

Feasibility Study for “Mobility as a Service” concept in London

FS-MaaS Project – Final Deliverable



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Executive summary

Hyper urbanization, climate change, and demographic and societal changes are some of the megatrends that have imposed pressures on transport networks and set obstacles to door-to-door mobility. By virtue of technological breakthroughs many of the obstacles could be hindered and seamless mobility could be achieved.

Novel mobility services that heavily rely on technological advances could contribute to seamless mobility. Mobility as a Service (MaaS) is such a concept. The objective of the FS-MaaS project is to propose the design of a MaaS concept for London, the MaaS-London, and examine its feasibility.

To work towards the concept of MaaS-London, first, the supply and the demand sides of the London transport market are analysed. There are a variety of mobility services supplied in London such as car clubs (car sharing), ride sharing, bike sharing, public transport, rail and taxi which altogether make London an ideal ground to exploit MaaS-London.

The MaaS-London is an integrated platform that includes registration and package selection, intermodal journey planning, booking, smart ticketing and payment functions so that the entire chain of transport can be managed in this centralised platform. The most outstanding feature of MaaS-London is the provision of mobility packages, which consist of tailored bundles of mobility services customised to individual needs.

The feasibility study indicates that the introduction of MaaS-London will benefit both the supply and the demand side. Transport operators will benefit by creating a larger market via the integrated platform. Travellers will also welcome the concept due to travel expense and time reduction, and better service experience. MaaS-London is a feasible product that can well serve London transport market and contribute to London’s 2020 vision.



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List of Abbreviations

CO ₂	Carbon Dioxide
DLR	Docklands Light Rail
GHG	Greenhouse Gas
GPS	Global Positioning System
ICT	Information and Communication Technologies
IJP	Intermodal Journey Planner
ITS	Intelligent Transport Systems
LTDS	London Travel Demand Survey
MaaS	Mobility as a Service
MTS	Mayor’s Transport Strategy
NGO	Non-governmental Organisation
NO ₂	Nitrogen Dioxide
OG	Overground
P2P	Peer to Peer
RP	Revealed Preference
SWOT	Strengths, Weaknesses, Opportunities, Threats
TfL	Transport for London
Tr	Tram
UG	Underground
UK	United Kingdom

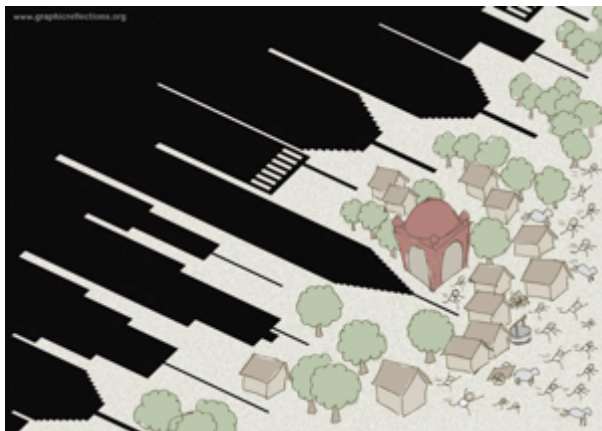


1. Introduction

Urban transport plays a fundamental role in meeting the objectives of economic competitiveness, social cohesion and sustainable growth. As such, an efficient transportation system has to be the heart of every successful city. However, the majority of today’s transport networks are the by-products of earlier systems that were designed to serve societies with rather different characteristics. Since then, certain key drivers have been restructuring the way we live and think, as well as the technologies we use in our every day life. This changed society strives for *efficiency and connectedness*, which need to be core features in modern transport ecosystems.

Understanding the drives, the pressures they place, and the changes they necessitate in urban transport networks are the first steps in creating transport systems suitable for today’s society. They can be grouped under four main megatrends, namely, hyper-urbanisation, demographic and societal change, climate change and technological breakthroughs, all that have been impacting the UK and especially London.

Hyper- Urbanisation



At present, about half of the world’s population lives in urban areas. In the UK, this number is as high as 60% of which 13% lives in London alone (ONS, 2011). London, as one of the world’s largest global cities, experiences all the challenges associated with urbanization and its effect on transport systems. The last decade of the 20th century saw London’s population begin to rise and between 1991 and 2011 the capital’s inhabitants increased by 1.7 million people.

London’s population in 2015 is 8.63 million, the largest it has ever been. Projected growth over the next thirty years is around five per cent per decade, with the population reaching 10.2 million in 2039 (GLA Intelligence, 2015).

As illustrated in Figure 1, the rapid growth of London led to urban sprawl, with high population increases in the outer boroughs and population decreases in central areas. The boroughs Hillingdon, Havering and Bromley, with the largest percentage increase in residents between 1939 and 2015, are all located in outer London. As the population of outer London grew, so did the need to travel to central locations, where most of the employment centres remain. This increased demand for travel has had and impending impacts on traffic volumes and congestion, which cause heightened economic and social pressures. For instance, the economic cost of congestion in the UK was £13.1 billion and £5.7 billion in London alone in 2013 (CEBR, 2014); while the average trip time has increased by 16% from 1995 to 2013 (DfT, 2014). The rate of urbanization, its imminent impact on traffic

Rapid
Urbanisation
=
Rapid Traffic
Congestion



volumes and resulting pressure on infrastructure capacity and resilience pose unprecedented challenges to urban mobility systems. Finally, all the pressures enhanced by urbanization also come hand in hand with increased emissions and air pollution, leading us into our second megatrend: Climate change.

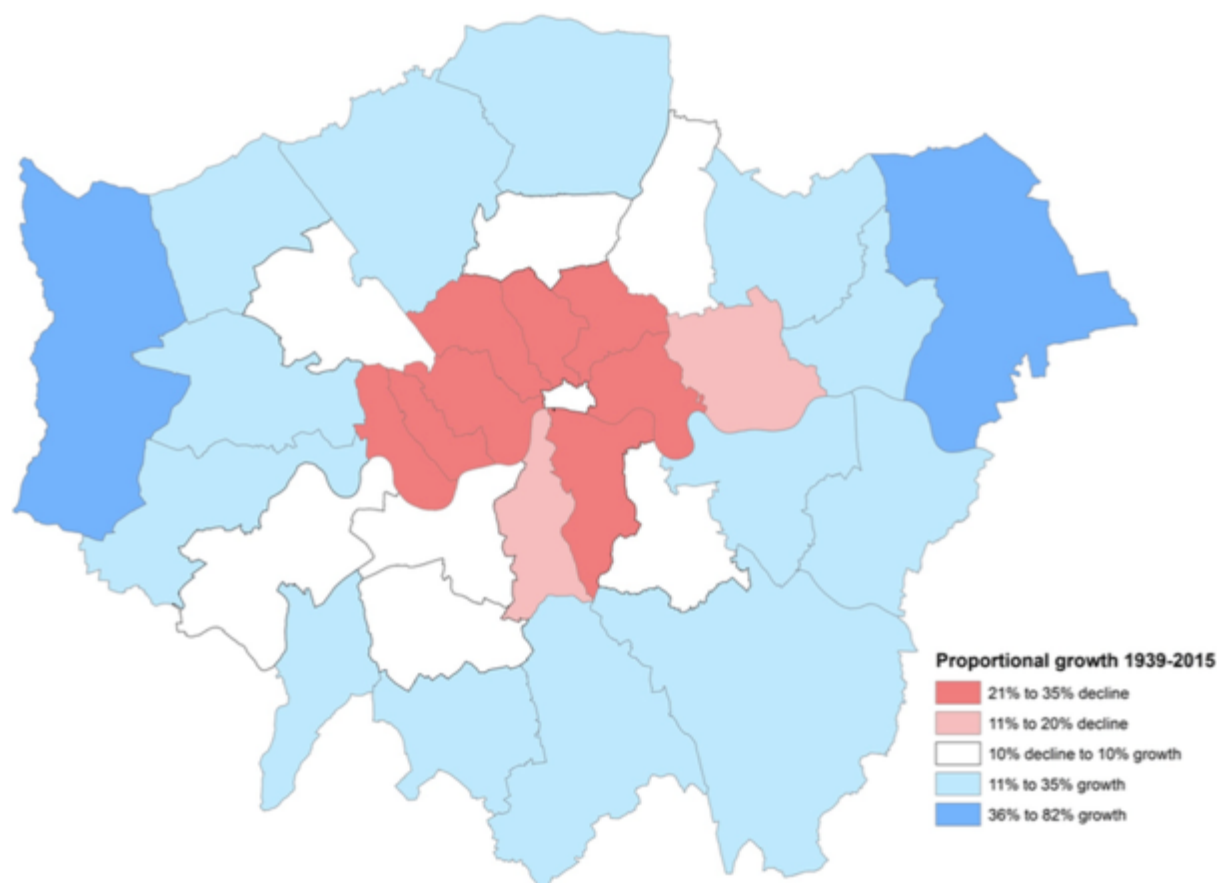


Figure 1: Population Change in London Boroughs, 1939-2015 (Source: GLA Intelligence, 2015)

Climate Change and Emissions

Climate change and transport have always been interrelated. As the transportation sector is one of the main contributors to greenhouse gasses (GHG) around the world, there have been countless policies and programmes to reduce their damaging effects. In the UK, 24% in 2009, of the GHG emissions were contributed to transport out of which 90% was accredited to road transport (VCA, 2015). Figure 2 presents the average levels of NO₂, an important GHG, related to transport across London in 2010. NO₂ levels in Central London, and especially along major roads are dangerously high. The same trend can be seen for other greenhouse gasses and pollutants.

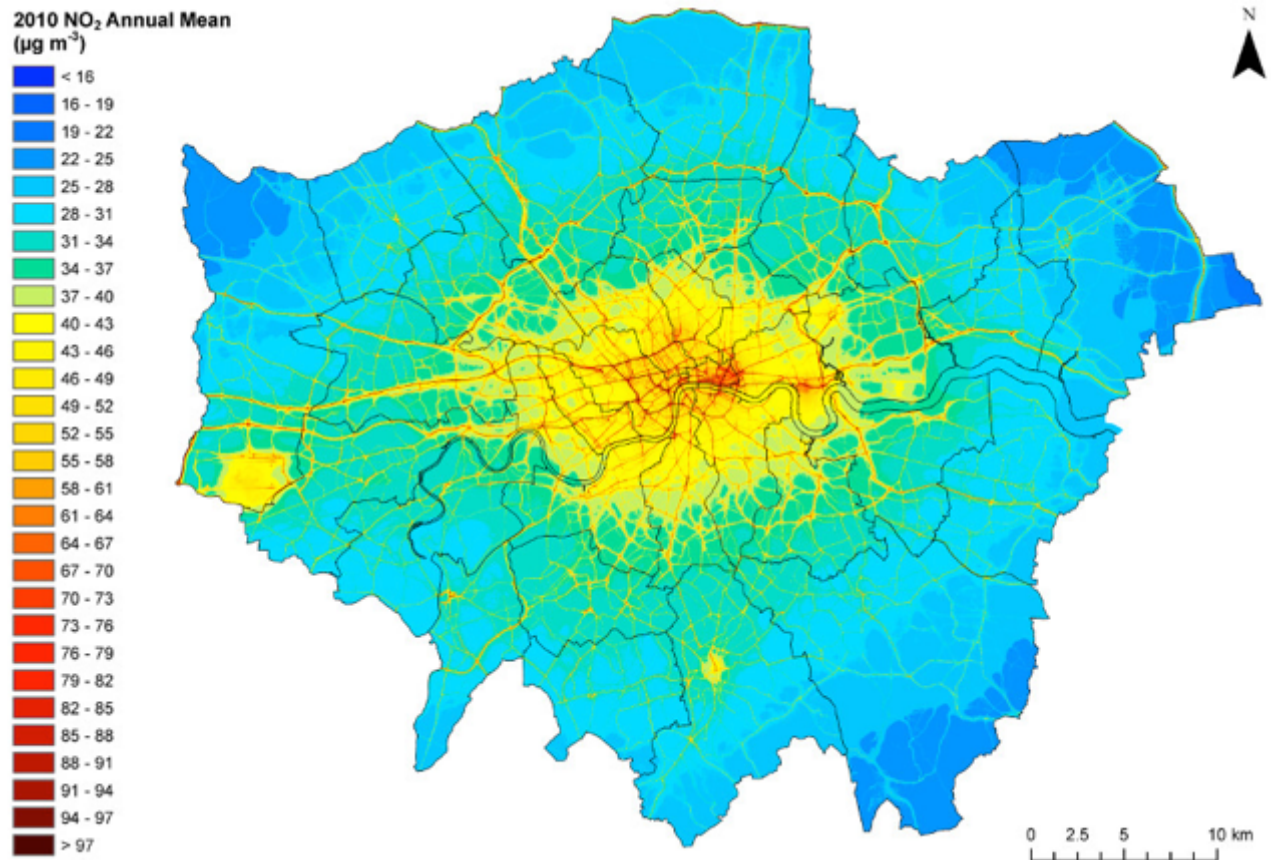


Figure 2: Average Levels of NO₂ Related to Transport across London in 2010 (Source: Cleaner Air for London, 2013)

An important way to curb emissions is to decrease private vehicle usage, which is a significant player in road emissions. This would also have the additional benefit of decreasing congestion. However, this requires severe attitudinal changes towards private vehicle ownership.

Demographic and Societal Changes

The average age of the UK population is increasing and is projected to rise to 42.2 by 2035 from 35.4 in 1985 (ONS, 2012). London's age profile however, stands out from the rest of the UK, as the median age at 34 is much younger than the UK average of 39.7 (ONS, 2011). This is especially important when looking at the changing mobility attitudes across generations. While the Baby Boomers vehicle buying habits were fuelled by the car's role as a status symbol, the significance of car ownership for Millennials has significantly decreased. Instead younger generations place much higher value on the electronic devices, such as laptops and smart phones, they own. While young baby boomers obtained their ultimate sense of freedom from owning their own cars, today teenagers and young adults achieve the same through mobile communication devices (Kamargianni and Polydoropoulou, 2014).

from
Ownership
to
Usership

This shift away from car ownership has brought a new consumer era with itself; the era of usership, instead of ownership. Today, young adults prefer *using services* rather than *owning products*. This trend is very visible in the transport sector, where young adults have fuelled the



emergence of car and bike sharing systems. According to the Carplus annual survey, in 2013 50% of car club members are under 34, while only 14% are over 50. These services are also able to better serve the increasingly heterogeneous mobility needs of urban residents.

Technological breakthroughs & Digital Gap

The past couple of decades have brought incredible advancements in information and communication technologies (ICT). Internet access has become widespread especially in urban environments. Figure 3 illustrates the regional distribution of Internet use for individuals over 16 years old. London has the highest proportion of ICT usage, with more than 90% of adults stating that they use the Internet. Almost everyone (99%) in the age group of 16 to 34 uses ICT. Only 37% of those above 75 use the Internet (ONS, 2014).

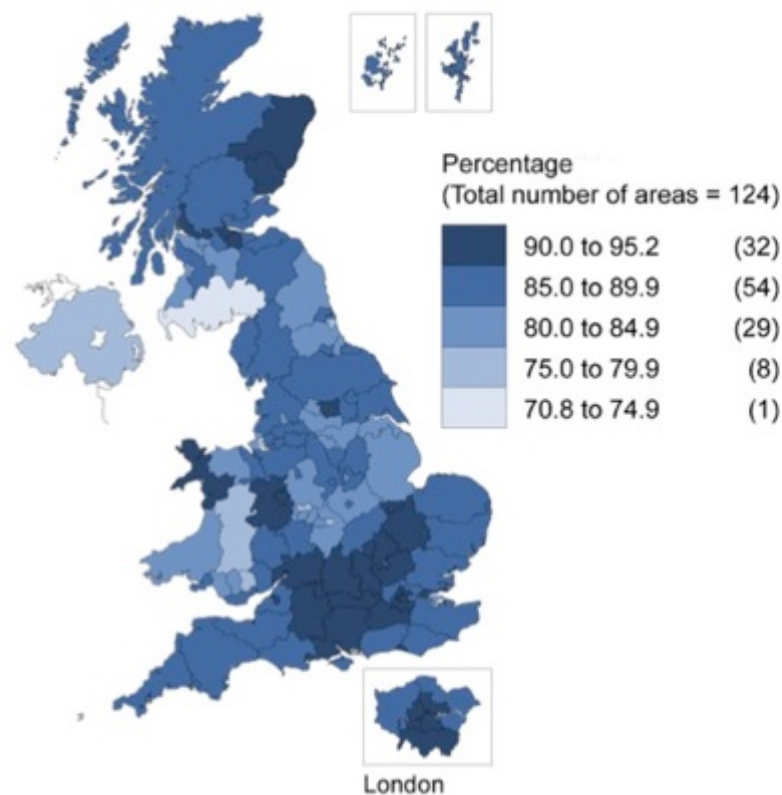


Figure 3: Internet Usage by Region, 1939-2014 (Source: ONS, 2014)

Such universally available Internet has helped facilitate ubiquitous data capture and allow robustly interconnected systems to surface throughout urban transportation networks. The presence of rich and real time data has had a tremendous effect on the personal mobility sector. They have enabled multi-directional communication between users and suppliers. From the demand side, it has revolutionized the way people plan their trips. There is a high level of dependency on real time data, especially in urban environments where even the smallest



disturbance in the transport network can have very large effects on travel time. The increasing penetration of smartphones has also helped facilitate this by allowing the exchange of information on the go. Whereas only one fourth of adults in the UK owned a smartphone in 2010, by 2014 this fraction increased to two thirds (Ofcom, 2014). Figure 4 illustrates smartphone penetration by age group. 18-34 year olds have the highest percentage of smartphone owners, while the over-55 age group has the least. From the supply side, technological advancements have enabled intelligent transportation systems (ITS) to support more efficient transport systems. Technology integration into the mobility infrastructure has become a core element of transport planning.

The Next Generation
has been “bathed in bits
and bytes” since birth.

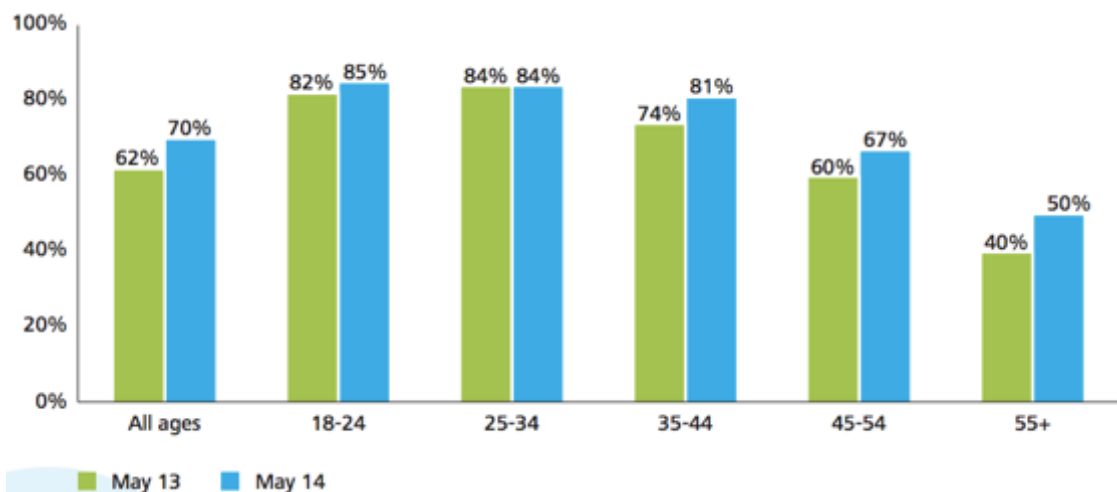


Figure 4: Smartphone Penetration by Age Group (Source: Deloitte, 2014)

What next

The discussed *megatrends* provide the necessity and opportunity for change in the urban transport sector. We believe that aiding sustainable modes of transport, such as shared and active modes, while at the same time offering seamless door-to-door mobility can provide a solution for the above-mentioned challenges. Seamless mobility is key to optimising the performance of the already existing transport infrastructure. The challenge is, that even though the transport industry has separate organisations for the various modes, this does not reflect how individuals think about and plan their journeys. The complexity of using a variety of transport modes (i.e. different payment methods, subscriptions, lack of integrated information etc.) discourages many people from using them. The key is to integrate the various transport modes in a way that creates seamless door-to-door journey experiences for users. The solution we propose to this urban mobility challenge is the Mobility as a Service (MaaS) concept.

The term “Mobility as a Service” stands for buying mobility services based on consumers needs instead of buying the means of transport. Via “Mobility as a Service” systems consumers can buy



mobility services that are provided by the same or different operators by using just one platform and a single payment. The platform provides an *intermodal journey planner* (providing combinations of different transport modes: car-sharing, car rental, underground, rail, bus, bike-sharing, taxi), a *booking system*, a *single payment* method (single payment for all transport modes), and *real time information*. MaaS users can use the service either as Pay-As-You-Go or they can purchase mobility packages based on their or their family’s needs. MaaS offers door-to-door seamless mobility and improves travel experience.

1.1 Objectives FS-MaaS

We present our analysis on the Mobility as a Service concept through a case study for implementation in London (MaaS-London). We chose London as our case study for a variety of reasons. First of all, the city is filled with young professionals who are septic to new ICT filled ideas. Second, London has a large basis of already existing transport options such as car and bike sharing and public transport, which can be built on in a MaaS concept. Third, the city has to withstand the challenges brought on by the above-mentioned megatrends and is hungry for solutions.

As such the two core objectives of the study are as follows:

1. Provide a vision for the design of a ‘Mobility as a Service’ platform for London;
2. Conduct a feasibility study to determine the viability of the concept.

In order to fulfil the two core objectives, it is important to analyse existing mobility integration projects to gain insights and identify key elements that lead to successful integration projects. Equally as important is examining the supply (London transport operators) and demand (Londoner’s travel patterns) side of the current mobility market in London. All these feed into the MaaS-London concept and are key to successful design.

For these reasons, three initial steps need to be taken to help fulfil the objectives:

- Classify existing mobility integration projects and analysing key elements;
- Identify transport operators in London who could act as potential stakeholders;
- Analyse current travel patterns of Londoners to assist with market segmentation.

1.2 Structure of Report

With the above points in mind, the structure of the report is the following:

Chapter 2 provides a survey of selected mobility integration projects worldwide. Special attention is paid to the level of integration within each project and the analysis of reoccurring key elements.



Chapter 3 consists of two main sections (3.1) a review of London transport operators and (3.2) analysis of Londoner’s current transport patterns. These both give valuable insights that will feed the later chapters.

Chapter 4 provides the design of our MaaS-London vision. Section 4.1 illustrates the concept from the users point of view; section 4.2 presents insights into mobility package design; section 4.3 assists understanding by giving an example story; section 4.4 describes the supply side of the concept.

Chapter 5 is the feasibility study, which evaluates operational (5.1), technical (5.2) and economic (5.3) feasibility and also provides market evaluation (5.4).

Chapter 6 concludes and provides next steps for testing and implementation.

The structure of the report is provided in Figure 5.

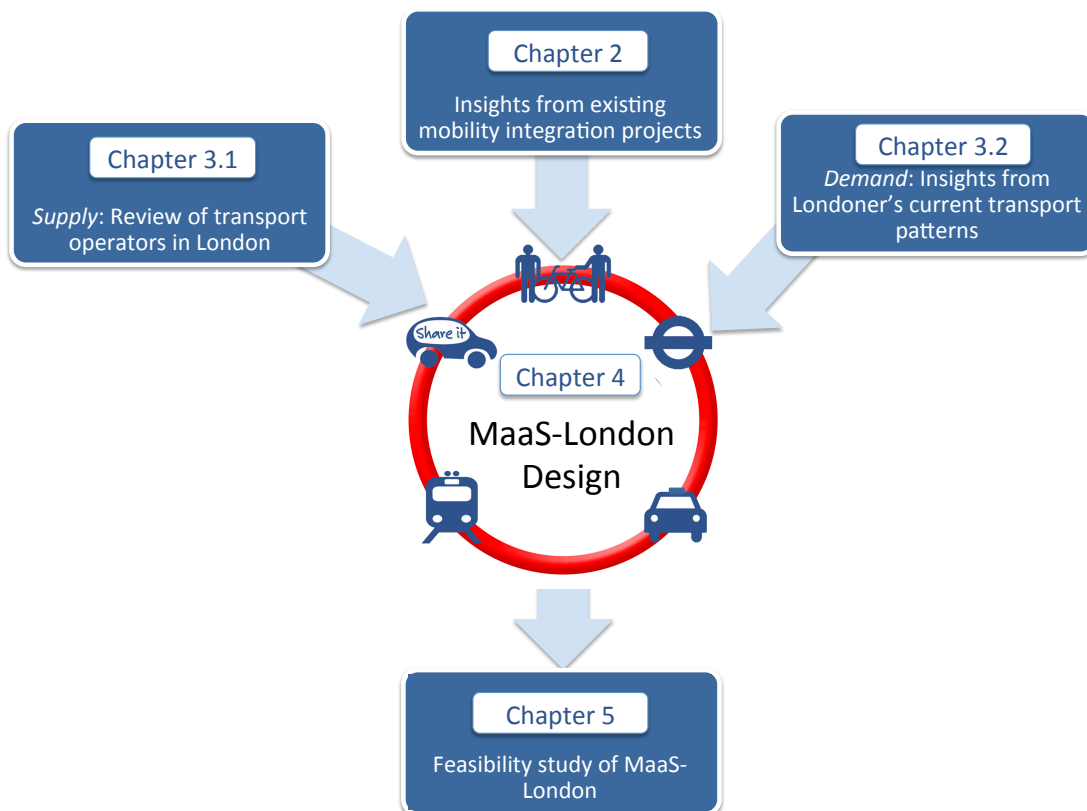


Figure 5: Structure of Report



2. Mobility Integration Around the World

With urbanization on the rise around the world, the traditional approach to urban transport planning is undergoing changes to adapt to these new urban environments. Cities have recognized the need to create a network of public and shared modes that provide viable door-to-door substitutes to private vehicles. However, in most such cities these transport modes operate independently from one another creating an intricate network of transport mode operators. The complexity of using unconnected sustainable transportation modes, each with separate tickets, payment, booking and mobile apps, discourages many people from taking advantage of them.

Nevertheless, some cities realized, that for public and shared services to be fully utilized, cooperation among the parties is necessary. The modern mobility needs of city dwellers demands flexibility, convenience and ease-of-use; all elements that can only be achieved by integration. Collaboration can eliminate those boundaries between transportation modes that previously discouraged travellers from choosing public and shared modes and can deliver seamless mobility. Finally, integration can facilitate access to virtually all areas without the use of private vehicles.

In the following we present selected services around the world where such cooperation is present. Six main stages of cooperation will be used to describe the services:

1. Cooperation only in terms of providing discounts for combined subscriptions
2. *Ticketing integration*: when one smart card can be used to access all the modes taking part in the service
3. *Payment integration*: when one single invoice is issued for all of the customers’ mobility needs
4. *ICT integration*: when there is a single application or online interface that can be used to access information about the modes
5. *Institutional integration*: when multiple modes included in the service are owned and operated by one company
6. *Integration with tailored mobility packages*: when customers can pre-pay for specific amounts (in time or distance) of each service tailored towards their needs

Figure 6 presents the geographic location of the examined projects. The three different colours indicate the level of integration within these projects with green indicating basic integration (integration level 1), yellow indicating advanced integration without mobility packages (integration levels 2-5) and red indicating advanced integration with mobility packages (integration level 6). All of the projects are in developed countries in North America and Europe. There is a high concentration of projects in Continental Western Europe, with Germany leading the way with more than one mobility cooperation project.



Figure 6: Mobility Integration around the World

2.1 Basic Integration

The most basic form of cooperation is when it only comprises of providing discounts for combined subscriptions. Two examples of these can be seen in Canada and Switzerland. In a number of Canadian cities, Communauto¹ the regional car sharing service has partnered with, BIXI, the bike sharing company, and the local taxi and public transport providers (bus, rail) to encourage subscription to a variety of services. Besides providing discounts for taxi bookings done through Communauto, special packages have been designed to encourage the subsequent usage of car sharing and other modes. For example, a user can save on the regular price of a public transport pass and bike sharing when subscribing to the BIXI-AUTO-BUS package.

In Switzerland, SBB the Swiss Federal Railways² has partnered with Mobility³ car sharing and car rental and Publibike/Quickbike bike sharing to facilitate the use of a combination of these modes (Hockerts, 2004; Truffer, 2003; Van Der Zwan and Bhamra, 2003). Car and bike sharing services are deployed at railways stations so that the user can enjoy seamless transfer. Also, holders of SBB travel passes are entitled to discounted subscription to these services. Finally an interesting feature of this service is that there is a voluntary option available to pay extra for offsetting CO2 emission generated in car trips.

Taking integration further to ticketing integration, Cambio⁴, the car sharing company, cooperates with STIB⁵, the combined mobility operator for public transport as well as bike sharing and taxi in Brussels (Hubert et al., 2008; Loose, 2010). However, unlike the previous examples, a common smart card has been designed for the use of both Cambio and STIB services. Similarly to the

¹ www.communauto.com

² www.sbb.ch/en/station-services/car-bike/hire-or-borrow/carsharing.html

³ www.mobility.ch/en/private-customers

⁴ www.cambio.be/cms/carsharing/en/2/cms?cms_knschluesel=HOME&cms_Feurocode=BXL

⁵ www.stib-mivb.be



examples above, a Cambio member can enjoy discounts when subscribing to STIB service. This joint operation has promoted more usage on public transport by linking Cambio stations to the STIB network.

2.2 Advanced Integration

Next, services that are more fully integrated will be described. Even though there is no clear divide between basic and advanced integrated services, the following services have at least some services that are fully integrated. While the previous examples are just the cooperation of providers, the following will all include, to a varying extent, ticketing, payment and ICT integration. Many of the more advanced services are built on a mobility platform that combines all the services. It is very interesting to observe that the payment and ICT integration always seem to be present together and only if there is also ticketing integration present. Four successful applications of integrated intermodal transport are the HANNOVERmobil, EMMA, SMILE and Moovel projects.

Hannovermobil⁶ was first introduced in 2004 but is being re-launched as Hannovermobil 2.0, which is currently being piloted. It has at its core the advanced integration of public transport, car sharing, and taxi, but only has basic integration with long distance rail and car rental (Eryilmaz et al., 2014; Rohrleef, 2008). Hannovermobil is an exclusive offer for customers who have subscriptions to GVH semester cards, that is, have local public transport passes. Hannovermobil subscribers pay only slightly more than their usual public transport pass price in order to access Stadtmobil car sharing vehicles and get discounts for taxi services operated by Hallo Taxi, car rental by Hertz and long distance rail. Customers receive an integrated mobility bill at the end of each month that includes all basic cost as well as taxi and car sharing usage fees. Long distance rail and Hertz car rental prices are not included in the mobility bill, which is why the integration is only basic between these parties. Further, one card can be used to access public transport and car sharing vehicles, providing ticketing integration between Üstra, the public transport provider, and Statmobil. Finally, ICT integration is currently being developed based on the Hannovermobil pilot scheme that will include a smartphone app with real time information.

The second example, EMMA⁷ is an integrated personal transport platform in Montpellier, France. Institutional integration can be seen within TAM, the transport provider of the city that operates the public transport system, the bike sharing system as well as car and bike parks. TAM customers can purchase either a monthly or a yearly mobility packages, called EMMA Contracts, including the usage of all services that TAM operates. These mobility contracts are tailored towards different user groups (EMMA Young, EMMA Senior) and differ in their payment structure. As the bike sharing service, Velomagg, and the parking services include hourly rates, these can be paid

⁶ www.gvh.de/service/rad-auto-carsharing/hannovermobil

⁷ www.tam-voyages.com/presentation/?rub_code=34&thm_id=5



after usage by cash or direct debit. EMMA also offers an online journey planner containing real-time information and the EMMA card is the single key to access all services. TAM also cooperates with Montpellier’s car sharing service Modulauto by offering users Multimodal Subscriptions. For a fixed annual or monthly fee, users have free access to the city’s public transport network, car and bike parks and can also borrow Velomagb bicycles and Modulauto cars. The bike and car sharing services have additional hourly usage costs that are not included in the subscription and have to be paid by direct debit. However, customers are given the option to buy a Velomagb extension to their subscription and be able to use the bikes for free the first hour. Both EMMA Contacts and Mobility Subscriptions show payment, ticketing and ICT integration. The main difference lies in the fact that the EMMA contract only includes services that are within the institutionally integrated TAM, while the subscription also includes the partner Modulauto car sharing.

Although still in its research stage, the third example is Smile⁸ in Vienna, Austria. This project provides a great example of cooperation not only between transport providers (public transport, rail, car sharing, bike sharing, car rental, taxi) but also between other interested parties such as software companies, engineers and environmental protection groups. It is an ambitious project trying to grow into a prototype of intermodal integrated solution by delivering information, booking and payment through a smarter and more efficient system. It includes ICT integration via the Smile app. Payment integration is also linked to the application, and for services that depend on usage (taxi, rental car, bike, parking etc.) the customer is charged right after usage. One unique proposed characteristic of Smile is that the CO₂ emission information for each mode and route will be estimated and provided to the user during the journey planning process. This is an important move towards sustainable transport as it provides the user with the necessary information to make green travel choices.

Finally, unlike the above mentioned intra-city projects, Moovel⁹, integrates countrywide mobility in Germany via a single smartphone platform. It includes public transport, car sharing, car rental, national rail, bike sharing and taxi all provided by separate operators such as Car2go, Nextbike and Deutsche Bahn (Ferber, 2013; Stopka, 2014). Car2go, an external car sharing service provider and the projects main partner, is the key to achieving such deployment. Car2go was the first car sharing system in the world without fixed rental locations, which ensures sufficient flexibility to meet demand (Ehningen, 2014). The core of the service is the Moovel mobile application that facilitates intermodal journey planning, booking and payment for all services (except for Nextbike). Even though Car2go and Nextbike accounts need to be linked to Moovel directly by the customer, there is ICT integration. However, there is no ticketing integration among the modes.

Overall, each of the four projects aims to simplify intermodal journeys by providing the platform for cooperation and integration between modes and service providers. Even though not all

⁸ www.smile-einfachmobil.at

⁹ www.moovel.com



services are integrated completely, they are all a step towards creating completely seamless mobility.

2.3 Advanced Integration with Tailored Mobility Packages

The final group of integrated mobility services is an extension of the previous group. The above-mentioned advanced integrated services all operate with a fixed monthly cost for public transport and access to other services. This is then complemented by a pay as you go payment method for the usage of all other modes such as car and bike sharing and taxi. An alternative way of creating the payment structure of such combined services is constructing mobility packages tailored towards the needs of each type of user. These are similar to service packages in other industries, such as mobile phone packages. This idea is fairly new so there are no fully developed models.

The first example is a very unique business model and the only fully institutionally integrated service. This service is SHIFT¹⁰ by Project 100 that was initiated in 2013 in Las Vegas. It provides services including shuttle buses, bike sharing, car rental, car sharing as well as a valet service. It does this by owning all of the vehicles in its fleet and not by partnering with other service providers. SHIFT is ICT integrated: the user chooses the destination in the journey planning tool and the SHIFT app will make a choice of transport modes for the user. SHIFT also provides a variety of membership levels each with a designated amount of Trip Time each month. One minute of travel time on bikes, cars or SHIFT’s Valet+ service equals one minute of trip time. As monthly trip time is determined to for total usage, customers have the flexibility to divide up the time among the services in a way that best suits their lifestyle. These pre-paid monthly packages allow customers to pay for all their usage beforehand at once. Of course if the customer runs out of Trip Time, they can buy it a la carte. SHIFT is unique in its complete institutional integration and its mobility packages provide a new business model compared to the previous projects. In addition, most of the cars owned by SHIFT are electric powered, which has shown a firm movement towards sustainable transport.

The second example is Ubigo¹¹ a project piloted by GO: SMART (Caesarius and Johansson, 2013). It was tested in the city of Gothenburg, Sweden in 2012 with 70 households and its team is now working on launching it on a larger scale. The project involves the cooperation between Västtrafik public transport operator, Sunfleet car sharing, Hertz car rental, TaxiKurr taxi and JCDecaux bike sharing. The ICT, payment and ticketing integrated service combines everything into one application - even the cars can be opened and access with the app. Households subscribe for prepaid tailored monthly packages determined in time or distance for each mode separately (Sochor et al., 2014; Sochor et al., 2015). For example, public transport is determined as days in

¹⁰ www.shiftconnects.com

¹¹ web.viktorias.se/ubigo



one or more zones, car sharing, as hours, car rental as days and taxi as distance. The household creates their packages based on their needs as a household as a whole, and the price of the package is cheaper than the same amount of service would be on its own. During each journey planning, the user makes their own travel decision on transport modes based on their monthly packages. If the subscription runs empty, additional trips are billed after. Further, electric cars and bikes are available and the user can get bonus points for sustainable choices that can then be used to purchase products from Ubigo’s partners.

The final example is the Helsinki Model¹² that advertises itself as the first Mobility as a Service project. Although it is in its initial stages it is expected to be fully applied by 2025. First proposed by Heikkilä (2014), MaaS discovers a way to reorganize the personal transport sector and to create a door-to-door mobility service. The project brings together 23 partners including a variety of research organisations, ITC and transport companies besides the transport operators. It aims at an open market model based on brand cooperation. Even though the project is not yet operational, it is projected to provide users with pre-purchasable and pre-constructed mobility packages. Each package will be tailored towards a specific socio-demographic group such as families, commuters or businesses. ICT, ticketing and payment integration are at the heart of the project. One interesting element of this project is that besides the modes included in the above-mentioned projects, it also plans on including on-demand transport services. These on-demand services are already being tested via Kutsuplus, the city’s on demand bus service, which responds to the real time needs of customers.

2.4 Key Elements

Table 1 presents an overview of the cooperations described in the previous section. It includes the place they operate, the integrator, the integration level and the modes that are included. The integrator is the party that stands out more than the others and provides the role of facilitating cooperation. Usually this is not explicitly defined but can be seen through the way the parties cooperate. In many cases the integrator in the public transport service provider, but in some cases the others have taken over this role.

¹² www.maas.fi



Table 1: Summary of Integrated Mobility Services around the World

Name	Place	Integrator	Integration level**						Modes included
			1	2	3	4	5	6	
Communauto + BIXI + Public transport + local Taxi	Canada	Communauto (car sharing)	X						
SBB + Mobilty +Publibike/Quic kbike	Switzerland	SBB (rail)	X						
STIB+Cambio	Brussels, Belgium	Cambio (car sharing)	X	X					
Hannovermobil	Hannover, Germany	Üstra (public transport)	X	X	X*	X			
EMMA	Montpellier, France	TAM (public transport)	X*	X	X	X	X*		
Smile	Vienna, Austria			X	X	X			
Moovel	Germany	Moovel (application)		X	X*	X			
SHIFT	Los Angeles, USA	SHIFT (all modes)		X	X	X	X	X	+ Valet
UbiGo	Göteborg, Sweden	CLOSER, Lindholmen Science Park AB (research)		X	X	X		X	
Helsinki Model	Helsinki, Finland			X	X	X		X	+ on demand transport
* Partial integration **1:Cooperation only in terms of providing discounts for combined subscriptions 2: Ticketing integration 3: Payment integration 4: ICT integration 5: Institutional integration 6: Mobility packages									

Some elements of all of these cooperations stand out and are worth addressing further. First, all of the examined projects (except SHIFT which is very unique in many ways) have the regional public transport provider and car sharing companies as core partners. This shows the importance of understanding the complementarity of these modes. As no public transport network is able to



service every area and every situation effectively, car sharing is powerful tool for deterring private car use in these situations.

Second, all of the advanced integrated projects include ICT integration. This is very important since it provides the platform for intermodal journey planning as well as payment integration. In some projects, for example Moovel and Smile, from the users point of view the journey planning tool is at the heart of the cooperation. ICT integration also facilitates real time information exchange between users and service providers. Instead of having to check numerous applications for travel information, users are able to gather this all from one platform. For providers, having access to users real time travel needs can provide information about where there is most demand for their services at every given point in time. This can be a bridge towards a more demand oriented transport network.

Third, just as important as ICT integration is ticketing and payment integration. All of the services that use these state the simplifying power of only having to use one smart card (or mobile app) to access all modes, and only have one account to pay. Even though in some projects, payments for modes that have usage costs (e.g. car sharing and taxi) happen separately after every usage, they are still paid through one single account.

Fourth, with the exception of SHIFT, all the examined projects are the result of cooperation between many separate service providers. This means, that institutional integration is not an essential part of simplifying intermodal travel. Further, it stands out that in most integrated projects there is only one service provider per mode per city. In some cases this is due to the fact that there is only one service provider, but in others the cooperation is only with one selected one. This, for a city the size of London would be very difficult, as there are already many service providers present for certain modes (such as car sharing discussed in Section 2).

Fifth, integration with tailored mobility packages is a very recent idea with only a couple of projects testing the concept. However, Ubigo’s pilot report states that all the 70 households who were included in the pilot continued using the service and buying packages after the project ended.

Through our research, we have found no cases where cooperation has provided a worse situation for users. Even though many of the examined integrated mobility projects are still in pilot phases, they all want to expand their operations (e.g. Hannovermobil 2.0 and Ubigo’s expansion from the pilot phase). Cities thrive on innovative solutions like these and the number of cities that experiment with such solutions increases every year.

The benefits of having packages are significant. The following table (Table 2) illustrates in what aspects a traveller may benefit from a mobility package.



Table 2: Benefits of a Mobility Package

Benefits	Without a Package	With a Package
Discount on bundled services		
Tailored service based on personal preference		
Flexibility in trip cancelation		
Budget (Travel expensed) control		



3. London’s Transport Context

The variety of transport options already existing in London, in combination with the Londoners openness to new products makes the city is an ideal ground for exploiting the market opportunities of MaaS and customising it to its citizens needs. The scope of this section is two-folded. First, the supply side is examined by identifying the main transport providers in Greater London, and the services they provide are analysed. Then, current travel behaviour of Londoners is investigated aiming to identify the modes they use, the time they spend on traveling and potential time savings from using other transport modes instead of private vehicles. The analyses in this section will provide significant insights for designing MaaS-London.

3.1 Transport Operators in London – The Supply Side

This subsection provides an overview of transport operators in London as well as a detailed examination of the services they provide. The analysis is based on the payment methods, the mobility packages or travel cards they offer, the geographical coverage and the mobile applications available for their users.

3.1.1 Public Transport

Transport for London¹³ (TfL) is the single body that operates the entire public transport system in Greater London. London’s public transport system includes bus, underground (tube), overground, DLR, tram, Emirates air line and river bus. TfL offers a range of travelcards and different payment methods. The user can access the public transport modes by buying a single paper ticket, an Oyster card, or by using a contactless card. It offers various mobility packages as well as single journey tickets, such as daily, weekly, monthly, annual travelcards, or even group daily travelcards. Tickets and travelcards can be purchased either from the ticket offices and ticket machines at stations, and authorized ticket sellers around London, or on-line. It also offers discounts for students and disabled persons and free passes to those over 60 years old.

A breakthrough in TfL’s history was the initiation of Oyster, which is a smart card that can be used either as pay-as-you-go (that is paying for each trip at the point of travel), or as the ticket for the aforementioned mobility packages/travelcards. It can be used to access all transport modes operated by TfL (except bike-sharing) and the vehicles of City Car Club (Figure 7). The introduction of Oyster caused a phenomenal growth in public transport use across London. Bus patronage has increased by 53% to almost two billion rides per year, while tube and DLR rides have increased by almost 20% and over 100% respectively (CUBIC, 2015). Cash-only fares now comprise 1.6% of all bus trips and 3.5% of Tube fares. This compares to 17.9% on bus and 18.8% on the tube in 2003-

¹³ www.tfl.gov.uk



2004 and, more significantly, 25.5% on bus and 20.7% on the Tube in 1999-2000. These statistics show that the initiation of a smart card that enhances seamless mobility is highly accepted by users.

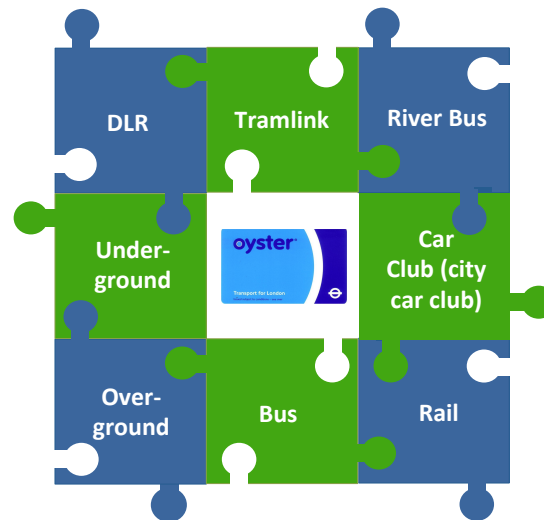


Figure 7: Modes That Could be Accessed by Oyster

TfL also provides a journey planner¹⁴ that lets users plan tube, bus, tram, DLR, train, river and cycle journeys across the UK capital, by using live travel information. The user is able to search by stop/station, point of interest or postcode, with a Locate Me option to quickly pinpoint his/her position and suggest the nearest station. The journey planner offers various options to users to plan their trip such as: bus only, cycle hire, least walking, fewest changes and full step free access. However the TfL journey planner is accessible only via its website and it is not available as an application for mobile phones yet.

3.1.2 Bike Sharing

The bike sharing system in London is also under TfL’s jurisdiction, while the operation of the scheme is outsourced by TfL to another company (Secro). The bike sharing scheme is currently sponsored by Santander. There are more than 10,000 bikes at over 700 docking stations situated every 300 to 500 meters in London¹⁵. However, the majority of the docking stations are located within Zone 1 and in some targeted locations in Zone 2. With rapid urbanisation hitting the Greater London, their expansion is necessary at least up to Zone 3, where many short trips are currently conducted by car (see 3.4.4 below).

London’s bike sharing scheme is a self-service scheme. Hiring and payment are both done by debit or credit cards through the screens/computers at the docking stations. The selected bike can be

¹⁴ <http://www.tfl.gov.uk/plan-a-journey/>

¹⁵ www.tfl.gov.uk/modes/cycling/santander-cycles



unlocked by entering the pin printed from the computer or provided on the mobile phone after the payment. In the end, the bike can be returned to any docking station.

The pricing scheme is a two-part tariff, which means the rider needs to pay a fixed price for access and a unit price for each 30 minute period. The first 30 minutes of every trip exempt from the unit price. There are also subscription packages available for frequent cyclists. Members to the bike sharing scheme have two options; either to buy an annual package, or to choose “Pay-as-You-Pedal” with 24-hour bike access at a fixed price. Shared bikes cannot be accessed using an Oyster card, which is because of the need to be able to take a “block payment” charge if the bikes are not returned. But with contactless payment, this could be achieved. However, the cost of upgrading the docking points to take cards would be high, but such docking points are available and in use in many of the newer bike-sharing systems around the world.

Finally, bike sharing is used as an option to the TfL’s journey planner, as well as to a couple of other journey planners that will be discussed below. There is also the Santander Cycles mobile application that offers information about bicycle and free spaces availability, and reminders to return the bicycle before the cost of the journey goes up.

3.1.3 Rail

National Rail companies also operate within Greater London. Rail is a convenient way for people living outside London to commute every day to their workplaces in the city centre. Residence standards and availability in London made workers with higher income relocate in locations further from the centre and benefit from more space, leading to increased demand for rail (Worsley, 2012).

To offer more convenience to rail commuters, TfL and National Rail co-operate closely. As a result, Oyster cards, travelcards and contactless payment cards can be used on all National Rail routes in London. The cost depends on the route they use and discounts are applied for specific population groups (i.e. students, elderly, disabled). Currently, 300 rail stations are part of the Oyster and they are equipped with 3,000 Oyster readers (Verma, 2012).

Rail is a popular transport mode, thus almost all existing multimodal journey planners include it as an option. Accessibility information (i.e. elevators) is also provided in most cases.

3.1.4 Taxi

The taxi market in London is currently filled with numerous providers offering different levels of services. The number of taxis has been steadily increasing over the years. Technology and ICT advancements have probably had a high contribution to this as the information offered now via



taxi mobile applications has made taxis more accessible. TfL indicates that around 200,000 trip stages per day are conducted by taxi within central London (TfL, 2011), while the demand is also high in the suburban areas, where other transport mode alternatives (private vehicles are excluded) are limited.

As it is difficult to identify every single taxi company in Greater London, an attempt has been made to classify them based on the services they offer, while only the most popular operators are analysed below.

Black Cabs

London’s black cabs are famous for their drivers’ intimate knowledge of the city and their ability in taking their occupants to their desired destination amid congestion. These types of taxis offer traditional services so that they can be flagged down on the street at any time without prior reservation. Mobile apps, like Cabwise¹⁶ and Hailo¹⁷, are available for booking the nearest black cab. There are three types of tariffs¹⁸ set by TfL according to different service times and locations (i.e. there are special fare zones like airports and rail stations). The payment can be processed via cash or bank card (if the taxi has a card reader). In case of using a mobile application, the payment can be conducted via the user’s account.

Mini Cabs

This type of service refers to those cars that can be privately hired to serve as taxis. There are plenty of traditional mini cab operators in London, which have their own fleets either at city or community level. As they are privately operated companies, they set prices on their own. Mini cabs must be pre-booked either online or by phone and the user must pay for the agreed price in cash at the end of journey. Examples are: Minicab for London¹⁹ and Kvcars²⁰. In recent years, new features have been brought forward in two directions. Comcab²¹ and Addison Lee²² both have provided mobile applications to allow instantaneous taxi service by bringing the cab to customer in minutes. Payments can be made either in cash or via the users online customer account. Another innovative direction is the introduction of low-carbon taxi service. The most well-known cases are Climatecars²³ and Green Tomato Cars²⁴. These services provide hybrid and electric cars, while mobile applications are available for fast booking.

¹⁶ www.tfl.gov.uk/campaign/be-cabwise

¹⁷ www.hailoapp.com

¹⁸ Taxi fares. Available at: www.tfl.gov.uk/modes/taxis-and-minicabs/taxi-fares

¹⁹ www.minicabforlondon.com

²⁰ www.kvcars.co.uk

²¹ www.comcablondon.com

²² www.addisonlee.com

²³ www.climatecars.com

²⁴ www.greentomatocars.com/uk



Peer-to-Peer (P2P) Cab Platforms

P2P cab platform is a disruptive technology for the taxi sector. P2P cab platforms connect taxi drivers and passengers with just the push of a button. The key difference between this P2P taxis and the above two types is that the company do not own its own taxi fleet. Instead, it serves only as an online or mobile app booking platform, which gathers information about partner operators. Examples are: Minicabster²⁵, Minicabit²⁶, London Cabs²⁷, UbiCabs²⁸ and Kabbee²⁹ which can be used to book with mini cab operators and, Hailo³⁰ and Gettaxi³¹ which are for black cabs. Uber³² and Wheely³³ are special cases of P2P platforms that connect passengers with independent minicab drivers instead of minincab companies like the cases before.

3.1.5 Car Club Operators

Car clubs (known as car sharing outside the UK) are a great compliments to other modes of transport and could contribute to the reduction of private vehicle ownership. A survey of Carplus (Gleave, 2013) found that for each car club vehicle in England and Wales, 16 private cars are taken off the road, and a further 12 are not purchased. In London, 6 private cars are taken off the road, and up to 14 future car purchases are deferred.

London is one of the largest markets in Europe and globally for car clubs (Gleave, 2013). Over the past five years, there has been sustained growth in both car club membership and the geographical coverage of car clubs across London. In 2013, 122,300 members were using a network of approximately 2,270 cars (Gleave, 2013). Joining a car club provides the convenience of owning a car without the hassle or costs of repairs, servicing or parking.

The main operators in London are City Car Club, Zipcar, Hertz 24/7, Drive-Now and E-Car Club³⁴. In general, they all follow the same procedure for a customer to use their services, such as joining the membership, booking a car online or through the mobile app, unlocking the door and driving. Nonetheless, each of them has more or less unique features in terms of pricing plans, services included, keys for access and car returning options.

City Car Club³⁵ operates a fleet of 300 cars and vans spread in a dense network across London. It offers a number of pricing plans designed for different user groups. Each plan covers different

²⁵ www.minicabster.co.uk

²⁶ www.minicabit.com

²⁷ www.londoncabs.co.uk

²⁸ www.ubicabs.com

²⁹ www.kabbee.com

³⁰ www.hailoapp.com

³¹ www.gettaxi.co.uk

³² www.uber.com/cities/london

³³ www.wheely.com

³⁴ EasyCar Club, a large operator across the UK, is excluded in this section due to its peer-to-peer feature such that it is only a platform that brings individual car owner and car driver to one place without providing shared cars itself.

³⁵ www.citycarclub.co.uk



amounts (in hours) and types of vehicles. Additionally, there is also a pricing plan targeting businesses. Users can access the vehicles by their membership card, the mobile app, or by their Oyster card and then have to enter a pin on the computer inside to obtain the key for driving. At the end of journey, the car must be returned to the original station where it was picked up. Insurance, fuel and breakdown cover are included in all pricing plans. Choices for using low-emission vehicles are available in order to be exempted from the London Congestion Charge. However, for all other types of vehicles this charge needs to be paid by the user.

Zipcar³⁶, which was initiated in the US and is currently the world’s largest car club service provider, also operates in the UK. Zipcar in London offers two pricing plans for its members, an annual and a monthly option depending on how frequently a customer will use the service. The mobile app and smart card can both be used to unlock the booked car, and the key can be found inside. It has the same return policy as City Car Club meaning that the car must be returned to its original station at the end of journey. However, unlike City Car Club, Congestion Charge is also covered in the pricing plans and paid by Zipcar instead of the customers.

Hertz 24/7³⁷ has a policy of free membership, in contrast to City Car Club and Zip car that require payments to become a member. Compared to the previous two operators, Hertz 24/7 is a pay as you go service based on fixed hourly or daily rates with no discounted prices. Access to the cars is provided by swiping a Key fob (a type of security token: a small hardware device with built-in authentication mechanisms) over the reader. After each trip, the car has to be returned to a designated location. Insurance, Congestion Charge and fuel for up to 20 miles are all covered in the price (excluding vans).

An innovative car club operator, Drive-Now³⁸, entered London market in 2014 by bringing a more flexible one-way car club service. Drive-Now operates only in an 84km² business area in Northeast London. BMW and MINI, which supply 240 vehicles in total, are the main supporters behind Drive-Now. All vehicles can be picked up, dropped off and parked freely³⁹ anywhere inside the area. This means a user can leave the car anywhere anytime free of charge (but only inside the Business area in Northeast London) after the trip instead of driving back to a designated car club station. Similarly to the aforementioned services, a mobile app is available for locating the vehicles, which is accessed by smart cards. There is only a one-time registration fee to become a permanent member and use is charged for each trip in minutes to provide more accurate pricing. Fuel and insurance are included in the price; however, users have to pay for the Congestion Charge at the standard rate.

³⁶ www.zipcar.co.uk

³⁷ www.hertz247.com/bq/en-gb

³⁸ www.uk.drive-now.com/#!/carsharing/london

³⁹ Free parking includes pay-and display, residential, and permit only parking zones. Exceptions are private parking areas, parking garages and reserved-use parking zones (e.g. handicapped parking areas, yellow and red lines, car club spots and taxi-only parking).



The final car club is E-Car club⁴⁰. Although it only has four locations inside Greater London with three in central London and one in Watford, it is substantially different from traditional car club operators as it provides solely electric vehicles. Moreover, the mechanism of using the car is also different. There is no mobile app available for booking or accessing the car. A smart card is the only key to unlock the door and a secure code is entered to ignite the car directly without using a key. The cost structure provides two different pricing plans for regular and occasional members, similar to that of Zipcar. Insurance and breakdown cover are included, and free electrical charging is granted. Table 3 summarises the key features of the main car club operators in London.

Table 3: Services of Car Clubs in London

Name	Areas Covered	Subscription Requirement	App Availability	Return policy	Items Included
 City Car Club	Greater London	Yes	Yes	Back to Base	Insurance, Fuel, Breakdown cover
 Zipcar	Greater London	Yes	Yes	Back to Base	Insurance, Congestion charge, Fuel for up to 60 miles
 Hertz 24/7	Greater London	No	Yes	Back to Base	Insurance, Congestion charge, Fuel for up to 20 miles (excluding van)
 Drive-Now	Northeast London	Yes	Yes	One Way	Insurance, Fuel, Parking (inside business area)
 E-Car club	3 locations in central London, 1 location in Watford	Yes	No	Back to Base	Insurance, Electrical charging, Breakdown cover

3.1.6 Ride Sharing Platforms

There are two types of ride sharing platforms. The most commonly recognized type is for individual users, and connects drivers who can provide rides with passengers who wish to take the rides. There is however, another rising type that provides services mainly or even exclusively to companies that would like to provide efficient transport solutions for their employees.

⁴⁰ www.e-carclub.org



For the first type, the most well-known cases in London are BlaBlaCar, GoCarShare, Carpooling and Liftshare. From a passenger’s view, the way to use the ride sharing service is very similar across the different platforms. The process involves using an online platform or mobile app to find a driver who will be travelling on the same date and route, contacting the driver and agreeing on a price and finally travelling together. Each platform has a rating system to evaluate the performance of both the driver and the passenger. The most notable difference among the platforms is in price setting and payment method.

BlaBlaCar⁴¹ displays the suggested price for drivers based on trip distance information and estimated fuel consumption. Although the driver has the option to increase or decrease the suggested price, the amount of this is restricted by BlaBlaCar. The price must be fixed before the ride takes place. The system is flexible in terms of payment, giving the choice between cash and online transfer via BlaBlaCar account.

GoCarShare⁴² offers a driver more flexibility in setting the price. It does not exert any cap on price and in addition, provides a guide for drivers to assist them in calculating how much to charge if they do not have sufficient knowledge on fuel costs. The payment is by cash only. Moreover, a unique feature of GoCarShare is that it provides a two-way communication channel so that drivers can not only receive requests from passengers but also can contact potential passengers to ask if they wish to take rides.

Carpooling⁴³ also provides a suggested price by considering the fixed and variable cost to the driver. However, Carpooling has a rule to set the fixed cost based on number of expected passengers slightly higher than the actual cost level in order to account for the risk to driver that some passengers do not show up. In the end, the final price will be agreed between driver and passenger. Passengers can choose either cash or online payment.

Liftshare⁴⁴ is again more passenger protective like BlaBlaCar. Besides the suggested price it calculates for a driver according to the essential trip and fuel information, there is an additional criterion adopted by Lifeshare. This is the HM Revenue and Customs Approved Mileage Payment Allowance to ensure the price is within a reasonable range. A cap restricts the price adjustment made by the driver and the price must be fixed prior to the trip. The payment must be made through its app platform.

The second type of ride sharing platforms in London targets the business sector. This includes Carbon Heros, Jambusters and Carshare Online.

⁴¹ www.blablacar.co.uk

⁴² www.gocarshare.com

⁴³ www.carpooling.co.uk

⁴⁴ www.carpooling.co.uk



Carbon Heros⁴⁵ supplies a technology-based solution for travel choice to reduce the impact on the environment. It has two main categories of clients, which are private companies looking to manage employee travel and regional government bodies promoting sustainable travel to their residents and business community. Although its core mission is presenting alternatives to single occupancy car use (i.e. ride sharing), the solution it provides also covers car clubs and taxi sharing.

Jambusters⁴⁶ is a software solution that could be purchased by public and private companies/organisations, which wish to make a positive contribution towards reducing their employees' carbon footprints, traffic congestion and their on-site parking needs. Jambusters is a car-sharing platform within each company allowing the employees to commute together to the workplace.

Carshare Online⁴⁷ offers online solutions for organisations. Similar to Carbon Heros, the main aim is to make use of empty seats in cars (i.e. ride sharing) and promote more sustainable ways of private transportation by sharing journeys together. A wide range of options are also available in the solution, such as car club, taxi sharing, cycling and walking.

Table 4: Ride Sharing Platforms for London

Name	Communication Direction	Rating System	App Availability	Price Suggestion	Price Cap	Payment Method
BlaBlaCar 	Passenger to Driver	Yes	Yes	Yes	Yes	Cash & Online Payment
GoCarShare 	Two-way	Yes	Yes	Yes	No	Cash Only
Carpooling 	Passenger to Driver	Yes	Yes	Yes	No	Cash & Online Payment
Liftshare 	Passenger to Driver	No (only profile)	Yes	Yes	Yes	Online Payment Only

⁴⁵ www.carbonheroes.com

⁴⁶ www.jbgb.com

⁴⁷ www.carshare.uk.com



3.2 Intermodal Journey Planners for London

An intermodal journey planner (IJP) is an IT system able to propose a set of one or more transport services to get a person from point A to point B. It is able to optimize shortest travel time taking into account arrival/departure time and date and other factors.

There are numerous journey planners for London that are either intermodal or focus on specific transport modes (i.e. bicycle). This section presents the characteristics of the most popular intermodal journey planners for London: Google maps, Citymapper, Moovit, Journey Pro and Ally. TfL’s journey planner that is described above is not presented in this section, as it covers only modes operated by TfL and does not have a mobile application.

In general, all IJP share some common features such as providing route options, which combine public transport, rail, driving, cycling and walking, as well as real time information and locations of stations for public transport. Nevertheless, other than these basic functions, some of the tools are equipped with more advanced functions and thus in accordance with such criterion, the tools can be classified into three levels.

Moovit⁴⁸ and Journey Pro⁴⁹ represent the basic level of journey planning tools by only offering essential services. They are free of charge, and travellers can access them through computers and mobile apps.

The next level of services is offered by Google maps⁵⁰ and Citymapper⁵¹. Both can be accessed through computers and mobile apps with no charge. The most distinctive function compared to the basic level of service is that both of them are in cooperation with on-demand taxi services such as Uber in order to provide users further options. For example, Google maps and Citymapper can show the estimated pickup time, fare, and travel time to the destination by Uber. At the same time, the destination address can be set seamlessly between Uber and the two journey planners, and then passed on to the driver upon pickup. Finally, there are also some differences between Google map and Citymapper. The latter offers additional information such as the estimated prices of various route options and calories for active modes. It also provides TfL bike sharing as a mode option.

More advanced functions are currently offered by Ally⁵², a free IJP mobile app. Similar to Citymapper, Ally incorporates price comparisons for various routes and offers TfL bike sharing as an option. Moreover, it has a wider coverage on taxi services than Google maps and Citymapper by providing a list of mini-cab companies in London and their contact information. Nonetheless,

⁴⁸ www.tripplan.moovitapp.com

⁴⁹ www.navitime.com/journeypro

⁵⁰ www.google.co.uk/maps

⁵¹ www.citymapper.com

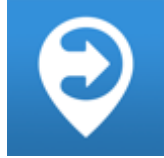
⁵² www.allryder.com



the most notable innovation of Ally is the inclusion of car club services into the journey planning process. By cooperating with Zipcar and Dive-Now in London, Ally can display various route options based on a combination of basic modes as well as car clubs, and provide corresponding duration and price information. Overall, travellers now have more flexibility when making travel choices.

Table 5 summarises the most widely-used multimodal journey planning tools, the services they provide and the modes that are taken into consideration when they propose routes.

Table 5: Journey Planners for London

Name	Platform	Services					Modes
		Route advice	Location of stations	Real-time info	Price info	Fitness info	
Moovit 	Computer + Mobile app	✓	✓	✓			public transport, rail, drive, cycle, walk
Journey Pro 	Computer + Mobile app	✓	✓	✓			public transport, rail, drive, cycle, walk
Google maps 	Computer + Mobile app	✓	✓	✓			public transport, rail, drive, cycle, walk +taxi⁵³
Citymapper 	Computer + Mobile app	✓	✓	✓	✓	✓	public transport, rail, drive, cycle, walk + taxi⁵⁴ + bike sharing
Ally 	Mobile app	✓	✓	✓	✓		public transport, rail, drive, cycle, walk + taxi⁵⁵ + bike sharing + car club

⁵³ Share function with on-demand taxi services

⁵⁴ Share function with on-demand taxi services and black cabs

⁵⁵ Have contact information of mini-cab companies



3.3 Londoners’ Travel Patterns – The Demand Side

As a “Mobility as a Service” system for London is the central case study of this report, it is important to analyse current travel patterns its citizens. As such, the following section provides analysis of Londoner’s trip characteristics. The insights gained from this section, such as the needs of different socioeconomic groups, will be used when customising the MaaS framework for London.

3.3.1 Data Used for the Analysis

The dataset used for the analysis of Londoners’ travel behaviour is the London Travel Demand Survey (LTDS)⁵⁶. LTDS, conducted by TfL, is a large-scale yearly travel survey with a geographic scope including all London boroughs as well as the Greater London area within the M25 motorway. LTDS is a revealed preference (RP) cross-sectional survey that includes a household- and a personal- questionnaire, as well as a one-day travel diary for each household member. Every household member over the age of 5 fills out the travel diary and the person questionnaire, while the household questionnaire is only completed by a representative member of each household.

For the purposes of this report, data from 2005 to 2013 is used to identify and analyse the trip characteristics within Greater London. The sample for all 8 years includes 162,068 individuals, 388,238 trips, and 805,865 stages in total. The analysis includes the decomposition of the trips into stages in order to identify how many and what combinations of transport modes Londoners use to go from A to B. Travel times by each mode are also analysed. Further, travel times with alternative transport modes for those who used car are calculated with ultimate goal to derive travel time savings from substituting private cars with other modes. Finally, transport modes used for each trip are examined based on various socio-demographic characteristics, such as gender, age, and household income.

Before presenting the analysis it is important to define the terms that are used in this section:

- ⇒ *Trip*: A journey from origin to destination regardless of how many transfers were made in between.
- ⇒ *Stage*: A subsection of a trip. Each individual element of a trip done by one single mode.
- ⇒ *Main transport mode*: The transport mode that was used for covering the longest distance in a trip (distance based main mode).
- ⇒ *Multimodal trip - Multimodality*⁵⁷: refers to the use of different modes for different trips, for instance using the bicycle to drive to work and the taxi to go to the opera.

⁵⁶ <https://tfl.gov.uk/corporate/publications-and-reports/london-travel-demand-survey>

⁵⁷ LINK Project. Available at: http://www.epomm.eu/newsletter/electronic/0711_EPOMM_enews.html



⇒ *Intermodal trip – Intermodality*⁵⁸: refers to the seamless use of several different modes in one trip chain. Intermodality can serve as a policy principle or it can be a characteristic of a transport system.

3.3.2 Trips and Stages

Londoners conduct an average of 3.2 trips per day, while 2 trips per day is the most common (trip median = 2). This can easily be explained by the fact that most people only travel to and from workplace (or education) during the day. 6 or more trips a day are fairly uncommon.

By breaking down each trip into stages, the number of transfers Londoners make while getting from point A to point B can be identified. It is important to note, that for this analysis walking is considered as a separate mode only for walking only trips; access and egress walking trips are excluded as separate modes as in many cases these are very short-distance trips. The average number of stages in each trip is 2.1. As it can be seen in Figure 8, 48% of the trips consist of one stage (no transfers), but over half of the trips have more than one stage, that is, at least one transfer. This shows that the majority of Londoners door-to-door travel includes transferring at least between two different modes during a trip (intermodal trip). Removing any potential obstacles during these transfers is of high importance both for improving citizens travel experience and for transport planners whose vision is to deliver seamless mobility.

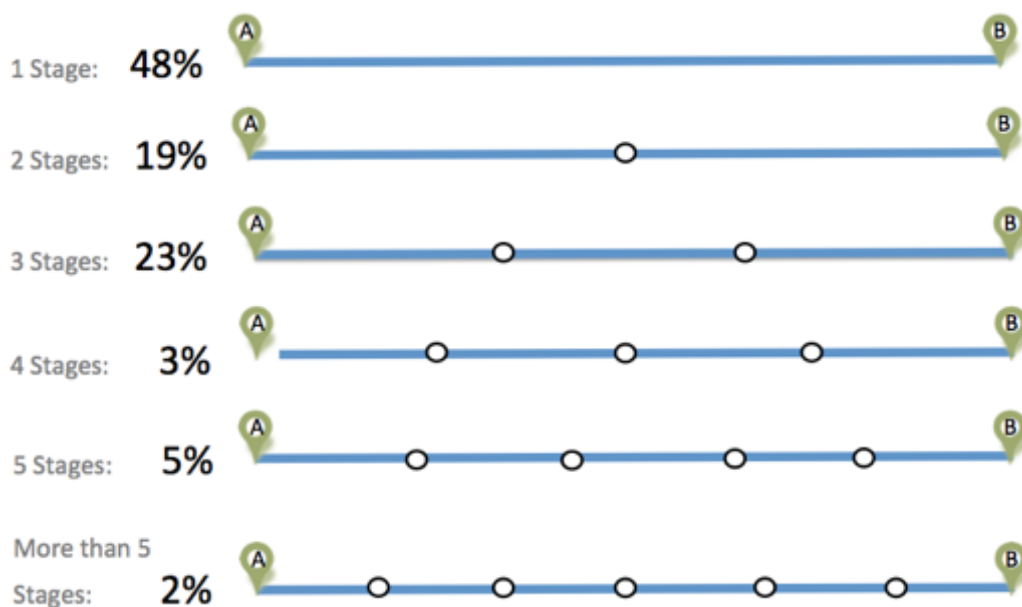


Figure 8: Number of Stages per Trip

⁵⁸ It is widely noticed in the market that when they use the term “multimodal”, they actually refer to “intermodal”. In this report we use the term “intermodal” as it is by definition the most appropriate one.



3.3.3 Trips and Main Transport Mode

The main transport mode is the basis of the analysis in this subsection. The modes that are considered are: 1.Walk, 2.Cycle, 3.Car-driver, 4.Car-passenger, 5.Bus, 6.Underground, Overground, Docklands Light Rail, Tram⁵⁹, 7.National Rail, and 8.Taxi. Motorcycle and van are the main transport modes in less than 1% of the trips, thus are not considered as separate modes and have been incorporated in the Car-driver and Car-passenger categories. Underground, overground, Docklands Light Rail, and tram are also grouped in one category, as the first three are part of the same system (user do not need to pay separately for each when transferring) and the percentage of tram usage is very small (only 0.1% of all trips). Finally, car is split into two categories; those who drive a car and those who are passengers. Car passengers are more likely to switch to another transport mode compared to car drivers (Polydoropoulou et al., 2013) and this can offer insights for designing the MaaS-London’s potential target groups.

Figure 9 provides an overview of the trends in distance based main modes from 2005 to 2013. Walking, car-passenger, and National Rail mode shares have remained constant over the examined time period. The percentage of trips, where Walking is the main mode remains around 30% every year. Cycling, bus, underground (UG), overground (OG), Docklands Light Rail (DLR) and tram (Tr) demand have slightly increased.

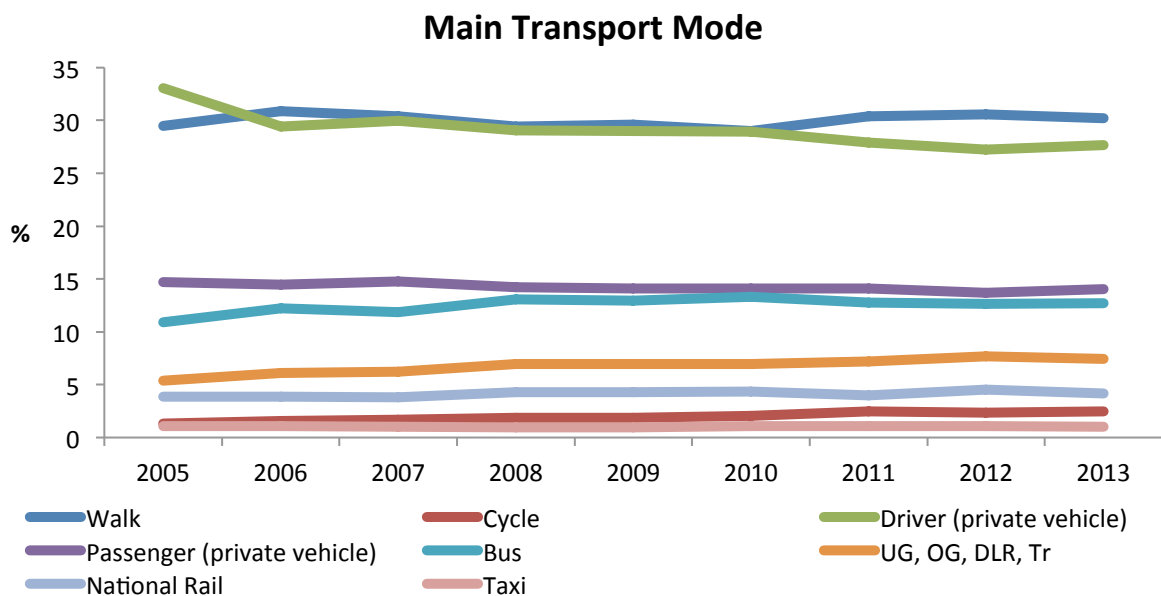


Figure 9: Trends in Main Transport Mode, 2005-2013

A steady decline can be seen in car-driving. Since 2005 a 5% decrease (from 33% to 28%) occurred in the number of trips where car-driving was the main mode. This reflects a now well-established trend of a net shift away from private motorised transport to the public transport modes and generally to other transport alternatives. The predominant reasons for changing personal vehicle

⁵⁹ This category is also mentioned as “TfL rail” in the text.



modes are presented in Figure 10. Although most of the reasons are related to moving or changing working place, there is a part of the population that stopped using their private car due to cost-related issues. Cost of motoring or vehicle maintenance, and availability or cost-of-parking are cited as direct vehicle related issues that negatively influence private car usage. These statistics indicate that there is an opportunity in the market for new mobility products that could contribute to the reduction of households’ travel expenditures.

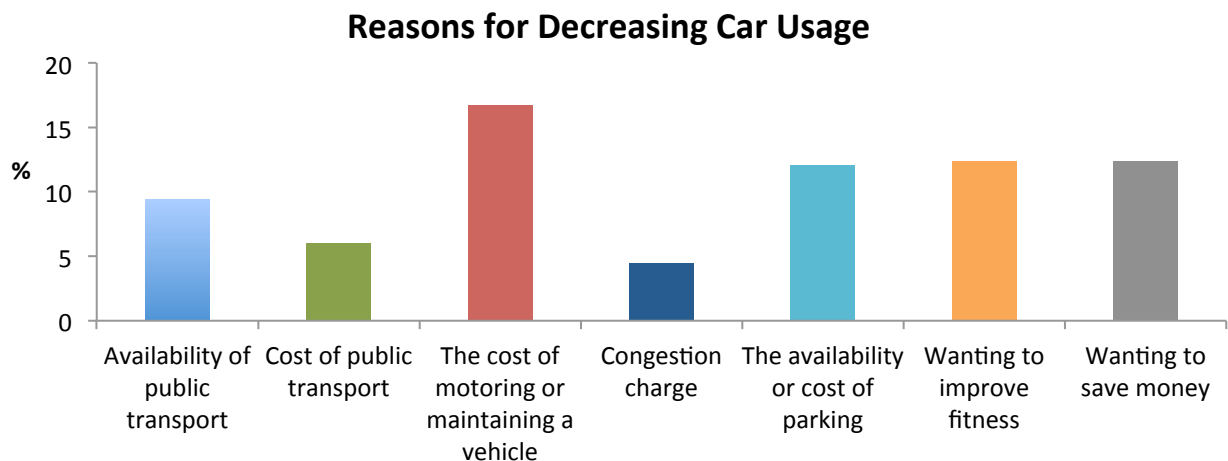


Figure 10: Reasons Stated for Changing the Amount of Car Usage

Main transport mode is further analysed by trip purpose (Figure 11). Car (in total) is the most popular mode when the trip purposes are work/education, leisure, and pick up/drop off someone. Walking is the most preferred mode (48%) when the trip is conducted for shopping purposes. Looking at cycling trips only, Londoners prefer using bikes most when the trip is work/education related. In the same context, public transport and national rail also mostly used for work/education trips.

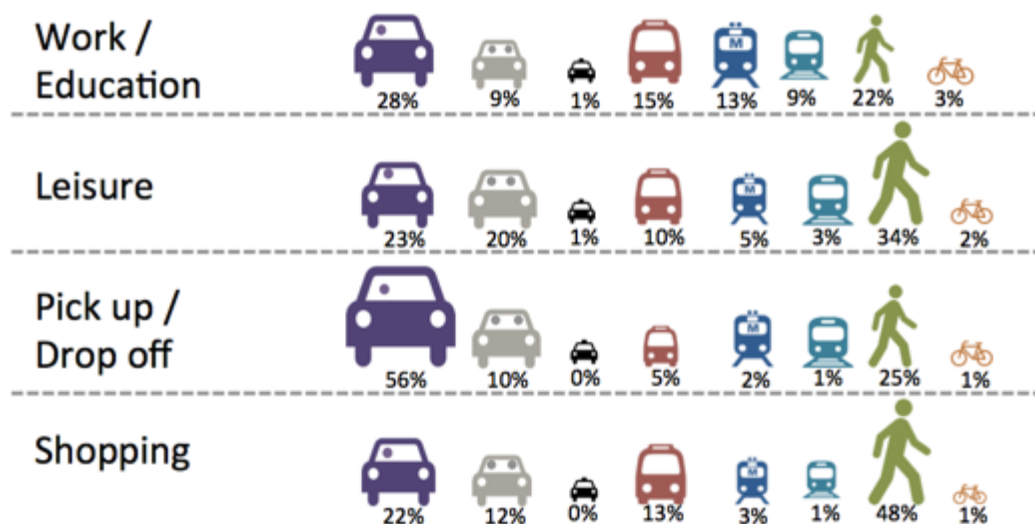


Figure 11: Main Mode by Trip Purpose



Despite the decrease in car usage over the years, car still remains the most popular transport mode. This fact imposes pressures on the transport network, contributes to traffic congestion, and has a negative impact on Londoners quality of life. Strict policies (such as congestion charging zone, increased parking fees) could definitely contribute to the reduction of car usage, especially in case of London, where so many other alternatives to private owned vehicles exist. To decrease private vehicle shares further, citizens need to be made aware of transport mode alternatives and have to be provided with the opportunity to experience new services that could convince them to move from vehicle ownership to vehicle usership.

3.3.4 Intermodal Trips

In this subsection each trip will be dissected into stages and the transport mode used for each stage will be examined. In this way, intermodal mobility and the transport mode combinations Londoners use can be assessed. Figure 12 presents the fraction of total stages by mode. Even though walking is used in the 59% of stages, it is not presented in the figure, as many of these are short-distance access and egress stages to and from other modes. Car-driver and bus are the most widely used modes in stages after walking. The fractions of cycle and taxi stages are very low, both around 1%.

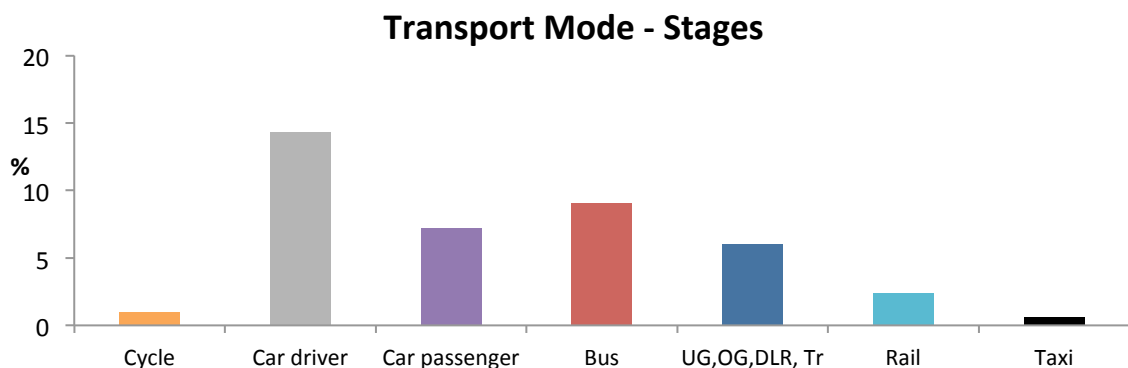


Figure 12: Mode Used in Stages

At this point, it is also interesting to analyse the modes used in each stage based on the distance travelled. Figure 13 presents the mode used for various distance categories of the stages. Although literature (indicatively Daniels and Mulley, 2011) usually uses 2km as an upper distance limit for walking trips, 97% of walking stages are under 1km distance (not included in the table as the table would provide no further explanatory power). Surprisingly, car (either driver or passenger) is the most popular modes for stages under 1km. This means that 23% of car-driver, 25% of car-passenger, 28% of bus and 19% of taxi stages could be easily substituted by walking. This is a very high percentage if it is consider that with an average walking speed of 4 km/h it would take 15 minutes to walk 1km and with an average speed of 12km/h it would take 5 minutes



to cycle to the destination (Müller et al., 2008). Rail is the only mode where most of the stages are over 5km in length.

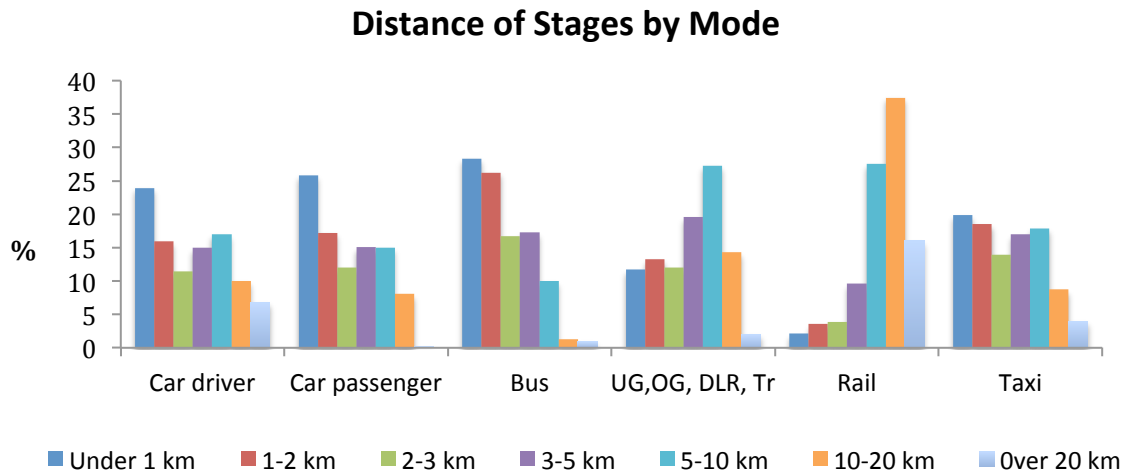


Figure 13: Distance of Stages by Mode

Trips that are under 2km in distance and are not done by active transport modes (walking or cycling) are further analysed. The geographic areas with a high density of such trips are shown in Figure 14. There is one clear main cluster in North-East London around the boroughs of Barking and Dagenham, Redbridge and Havering. In this area, there is a large amount of short trips that are made with car and bus and some with overground. One important point to make is that these areas are outside the operation of the London bike sharing scheme. There is also a second cluster in Central London where underground, taxi, and bus are all used for short trips. As central London public transport can be very crowded, informing people about short walking or cycling routes can relieve some of this congestion.

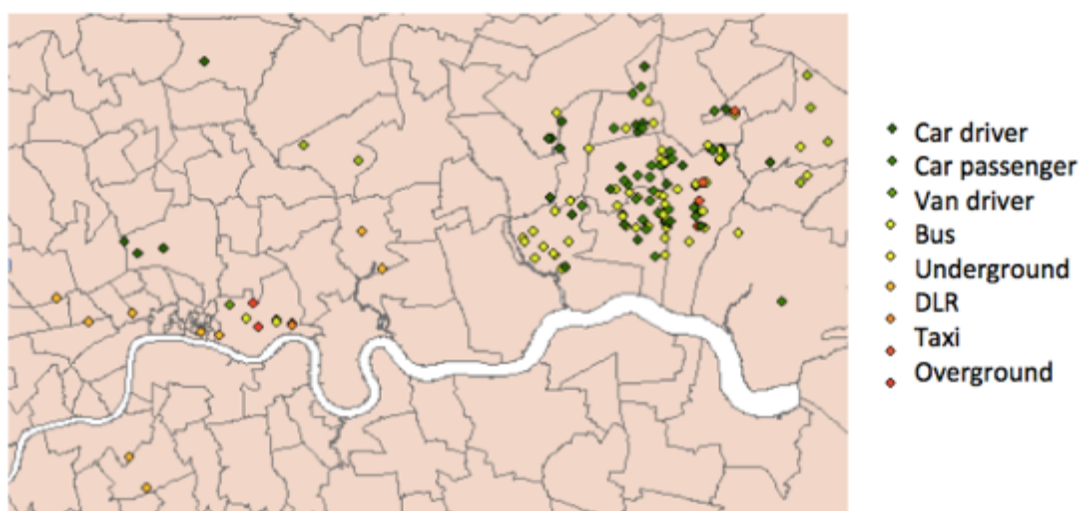


Figure 14: Stages Under 2km by Mode



Moving on to the analysis of intermodal trips, Figure 15 highlights the percentage of trips by main mode, which were made by different combinations of transport modes. Here, access and egress walking was not counted as a separate mode. It is striking that only those trips, where the main mode is Rail or TfL rail, have significant presence of intermodal trips. 72% of trips where the main mode is rail and 62% of the trips where TfL rail is the main mode are intermodal trips. One reason for this is that these modes operate on fixed routes and accessing them directly is possible only for few citizens.

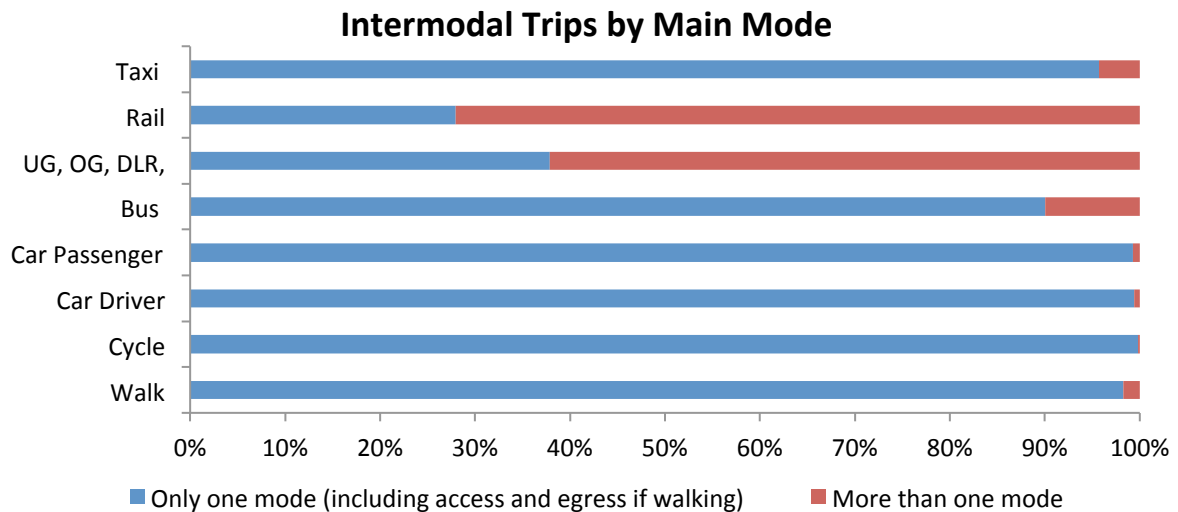


Figure 15: Intermodal Trips by Distance Based Main Mode

Trips where car-driver and car-passenger are the main modes are solely done by these modes in 99.7% of the cases. This means that if an individual has started a trip with a personal vehicle they are bound to finish it with the same vehicle. For the intermodal trips illustrated in the figure above, car-driver and car-passenger are rare among the non-main-modes. This may also show the lack of park and ride options in London.

The stages of trips where the main mode is either National Rail or the TfL rail modes is worth exploring further as they have a significant percentage of intermodal trips. Figure 16 presents the makeup of intermodal trips when the main transport mode is one of the TfL rail modes. 64% of these trips are made by these modes only (including walking). When those trips are added to those that were conducted using TfL rail modes, and one additional mode, we arrive at 97% of all trips. That is, access and egress travel tends to be done by one mode besides walking. TfL rail modes and bus has the largest share of the bi-modal trips making up 72% of them. Most of the National Rail trips are combined with TfL rail modes and bus. As mentioned above TfL rail and car only account for 16% of these trips showing the lack of park and ride opportunities in London.



Breakdown of Intermodal Trips when Distance Based Main Mode is UG,OG, DLR, Tr

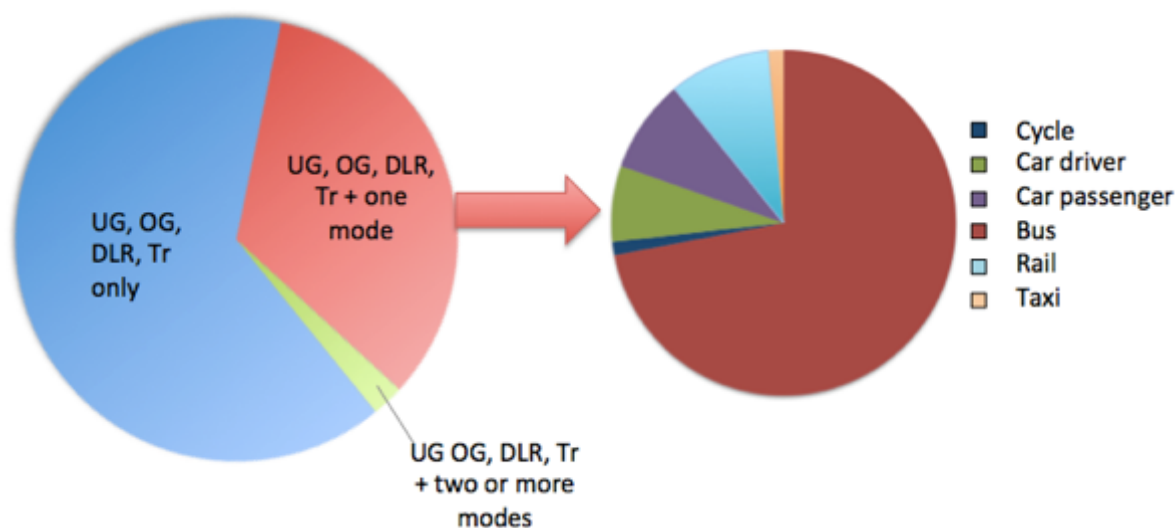


Figure 16: Multimodal Trips When TfL Rail Modes are the Distance Based Main Mode

The largest share of intermodal trips can be seen when the main mode is National Rail (Figure 17). Half of these trips are made using one additional mode, while 17% use more than one additional mode. Intermodal trips using rail, TfL and bus have a very high shares. Interchanges between these modes is generally easy as the stations are usually at the same place, and access to all of these modes is available with one single travel card. This boosts the fact that ease of transfer motivates the use of multiple transportation modes and contributes to seamless mobility.

Breakdown of Intermodal Trips when Main Mode is National Rail

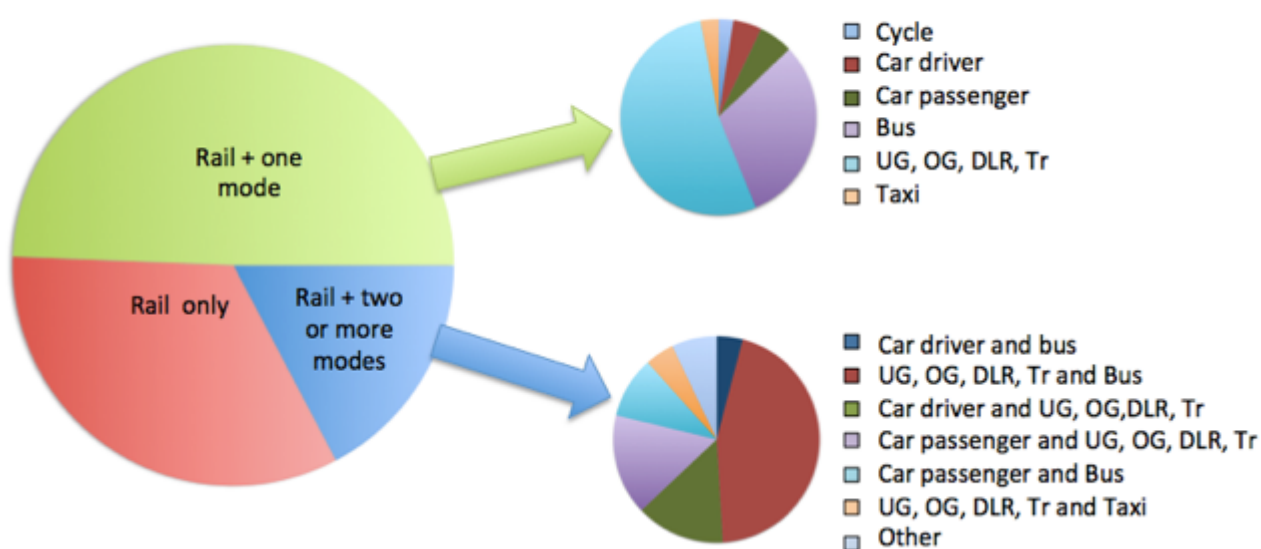


Figure 17: Multimodal Trips When National Rail is the Distance Based Main Mode



3.3.5 Main Transport Mode by Population Segments

In this sub-section, main transport modes are further analysed based on various market segments. This analysis could provide significant insights about the travel needs of various population segments and can contribute to the design of customised MaaS–London services.

Figure 18 illustrates the breakdown of main transport mode by gender. Males drive cars 1.2 times more than females, making them more prominent car-drivers. Females tend to be car passengers more often than males, which is a direct consequence of males driving more often. Another important point is that males choose cycling as their distance based main mode 2.5 times more often than females. Moreover, 45% of males stated that they ride a bike at least once a week, whereas this value is only 34% for women. This trend is also present when looking at the bike-sharing scheme, where out of those who are aware of the scheme and have used it, 63% are males, while only 37% are females.

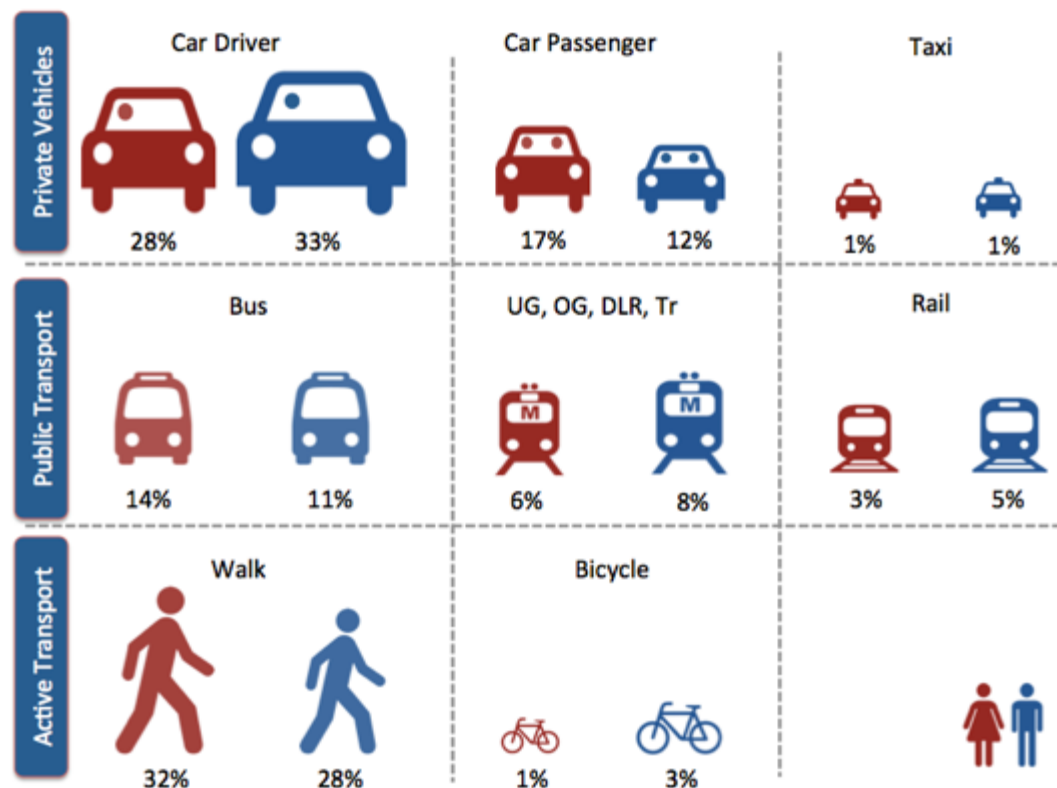


Figure 18: Main Mode by Gender

When breaking down main transport mode by age group some very important insights can be drawn. Figure 19 provides an overview of main mode by age. First of all, under 30's drive cars less than a third as often as the older age groups. Another interesting fact to point out is that cycling is not only for the under-30 age group. Out of those that stated they have cycled at least once in the



past 12 months, only 16% of under 30 years old cycled at least 3 times per week, while the same number for over 30 is 22%.

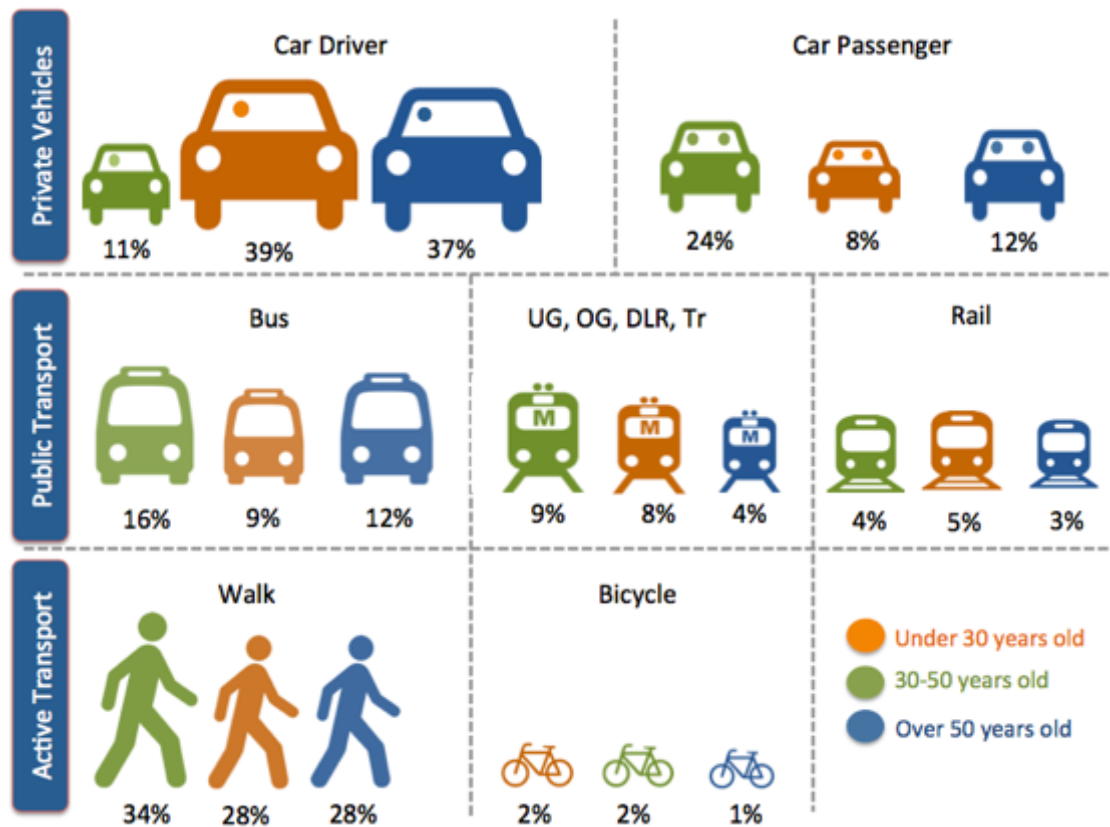


Figure 19: Main Mode by Age Group

Figure 20 illustrates the main mode with respect to household income. A nice symmetry can be seen between walking and car-driving. As household income increases the percentage of walking trips decreases significantly and then increases slightly at the highest income levels. The opposite trend can be seen with car driving; as household income increases car-driving trips increase too, but at the highest levels slightly decrease. Bus usage decreases constantly with income, while UG, OG, DLR, TR and rail usage increases. Cycling is most popular among middle- and high-income households.

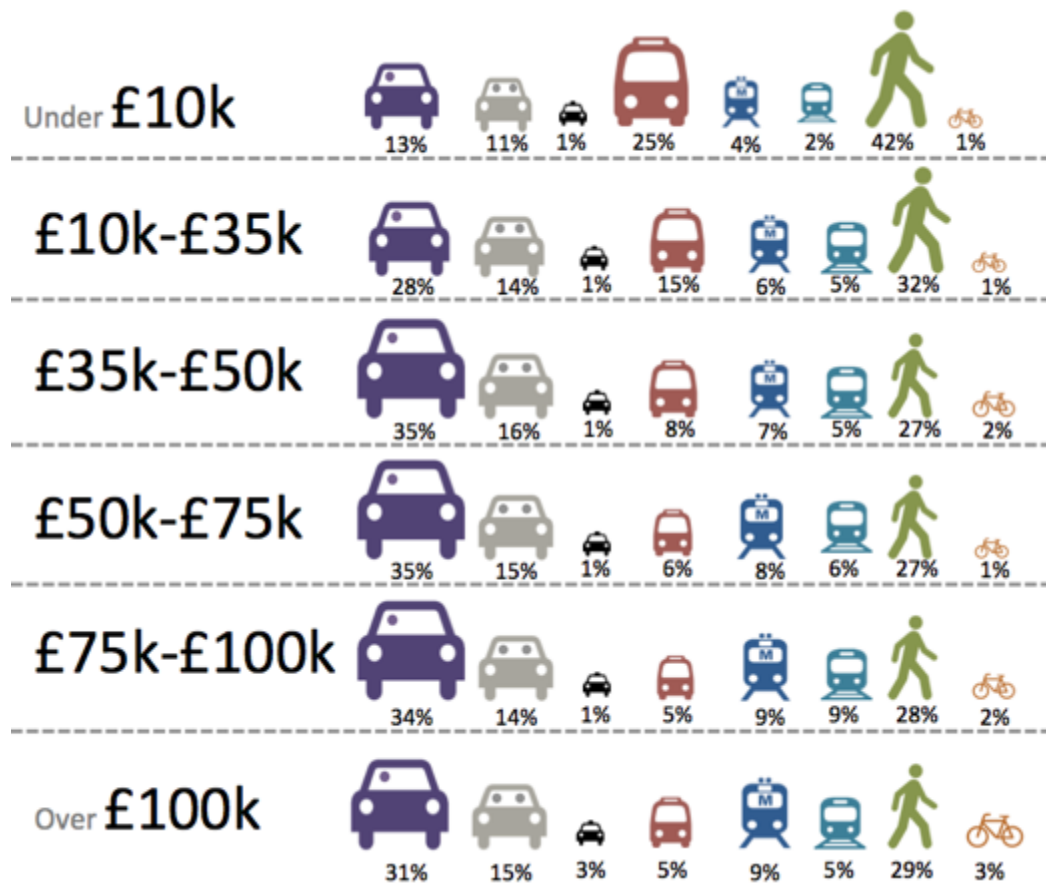


Figure 20: Main Mode by Household Income

3.3.6 Londoners’ Awareness of Shared Modes

Finally, as shared modes (bike and car) are part of the London’s 2020 vision, it is also important to analyse citizens’ awareness and use of these modes. Among those individuals who stated that they cycled at least once in the past year, 79% of males and 75% of females indicated that they are aware of the bike sharing system. However, only 6% and 3.5% respectively actually use the system.

LTDS does not provide in depth information about car sharing schemes, however, Carplus’ annual survey does (Gleave, 2014). According to this survey 67% of members are male and 76% are under the age of 45. The average use of shared cars is about 9.2 hires per year. Valuable information is provided about the use of other shared schemes among car club members and this is illustrated in Figure 21. Members of car clubs tend to use bike sharing and ride sharing schemes (including lifts from friends/family) more often than the average Londoner. They also tend to use traditional car rental services at least once per year.

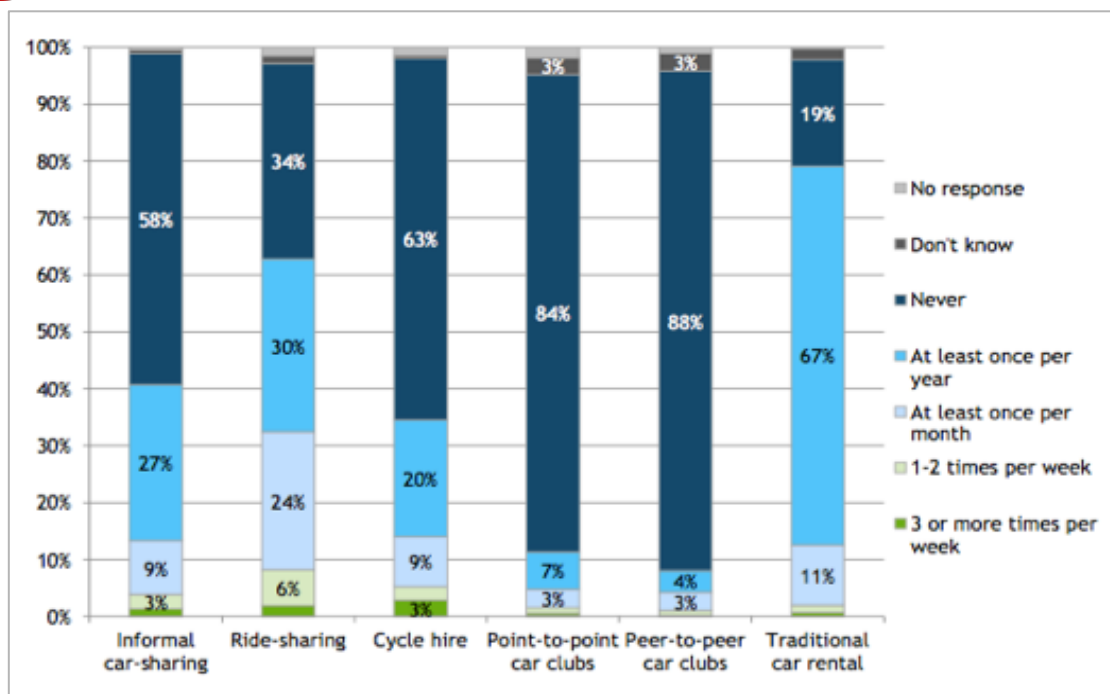


Figure 21: Frequency of Use of Other Shared Modes by Car Club Members (Source: Gleave, 2014)

3.4 London’s transport system as a whole

The vision for London in 2020 and beyond is a city where mobility is seamless, and the transport system provides such convenient services that there is no need to own a private vehicle anymore. London already has all the means to achieve this, as most alternative transport modes that could substitute private vehicle usage are available in the city. Although there has been a trend during the last couple of years moving from car to alternative transport mode solutions, there are still many issues to be solved to revert car-addiction. Londoners have an extensive public transport system (including tube, bus, overground, DLR etc.), a well-organized bike sharing system in the city center, taxis, rail, and car clubs (car sharing), and above all real time transport information on their smartphones all available to them. However, currently, car is still the predominant mode citizens’ use for travelling.

To support the aforementioned case, specific London areas are chosen as case studies. The first case study area is Bank; a rapidly growing business area that provides people travelling in the area all transport alternatives that can be easily combined for intermodal trips. Figure 22 depicts⁶⁰ the tube, bus, and rail stations in the area, locations of City Car Club shared cars, bike sharing docking stations, and car trips that start from this area (from LTDS). The car trips that are depicted are only those that could have been conducted by another transport mode instead of car, as these car users have the options of using tube, bus, rail, car/bike sharing, or walk. Despite the alternative

⁶⁰ The analyses have been conducted by the research team using the LTDS dataset, TfL’s open data, and Geographic Information Systems (GIS).



options, a significant number of trips are conducted by private motorized vehicles. By providing integrated information about all the other transport alternatives, and by removing any payment obstacles during transfers, a number of these car trips could be substituted. Moreover, if car users still want their privacy and the level of convenience they get from car, they can use car clubs as an alternative.

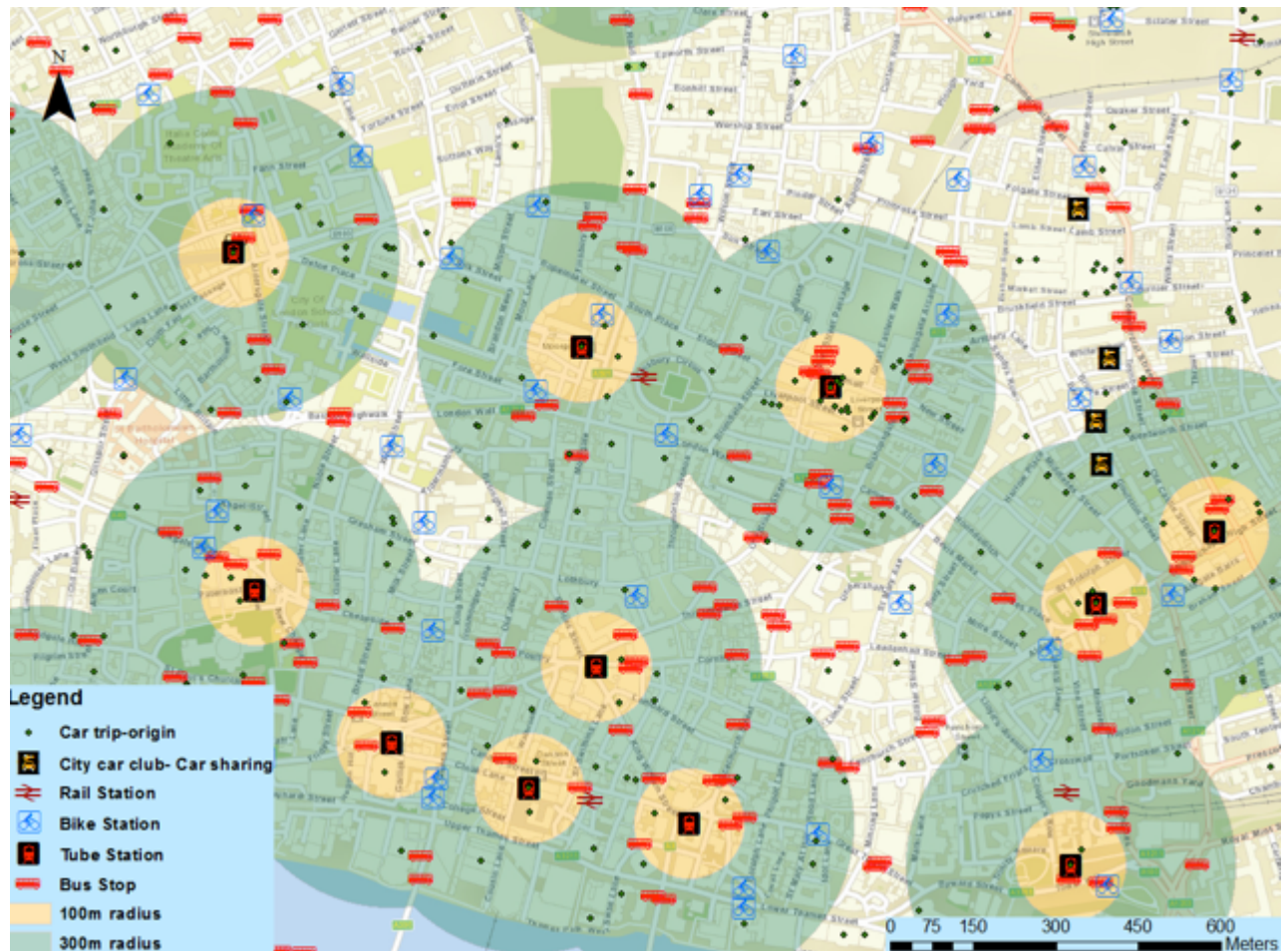


Figure 22: Transport System in Bank Area

The second case study area is the Kings Cross and Euston Stations area (Figure 23). The stations have very good connectivity with tube, bus, bike sharing, and car clubs. Similar to the first case study, the car trips that are depicted could have been conducted by another or a combination of other modes. Most of the car trips’ origins are in a walking distance from tube and bus stations (within 500m). This area has good coverage of City Car Club cars and it is also included in DriveNow’s business area. This means that the car club option offers even more flexibility to drivers by allowing them to park the shared cars wherever they want and not in a designated parking spot. Once again, it is difficult to convince car users to change modes. However, by providing them information based on their needs, and by giving them the opportunity and freedom to use various car clubs without having to become members in one of them could contribute to car switching behavior.

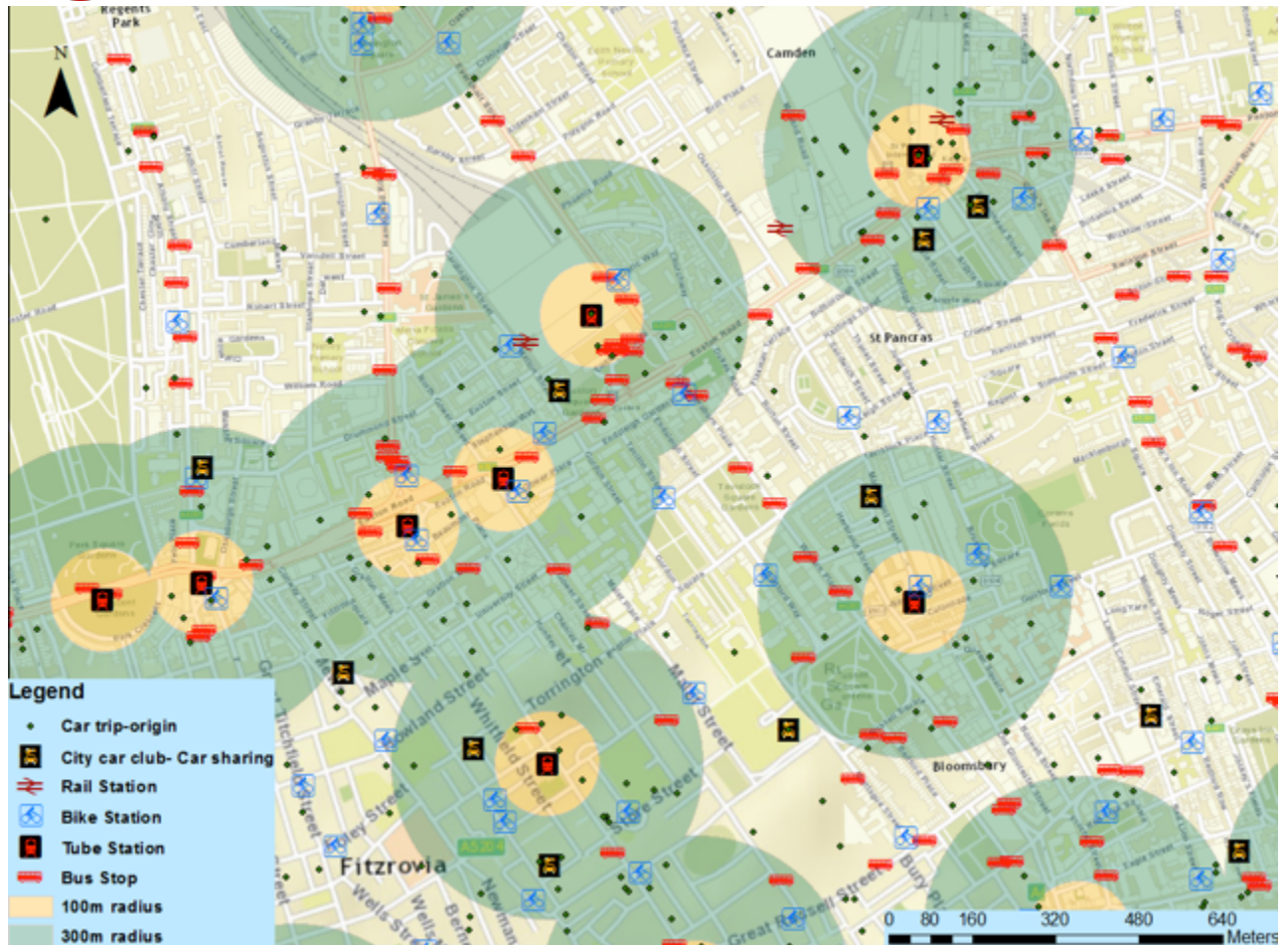


Figure 23: Transport System in Kings Cross and Euston Stations Area

The third case study is the area between Finchley and Hampstead is located in Zone 2. It can be seen in Figure 24 that there are no bike sharing docking stations, and the tube stations are not that dense as in the city center. However the bus network is quite satisfactory, and there are a lot of City Car Club cars available. A certain number of the car trips depicted on the map could be easily substituted either by public transport (especially those where the origin is within walking distance from the tube stations) or by shared cars. Unawareness of car clubs and the benefits (i.e. cost savings) they can offer, and the impression that there are certain constraints in using a shared vehicle (i.e. registration in the club and booking a car) may be reasons that hinder a private vehicles free lifestyle.

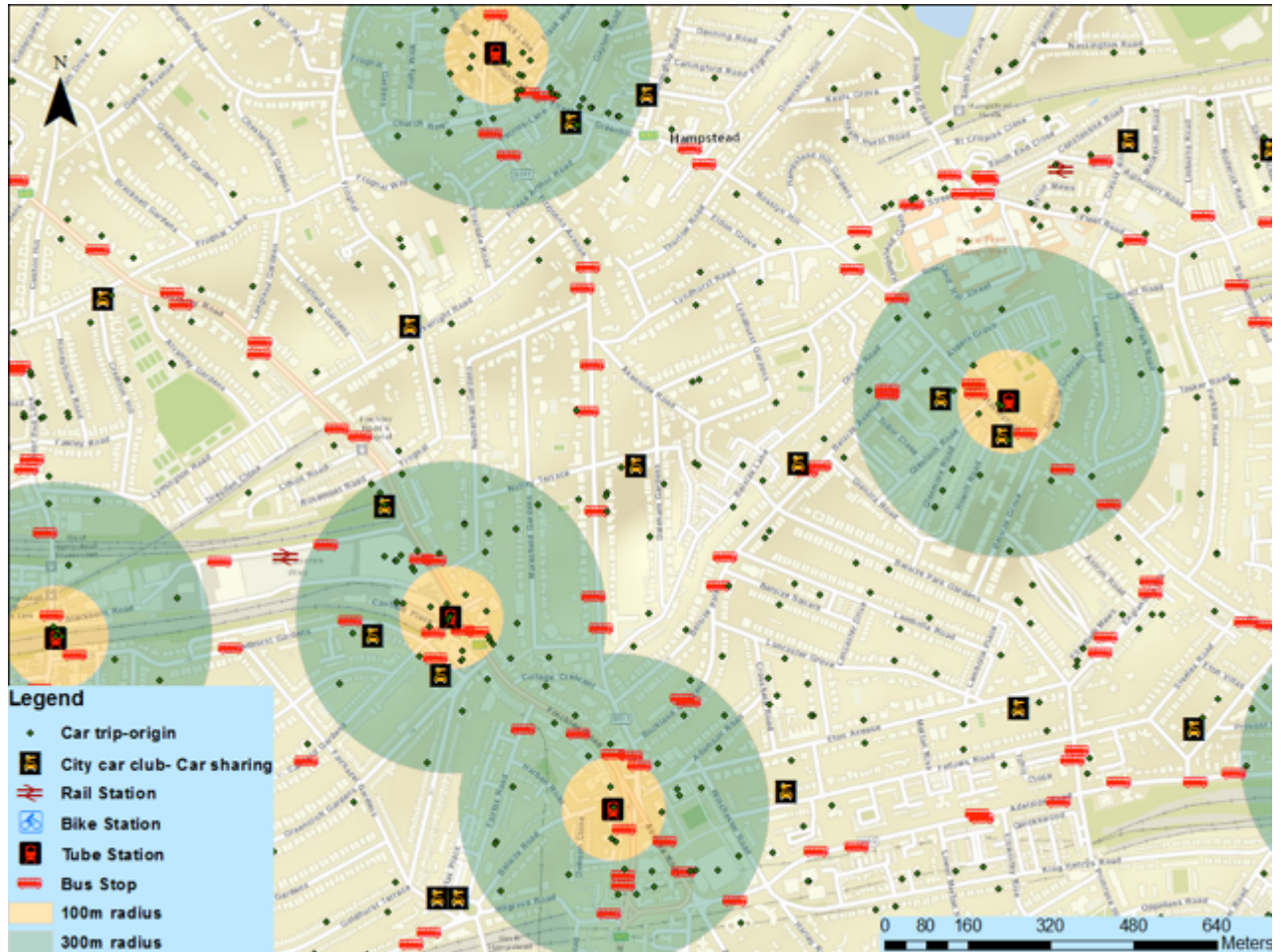


Figure 24: Transport System in Finchley and Hampstead Area

To further enhance the case for a car-free lifestyle, time and cost savings are calculated for the trips where car could be substituted by another transport mode. These analyses are only conducted for the trips in the LTDS 2013/2014 dataset. Due to data availability issues, parking costs are not included in the calculations. It is expected that if parking cost were included in, the cost savings would be higher, and there would be more cases with savings instead of losses. Table 6 presents the average cost and time savings when car is substituted by another mode that is available to the car user. The upper part of the table presents the savings for all the stages within Greater London, while the lower part presents the stages that start or end within Zone 1 (where congestion charging zone is mostly applied). 24% of car trips within Zone 1 that could be replaced by bus, could save an average of £5.22, while 28% of these trips could save an average of 15.07 minutes per trip. Using the weights in the LTDS dataset to aggregate a daily trip to a week, and then to a month, we find that the total savings in a month from substituting car with bus are £104.4, and 5 hours. In the same way, 18% of the car trips that could be substituted by tube and save money, could save an average of £8.16 per trip and an average of £163.2 per month. 79% of the car trips that could be substituted by tube and at the same time reduce travel time, could save an average of 16.21 minutes per trip, or 5 hours and 24 minutes per month. It is also worthwhile to mention that 62% of car trips that save time when they are substituted by taxi within Zone 1, save an average of 14.6 minutes per trip. Although the characteristics of these two transport



modes are the same, travelling by car usually takes more time as it also includes the time looking for a parking space. By using shared cars, this time can be saved as there are designated parking spots for car clubs and real time information about the availability.

Table 6: Cost and Time Savings for a Trip when Switching from Car to Another Mode

Main mode	Total cases	If alternative mode were:	% of cost saving cases	Average cost saving per trip (£)	% of time saving cases	Average time saving per trip (minutes)
Stages by car						
Car	14,784	Bus	24%	0.68	28%	6.32
		Tube	3%	2	81%	8.28
		Rail	3%	2.04	94%	10.2
		Taxi	2%	1.38	63%	7.16
Stages that either origin or destination are within Zone 1						
Car	556	Bus	38%	5.22	28%	15.07
		Tube	18%	8.16	79%	16.21
		Rail	18%	6.68	96%	18.41
		Taxi	12%	3.71	62%	14.6
* In the calculation of cost savings, the cost of parking is excluded, as the data is not available. Only fuel costs, and congestion charging costs are included. If parking costs were available and included in the analyses, cost savings cases and average cost savings would be expected to be higher. Furthermore, insurance and road taxes costs are out of the scope of these analyses.						

Based on the analyses in this section and the aforementioned case studies, seamless door-to-door mobility remains an issue, as not all of the transport services are integrated, information is usually provided by different sources, and citizens are not well informed about their transport mode alternatives and their potential travel time and cost savings. Although TfL makes a considerable effort in this direction, especially with the implementation of the Oyster card, seamless mobility requires the integration of many more aspects (i.e. real time information, IJP) that could enhance travelers’ experience and remove all the obstacles in door-to-door mobility. Technology plays an important role to delivering seamless mobility and a platform where all the available transport operators in London could meet and provide their services as bundles, seems an ideal solution for removing many of the obstacles in door-to-door mobility. By using this platform customers could have integrated information about the transport mode alternatives and combinations of them, information about time and cost savings by each mode or combination, real time information for the modes they choose, integrated payment, and the opportunity to book taxis or shared cars in advance.



4. “Mobility as a Service” Concept for London

London, with a population of nearly 8.5 million, is much larger than any of the previously discussed cities with integrated mobility services. However, this only supports the need for a completely integrated service such as MaaS-London, as a city with so many people has to work as efficiently as possible to tackle congestion both on and off the roads. As shown above, Londoner’s travel habits urge for the integration of sustainable modes with public transport in order to encourage substituting private vehicles with these modes.

Taking into account the insights from the survey of mobility integration projects in other countries and our analysis on the London transport context and current travel patterns, we propose our MaaS-London vision. The concept is first presented from the users point of view to better illustrate its ease of use. Section 4.4 will provide analysis from the supply side.

4.1 MaaS-London services

MaaS-London comprises of the following five steps: (1) Registration and package selection; (2) Journey planning; (3) Booking; (4) Getting on board; and (5) Payment. These are illustrated in Figure 25. Registration only needs to be completed once. Package selection has to be renewed or changed every month. In the following, each step of the process is described in more details.



Figure 25: Process of Using the MaaS-London Platform

Registration & Package Selection



To start, a new user first needs to go through a one-time registration process. To register, the user needs to be older than 18. For children,



parents have to register them and give their consent to use certain modes (bike sharing, taxi). By creating an account, the user provides personal data that are essential for MaaS-London to design suitable journeys and mobility packages at later stages. These include: age, gender, family status, health conditions and disabilities, vehicle license availability, bicycle and car ownership, how much they usually use each mode, whether they own travelcards and mobility preference information (e.g. doesn't want to be shown bicycle as an option or prefers bus to tube etc.). For instance, the question of whether car sharing will be recommended as a viable option depends on the user having a driving license and no health or disability issues that would prevent him/her from driving. In general, the registered account acts as a personal database that allows MaaS-London to maximise its value. The individual has the option to skip any questions if it makes them uncomfortable, however it is pointed out to the registrant that the more information they provide, the better MaaS-London can serve their needs. The user is encouraged to upload license information, as this is necessary for the usage of car sharing services. Finally, bank or PayPal account information is required to set up payments.

In order to finish the registration, the customer has to pay a one-time registration fee by purchasing the MaaS-London core package. This is the subscription to the service. The core package provides full access to the whole MaaS-London platform. The functions included in the core package are the following:

- Journey planner
- Booking system
- Real time information
- Intermodal smart ticketing
- Pay-as-you-go payment for all transport modes

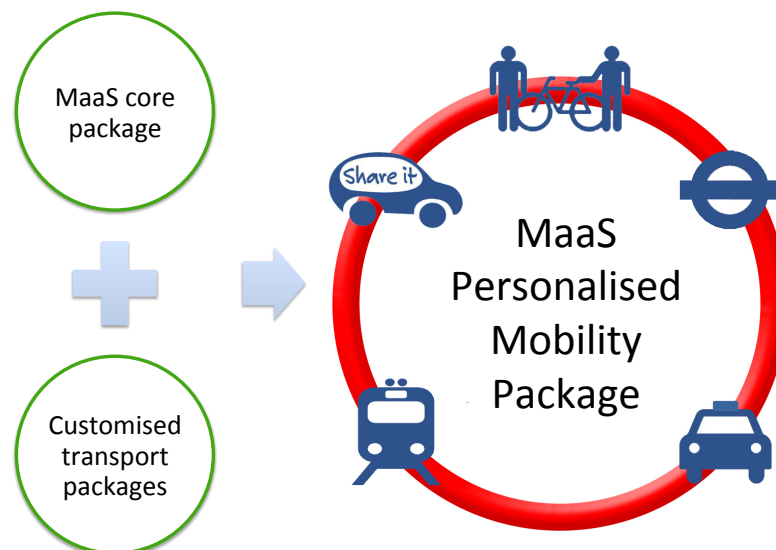


Figure 26: Formation of a MaaS-London Personalised Mobility Package



After purchasing the core package, the user has the option to buy customized monthly mobility packages in a one-stop-shop way. These are additions to the core package, but provide the most revolutionary aspect of MaaS-London. An overview of the MaaS-London packages is presented in Figure 26. Each package is pre-designed to target the needs of various population/market groups in London. The concept is simple: pre-purchase mobility packages to get better value for your money. The price of each mobility package is less than each element would be separately in the pay-as-you-go system; much like it works in other service industries. The mobility packages have a fixed monthly price and include various combinations and ‘amounts’ of transport modes. These ‘amounts’ can be defined either in duration, distance or in monetary terms. For example, 3 hours of car sharing, 5 km of ride sharing or £50 worth of taxi. The denomination depends on the agreements between the service providers. Moreover, in order to guarantee sufficient flexibility, users have the option to add further customization if the chosen mobility package still fails to entirely satisfy the needs (e.g. can add more taxi service). Users are also allowed to select the most suitable package for the current month and change to another one if the transport needs change in the future. Finally, if the user exceeds the pre-specified ‘amounts’ in his or her mobility package, he or she can use the pay-as-you-go option for additional usage. The whole service is built on providing the user as much flexibility as possible

Journey Planning:



Once the user has registered and set up either the pay-as-you-go option or the mobility package, customers are ready to use the service. In order to travel, the user enters essential information (i.e. destination) and optional advanced information (i.e. preferred duration, budget and modes etc.) into the mobile application interface. MaaS-London will then rank route options accordingly and match the most suitable route for the user based on the journey information they provided and their selected mobility package. It embraces some outstanding features:

- All transport modes available in London are considered in planning a route. The intermodal journey planner includes car clubs, ride sharing, bike sharing, taxi and all types of public transport (London underground, overground, bus, tramlink, DLR, river bus and national rail).
- For the mobility services that have multiple operators (e.g. car club, ride sharing and taxi), the journey planner is able to recommend the “best” option based on user’s personal and journey data, but meanwhile keep the other options visible as well. A direct example is the car club operator with the nearest parking spot will be identified as the suggested option. Another example is, if there is preference of sustainable travel stated in a user’s personal account, the journey planner will rank the car club operator which offers electric vehicles or sustainable rewards (e.g. the current service offer by E-Car club in London) as the “best” option to this user every time unless some other criteria are entered.



- Given the inclusion of all transport modes, the interactive map in the journey planner offers full coverage of locational information for all stations. Users can be informed about the on-foot distance, duration and directions to a particular station.
- Journey planner can identify the journey sections that require advanced booking. Then the user can be transferred to the booking system (more details are given in “Booking System” section).
- Price information (i.e. prices of individual modes and total journey price) is available to support user’s decision making when using the pay-as-you-go service.
- In both the planning and travelling stages, the user can be instantly informed of real-time traffic conditions. Suggestions about viable alternative modes or routes will be provided to tackle risks of any delays, cancellations and other unexpected disruptions in order to maintain transport efficiency.

Booking:



In order to book vehicles, the user is transferred to the booking system, which is a centralised platform that brings users and transport operators all into one place. Bookings with different operators are no longer required to be done separately as the MaaS-London booking system integrates the booking systems of all transport providers.

As already explained in “Journey Planner” section, the booking system follows the journey planning stage. If the user chooses to take a mode that requires booking (taxi, car sharing) the system provides a “book” button where the individual can book their journey. The company and price are all presented to the user, so that they can make informed decisions when booking with certain companies. MaaS-London even sends a booking complete message with the information of the car/taxi so that the traveller is aware. For vehicles equipped with GPS devices it can also be possible to view when the taxi is approaching/how far it is. However, it must be clarified that sufficient travel flexibility is still guaranteed since not all parts of a journey have to be booked ahead and any required bookings are only for securing usership.

Smart Ticketing:



Once the user starts his or her journey, MaaS-London is used to access all transport modes. Given the current technological frontier, a smart card can serve as the sole ticket to access mobility services such as public



transport or release a shared car. As shared bikes are already accessed by codes that have to be punched in to release the bike, this code could be provided through MaaS (much like it is currently provided by the Santander Cycles mobile application).

When the technology becomes more mature, smartphones can be used as the sole ticket instead of a card. In this case, the smartphone would be scanned in the same way as a smart card would be to access the modes.

Payment:



The final step the user encounters is payment. If he or she purchased a mobility package and the trip was included in their package, they do not have to pay anything at the point of usage. However, if the user has not purchased a pre-paid package, or exceeds their package, there can be several payment options depending on service type. By using the pay-as-you-go service, the amount will be deducted at each time of use. The system also offers flexibility to the user to either deposit/charge his or her account in advance (before getting on board; like the way the London Oyster card works). If the user purchased a monthly package direct debit and automatic renewal are available. During each journey, the smart card will record the amount of use for each corresponding mode taken and recalculate the balance of monthly package. For any excessive part used over monthly package, the user has options to either pay separately by receiving a monthly bill or proceed with direct debit to pay their monthly package plus the excessive part altogether.

4.2 MaaS-London - Mobility Packages Design



Packages provide the heart of the innovation in MaaS-London. They redefine current passenger transport, offer seamless mobility and work much like product bundling in other sectors (i.e. telecommunications). Packaging is based on the idea that customers value the grouped bundle more than the individual item. Literature sites desire to reduce risk and search for costs, variety seeking needs and product interrelatedness as core reasons for customers buying bundles (Venkatesh and Mahajan, 2009). These all apply in a transport setting. For the suppliers, packaging can offer increased marketing channels and per unit sales although at a lower per unit cost. Packaging transport modes exposes customers to modes of transport they may not regularly use, which can have an effect on their mode choice. If packaged correctly, this can mean exposure to sustainable modes and an increase in their share of use.



However, traditional packaging approaches will not provide the necessary flexibility to serve the diverse needs of today's travellers. This is especially true for a city as complex as London, and for a concept incorporating as many services as MaaS-London. Addressing customer heterogeneity provides greater overall benefits for both users and service providers. This is why we propose using a version of mass customisation, namely *collaborative customisation* for packaging MaaS-London services. Collaborative customisation consists of a dialogue with individual customers, allowing them to articulate their needs and then using this information to create customised products/services for them. This method increases customers' involvement with providers by allowing them to influence their products. Many sectors refrain from using this type of customisation as it results in demand for a large variety of product, which for sectors with tangible products may prove to be too difficult to produce. However, in our case, as there is no physical product, just levels (amounts) of each service, this is not a problem. Also, contact with customers can be done through the platform itself, which is all automated so it doesn't result in increased labour hours.

Building on the concept of collaborative customisation, the key to successful package creation is extracting as much information as possible from the user in order to tailor the bundles to their needs. However, consumers are only able to answer a limited amount of questions before they get irritated with the process and discontinue. This is why it is important to understand the target market before creating the questions that will assist package creation. Minimising the burden to users increases the response rate to each question. In the case of MaaS-London, this means identifying the key market segments and factors that place individuals in each of these segments. These key factors and characteristics can then be turned into areas that need to be addressed during the questionnaire at the registration phase described in section 4.1. There also needs to be a “home” section of the platform where any of provided information could be changed or expanded later.

Building on our analysis of the London Travel Demand Survey (see section 3) and review of relevant literature, we identified the most important factors that should be key to package creation. In the following we propose the main elements that should be included in the information provided by the customers. A general overview of the elements is provided in Figure 27.

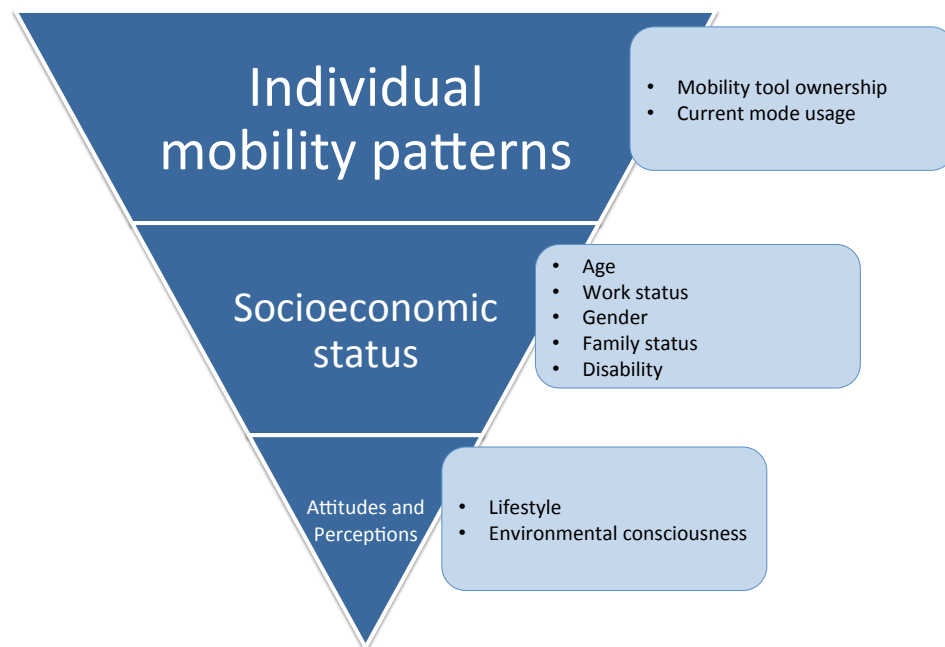


Figure 27: Key Elements for Package Design

The central element of customised package design is the information provided by registrants on individual mobility patterns. It is important to point out that MaaS-London is not expected to drastically change anyone’s mobility patterns, at least not in the short term. Its aim is to simplify intermodal journey experience and as such may cause changes in travel behaviour. For this reason, current travel behaviour and mobility patterns provide the core of the information necessary for package design. Two key areas that need to be addressed are mobility tool ownership and current mode usage. Mobility tool ownership refers to driving licenses, which are key to the availability of certain modes (car sharing), travelcards/passes and subscriptions to any services. Current mode usage information refers to which transport modes the individual uses and to the frequency he or she uses each mode. This provides the basis for passengers demand for each mode.

The second body of questions that assists package creation is the socioeconomic status of the respondent. Key information here includes age, work status, gender, family status and disability. Age is an especially important category. As discussed above, the young adults age groups should be specifically targeted by MaaS-London as they are more open to the ‘usage instead of ownership’ lifestyle. Further, if they get used to using sustainable and shared modes on a regular basis early on, they are more likely to carry these habits on when they are older. For these reasons, we would suggest providing special discounts for young adults, specifically students, to incentivise them to become regular users of all the MaaS-London sustainable modes. If, for example, young MaaS-London users get special discounts on car and bike sharing now, they will



get used to the service and will be more willing to pay for shared services when they get older (and earn more) and will be less likely to buy their own car (or second car).

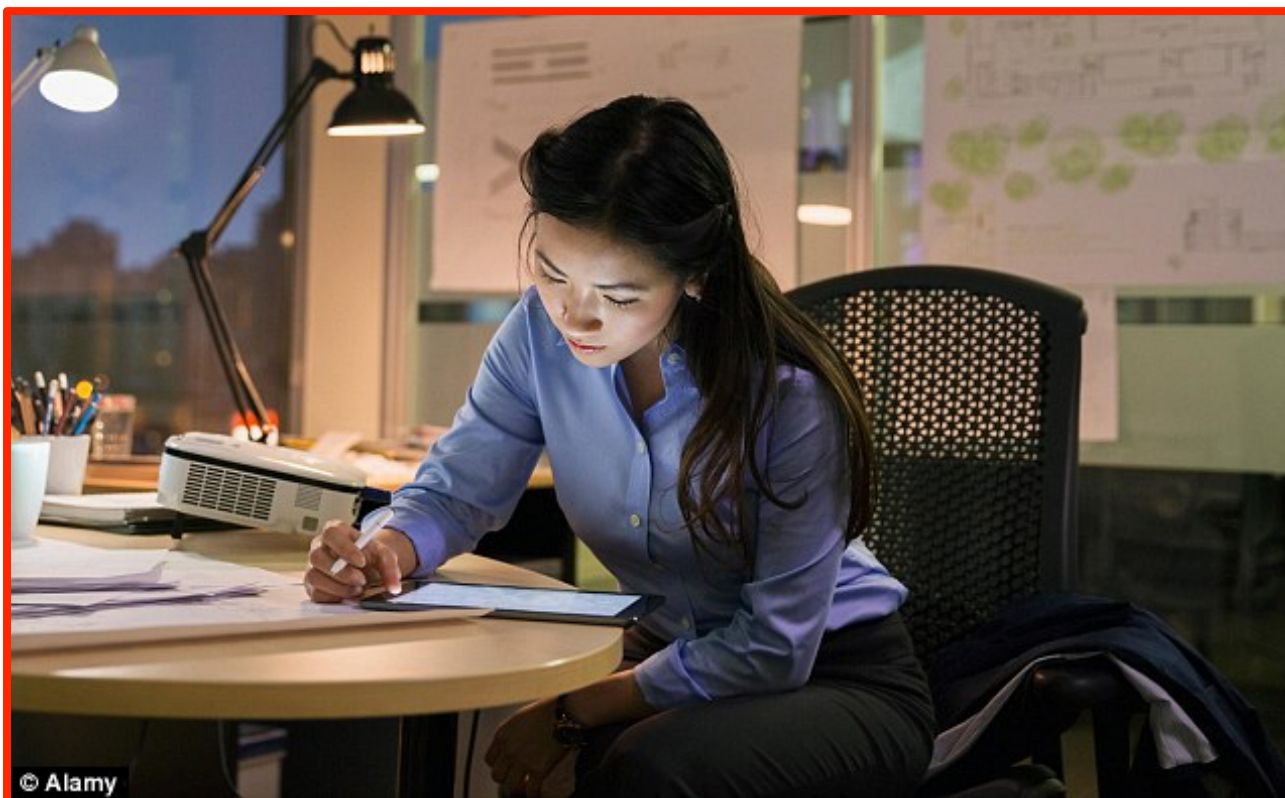
Working status can also influence packages as certain occupations mean regular office destinations with constant weekday travel patterns, while others require more flexibility in everyday travel. Further, students can also be separated and following the argument in the previous paragraph, can be specifically targeted. Gender and family status are especially relevant when talking about dependent individuals. Parents with young children for example will have larger needs for vehicles (car sharing) to transfer their kids. Families can link their MaaS-London accounts together to be aware of each other’s whereabouts. This can be great for families with teenagers, as they can keep track of their children through integrated systems. Finally, disability is crucial, as it excludes certain modes.

The final group of questions for package creation is attitudes and perceptions towards environmental consciousness and lifestyle. This provides customers the opportunity to indicate their openness to active modes such as cycling and walking or to luxury mobility services.

By gathering the above-mentioned information on users, packages can be tailored to their needs. However, we are proposing not to ask them “what do you want in your package” on purpose. This way, MaaS-London is able to offer packages that suit their needs, but also encourages them to use shared and sustainable modes. For example, for someone who only uses public transport but wants to live a healthy life-style, MaaS-London can include bike sharing in their package in order to encourage their use. If MaaS-London offers this person bike sharing on a regular basis, they will probably eventually try it and may even love it! This is the whole idea behind MaaS-London, to expose people to new and sustainable modes and make it easy and convenient for them to use. By doing this, it influences both their short-term mode choice and induces long-term behavioural change (e.g. getting used to using car sharing and not buying a private vehicle).



4.3 Example Story

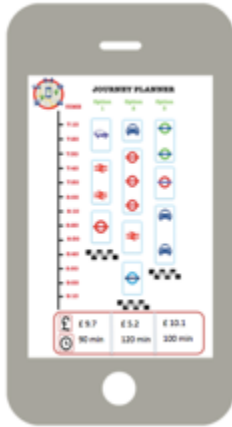


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Beth is 28 years old living in Watford with her husband. She is a regular commuter who must travel to her office in Marylebone every morning. After suffering enough traffic problems by travelling in the cosmopolis by car every day, Beth decides to use MaaS-London to make her trip faster and less stressful.

She first downloads the MaaS-London App to her smartphone and opens her personal account via the quick registration process. She now has access to the core package and she has to choose between using the simple pay-as-you-go service or purchasing a package that suits her. During registration process she answered all the questions and MaaS-London offers her a “Commuter Package”, which she finds very appealing. The package includes sufficient amount of national rail, London underground, bus and car sharing services, which is perfect for an office lady like her. However, Beth wants to occasionally take taxi when she feels tired so she customises the package by adding taxi. Now the customised “Commuter Package” is exactly what she needs. She clicks on it to confirm the choice and now is ready to use it:

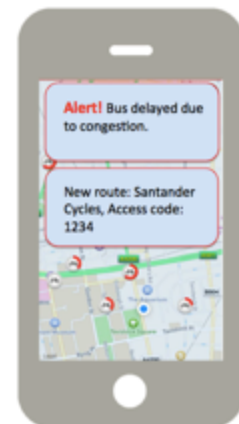
⁶¹ By Ellie Zolfagharifard For Dailymail.com, Available at: <http://www.dailymail.co.uk/sciencetech/article-3088186/Men-FAKE-working-hard-office-promoted-women-ahead-claims-research.html>



Beth wants to leave her home in 5 minutes. She enters her office address into the journey planner and asks for the fastest route option. The App suggests taking car sharing, rail and bus to get to her office. MaaS-London shows that it will only take her 40 minutes compared to her regular 1 hour and 10 minute commute. Besides, the journey planning process has only taken 1 minute to clearly inform Beth what to do next. Beth sees all relevant information for her trip today: direction of the car sharing spot, the fact that no booking is required now due to a good availability level, and that there is good service on all underground and bus like in the App without having to check separate websites for each mode. Beth kisses goodbye to her husband. The car sharing spot recommended by MaaS-London is only 200 meters away from her home.

After a short walk, Beth arrives and a car is ready for her. She touches the smartcard to the reader to unlock the door and ignites the car inside straightaway to start driving. A car sharing parking spot is available at Watford Junction rail station, which enables Beth to be completely freed from this car after 10 minutes of driving. Without queuing for ticket, Beth passes the baffle gate and flies on board to London Euston simply by scanning her smartcard as a virtual ticket.

During her rail journey, Beth receives a text alert saying that her next bus is likely to be delayed due to congestion and another text arrives instantaneously to recommend her switching to Santander Cycles as the fastest alternative. The train takes 20 minutes to arrive. With the help of the map in MaaS-London, Beth easily finds the nearest bike docking station right next to Euston station. Her phone provides her with a release code for the bike and she rides for 15 minutes to Marylebone without worrying about congestion.



Although the whole journey took 5 more minutes than the original plan due to the unexpected matter with the bus, Beth still sits on her office chair 25 minutes earlier than yesterday. She is now in love with MaaS-London and recommends the App to her colleagues.

Where is the payment? Is it forgotten? You may ask. Beth will tell you she has forgotten about it too. Since direct debit does everything for her she has not thought about issues like top-up or cash withdrawal for a long time.



4.4 MaaS-London Concept – The supply side

The integrative characteristic of MaaS-London can only be achieved through a collaborative partnership between MaaS-London and transport service suppliers in London. The services that MaaS-London aims to include are public transport, rail, bike sharing, car club, ride sharing and taxi. To become a partner, each individual supplier has to agree to the terms are set by MaaS-London and sign the contract in order to fulfil the following obligations (Table 7):

Table 7: List of Supplier Obligations

Suppliers	Obligations
Public Transport	- Provide timetable information - Provide price information - Provide station locations
Rail	- Provide timetable information - Provide price information - Provide booking information - Provide station locations
Bike Sharing	- Provide price information - Provide locations of docking stations and bike availability - Provide health information (e.g. calorie consumption)
Car Club	- Abandon registration requirement - Provide price information - Provide vehicle information - Provide booking information - Provide locations of parking bays and vehicle availability - Provide sustainability information (e.g. availability of sustainable rewards and electric vehicles) - Provide information of special service (e.g. one-way service)
Ride Sharing	Provide drivers’ database
Taxi	- Provide price information - Provide vehicle information - Provide booking information - Provide sustainability information (e.g. availability of sustainable rewards and electric vehicles) - Provide information of special service (e.g. valet service)

In general, the core information that operators of different services must supply is the price they charge on a unit basis (i.e. how much it will cost for each mile or each hour). This is an essential requirement for the provision of mobility packages. Operators are also obliged to supply a number of basic information such as real-time information (i.e. instantaneous timetable for public



transport and rail, availability for bike sharing and car club vehicles), location information and booking information so that MaaS-London can use it to plan the “best” journeys for customers. In addition, more advanced information is welcomed such as vehicle characteristics in car club and taxi services to meet different preferences, sustainability information so that customers who have intentions to be environmental friendly have options to choose from and any other special services that operators can offer to satisfy relevant needs.

In the end, two special issues must be pointed out. First, car club operators have to give up their registration requirements for new customers in order to avoid double registration when using MaaS-London and car club service. As this provides one of the major revenue sources to car clubs, they will need to compensate by increasing usage rates. Second, ride sharing needs to be described in greater detail. As ride sharing works through various online platforms that connect people who are looking for a ride, with drivers willing to take passengers, the information from these platforms needs to be incorporated into MaaS. Our vision is that MaaS would collect all the ‘rides’ (being offered and being searched for on every ride sharing platform that signs up to be part of MaaS) into one database and would provide ride sharing as an option if the origin and destinations match. It is important that those ride sharing platforms that sign up share the rigorous scanning process and feedback options for drivers and passengers to ensure safety. Thus, ride sharing platforms are required to provide their drivers’ database to enable MaaS-London to add ride sharing as an option in journey planning when a driver satisfies the criteria (e.g. nearby origin and destination, acceptable price etc.).



5. Feasibility study

This chapter examines the feasibility of implementing the MaaS-London mobility service. The feasibility of MaaS-London is assessed based on operational, technical, and economic criteria. In addition, a SWOT analysis is conducted to evaluate the market for the implementation of the proposed product.

5.1 Operational Feasibility

It is expected that MaaS-London could initiate a new era for the way transport services are provided by operators, and purchased by travellers. Many of the parties that are currently involved in the transport system are expected to be influenced by the proposed MaaS-London business model. Understanding their interests in MaaS-London is crucial in order to evaluate whether the concept will be accepted or not. The following section evaluates the operational feasibility of MaaS-London based on its acceptability by two different categories of stakeholders (Figure 28): 1. internal stakeholders (parties within the organisation that implements MaaS-London), and 2. external stakeholders (i.e. parties outside the organisation that implements MaaS-London).

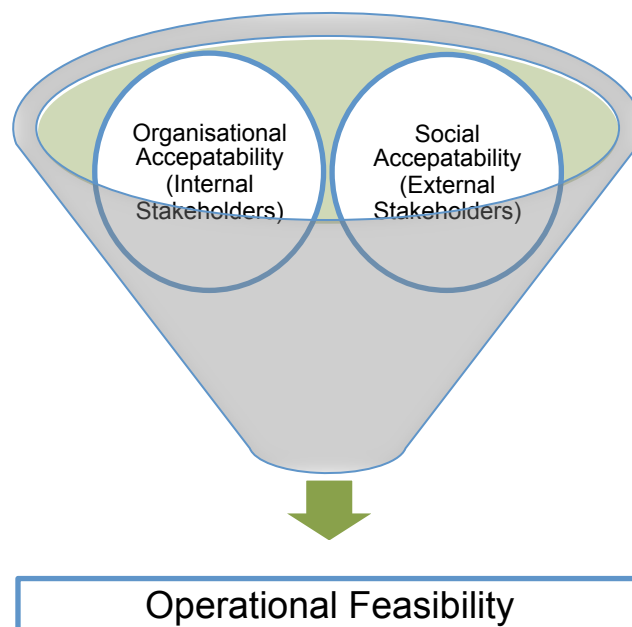


Figure 28: Elements of Operational Feasibility

5.1.1 Organisational Acceptability

The ideal organisation to implement MaaS-London is TfL, as it is already the organisation responsible for the transport system in London. Thus, the evaluation regarding internal stakeholders' acceptability will be conducted making the assumption that TfL is the core of MaaS-London. In addition, the internal stakeholder (TfL) is further categorised into two levels: a. the Managers (leadership of TfL), and b. the Staff (manpower).



5.1.1.1 Managers

MaaS-London is expected to fit well with TfL’s interest and its vision for the transport system of London. The new service could contribute to the implementation of the Mayor’s Transport Strategy (MTS)⁶², which broadly speaking aims to deliver social welfare to Londoners from a transport perspective. Table 8 compares and evaluates MaaS-London’s contributions in general, and to the public benefits addressed by MTS. High-level contributions are indicated with green, medium contribution with orange, and low contribution with grey. MaaS-London is expected to highly contribute to travel cost and time savings (supported by the analysis in 3.6), and to the dissemination of real time information that could help travelers make well informed mode choices. As far as MaaS-London’s contribution to the MTS, it will have a significant impact on improving mode interchanges, as the IJP will provide travellers all the necessary information for their transits (transit locations, distances, walking time, costs, real time information for modes arrivals/departures/delays etc.). Having better information will improve the accessibility to the transport system. However, accessibility also refers to infrastructure (i.e. availability of elevators, step-free access), thus overall the impact of MaaS-London on this topic is expected to be moderate. As MaaS-London targets to reduce private vehicle use, it is expected in the mid-term to also have an impact on smoothing traffic congestion, and as an indirect result improve the surrounding environment and quality of life. Based on this evaluation the adoption of MaaS-London by TfL is highly feasible.

Table 8: Comparison between MaaS-London and MTS

	Level of Contribution
Contribution of MaaS-London	
Save costs	High impact
Reduce journey time	High impact
Improve dissemination and provide real time information	High impact
Improve service experience for the transport user	Medium impact
Provide better connectivity	Medium impact
Reduce traffic jams	Medium impact
Reduce transport pollution	Low impact
Contribution to MTS’ proposal	
Improving interchanges	High impact
Better information	High impact
Improved access to transport system	Medium impact
Smoothing traffic flow	Medium impact
Better streets and environment	Medium impact
High impact Medium impact Low impact	

⁶² The Mayor’s Transport Strategy. Available at: <https://www.tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/the-mayors-transport-strategy?intcmp=2691>



5.1.1.2 Manpower

It is also important to examine whether such a new service will raise any issues for the employees of TfL; in other words, whether TfL employees will accept MaaS-London. It is anticipated that MaaS-London will maintain the manpower structure in TfL and keep its employees satisfied through introducing some role changes. For example, although MaaS-London will revolutionize the ticketing process, TfL employees who are responsible for ticket sales will not confront any job cuts since they will remain at stations by dealing with more passenger enquiries as a result of larger traffic flows. There will probably be need for training in order to be able to respond to new requirements. In general, most employees’ responsibilities under the current system are expected to be unaffected. For example, staffs that patrol in stations to help with gate pass, ticket inspection and other emergency issues etc. will still hold their positions.

Besides, MaaS-London can also create new vacancies, especially in the Departments of Marketing and Communication, Transport Planning and Strategy, and Commercial Development. It is a very technology-intensive transport solution and there will probably be demand for more employees to successfully operate and maintain the platform. Since no reductions in staff numbers is anticipated, it is expected that MaaS-London will also be accepted by TfL’s employees.



5.1.2 Social Acceptability

This section examines the external stakeholders. As MaaS-London brings together the supply side (transport operators) and the demand side (customers) in London, this means that both parties must be willing to join and use the platform to make it feasible.

5.1.2.1 Supply side – Transport operators

The transport services that MaaS-London aims to include are public transport, rail, bike sharing, car clubs, ride sharing, and taxis. Each has different market structures, indicating varying perspectives regarding the evaluation of their interest in joining MaaS-London. Table 9 illustrates the number of service suppliers for each service.



Table 9: Market Structure for Each Service

Service	Number of Service Suppliers
Public Transport	1
Rail	1
Bike Sharing	1
Car Club	Multiple
Ride Sharing	Multiple
Taxi	Multiple

Public transport in London is entirely operated by TfL. If TfL is willing to implement the MaaS-London concept, the public transport system will directly be integrated to the platform. The same idea can be applied to bike sharing. Although the bikes and docking stations are sponsored by Santander, the body in charge for its operation is TfL.

The rail service is in a slightly different situation as National Rail is the operator in Greater London. However, National Rail is also a governmental body that aims to promote railway services and provide harmonisation to passengers. In fact, it is already a platform itself integrating different train companies and as such, its interests are expected to fit well with the MaaS-London concept that will simply create a larger platform including more suppliers.

Assessing the integration of car clubs, ride sharing, and taxis, are more complex as each of these sectors is occupied by multiple private companies. Generally speaking, the integration will be welcome by each market if all parties can be clear about one fact: *MaaS-London is not designed to replace any of the existing businesses; it only offers an innovative way to bring a larger market to each individual transport operator.* The rest part of this section will explain the idea of how MaaS-London can benefit operators in each market.

Car club operators will continue to run their services and in addition, they now have the opportunity to embrace a larger market by providing their information (as described in section 4.4) to an integrated mobility platform on which travellers will plan their journeys by taking these car club services into account. It is an absolute gain with nothing to lose. Nonetheless, the only potential issue, although not affecting the principal benefit, has to be pointed out. Under current system, registering for membership before using car club service is a requirement set by each operator. MaaS-London, however, also requires a one-time membership registration in the beginning. As a result, if both registrations exist, a user will find difficult to switch freely among different operators for different journeys, which is contradictory to the MaaS-London vision.

The existing ride sharing platforms will also benefit from joining MaaS-London by enjoying a larger market but encounter a slightly different situation. These platforms are similar to MaaS-London in that they communicate between passengers and transport service providers (i.e. individual drivers in this case). Therefore as section 4.4 has pointed out, after the integration, the matching



function that is currently managed by ride sharing platforms will be done in the intermodal journey planner of MaaS-London.

The taxi sector involves mixed elements from car club and ride sharing markets. Recalling the different taxi services operating in London from section 3.1, the three types of them are Hackney carriages, Mini cabs and P2P platforms. Taxi P2P platforms share the same characteristics as ride sharing platforms by connecting drivers and passengers without owning any fleets. Again, their businesses will not be affected by only supplying drivers’ information to MaaS-London. Mini cab operators are similar to car club operators since they both provide the actual on-road services. Thus, they can in the same way be integrated into the centralised platform, and more importantly, the registration issue in car club case will not apply to Mini cab operators since they do not normally require any membership registration. Hackney carriages, also referred to as black cabs, are influential players in the London taxi market. According to past experience (e.g. when Uber entered the market), individual black cab driver may dislike the entry of MaaS-London as fewer passengers need to hail a ride on street. Nevertheless, living in the era of technology, black cabs should consider modernizing the way they operate to be able to survive. Many black cabs have already accepted advanced booking and it is prospective to incorporate more black cabs into the platform though more negotiation and coordination to make it come true.

5.1.2.2 Demand side – Customers

The integrated service offered by MaaS-London enables customers to enjoy savings in travel expenses and journey time. Apart from these directly associated benefits, some additional evidences will in fact reinforce the link between MaaS-London and public interest.

First, there are a few indicative trends from the analysis of Londoners’ travel pattern (see 3.3): 1. a large share of intermodal trips are made by various forms of public transport; 2. the main reasons for changing car use are the cost associated with this mode, and the cost and availability of public transport as an alternative; 3. car sharing membership and bike sharing usage have both been steadily increasing. All these trends in recent years indicate that Londoners have started to shift towards more intermodal and sustainable transport options, and MaaS-London is just about to bridge the gap to satisfy this need.

Second, the introduction of MaaS-London is very timely as Generation Y (born between 1980 and 2000) is replacing the baby boomers as the working population, the main group of transport service users. The older generation views private vehicle ownership as a status symbol. However, the Millennial does so much less and are considerably more open to new ideas and technologies.

Third, the adoption of smartphone has widely spread under the era of informational technology revolution, especially in London, a global cosmopolis. Such technology penetration is now providing an ideal ground for MaaS-London to simply build everything in an App. Meanwhile, in

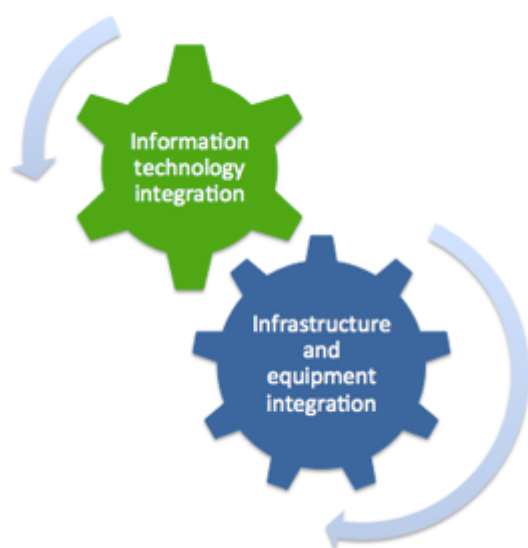


order to achieve wider promotion to the group that are less familiar with new technology (e.g. the elderly), smart card as the virtual ticket and PC as the online platform can also be designed especially during the transitional phase towards MaaS-London.

Concluding, MaaS-London will fit well with TfL’s interest and will bring no harm to its employees’ welfare. Supply and demand sides of the market have also been assessed with the insights that transport operators and customers will both find MaaS-London attractive as this new service is expected to benefit them in different ways. Finally, in addition to the parties that have been identified to be directly involved in MaaS-London, other parties such as DfT will also need to be involved if the concept is going to be promoted across UK in the future.

5.2 Technical Feasibility

At the heart of the MaaS-London concept is an integrated platform that has the capability to provide real time information, process booking and payments, and if the technology become mature enough, even act as a virtual travel ticket. It is the link that ties together various transport providers and users. It is the component that would become part of users’ daily life and would provide the two-way communication between users and transport operators. The design,



operation and maintenance of this platform are the most important elements of the MaaS-London project. However, it neither has to be built from scratch, nor should it be. The main components of the platform can be created by the integration of already existing elements. In order for the MaaS-London concept to work, the platform needs to be complemented by the necessary integration of infrastructure and equipment. These include creating compatible smart card readers and geographic concentration of stations and terminals for several modes. With these in mind, the following section will focus on the two main technical elements that go hand in hand for the successful development of

MaaS-London, namely, *information technology integration*, and *infrastructure and equipment integration*.



5.2.1 Information Technology Integration

MaaS-London is not a new physical mobility device or a completely new technology. It is solely the integration of already existing mobility tools into one, easy-to-use platform. The best aspect of the idea is precisely this, the fact that the elements necessary to make MaaS-London viable already exists piece by piece; MaaS-London just restructures (i.e. Oyster card) and repackages them (i.e. travelcards to offer bundles of transport modes) in a way that makes them more attractive for users. What IT elements need to be integrated into the platform? An intermodal journey planning tool which includes information from each contracting company’s platforms such as availability information and booking, real time information about public transport modes, traffic congestion and accidents, and a payment method.



The IJP provides the backbone of the platform. There are three possible options that can provide the basis for it: (1) TfL’s current web-based journey planner could be expanded; (2) one of the existing journey planners could be brought on as a partner; (3) a completely new one could be developed.

Table 10: Advantages and Disadvantages of Intermodal Journey Planner Options

	+	-
Expanding TfL journey planner 	- Existing link with TfL - For public transport, cycle, walk and cycle hire modes - Existing customer basis	- No existing mobile app - No link with car/ride sharing - Would need to be re-designed to fit other modes/booking etc.
Existing journey planner as Partner 	- Existing customer basis - Existing app to expand - Existing expertise in system	Partnership would have to be established, which may be difficult
Creating new one	Design would be specific to MaaS	- No existing customer basis - Would have to build from the ground up which would take more time



Table 10 compares the advantages and disadvantages of using each of the possible journey planners as a basis. Creating a completely new intermodal journey planner has one main advantage over the other two options, namely that the design could be made very specific to MaaS-London. There would be no need to restructure and work around an already existing platform. However, this also provides one of its drawbacks, as it would take much more time, money, and effort to build a new one. Also, a completely new intermodal journey planner would have no existing customer base that could easily be exposed to the new platform. As the first two options build on already existing platforms, and they both have already existing customer bases, it would be advised to use one of these as the core of the MaaS-London platform. On the one hand, while the TfL journey planner has existing ties to TfL (who believe is in the best position to be the integrator of MaaS-London) its journey planner only exists on an online platform and the mobile app would need to be developed. On the other hand, existing journey planners, such as Ally or Citymapper, have well developed mobile applications they do not have ties to TfL and would mean an additional contracting partner to MaaS-London. Taking these into account, if TfL becomes the integrator, expanding their intermodal journey planner would be the best option.

As mentioned above, all necessary elements that are needed to create MaaS-London already exist. They just need to be integrated into the intermodal journey planner core. Regarding cycling, the new Santander Cycles application already has all the necessary elements that would need to be incorporated into the platform. The application can provide release codes for the bikes, locations for docking stations; users can buy subscriptions and even includes cycle journey planning. Similarly, current car club apps already tell you where each car is and some are even able to remotely open the car for the user (without using a smart card). The key word here again is integrating these systems into the MaaS-London platform.

It is important to point out that this does mean that these individual services, such as the car club apps will cease to exist, MaaS-London will just provide an additional channel to link users with the services.

5.2.2 Infrastructure and Equipment Integration

As previously pointed out, the MaaS-London platform needs to be complemented by infrastructure and equipment integration. The principal element is having *interoperable smart readers* at every transportation node for service provider taking part in MaaS-London. One of the reasons that London was chosen as the case study city for a MaaS-London introduction in the UK is that its public transport system already has a high level of ticketing and payment integration. The Oyster smart card, which has been available to the public since 2003, can be used on every public transport mode operated by TfL as well as





National Rail services within London and the City Car Club. The card uses radio-frequency identification (RFID) and is compatible with ISO/IEC 14443 types A and B (Chirico, 2014). Oyster cards currently use MIFARE DESFire EV1 chips that are widely used as transport smartcards around the world. These chips have sophisticated computational power and are activated only when they are in the proximity of an electromagnetic field compatible with ISO/IEC 14443⁶³. The information on the Oyster card can only be read with encryption specifically designed for the Oyster system. The system was designed, developed and installed by Cubic Transportation systems. The card readers were also developed by Cubic and the current maintenance and support are still conducted by Cubic. Just recently, Cubic was awarded the Electra contract for the next seven years (starting August 2015) to assume responsibility for revenue collection systems in London. As Cubic has prior extensive expertise in the smart card systems in London and will continue their efforts in the next seven years at least, they would most likely be best candidates to integrate smart card readers over other modes as well.



TfL has been working closely with the payment industry to take simplified payment a step further. Recently it introduced contactless payment option on its services. This allows passengers to pay for their travel using contactless debit or credit cards or even mobile phones with an American Express, Maestro, Mastercard or Visa contactless payment application or tag⁶⁴. Payment via mobile phones requires the phone to be equipped with Near

Field Communication (NFC). However, these payment methods do not store information for monthly or yearly passes or discounted travel. This is a great drawback of the technology.

Interestingly, even though it is operated by TfL, Santander Cycle Hire bikes cannot be accessed using Oyster Cards. The bikes are released either by using a release code or by an access key. As detailed above, the new mobile app provides access codes, which could be integrated easily into the MaaS-London system. This means, that as a first step, no infrastructure or equipment changes would be necessary at Santander Cycles docking stations.

All of the car sharing vehicles in London can be accessed using a smart card provided by company. Unfortunately there is not enough information publically available on the card reader technologies that the companies use, so the ease of integration is hard to determine. Yet, one specific company needs to be highlighted. City Car Club uses the same smart card standard as the Oyster Card. Thus, if members register their Oyster card number to their car club account they are

⁶³ International standard that defines proximity cards. The standard defines characteristics such as, physical characteristics, radio frequency and transmission protocol.

⁶⁴ What is a contactless payment card? Available at: <http://www.tfl.gov.uk/fares-and-payments/contactless/what-is-contactless#other>



able to access the vehicles with their Oyster. This is the single example where ticketing integration has been created to foster intermodality and seamless transfer between these modes. The partnership between the two parties is the first step towards total integration expanding not only ticketing, but other aspects as well. In order for other car sharing companies to remain competitive, they should also move towards this direction. Having compatible access cards and readers has put City Car Club one step ahead of its competitors in this perspective.

With regards to taxi, including card readers in every taxi and minicab in London would be too difficult and would most likely result in insufficient availability in these vehicles for the system to be effective. However, it is already possible to pay for taxi (both black cab and minicab) trips through applications. This service would be included into the MaaS-London platform making it unnecessary to install card readers.

In order to make the transition to MaaS-London simple, the technical aspect should be done in two stages. Initially, a smart card should be provided at registration and this should be programmed to access public transport and car sharing services. The best way would be if the Oyster card could be expanded to be accepted on all modes as it already integrates most. Then, when the technology becomes more mature, smartphones could replace smart card all together and be the sole mobility tool necessary to get around London.

Besides the smart card readers, creating intermodal transport nodes is also the key for the success of MaaS-London. The analysis of LTDS showed that Londoners tend to conduct intermodal trips when the transfer points are close together. This includes bike-docking stations, car sharing only parking spots and ride sharing pickup spots at underground and train stations.

In the end, although users will not be directly affected, there is an essential backstage hardware that must be properly equipped, the server. Just like other businesses, the server for MaaS-London is the central system through which the requests made by MaaS-London users and the corresponding responses provided by the platform are connected and is also the place in which all data are stored. In general, two types of server can be used by businesses depending on business size. Cloud server, not belong to any single owner, is more suitable for medium or small businesses due to its relatively limited storage space for each business and in contrast, dedicated server, which is a physical server exclusive to one business, suits large businesses more to handle big volume of data. Although it is hard to precisely determine the size of users at this stage, dedicated server is more likely to be adopted given the expected market potential of MaaS-London in order to cope with high volume of transactions.



5.3 Economic Feasibility

As MaaS-London integrates so many different types of transport operators, with one payment system, managing fares systems and revenue distribution are key issues. As discussed in Chapter 3, all of the transport providers have very complex fare structures, which are designed taking into account a number of inter-related components. When all of them are integrated into MaaS-London, these integrated components have the elements shown in Figure 29.

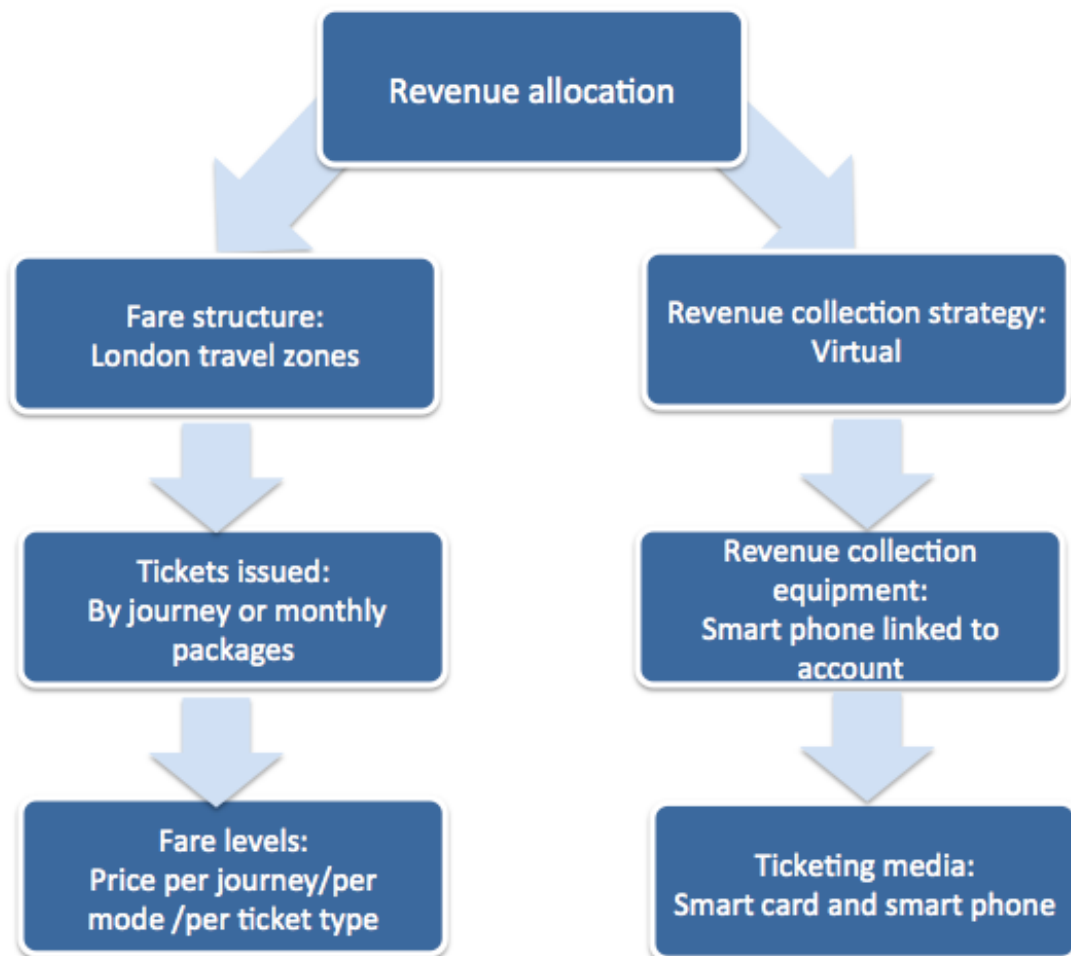


Figure 29: Fares and Ticketing Integration

All these elements will need to be managed effectively and one party needs to hold this responsibility. TfL, as is the ideal implementer, should be at the heart of this project. TfL would also be in the best situation to manage this, or should determine what party to outsource revenue management to.

In addition, usually an innovative product will inevitably incur significant fixed R&D cost in the start-up phase. However, MaaS-London is a unique concept that can be created avoiding huge upfront costs. It is a technology-intensive product involving multiple functions such as intermodal journey planning, booking, smart ticketing and payment that must all be properly developed. The fact is that as illustrated in section 5.2, mature information technology, infrastructure and



equipment etc. that MaaS-London needs have already been developed for London. The only required effort is integrating these existing software and hardware infrastructures; in other words, the isolated functions to make up a new integrated platform. Therefore, the introduction of this new service does not require huge upfront costs.

There could also be other types of costs that MaaS may incur. For example in the product launching stage, the marketing cost to penetrate user market and the lobbying cost to persuade transport operators to join the platform; in later stage, routine operation and maintenance costs and a variety of taxes. Nonetheless, since the largest part of the developing costs has been avoided, the other types of costs are expected to not raise any significant cost issues.

Figure 30 identifies the main costs as well as benefits that MaaS-London will confront. In terms of comparison, it must be noticed that wider social benefits are not included here. Overall, in virtue of the existing software and hardware infrastructures for London, the benefits are expected to overwhelm the costs, which imply MaaS-London will be an economic viable project.

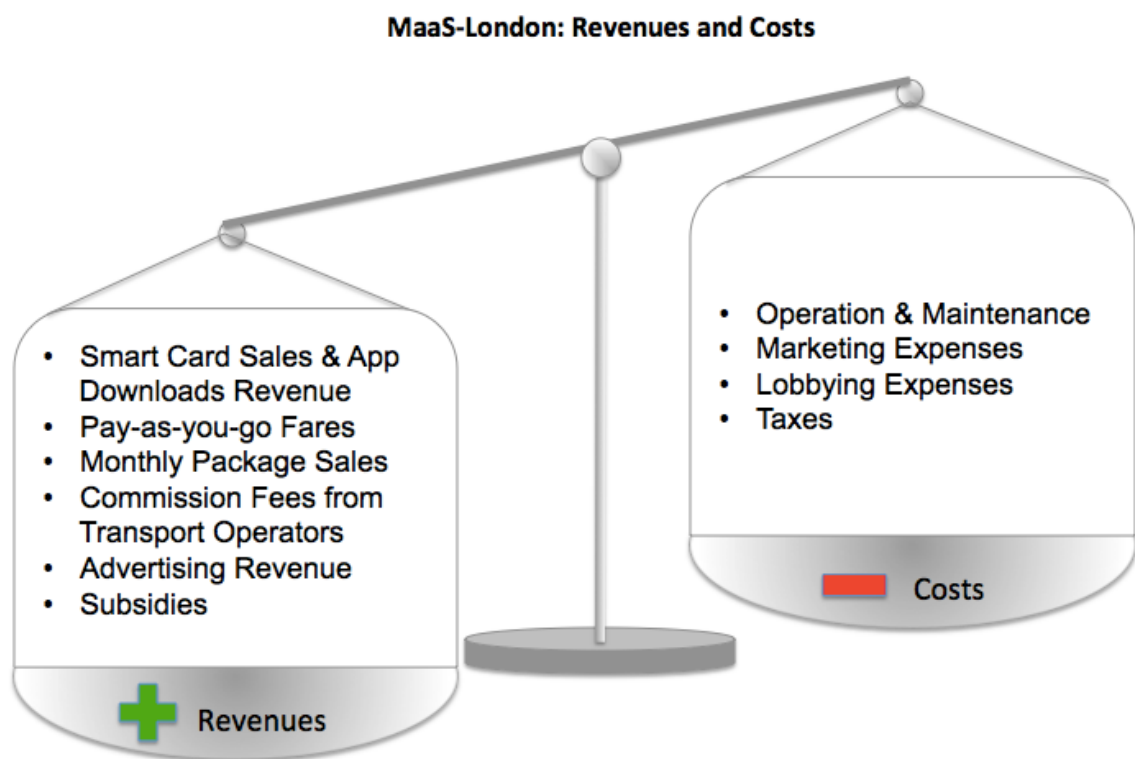


Figure 30: MaaS-London Revenue and Costs

5.4 Market evaluation

Based on the arguments from feasibility evaluation, we use SWOT analysis to present an overview for the market potential of MaaS-London (Table 11).



Table 11: SWOT Analysis of Project

	Advantages	Disadvantages
Internal Sources	Strengths - Low upfront cost; - Integration of all the procedures required for travelling; - Collaborative nature in relation to existing market players; - Promote sustainable and healthy lifestyle; - Maintain manpower structure and protect labour welfare in transiting to the new system.	Weaknesses Vulnerability of computer power under high demand in the implementation phase.
External Sources	Opportunities - Sustainable and intermodal travel demand; - London’s young generation; - Extensive penetration of smartphone technology; - Mature software and hardware infrastructures; - Along with public policy direction; - Advance media network; - Stable economy.	Threats - Uncertainties in partnership establishment with service providers; - Pricing and managing revenue distribution; - Irrational market response/reaction.

Strengths of MaaS-London:

Low upfront cost: MaaS-London is indeed an innovative concept and will be a fresh product to London transport market. However, delivering this concept to a market product does not require high upfront cost to start. The development of intermodal journey planner as well as booking, smart ticketing and payment functions can be built upon existing infrastructures, which will effectively reduce the market entry barrier (Details in “Economic Feasibility” section).

Integration of all the procedures required for travelling: The integration covers journey planning, booking, ticketing and payment parts; in other words, the entire chain for conducting a trip. By having such integrated platform, customers are expected to benefit from both significant travel cost and time savings which can serve as great incentives for participation (see 3.6 and 5.1).



- **Collaborative nature in relation to existing market players:** The entry of MaaS-London into the market will not be resisted by bringing any hostility; instead it is designed to open up broader opportunities for the existing service providers in transport market. Most transport operators can be seamlessly integrated into MaaS-London as partners, and even those ride sharing platforms and P2P taxi platforms, which are also agents that communicate service operators (i.e. drivers) and customers, can still be smartly integrated without taking over their businesses. In addition, it is also possible to build partnership with existing journey planning platforms to suit MaaS-London into one of them. (see 5.1).
- **Promote sustainable and healthy lifestyle:** This is a special contribution of this integrated platform in the context of London in which bike sharing, ride sharing, and car clubs all exist as available options. The inclusion of these modes along with a shift from ownership to usership represent a firm movement towards more sustainable and healthy transport future. Besides, the attached functions such as offering calories and emission saving information will further attract customers who have interests and needs for a “green” lifestyle.
- **Maintain manpower structure and protect labour welfare in transiting to the new system:** Although MaaS-London will bring changes in terms of the way of travel, it only serves as a more attractive alternative without replacing any existing services. Employees directly involved in the transition (e.g. TfL staff) do not need to concern about any labour market instability and even more additional positions may be demanded (see 5.1).

Weaknesses of MaaS-London:

- **Vulnerability of computer power under high demand:** Either cloud or dedicated server needs to be used to store data for the communication between customers and the platform. Given the population size in such cosmopolis and the market potential of MaaS-London, it is concerned about the computer power when there is high demand in the market especially in the implementation phase and at certain peak time (see 5.2).

Opportunities for MaaS-London:

- **Sustainable and intermodal travel demand:** In the past few years, the travel patterns in London have demonstrated some promising trends that embrace the concept of MaaS-London, that is, the needs for more sustainable and intermodal transport (see 3.4).
- **London’s young generation:** The city is filled with young professionals who are septic to a change in lifestyle by the emergence of new ideas and new technologies (see 5.2).
- **Spread of smartphone technology:** The revolution raised by smartphone has changed many aspects in life to a great extent including transport sector. Smartphone is an ideal



carrier for MaaS-London to be delivered into real life (Details in “Operational Feasibility” section).

- **Mature software and hardware infrastructures:** Not only are Londoners open-minded to new ideas, but more importantly, London is a perfect place to apply MaaS-London also owing to its mature transport infrastructures in both software and hardware. The availability provides a solid ground for developing and implementing new concept such as MaaS-London by simply integrating existing infrastructures without investing in anything completely new (Details in “Technical Feasibility” section).
- **Along with public policy direction:** The expected deliverables of MaaS-London are in two dimensions, more efficient individual transport and wider social benefits. For MaaS-London itself, it can help delivering the goals of MTS in London area. For promoting MaaS-London as prototype across the UK in the future, the concept can still fit in line with public policies not only in transport dimension (e.g. DfT’s objective) but also along with the interests of other dimensions such as climate change, environment and business etc. (Details in “Operational Feasibility” section).
- **Advance media network:** Media sector has experienced drastic transformation during the information revolution. An attractive idea can spread fast even only in its sprouting phase under the current media network, which will provide favourable environment in disseminating the concept of MaaS-London to public.
- **Stable economy:** The demand for transport is heavily related to macro-economic performance. A booming economy will generate significant volume of transport opportunities derived from business and other related purposes. Fortunately, the UK economy has recovered from the economic crisis better than average among developed countries and has maintained its strength in the following periods.

Threats for MaaS-London:

- **Uncertainties in partnership establishment with transport service providers:** In general, the introduction of MaaS-London will benefit existing service providers via collaboration not competition. However, conflicts may still exist between the two sides. There are two anticipated challenges. First, negotiations are required for determining a commonly acceptable registration procedure with car club operators although their principal benefits are consistent with MaaS-London. The other problem is with existing journey planning platforms. If MaaS-London is going to be built upon the existing services, it is uncertain about whether they will be willing to accommodate the incomer since the power structure and the way of operation etc. are all likely to change (see 5.2).



- **Pricing and managing revenue distribution:** Modern fares systems are complex. They have a number of inter-related components as discussed in 5.3. In order to deliver an integrated ticketing system TfL (or the agency managing the scheme) should be concerned with and have some measure of responsibility for all these elements.
- **Irrational market response/reaction:** Even though uncertainties do exist in relation with transport operators, it is expected that the prospect of cooperation can still be properly achieved since these businesses usually have mature protocols in evaluating a proposal and thus, rational decisions can be ensured in most cases. Nonetheless, rational performance by individuals in the market can hardly be fully guaranteed. Behavioural issues such as bounded rationality (e.g. cannot realise the deliverables of MaaS-London), cognitive dissonance (e.g. unwilling to accept the transition from car ownership to car usership as a symbol matter) and status quo bias (e.g. preference for current way of travel over any changes) are all possible to arise. The solution for such irrational behaviours can involve better information supply especially during the beginning phase of MaaS-London. However, after the introduction stage, behavioural issues may positively affect the adoption rate via social proof (i.e. the use of MaaS-London in neighbour environment will increase its attraction).

5.5 MaaS-London: Feasible or Not?

Based on the analyses provided in this section, MaaS-London is a feasible project. However, there are some key elements that need to fall into place for it to work. The most important of these is that TfL has to be willing to take leadership in the project. Also, all the stakeholders have to be willing to cooperate with each other and adjust their business plans to fit MaaS-London. Even though the concept may result in some short-term sacrifices such as the car clubs waiving their registration fees, it is expected that in the long-term every affected party would benefit from the service.



6. Conclusions and Next Steps

6.1 Conclusions

The FS-MaaS project was led through by two core objectives: 1. Provide a vision for the design of a ‘Mobility as a Service’ concept for London; and 2. Conduct a feasibility study to determine the viability of the concept. The report started by illustrating today’s megatrends including hyper-urbanisation, climate change and emissions, demographic and societal changes, and technological breakthroughs and digital gap to demonstrate the necessity and opportunity for shifting towards an innovative urban transport system. The key is integrating various transport modes in a way that creates seamless door-to-door mobility, that is, the concept of ‘Mobility as a Service’.

The report next reviewed a number of representative MaaS systems around the world, classified by three different degrees of mobility integration. Basic integration merely offers discounts for combined mobility through cooperation between mobility operators. Advanced integration is represented by a fully integrated platform on which ticketing, payment and ICT functions for different mobility services are all included. The ultimate level is advanced integration with tailored mobility packages such as transport can now be delivered as a service by capturing the needs for different types of travellers. This final case is what MaaS-London aims to deliver. As this is a fairly new concept, there are not mature models around the world at the moment.

To work towards the application of MaaS-London, the report then analysed both supply side and demand side of London transport market to identify the current situation. There are a variety of mobility services supplied in London such as car clubs (car sharing), ride sharing, bike sharing, public transport, rail and taxi which altogether make London an ideal ground to exploit an intermodal platform. The insights derived from the travel pattern analysis by using LTDS data also support the application of MaaS-London from market demand perspective.

Having justified the needs and advantages to use London as the case for implementation, the report illustrates the design of MaaS-London concept. For users, MaaS-London is integrated platform that includes registration and package selection, journey planning, booking, smart ticketing and payment functions so that the entire chain of transport can be managed in this centralised platform. The most outstanding feature of MaaS-London is the provision of mobility packages which will consist of tailored bundles of mobility services that customised to individual needs. For suppliers, their role under MaaS-London is providing travellers with the actual on-road journeys which will be allocated to corresponding transport operators based on the information they supply to the platform.

Through the feasibility study in the end, operational, technical and economic aspects for developing MaaS-London were evaluated. It is expected to satisfy both potential internal and external stakeholders of MaaS-London. As a prospective implementer, TfL’s current pursuit is



perfectly in line with the deliverables of MaaS-London and its organisational structure will not be affected by undertake the leadership. The introduction of MaaS-London will benefit transport operators by creating a larger market via the integrated platform. Travellers will also welcome the concept due to travel expense and time reduction, better service experience. Overall, MaaS-London is not designed to replace any existing businesses by introducing competition but only offers a new option that can facilitate individual travellers, enlarge market shares for transport operators and contribute to an increase in social welfare. Besides, there are good availabilities of information technology and infrastructure and equipment at the moment in London such as journey planning platforms and the Oyster card system, which can be integrated to set up MaaS-London without developing everything from the ground. As a result, the project costs will be significantly saved. In addition, a SWOT analysis was performed based on the feasibility study to demonstrate the competitiveness and prospect of MaaS-London. It can be concluded that MaaS-London is a potentially feasible product that can well serve London transport market and contribute to Londoner’s quality of life.

6.2 Next Steps

The scope and timescale of this study only allowed for basic analysis for determining the proof of concept. In order to fully decide the viability of the MaaS-London concept, reaching out to the above-discussed potential stakeholders and gaining insights into their view of the concept is essential. First, in depth discussions with TfL about their role as integrator and leader would have to be established. Without their cooperation, the concept would not be feasible in London. Next, round table discussions with each affected party present would provide better understanding of their willingness to cooperate and revenue sharing of such an integrated service. Additional issues can be raised by any of the parties at these discussions, which will also provide insights into the strengths and weaknesses of a potential implementation.

In parallel with discussions with stakeholders, demand and impact for the concept should also been examined in more depth. In order to analyse citizens’ reactions, willingness to pay for such a service, and the potential effects it will have on transport network demand, an in-depth survey needs to be conducted collecting both revealed and stated preference data. This was not possible under the time scale of this project, as it would take up to a year to create the necessary questionnaire, carry out the survey, analyse the data, estimate and validate the demand model. Such a survey and a model could help determine the exact details of optimal package design as well as the transport mode changes it would result in. The Urban Transport team of the UCL Energy Institute has already started working on the design of the survey and is planning to launch a survey the next academic year (2015-2016).

If cooperation with stakeholders has been established, the next step is to design the actual platform. A software engineering team needs to be contracted to develop the platform, while



cooperating with all the stakeholders to make the system compatible with those of all the service providers. Once the platform is developed a small pilot should be conducted to raise any unidentified issues. The review of mobility integration projects around the world indicated that most of these projects started of as small pilots to determine how they will function before committing to large-scale introduction.

Finally, it needs to be pointed out that this research only included a case study for MaaS-London. The same MaaS concept can be applied in any urban environment around the UK, though each would have a different stakeholder structure. Similar analysis for other cities can also be conducted if there is interest from local transport authorities. An ideal target would be to create a MaaS-UK platform, where all transport modes within the whole country are connected.



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