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Improving journeys by opening data: The case of Transport for London (TfL)

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Abstract

Purpose – This case study describes how one of the world's largest public transport operations, Transport for London (TfL), transformed the real-time availability of information for its customers and staff through the open data approach, and what the results of this transformation were. Its purpose is therefore to show what is required for an open data approach to work.

Design/methodology/approach – This case study is based mainly on interviews at TfL and data supplied by TfL directly to the researchers. It analyses as far as possible the reported facts of the case, in order to identify the processes required to open data and the benefits thereof.

Findings – The main finding is that achieving an open data approach in public transport is helped by having a clear commitment to the idea that the data belongs to the public and that third parties should be allowed to use and repurpose the information, by having a strong digital strategy, and by creating strong partnerships with data management organisations that can support the delivery of high volumes of information.

Research limitations/implications – This research is based upon a single case study, albeit over an extensive period, so the findings cannot be applied simply to other situations, other than as evidence of what is possible. However, similar processes could be applied in other situations as a heuristic approach to open data strategy implementation.

Practical implications – The case study shows how open data can be used to create commercial and non-commercial customer-facing products and services, which passengers and other road users use to gain a better travel experience, and that this approach can be valued in terms of financial/economic contribution to customers and organisations.

Social implications –This case study shows the value that society can obtain from the opening of data in public transport, and the importance of public service innovation in delivering benefits to citizens.

Originality/value – This is the first case study to show in some detail some of the processes and activities required to open data to public service customers and others.

Keywords Open data, public transport, app development, customer information, cloud hosting, customer benefits

Paper type Case Study

Introduction

This case study describes howone of the world's largest public transport operations, Transport for London (TfL), transformed the real-time availability of information for its customers and staff through the open data approach, and what the results of this transformation were.This study is based mainlyon interviews at TfL and data supplied by TfL directly to the researchers.It describes how TfL makes data available through APIs, static data files and different feeds.This data includes live arrivals, timetables, air quality, network performance and accessibility, available under a version of the Open Government Licence, soit can be used for commercial and non-commercial purposes. TfL does not release personal or commercially sensitive data. Businesses such as Waze, Twitter, Google, Apple, Citymapper, Bus Checker, Bus Times and Mapway, as well as academics and professional developers, partner with TfL and use the data to create commercial and non-commercial customer-facing products and services, which passengers and other road users use to gain a better travel experience. Insights from the data can stimulate new ways of thinking at TfL, increase network demand and improve customer satisfaction.

The context

Urban public transport is part a wider system that helps hundreds of millions or more people travel every day, whether as workers, tourists or shoppers. It attracts billions of dollars of investment by national and local governments annually. Innovation by urban public transport authorities is a key contributor to industrial progress and to the happiness and well-being of those who live in cities. In London, one of the capitals of the world's digital industries, hosting asit does the European headquarters of some of the world's top digital companies, there is an expectation that public transport management will take advantage of the

latest in digital technology. It is TfL's task to ensure that it does so, particularly in the capital of a country where most citizens are comfortable with digital access to information. In this, it is helped, as are some other large city public transport authorities, by the fact that it reports to a single point of authority, the Office of the Mayor, which has few other direct responsibilities, so London's transport quality is a key indicator of the success of the elected Mayor. This is against a background of questionable progress in public services innovation, not just in the UK but also in other developed countries (Kelly *et al.,* 2014) and of a realisation that public service transformation requires a new approach to the use of public data (Peel, 2017). In the UK, digital innovation tends to succeed more in public agencies that are relatively compact and very focused on delivering public services efficiently e.g. the Passport Office and the Driver and Vehicle Licensing Agency.

TfL's scale

The scale of TfL is indicated by the statistics below:

- Delivering7 million passenger bus journeys per day, managed through contracting out operations to other experienced transport operators, stopping at 18,000 bus stops
- Directly delivering 5 million Underground train passenger journeys per day, stopping at 270 stations
- Regulatingover 21,000 London taxis (black cabs) London taxis and over 88,000 private hire vehicles
- Ensuring the safety of an estimated 670,000 cycle journeys every day
- Managing 580,000 km of London's roads, carrying 33% of London's traffic
- Helping millions of pedestrians go to work, shop or enjoy themselves by walking on London's streets
- Providing safe and secure transport for the 8.7 million London residents (it will be 10.5 million by 2041) and the 7m who commute to London, but also for the millionsof tourists who visit London every year.
- Managing 33,000 passenger river trips every day.

Public transport services are dominated by TfL, the executive agency for transport in London. TfL controls most public transport, including the Underground, London Buses, Tramlink, the Docklands Light Railway, London River Services and the London Overground train network. It also controls most major roads in London, but not minor roads. There areseveral independent airports in London, including the UK's busiest airport, Heathrow, the expansion of which will (if it happens) place greater demand upon London's public transport network. TfL is engaged in several major development projects, including the nearly completed CrossRail, which will link Heathrow to the centre and East of London, and possibly in the future CrossRail2.

London's public transport network is very advanced, due to continued investment over the last two decades, leading to a rise in underground and bus service capacity of 29% and 35% respectively in 2000-2017, and improved reliability of 47% and 46% for underground and bus. Network improvements have allowed London to rise above other large European cities in the public mode share, from being one of the lowest (24%) in 1995 to the highest (47%) in 2012. Satisfaction with the public transport network exceeds 86% across all modes – an increase of around 7% since 2009/10. The network also includes several national and suburban rail companies not controlled by Transport for London, whose major termini includeVictoria, Charing Cross, Waterloo, Paddington, St Pancras International, Euston, Liverpool Street, Fenchurch Street and London Bridge.Bus services are provided under contract by several specialist public transport operators, such as Abellio, Go-Ahead, First Group, RATP, Stagecoach and others.

Opening of data in public transport

The opening of public transport data has attracted increasing interest from academics (Jäppinen*et al.*, 2013; Hillsman and Barbeau, 2011). One angle is analysis of ticket purchasing data or smart card use (Pelletier *et al.,* 2011; Brian *et al.*, 2017). Some research is in the wider context of the idea of smart cities, monitored and managed by pervasive computing, with benefits of reduced congestion, more cost-effective travel to and from work and leisure, and wider benefits such as improved lifestyle, innovation, creativity and entrepreneurship (Kitchin, 2014; Bakici*et al.*, 2013). However, until now little has been published about how a city moves to opening its public transport data and the consequent benefits to stakeholders, from the passengers (whether leisure or travelling on or to work), to organisations and to the city overall. This is a case study of how London, more specifically TfL, opened its transport data to achieve a range of benefits.

TfL as information platform manager

TfL operates through several different business models, which include the following:

- Direct provider, in the case of the underground rail network
- Customer, in the case of the bus contracts
- Regulator, in the case of taxicabs
- Infrastructure manager, in the case of most of the main roads and their signage and signalling

Consciousness of business model and the need to manage business model innovation is an important theme of strategic management thinking (Stott, 2016).This article describes the emergence of a further business model, that of information platform manager. Here, TfL is part of a significant trend, in which "real" businesses identify that one of their assets is information that arisesfrom their activities, usually their day to day operations but in some cases their marketing activities, and that it must be managed as an asset (Stone *et al.*, 2017), becoming a platform that unites the activities of an ecosystem.

The digital drive in London

The opening of London's transport data is part of a wider digital drive by TfL. This includes:

- A TfL website offering a full range of services (interactive travel and customer information, email messaging and ticketing services), optimised for mobile access and with on-system travel information provision via electronic information displays providing real-time, multimodal travel information
- Data openly syndicated to third parties, where this is commercially, technically and legally feasible
- Digital marketing channels integrated with traditional media, wherever relevant to the target audience
- Social media used on the TfL website, and engagement with relevant 'off site' communities
- TfL digital collateral used to generate secondary revenue and to build strategic partnerships that allow cost-effective service delivery.

The syndication model is via the TfL website, using common licensing, processes and agreed standards for electronic data, with self-service, plus bespoke support for key partners. Core information will be on the TfL website and on-system digital information. Additional TfL services are the mobile version of tfl.gov.uk, syndication of data and digital marketing messages. Third party services are mobile applications, web services and live travel information on digital signage at venues.

TfL's digital strategy

TfL's digital strategy is as follows:

- Providing consistently high-quality user experiences in all channels and touchpoints, allowing fast and efficient interaction
- Creating user interfaces that are consistent across services and channels and centredon the user
- Quality of experience that matches customer expectations in the world outside TfL
- Integration of customer experience across multiple services and channels, so the same task can be performed on different devices by customers or by staff, in a seamless way.

Specific customer-related aspects of this include:

- Experiences can be continued seamlessly from channel to channel
- Unified customer account for all services with a TfL ID
- Shared information across all channels and services, to serve customers faster and better
- Each interaction always builds upon the last, to save customers time
- Staff empowered to assist customers with the right details at the right time
- All customers registered where possible, so that they can receive the best service and be notified of things they need to know
- Push messaging in customers' channels of choice, tailored by customer preferences
- Using all TfL information to get the right message to the right customer at the right time, not overloading the customer.

The importance of innovation

The innovations visible to most TfL customers include the Oyster contactless payment card (and now the use of contactless payment cards of all kinds), the use of data arising from social media to provide information to customers, and the use of data on the state of the network to make journey planning easier for travellers. The latter has been shown to be one of the top priorities of travellers (Beck *et al.*, 2016). London is not alone

in innovating this way – indeed, public transport authorities are known for their sharing of information on innovations.However, TfL's approach is world-leading and the subject of this article.

The role of data

TFL aims to deliver its digital strategy by producing, acquiring, analysing, linking, sharing and using data, to improve services, to keep customers and staff better informed and to focus commercial propositions, by:

- Investing in storing, linking, analysing and sharing data to improve performance, reduce cost and improve service
- Usingthe 'Internet of things' to supply data to power operations and customer services
- Developing methods and systems to enable a single view of the customer
- Using interfaces to make existing and new data available to improve service for customers and staff
- Giving staff access to customer data needed to deliver better service
- Continuously improving reference and real-time data
- Providing data to a community of third parties to help address London's challenges, create new and innovative services, link information from different sectors and to make things better for customers

To preserve privacy, TfL explains to customers what data it has and how it will use it, while customers can control how TfL uses their data, by giving thema choice of levels of data usage, tracking, and control through a TfL privacy centre of information. Customers (and staff) receive information and can interact with TfL in their locations, devices and channels of choice, with universal access to an integrated suite of tools and services through popular web browsers, using native mobile apps for core TfL services on the key mobile platforms, a social media presence to deliver information, engagement and customer service, and push notifications through the key messaging platforms.

The shift to customer focus and its information implications

TfL's customer promise, "Every Journey Matters", represented a big shift for TfL, from being a transport operator, focused on operational performance and efficiency, to a customer-focused operation whose main measures of performance relate to whether its customers get to where they want to go, and when they want to be there.It is of course an aspiration. London is one of the world's busiest cities, with - it seems - everyone trying to get to and from the centre in a few hours every day, many of them wanting to do it "their way", whetheror not it would make sense to a "rational" transport planner - driving cars into congested areas, travelling when everyone else is travelling. It is the same in most cities, so transport networks come under pressure, not just in the morning and evening rush hours, but for most of the day. This can be exacerbated by policies with other clear benefits, such as encouraging particular customers (e.g. the young and the old) to use public transport for health and other social reasons (Jones *et al.*, 2012; 2013).

The slightest glitch multiplies pressure on transport systems, so customers need not only to know when and where to travel and by what means (or "mode"), if all is going well, but also which Plan B to use when their preferred mode is not operating as they would like or as planned. They therefore need a full and free supply of information, perhaps when they are in a hurry or when moving between different modes or between two parts of the same journey by a given mode - changing trains or buses.The idea of a perfectly integrated transport system has long been in the sights of TfL, but is hard to achieve, although customers appreciate the benefits of integration(Chowdhury *et al.*, 2015). A large urban public transport system is very different from an airline, which may have a relatively small number of aircraft arriving and then departing from the same airport.TfL's main focus is to keep the frequency and routes right and avoid delays.The need for this is particularly acute, as London's population keeps growing. If this growth persists with no change in transport habits, particularly use of cars, then London will become more congested, so the Mayor of London's Transport Strategy(2017) aims to increase public transport and foot journeysi.e. excluding car, private hire or taxi services) from 64% to 80% of all journeys, by 2041, with the total number of journeys rising from 26.7 million to 32 million. This will be helped by digital technology reducing the number of journeys made to shops and increased ease of working from home. Digital platforms –smartphone apps or websites – help peer-to-peer transactions between those seeking information on or access to transport and transport service providers, including journey planners, car clubs and on-demand private hire, and, when operating in a network, may help travellers to move from ownership of vehicles to their use as a service.A critical step on the path to greater efficiency was to open data on the travel system.

Initial concerns

The journey to opening the data was not smooth. Many at TfL, an operation concerned with the safety and well-being of its customers saw all the risks. What would happen if the information was not presented accurately or was presented late? What if it was plain wrong? Who would be liable? If there was serious misinformation and this led to overcrowding, who would have to manage the problem? What about the security risks? What about customers who were not connected? What about more vulnerable and younger customers? However, app developers were already downloading PDFs of timetables and "scraping" them to redigitisethe information, but timetables told only a static story, of what was meant to be. In other cities and transport sectors such as airlines, opening data was the preferred option (e.g.flightlocation, planned, actual and forecast arrivals and departures). For TfL, it meant providing the location of every bus and train.

The first steps

The decision to open the information was taken in 2007, in the context of the then forthcoming Olympic Games (2012). The team focused on how to do this in innovative ways - being innovative is considered a central aspect of management at TfL.TfL first opened the data, and then engaged fully with the high-tech industry, particularly app developers. A crucial part of this was the recognition that TfL was effectively a very large information platform, which "happened" to run a transport operation. This advanced view of managing operations is taking hold in many sectors, leading to probing customers' needs for information (including the many organisations who depend on making travel work – including other transport operators - and/or who make money out of providing travel information in ways that customers want). Network Rail, responsible for data on national rail services,has followed a similar course in opening its data. Network Rail and TfL work closely together to provide information for journeys combining rail and TfL travel. The contracting bus companies also needed to be included.

TfL faced two choices - to provide all the information themselves to customers, or to open their information, which is used by at least 42% of Londoners, to any app developer who could provide the information to customers in better ways, on a variety of devices – computers, mobile phones, intelligent agents etc. TfL chose the latter route, accepting that the public, who funded it, owned the data, and announced that it would be made widely available, as providing free open data was part of TfL's commitment to transparency and offering better products and services for customers. It would help developers use the data to produce innovative and valuable travel information and other apps for their customers. TfL would continue to develop its own resources, such as the Journey Planner and the live bus timetables, complemented by the emerging digital economy or third-party developers creating smartphone apps using TfL data.Some legal issues needed to be dealt with. For example, the terms and conditions for the use of the data were formally for personal use only, and this clearly had to be changed.

In 2010, the Greater London Authority (GLA) set up its London Datastore (https://data.london.gov.uk/), the data in which can be used, re-used and redistributed by anyone. It can support operational service improvements, development of new customer-facing products and services, increase transparency and innovation and challenge existing ways of working. It now includes not only TfL data, but many other data sets, including planning and employment data.TfL made over 80 data sets, including real-time travel feeds, available to developers via the TfL websiteand the GLA London Datastore.TfL engaged developers of apps and worked with them on the design of the API, allowing access to early versions, and working in partnership to exploit the possibilities that the data provided. TfL's own apps are also important, TfL is particularly strong at apps which deliver accessibility for the 14% of Londoners who have an accessibility need.

Platform requirements

The platform had to be provided:

- Securely – so that it could not be tampered with and so that the running of transport operations could not be affected by unauthorised people
- Equitably – so that every user had the same, excellent, quality of access
- Reliably – so that the data represented the reality
- In real time – so that the reality was the reality of the second, not that of a few seconds ago
- Openly – so that anyone who wanted the data could get it unless there was a clear, undisputable legal, commercial or technical reason why it could not be provided.

The data includes timetables and real-time tracking of buses and trains, congestion information and fares. The information is accessed about 10 million times per day and is updated at least every 30 seconds.

The timeline

Over the last ten years, TfL has become a leader in publishing Open Data through APIs, the cloud, the web and across its physical network, available to use by registered developers. The timeline for these developments is shown in Table I below.

[Table I Here]

Progress

By 2013, TfL had a new web site, hosted by Amazon Web Services (AWS), guaranteeing that high volumes of usage could be sustained. Amazon's strength lay in its own experience of extraordinarily high data volumes, including of logistics. AWS also hosts data for another UK public service agency cited for its digital innovation, the Driver and Vehicle Standards Agency (Illsley, 2016). Other cloud providers are also used.

Migrating TfL's digital projects to the cloud has enabled TfL to become much more agile as it iterates new website and service designs, in response to changing customer requirements (e.g. a rise in mobile and geo-location based queries for journey planning) (Wentworth, 2015). The migration has made it easier for development teams to access real-time streams of travel and transport data, bringing much more immediacy and higher granularity to its services. TfL has been able to deliver its high volume of interactive services by using AWS services as a buffer between its back-office services and customers.

Peak loads on the website can occur due to bad weather or rail strikes, which can lead to a 20-fold surge in site visitors (most in a single hour at the start of the working day). In the past, TfL would have had to over-provision, but now it can auto-scale on AWS, scaling usage down later, to get more efficiency. Prior to TfL moving to a cloud-based infrastructure, TfL was mainly limited to supply of flat files of data. There were few real-time feeds and it was difficult to cope with releasing travel data to multiple parties at web-scale.

TfL's move to cloud has unified all its transport data (compared to before, where it was all on different systems, in different formats, in different parts of TfL). This has simplified developers' access to data and facilitated access to real-time streams in consistent formats they can work on. Data is supplied by TfL's own teams (those responsible for managing the services that collect or generate the data). They also become internal data consumers themselves (for TfL's projects based on this data) alongside external developer / researcher consumers in TfL's ecosystem. In some cases, vendors also become involved, where an API is needed to connect with back office systems.

TfL has found AWS' cloud platform very flexible. It can rapidly prototype ideas on its 20 development environments (where it previously only had 4), and replicate the production environment for parallel work to meet the dynamic demands of the business. This has much reduced time to-market for new services (for example, being able to move to an entirely new cloud infrastructure for its Journey Planner engine in under two months). TfL has also experienced lower costs because AWS' services are paid for by the hour.

From its growing ecosystem of mobile app developers helping today's travellers get from A to B, to academic research teams helping TfL improve London's transport network in the longer term, TfL's open data policy has enabled third party organisations to benefit from real-time, highly granular, high quality transport data. The interest these parties have shown has created a quality feedback loop that has encouraged all data contributors within TfL to improve their data. The success of TfL's third-party app ecosystem has encouraged TfL to make a strategic decision to work more closely with developers.

Apps are the key

Over 600 apps have been developed, reaching millions of active users, although most usage is from a surprisingly small number of apps – just over 40, with the top apps amongst travel app users (based on claimed usage) shown in Table II:

[Table II Here]

Live bus travel data accessed via these apps saves as much as £58 million a year, by helping Londoners and the city's many visitors plan better routes and avoid long waits at bus stops. The service was so popular that in July 2010, a temporary halt had to be called on the newly-introduced API feed due to huge demand by apps that use the service, the feed was temporarily suspended.

How much does TfL know about journeys and customers?

Despite ticketing innovations (Oyster and other cards), TfL does not have perfect information on all the journeys its customers take. Many bus journeys are not tracked (e.g. for customers with paper Travelcards, or where the ticketing machine fails but the bus journey continues). With bus journeys, information is only logged on entry, not leaving. Many journeys from stations with no barriers are missed – for example, by those entitled to free travel. So, the information must be supplemented by classic market research-based Origin and Destination surveys, for TfL to meet its objectives of providing travel people want. This approach conforms with that of many public transport authorities, for whom market research is a central part of customer-focused innovation (Camacho *et al.*, 2016).

An additional information source for TfL is social media. This was valuable during the Olympic Games, when 6 million people used Twitter to talk about TfL. Customers often message about the state of transport, and this ensures that TfL receives notification from customers very quickly.

Passenger flow information is important for another area, TfL's advertising revenue, which funds improvements in the service, as TfL is not a profit-making body. TfL has one of the largest advertising estates in the world, and it is increasingly electronic. On the TfL website, if a customer is investigating a journey to Oxford Circus, then relevant advertising can be displayed, using a programmatic approach to show relevant offers from retailers, for example. Of course, the individual's own data is not revealed, in observance of data protection regulations.

The resulting ecosystem

The ecosystem that results from opening public transport data is shown in Figure 1. This shows the many different parties who benefit from and support the opening of data.

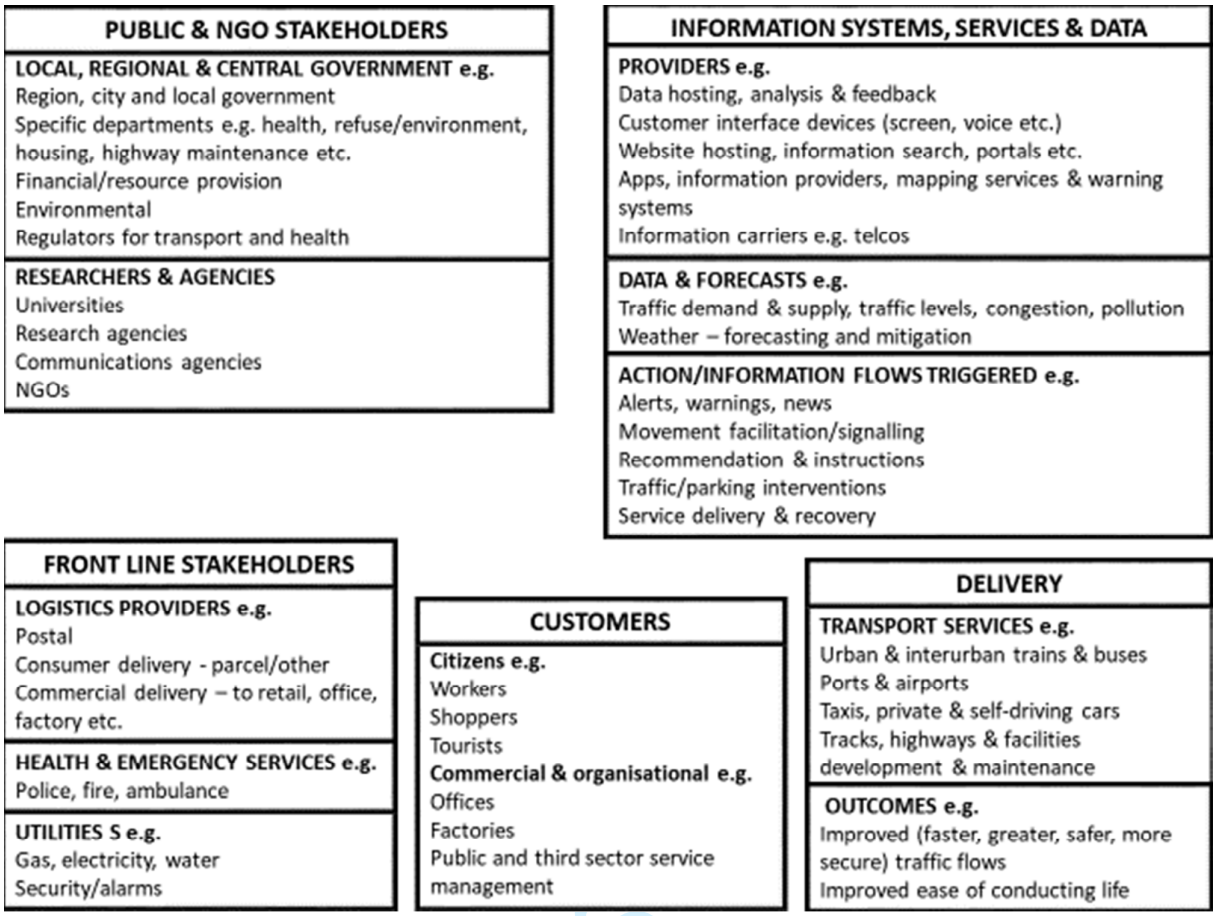

Figure 1: The ecosystem for open public transport data
Source: Authors

The savings

The savings to individual passengers and businesses fromopening TfL's data were quantified as worth £130 million per year (Deloitte, 2017), increasing the estimate published earlier (Hogge, 2016). Although the methodologies for these estimates (which are presented in these source documents) can be criticised on the grounds of its accuracy, the estimates had to be based on the data available at the time and on methodologies whose usefulness could only be tested after the launch of the approach (Hogge, 2016).The main savings are shown in Table III.

[Table III Here]

Encouraging its own competition?

TfL understands that by opening data, it may create opportunities for competitors. For example, Citymapper launched a central London bus service, using data on bus journey enquiries which users might think relates only to TfL. However, TfL's role is to improve every journey of its customers and not to make a profit. If a third-party provider, whether Citymapper or Uber, adds to customers' choices, this might be regarded as good. On the other hand, having different bus companies compete can lead to excess capacity and more congestion and pollution, while taxi firms with poor quality processes can threaten customer safety.

Continuing improvements

Information continues to be used to make improvements for travellers. Following trial at 23 Tube stations in February 2016, achieving a 3-5% shift in the times at which people travelled, localised station demand information showing busiest times at each station and on the lines serving it was released for all London Underground stations. The data was launched as part of new functionality on Tube station pages on

tfl.gov.uk. This was complemented with a social media campaign highlighting the busiest times at the 94 most heavily used stations, encouraging travel outside these periods if possible and suggesting alternative travel options including walking and cycling. Passengers told TfL that they found this useful. 64% of those who saw the campaign changed their travel. Busiest times for the River Thames Blackwall Tunnel and forkey DLR were also released in 2017.

The near future

The future is going to be interesting, as TfL's status as a massive Open Data platform has meant that the tech giants of this world, such as FaceBook, Twitter, Google, Apple and Microsoft, take it very seriously. TfL met with these players in its digital partnership summit on accessibility in June 2017 to identify what they can do together to make the lives of their shared customers better, using TfL's open data. Building on several apps already using TfL's open data, major technology organisations, app developers and representatives from disability groups worked on the challenges together. Trials are being carried out with FaceBook on the use of bots. The area of voicebots is under wider exploration, given the success of voice personal assistants such as Siri, Cortana and Alexa. One area of focus is to help disabled people. For example, Moovit, used by more than 60 million users in 1,200 cities, has implemented features to help disabled people, including comprehensive VoiceOver/TalkBack support for visually impaired people and larger buttons strategically placed on the app's bottom bar. This month, Moovit announced the most comprehensive route-planning service for London travellers with restricted mobility, such as step-free routes from street level to the train and lift availability. TfL is also working with partners and app developers to standardise features for users through consistent guidelines, irrespective of the app. In late 2015, TfL also began to hold "hackathons" with several London universities to see how TfL data could be used to manage the road network more efficiently.

TfL's open data API is being updated to include London's new cycle superhighways and the first Quietway. This data can be accessed by all app developers and mapping websites, allowing them to incorporate TfL's new cycle routes into their online mapping and journey planning information.

The long-term future – mobility as a service

TfL is examining the idea of Mobility as a Service (Jittrapirom *et al*., 2017). This involves moving from personal- owned transport towards transport consumed as a service, with public and private transport accessed via a unified gateway that creates and manages trips, which users can pay for with a single account, either pay as you go or on subscription. Services may include sharing of rides, cars and bikes and on demand "pop-up" buses. Cars may be self-driving. This move involves combining different transport modes into trip chains, using unified supply and demand data that allow users and providers to work together more effectively, focusing on mobility between destinations through all transport modes instead of forcing choice between competing modes. Without this integration, higher efficiency within modes can increase congestion, as has the rise of private hire vehicle use in London.Travel planning for customers begins with a travel planner not unlike today's, except that it shows options based on cost, time, and convenience and allow combined booking.

Implications of the case study

This case study shows the closeness of the relationship between success in achieving strategic objectives (in this case for customer service) and innovating in information management. It also demonstrates how far the opening of data can be taken, benefitting both supplier and customer. It also shows the benefits when an organisation creates and manages a data platform which it opens it up to end-users and intermediaries, using a partner's high capacity data hosting for where processing loads are subject to extreme fluctuations.

In teaching strategy, it is conventional (though becoming less common) to separate market-focused elements of strategy (products, target markets etc.) from information management aspects. This case study demonstrates the importance of an integrated approach.

Conclusion

TfL's open data policy has led to significant benefits for London's travellers and the organisations that employ them, receive them as tourists or shoppers, and for many others. The opening of the information has been key to these benefits, and as more data becomes available, for example for the deployment of the Internet of Things, new application areas will be explored, such as improvements in way of looking after London's growing and ageing population.

The open data approach works particularly well in public transport in situations of high user smartphone adoption, increasing ease of access to data and savings from app development as well as trust. Until the approach was adopted, it was hard to estimate the benefits, so public transport authorities might want to take TfL as an example of what is possible in terms of outcomes and benefits, and also as an example of how the benefits of opening data may be as large as those from major transport infrastructure development projects (Hogge, 2016). Put simply, having a great leap forward in infrastructure may deliver no more benefit than allowing users to use data to optimise their use of existing infrastructure.

However, providers of open data must also be wary of how the market for the information that they are providing freely and openly may develop, to ensure that companies that derive an economic rent from exploiting data do not try to capture the market for the information.

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Table I: Timeline for opening TfL data
Source: Deloitte (2017)

Year	Milestone	Number of registered developers
2007	Embeddable 'widgets' for live travel news, map and Journey Planner	
2009	Special area for developers launched on TfL website	
2010	London Datastore launched; additional TfL real-time feeds	100
2011	London Underground train location and Journey Planner APIs launched	1,000+
2012	Live bus arrivals API launched, full Olympic/Paralympic Games transport data	4,000+
2013	30 data feeds, hundreds of apps on the market. Review finds TfL data saves up to £58m annually for passengers	5,000+
2017	80+ TfL data feeds covering operational and corporate information across all transport modes.Around 75% of data available via APIs. 42% of Londoners use an app powered by TfL data; 83% use TfL website. TfL has data partnerships with app developers and digital partners, making its data available and receiving data back. Data is also made available via the GLA and data.gov.uk. Several hackathons held to engage with the community and receive feedback.	12,000+

Table II: Top apps for accessing TfL data
Source: TfL

Google Maps	56%
Apple Maps	42%
Bus Times London	25%
London Underground Map	25%
Citymapper	24%
London Live Bus Countdown	23%
London Underground	21%
Live London Bus Tracker	16%
Tube Map London Underground	16%
London Bus Checker	15%

Table III: Savings from opening data
Source: Deloitte (2017)

Savings for	Category of saving	Estimated annual savings
TfL passengers and other road users.	Saved time for network passengers on existing journeys due to better journey planning. More journeys taken. Unquantified - improved customer satisfaction from having accurate, instant information available.	£70-90m on existing journeys. Up to £20m on new journeys.
	Savings made from moving from SMS alerts - passengers can use free apps or free web services - a cost saving for those who used to use fee-based SMS alerts.	Up to £2m. Real time alert services - up to £3m.
London employment, companies and other organisations.	London-based companies generate revenue from TfL data commercially.	Gross Value Add directly and across the supply chain and wider economy - £12-15m.
	Job creation.	Around 500 jobs in London that would not have existed, 230 indirect jobs in the supply chain and wider economy.
Other savings for TfL include savings from not having to produce apps in-house, not having to invest in campaign systems, larger contact centres and publishing data, and through partnerships with data and software organisations, receiving back significant data where TfL does not itself collect data (e.g. crowdsourced traffic data), and allowing new analyses to be undertaken. In the long term, improved transport products will be facilitated, including transport as a service. Savings for citizens include improved lifestyle, through increased likelihood of taking public transport because data is available, leading to a healthier lifestyle (more walking), with reduced congestion leading to increased cycling. Since 2007, the number of people walking as their main mode of transport has increased by 13%.		