most efficient, cheap and frictionless way.

3 Micro-mobility. Micro-mobility generally refers to pool bikes, electric bikes and scooters, and other small personal lightweight vehicles like electric skateboards.

First introduced by schemes like London's 'Boris bikes' in 2010, bike-sharing offers are typically designed for people to complete their 'last mile' to work or home.

There are two types of shared bikes:

- Docked, where there are defined docking stations around the city, now present in many larger-sized cities, and operated with a smartcard or mobile app.
- Undocked or dockless, where bikes are left in any place, and are picked up by another rider, using a mobile app. Good examples of this are oBike, or Pony. Most schemes would use geo-fencing to locate bikes, publishing their location through a mobile app.

There are also web portals and apps with location maps for bikes, such as https://bikesharemap.com

Bikes can be traditional, or electric and docked onto an electric charging point.

More recently, there has been a lot of development in shared electrical scooters, Lime being a great example.

Micro-mobility is very likely to grow significantly in the next few years, as it is a significant enabler for Active Travelling, an important and growing element of most local authorities transport planning strategies.

Active travelling (or Active mobility) refers to the transport of people through non-motorised non-fossil fuel means, using human physical activity instead (e.g. bicycles or scooters).

4 Demand-Responsive Transport (DRT).

Demand Responsive Transport (DRT) provides services on-demand from passengers using fleets of mid-size vehicles scheduled to pick up and drop off people on locations chosen via web sites or mobile apps. DRT is a hybrid form of transport, somewhere between a bus and a taxi. DRT systems typically provide a public transport service for low passenger demand areas, such as rural areas, or marginal times of the day, where a regular bus service may not be commercially viable, and taxis being a little expensive for regular use. DRT is not new (it is really a digital adaptation and enhancement of 'dial-a-ride'), but the use of digital tools makes it a lot more powerful. Algorithms design the most efficient routing, providing potential passengers with estimated times of arrival. This creates a customer experience in some ways similar to Uber. An excellent example of DRT in the UK is Arriva Click.

Companies may also decide to sponsor a shared drive for employees. Large working communities like airports may decide to offer a car share service for employees, operated by an app linked to their rostering systems, with algorithms working out the best routes and times to pick up and deliver employees from their homes.

Digitalisation – New Digital Models

At the heart of any potential disruption (or opportunity) in transport, we will have the Value Proposition: moving a customer from A to B in the most efficient, cheap and frictionless way.

5 Mobility as a Service (MaaS) integrates various forms of transport services into a single mobility service accessible on demand. The Transport Systems Catapult in the UK has defined MaaS as using a digital interface to source and manage the provision of a transport-related service(s) that meets a customer's mobility requirements. Or, in other words, an end to end trip is created using a web site or mobile app. Algorithms calculate the best way to combine public transport to achieve that trip, and sells a combined ticket for all those transport methods.

Mobility as a Service is often heralded as the solution to all transport problems. The passenger can hop on and hop off several means of public transport seamless. At the end of the day (or the week), an intelligent back-office charges the relevant fare and apportions it amongst the scheme's participants.

There are two current approaches to MaaS:

- Pay as you go – the passenger gets charged a fare for the actual journeys requested via app or web site, on a 'pay as you go' basis.
- Monthly subscription – marketed as the 'Netflix of public transport', where the MaaS operator offers a monthly subscription all inclusive, and takes the risk.

There are a few MaaS players in the market: Moovel; Whim; Axon Vibe, Moovit or Mobilleo.

Mobility as a Service schemes are incredibly attractive, both for passengers and for transport authorities. However, these schemes face two key issues:

- The exchange of data, and data sharing, which is not always easy. There have been a few attempts to help the matter (TransXChange, NaPTAN, SIRI), and, more lately, the DfT Open Data project. In the Netherlands, the Urban Data Access Platform (UDAP) is the latest attempt at making data sharing a reality. However, we are still far from a standard good enough to enable true mobility as a service.
- The commercial model, especially when a significant part of the offer is in private hands, complicates the scheme's viability. Private operators may or may not agree with the commercial scheme proposed, and commercial negotiations become key.

With increases in the use of bicycles and scooters and an increase in environmental causes, healthy living, and active travelling, we are very likely to see the incorporation of walking and cycling as part of MaaS and integrations with health apps like FitBit.

Digitalisation – New Digital Models

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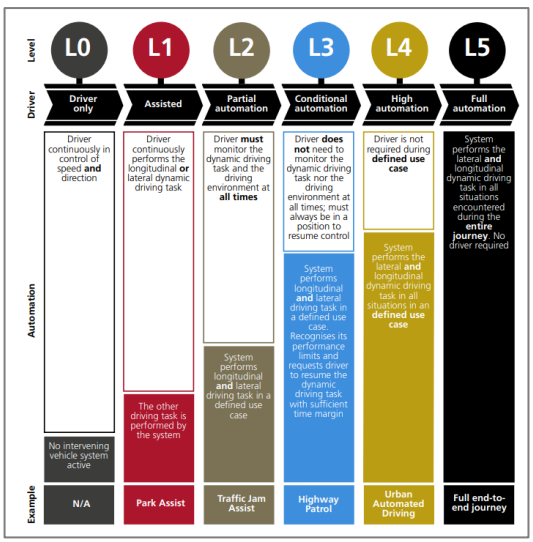
6 Connected Autonomous Vehicles (CAV).

Connected vehicles are vehicles that use any of several different communication technologies to communicate with the driver, other vehicles on the road, roadside infrastructure, and other 'cloud' systems. Autonomous vehicles are those in which the vehicle's operation occurs without direct driver input to control the steering, acceleration, and braking — designed, so the driver does not have to constantly monitor the roadway while operating in self-driving mode. Some vehicles are both autonomous and connected. Others are connected vehicles only. They are often referred to by the generic term 'Connected and Autonomous Vehicles (CAV)'. There are a significant number of companies working on prototypes for CAV vehicles, and a substantial amount of progress has been achieved in the last few years. There are 5 different levels of automation for road vehicles:



Without a shadow of a doubt, CAVs will revolutionise the public transport industry. However, generalised use of CAVs for public transport is very likely to be some good years away from today. This is because technology is only one of the key factors that will contribute to their success. Infrastructure will also have to be aligned before the use is generalised. And, more importantly, society also needs to be aligned.

Technology is, perhaps, the simplest of the requirements. A vast amount of money has gone into the development of CAV. Although much progress has been made, we still have no autonomous vehicles capable of fully autonomous driving outside small experiments in places like business parks or university campuses. Or, as a tourist attraction in the case of Waymo. Industrial use of autonomous vehicles requires a significant amount of road and mobile network **infrastructure**, including widespread 5G mobile technology. CAVs must be constantly connected to get information about their surroundings, conditions and routes. Although the introduction of 5G has started, it will take years of heavy investment for the network operators to be in a position where a reliable and fast mobile network reaches everywhere.

Legislation. For autonomous vehicles to be widely adopted, there is a need for legislation. Some countries have recently passed some legislation (e.g. the Netherlands, or the UK to a degree). The task, though, is not simple: who's responsible for the death of a pedestrian? The designer of the software, the car maker, car owner or the telecoms company? And who is liable; the insurance company, or the designer of the faulty software?

The last element on the journey to CAVs is the need for **social acceptance**. Not everybody was comfortable going over 20mph on a vehicle propelled by petrol instead of a horse, and, initially, not everybody will be comfortable going over 20mph in a vehicle with no driver.

But even when that eventually happens, there will be significant **social disruption**: many jobs will be lost (taxi drivers, bus drivers), and society will have to find a way to compensate for this, just like it did with mining. But it will take time.

We are, in my view, at least a generation away from a world where vehicles generally drive themselves.

Digitalisation – New Digital Models

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7 Autonomous pods. Autonomous pods are small driverless pods designed to travel short and medium distances in dedicated lanes. These will become common soon, with good examples currently in Dubai or Heathrow Airport parking.

8 Autonomous trains. Trains are also moving towards automation, with some real examples already live in the UK (DLR in London, Thameslink Railway). The principle is similar to cars: the train can drive itself without human intervention, stopping at the right place in the right station. Autonomous trains require the implementation of ETCS (European Train Control System) as a prerequisite, and, as for autonomous vehicles, there are several automation levels. As trains go on tracks, autonomous trains will generally be easier to implement than cars. However, social and Union acceptance may also prove complicated.

9 Platooning.

If you own a car with dynamic radar cruise control, like a Tesla or a Lexus, you may have already experienced the concept of platooning. Dynamic radar cruise control uses radar to maintain a constant distance with the car in front, up to the speed set up by cruise control. When the car in front accelerates, our car accelerates; when it slows down, ours slows too. If somebody gets in between us and the car in front, our car slows down to go back to the safety distance originally set up.

Platooning is likely to become popular for trucks driving as a convoy. The truck in front makes the effort; the trucks behind just follow automatically. This new use of technology means convoys can do longer hours on the road (only the driver in front really drives), as well as saving fuel (as the truck in front takes all the air resistance hit). Peloton, a good example of software for platooning.

It is difficult to imagine a practical use of platooning in Public Transport. The concept feels in great contradiction with the concept of headway management, and it is unlikely to find its way into Public Transport.

10 Drones.

Drones are, in simple terms, unmanned aircrafts. These aircraft may be remotely controlled or can fly autonomously through software-controlled flight plans. In some remote areas, Drones are already used for parcel delivery. Only a few weeks ago Tesco announced the launch of a trial drone for small basket home deliveries in County Galway, Ireland.

Some companies envisage an offer for passenger transport soon: Ehang, Kittyhawk, Wisk, Volocopter, some others.

Whether drones will become a general means of public transport, a tourist attraction, or an easy (and expensive) way of travelling for wealthy people, remains to be seen.

Digitalisation – New Digital Tools

At the heart of any potential disruption (or opportunity) in transport, we will have the Value Proposition: moving a customer from A to B in the most efficient, cheap and frictionless way.

In Public Transport, we already have many cases of New Digital Tools. This is because digital developments intensify competition among public transport operators, enhancing the basic products or services (transporting people from A to B) and business models (public service and profit where private). There are two different reasons or case studies for new digital tools:

- The offer to the customer may be significantly enhanced by digital means, such as real-time information on services via mobile app or the use of augmented reality to find our way in complex stations or interchanges.
- Those digitally astute may also be able to run services more effectively and efficiently by using data and digital tools to prevent breakdowns (predictive maintenance), design more efficient routing or rostering, or regulating the traffic better (headway management).

Several technologies may help operators improve public transport.

1 Passenger Mobile Technology. In the last few years, we have seen a huge increase in mobile devices (including wearables) in our daily routines. The UK is the world leader on smartphone penetration, with 83% of the population using one in 2019, closely followed by Germany at 80%.

In public transport, we have seen a significant increase in the use of mobile phones, mainly in these areas:

- Journey planning and ticketing, offering passengers the possibility of planning a journey and buying a ticket through a mobile app, getting the actual ticket in electronic form, typically a dynamic QR code or 'flash-pass'. All large operators in the UK have this type of offer for passengers.
- The provision of passenger information: timetables and bus stops, transport interchanges or train stations facilities.
- Real time location on vehicles and time to arrival. Help with planning alternatives when things go wrong. Information about passenger volumes and crowding.
- Costumer sentiment, when people can express their feeling about the service through the use of an app.
- Passenger portals, with information on charges and their travel history (smartcards and contactless ' model 2' Pay as you Go).

Mobile apps have vastly improved the passenger journey, making ticketing and passenger information easier, and we should see a significant increase in the use of mobile apps by all generations of customers.

Digitalisation – New Digital Tools

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2 Internet of Things (IoT). Simply put, Internet of Things (IoT) is the concept of connecting a device with the Internet. This includes everything from smart phones, coffee makers, washing machines, headphones, lamps, wearable devices and almost anything. This also applies to components of machines, for example a jet engine of an airplane or the drill of an oil rig. In many cities, smart waste bins notify councils when bins are ready for collection (e.g., bigbelly.com).

IoT allows us connectivity to devices in movement. For public transport operators, IoT could give the power to see what is happening around their world, from remote alerting when an engine is heating unusually or when coolant liquid on an engine is low, to sensors on stores warehouses alerting of buckets running out of spares.

Two key areas of growth:

- Preventive / predictive maintenance. Sensors in vehicles can help us predict failures in mechanical and electrical parts. Preventing outages will improve passenger satisfaction and save costs.
- Peer to peer connectivity. Sensors and internet can enable devices connecting to each other. A prime example is connectivity between buses and traffic lights, modifying the lights to give priority to buses over private cars.

The Internet of Things is on its infancy, but it is very likely to help transport operators improve their customer service and cost base.

3 Digital Twin. A Digital twin is a dynamic software model of a thing or system that relies on sensor and/or other data to understand its state, respond to changes, improve operations and add value. Potentially, it could be used to create simulations of engines and support engineering work. A good example of digital twin is the 3DEXPERIENCity project 'Virtual Singapore', where the whole City has been plotted as a digital twin in a computer, to help city planning activities. Airlines tend to run digital twins of their engines, to help monitoring performance and prevent failures.

4 Geofencing. Geo-fencing uses the Global Positioning System (GPS) satellite network and/or local radio-frequency identifiers (such as Wi-Fi nodes or Bluetooth beacons) to create virtual boundaries around a location. The geofence is then paired with an application that responds to the boundary in some fashion as dictated by the parameters of the application.

Digitalisation – New Digital Tools

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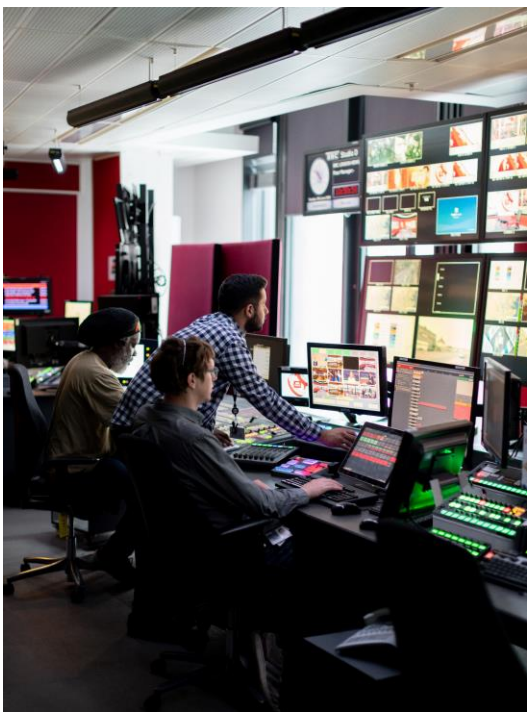
A few uses of geofencing:

- Ticketing. When a phone enters into a geofenced area, or leaves it, the device sends GPS data to calculate the fare and charge through a back-office system (more later in this paper).
- Another great use of geofencing is the determination of Ultra Low Emission Zones (ULEZ). On approach to the geofenced area, a diesel bus switches onto electric, working on electric mode until leaving the geofence, reverting to diesel.
- Geofencing also has great safety use cases. Two examples; remote workers on train tracks, where geofence can detect an incoming train and warn the individual at risk (or stop the train). Or stopping vehicles in depots going too far against a wall, avoiding an employee getting trapped in between.
- Finally, it has been used throughout the COVID pandemic, as a means of keeping social distance in bus stops and rail stations.



5 Big Data. The term 'big data' refers to predictive analytics (or behaviour analytics) to identify behavioural patterns. Big data uses advanced data analytics methods that extract value from large quantities of data, generally through statistical correlations. Once this is done regularly on the same data, systems, using artificial intelligence, learn patterns and can predict even better future outcomes.

A few areas where Big Data is being introduced in Public Transport:

Planning, routing and rostering are experiencing a revolution with the introduction of algorithms and big data. Two key areas:

- For transport authorities, they get better tools for planning routes, timetables and frequencies of public transport services.
- For operators, data and algorithms allow more efficient use of resources when planning and rostering and scenario planning. Optibus (Optibus.com) is a great example.
- Daily operations are also starting to see a significant change through Big Data and Analytics. Control rooms get real-time information on services, as well as other useful feeds such as weather or traffic information. Digital tools help produce simulations and scenarios, helping controllers manage the daily operation of the transport services.

Review and efficiencies. Big data can also help refine the operation in several areas:

- Income management. Through Big Data, we can 'follow the customer' (e.g. pedestrian flow areas with no public transport provision), and design routes in a scientific way, complemented by traditional intuition.
- We can also use Big Data to calculate and predict capacity. Not just for the obvious (e.g. sports events or concerts), but also for the regular changing patterns of people travelling.

Digitalisation – New Digital Tools

At the heart of any potential disruption (or opportunity) in transport, we will have the Value Proposition: moving a customer from A to B in the most efficient, and cheap way, frictionless.

We can then assigning a single-decker bus or an eight coach train instead of a double-decker or a twelve coach train if these are not required, reducing costs.

- Another excellent use of Big Data is identifying **bad behaviours leading to cost** e.g. misuse of spares, or productivity deviances.

Data Analytics and Big Data are likely to become one of the key digital transformations in Public Transport.

6 Virtual Reality. Virtual reality is a computer-generated simulation of an environment that can interact in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors. Virtual reality could help public transport in some key areas:

- **Route learning**, traditionally done 'on the street' or with expensive simulators.
- **Engineering**, with more expert or specialised engineers supporting less experienced ones from a distance, even from home.

7 Augmented Reality. Augmented reality is a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view.

Augmented reality can be used in some areas:

- Providing **extra information** to passengers (e.g. station environments or complex transport interexchange), overlaying navigation instructions on a mobile phone camera view of the reality.
- Facilitating **engineering** by overlapping virtual information on the physical engine or device.

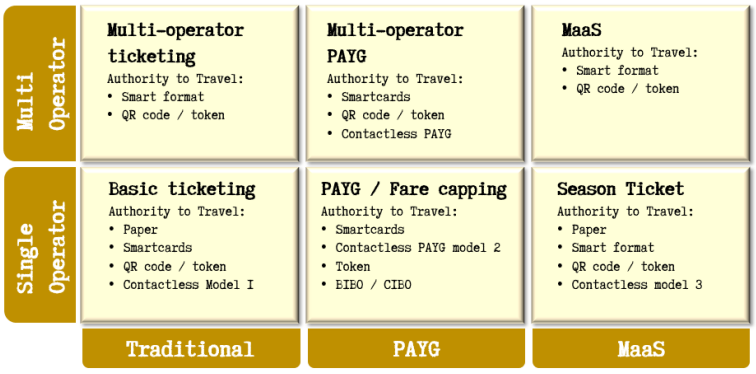
8 Robots. The Oxford dictionary defines robots as a machine resembling a human being and automatically replicating certain human movements and functions.

In the future, we are very likely to see robots in many roles in public transport, starting with those involving risk (e.g. rail tracks), or those manual and repetitive such as station gate management.

Digitalisation – Ticketing

When it comes to ticketing in Public Transport, we need to look carefully at the Value Proposition: the customer does not value a ticket, or a payment. The customer wants to move from A to B in the most efficient, and cheap way, frictionless. They only value price and simplicity of process.

Unfortunately, travelling is not cheap. Or simple…



Ticketing and payments are among the most challenging areas to predict, as digital tools' development will depend significantly on the development of social and transport policies. Three potential scenarios:

- Artificial Intelligence is very likely to eliminate a significant number of jobs, leading to the introduction of a universal salary. In this context, all public transport may simply become free, with no need for tickets.
- As Public Transport grows in importance due to congestion, and good links, speed and efficiency become key, Local and Regional authorities may become more powerful and regulatory, franchising (or even owning again) all public transport.
- Public transport may evolve further into private hands, in a deregulated environment, encouraging competition.

After COVID, the most likely scenario is the second one, where public authorities may take the risk on income, while private operators run the operation in the most cost effective way. This is, in essence, the model for Transport for London.

In any case, we are very likely to see a big difference between ticketing in cities ('islands') and long-distance ticketing ('bridges').

Cities are very likely to run their own ticketing schemes, similar to what TfL does in London. In this scenario, fares will become really easy (probably Zonal), and 'post-payment', where payment happens after travelling, not before travelling, becomes the rule.

The 'Islands'

There are 50 populations in the UK with over 100,000 inhabitants. And the trend is growing. To cope with this influx of people, Public Transport serving these urban populations needs to have the following characteristics:

- Intensity of services, especially at peak times.
- Diversity of services: train, tram, bus, park & ride, underground, taxi, micro-mobility.
- Strong need for simple tariffs, simple ticketing and payments.
- Strong need for interoperability between operators.
- Fast onboarding and alighting.

Digitalisation – Ticketing

The way to reconcile all these requirements is through tokens and post-payments through an Account Based Ticketing (ABT). A Token could be anything, a smartcard, a QR Code, a tag, anything that couples the travelling individual with a bank account. The most common ones are very likely to be contactless cEMV (credit and debit cards) and Apple or Google Pay. However, a simple RFID enabled tag or bangle linked to a credit card could also work as a token. In reality, post-payments through an ABT, eliminate the concept of a ticket, as this is not a critical part of the value proposition. You just pay for the service, as you go.

Anything can be connected to an ABT system. The 'islands' will start small, offering post-payment on a certain mode of transport, quickly realising that this principle can also be applied to other costly areas such as public car parks.

The topic of the unbanked often comes when cEMV and tokens are discussed. The likelihood is that this issue will get resolved by introducing pre-paid cards by Fintech companies, maybe white labelled with the name of the Public Authority funding the cash in the first place.

Geo-fencing may also become very prominent in the 'islands'. Geo-fencing uses the GPS signal on the phone (location services) or an i-Beacon (Bluetooth), or both for safety, and can be used in combination with a registered mobile application, to offer post-payment through an ABT system. On proximity with the geo-fenced area, the phone creates a 'virtual tap'. On exiting the geofenced area, the phone creates a second 'virtual tap'. Like physical taps, virtual taps are used to calculate the fare and charge by a back-office system (ABT). The fare can then be capped to a limit, for instance, a daily limit. The use of this technology is very likely to be generalised in the future, and will lead to many opportunities on top of the basic ticketing:

- Personalised real-time information (e.g., targeted alerts to users for their specific or habitual transport needs, based on location).
- Personalised offers, in conjunction with local retailers (using the geofencing and location services to tailor the offer when the person comes into the geo-fenced area).
- Sentiment mapping, where passengers express their views on services through their phone, suggest improvements to routes, maybe provide electronic alerts when something is nor working (something like Waze do on roads).
- Identifying vulnerable passengers and their location so we can provide protection.

The 'bridges'

Unlike travelling in urban populations, long-distance travelling has the following characteristics:

- Time to plan the journey.
- Expensive tickets, typically over the limit set for contactless cards.
- Possibility of printing a ticket.
- Often multiple legs and means of transport.
- Slow onboarding and alighting.

In long-distance travelling, passengers are more willing to accept the concept of a ticket. The idea or post-payment is very likely to struggle in a long-distance environment. For operators, missing a £100 payment on a fraudulent long-distance ticket is a lot more significant than missing a payment on a £2.50 urban ticket. For customers, the risk of being charged the maximum fare should they forget to tap off on exit is unfathomable: a single ticket between St Ives in Cornwall and Inverness in Scotland for a day in November 2020 was £259.30 (£380.40 first class).

Digitalisation – Ticketing

For post-payment to work in a long-distance trip it would require a digital way to verify an individuals presence at the beginning and end of the journey, and in the interim locations. This could be achieved through a 'closed system' of full gated stations, similar to the tube in London, or through an 'open system' with an 'always-on' GPS tracker attached to the individual, like a chip implant. Apart from the obvious limitation on acceptance of the implant, and the probably unaffordable cost, there would be a whole host of data security and data privacy issues, making post-payment on long-distance an improbable solution to travelling.

This, leaves us with the following digital options for long-distance travelling:

- QR Codes, on phones or 'print from home', which is, of course, the solution chosen by the airlines, or;
- Contactless cEMV 'Model 3', the credit or debit card used to pre-purchase the ticket is also used as authority to travel for the journey.

There is a very strong possibility that anything not belonging to an island or a bridge may get forgotten. Typically in rural areas. An excellent solution for these may be **Demand Response Transport**, explained in page 8 of this white paper.

Ticketing as a Service

Just like the significant move to Software as a Service (e.g., Office 365), we are very likely to see a significant increase in the offer for Ticketing as a Service. Just like Office 365, it may be a little more expensive than a traditional software and hardware purchase. However, the advantages on availability and lower need for internal resource to support and maintain, will make it very attractive and, properly deployed, even maybe cheaper than today.

Blockchain

Blockchain is one of the most complex technologies developed in the last few years and one that we may not be using much in Public Transport.

Blockchain (or Distributed Ledger) is a growing list of records called blocks linked using cryptography. A blockchain is resistant to modification of its data by design, making it an ideal tool for adding trust in an untrusted environment. A great example of the application of blockchain is in the food supply chain. As changes cannot be made in a block chain, it can help suppliers prove the origin of a certain batch of food and track its origins safely.

The potential use of blockchain in Public Transport could be ticketing, especially for inter-operable transactions that require trust. However, blockchain is today a costly tool, requiring much energy to create the blocks. I can't see blockchain making its way into Public Transport any time soon.

Conclusions

"I do not believe that you can do today's job with yesterday's methods and be in business tomorrow."
Horatio Nelson Jackson, physician and automobile pioneer

Although Public Transport is a somehow traditional and asset-based sector, it is improbable to be immune to digital disruption, and both transport authorities and transport operators need to remain open to new opportunities and vigilant of new threats. Both opportunities and threats can come from three different angles: new digital businesses (mainly 'digital layering'), new digital models and new digital tools.

If somebody had told us in 2019 that we would all be working from home throughout 2020 (and most probably a big part of 2021), we would have laughed. New Digital Models are happening and will continue happening. New physical needs will bring new digital models that complement traditional ones. The 'gig economy' and the 'share economy' are very likely to be on the increase, with younger generations being more willing to share with others than those of us maybe a bit more uncomfortable with it. Operators must take these new entrants seriously, and try to compete at the same level, even if this means introducing an element of 'business cannibalisation'. Or partner up with them. Otherwise, income will simply erode.

Healthy living and Active Travelling are very likely to become the starts of the 2020s and one to embrace and incorporate in our offer.

However, the most significant threat for public transport is not from the digital world, but from the aftermath of COVID-19. Many people are staying at home for work, and some others reverting back to their cars after using them for months as a theoretically 'safer bet' on the virus. New Digital Tools will help operators and authorities deal with the impacts of this pandemic in Public Transport, making it more attractive to customers, and increasing efficiencies or reducing costs. Those clever enough to embrace new digital tools and to create internal capabilities will reap the rewards of a happy customer and a healthier P&L account. Those who ignore these new tools and insist using traditional approaches, do at their own peril.

Throughout this paper I have highlighted how at the heart of any potential disruption (or opportunity) in transport, we must chase the Value Proposition of moving a customer from A to B in the most efficient, cheap and frictionless way. This is all customers want from us. When implementing new digital models and tools there is always the temptation to go for the new and trendy. When evaluating digital implementations, we must always design them in the context of the value proposition to the customer. Fads, will waste our hard earned money. Gimmicks, may alienate the customer.

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