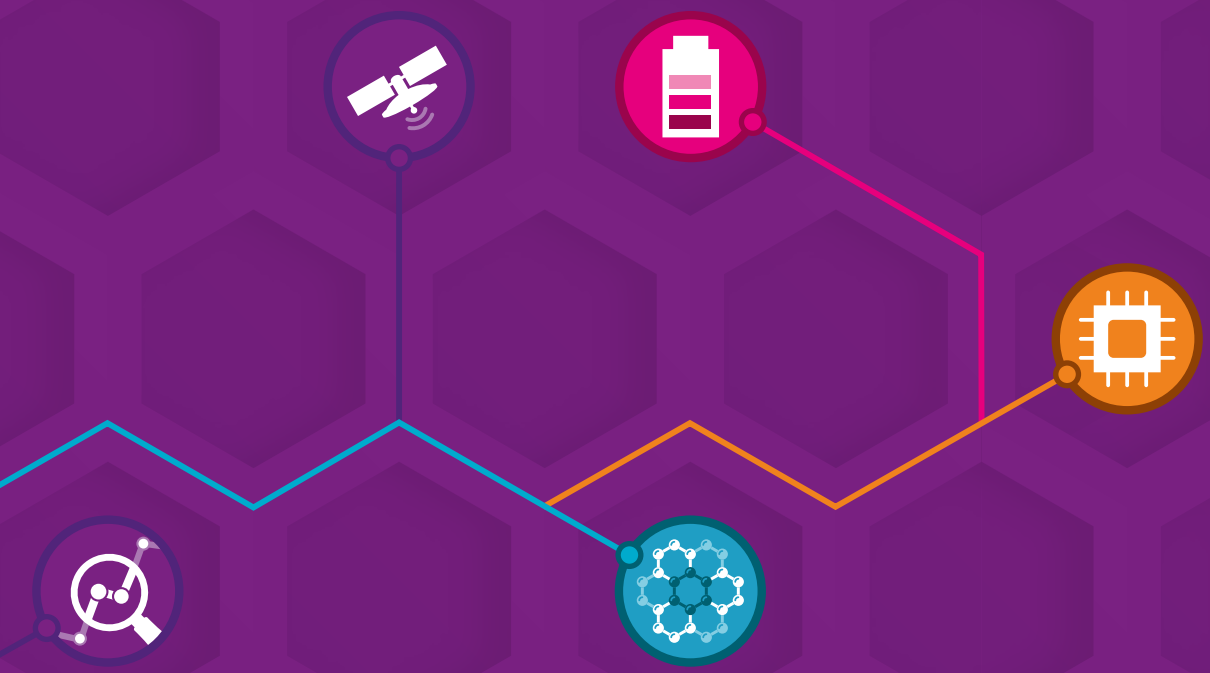
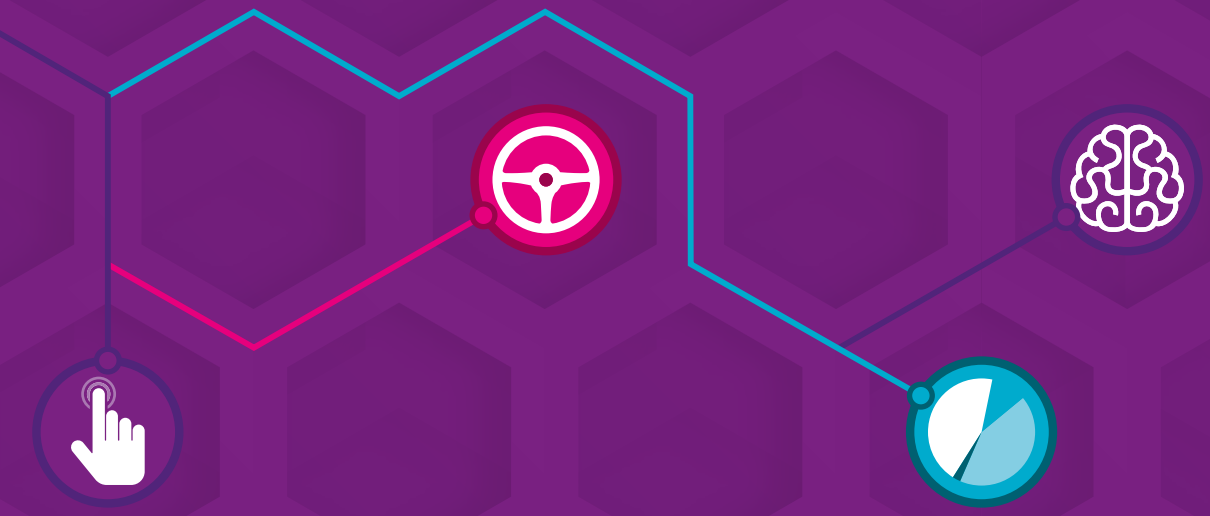
CATAPULT Transport Systems



IM TRAVELLER NEEDS and UK CAPABILITY STUDY

Supporting the realisation of Intelligent Mobility in the UK



OCTOBER 2015

Study funded by:

Department for Business Innovation & Skills

Department for Transport

We work with Innovate UK

About the Transport Systems Catapult

Exploring Intelligent Mobility

WE ARE THE UK'S TECHNOLOGY AND INNOVATION CENTRE FOR INTELLIGENT MOBILITY – THE FUTURE OF TRANSPORT SYSTEMS.

We exist to drive UK global leadership in Intelligent Mobility, promoting sustained economic growth and wellbeing, through integrated, efficient and sustainable transport systems.

Our vision is to create an environment that will make the UK a world leader in transport systems innovation.

www.ts.catapult.org.uk

Opp:
The Transport Systems Catapult LUTZ Pathfinder Pod.

TSC-TN-OCT15-V01

Foreword

THE UK HAS A LONG HISTORY OF TRANSPORT INNOVATIONS. FROM THE SHIPBUILDERS WHO PAVED THE WAY FOR GLOBALISATION, TO THE RAILWAYS THAT UNDERPINNED THE INDUSTRIAL REVOLUTION – **THE UK HAS ALWAYS BEEN A GLOBAL LEADER IN THE TRANSPORT INDUSTRY**.

Marking the beginning of the Information Age, the Digital Revolution has already dramatically changed how we live our lives and is poised to transform how we travel in the future. As we move into this new era of **'Intelligent Mobility'** characterised by the smarter, greener and more efficient movement of people and goods, the UK must not waver in its commitment to drive global leadership in transport.

Moving from the current 'modal-centric' to future 'user-centric' transport systems is by no means a small feat. It will require new thinking and collaboration across industry, academia and government to define and develop Intelligent Mobility opportunities worth pursuing. The Transport Systems Catapult is committed to creating an environment that will help make the UK a world leader in this area.

In order to capture a substantial share of this emerging market, it will be essential to understand the barriers and fundamental enablers required to prioritise targeted investments that build sustainable capabilities.

The Automotive Council Technology Group was established to analyse evidence and provide advice on UK automotive research and development investment opportunities. It is developing an Intelligent Mobility strategy for the UK which will utilise emerging technologies to enable user-focused, integrated, efficient and sustainable transport systems focused on meeting the needs of travellers in the UK.

This study represents such an endeavour and is unique in its kind, taking a multi-modal and end-to-end approach to both traveller needs and Intelligent Mobility capabilities in the UK.

We hope you find this report an enjoyable, interesting and stimulating read into understanding the UK traveller.

> BY 2025, THE INTELLIGENT MOBILITY MARKET IS ESTIMATED TO BE WORTH **£900BN ANNUALLY** AND AS THE FUTURE OF TRANSPORT SYSTEMS, IS VITAL TO CREATING JOBS AND SECURING LONG-TERM ECONOMIC GROWTH IN THE UK.

STEVE YIANNI
CEO Transport Systems Catapult

GRAHAM HOARE
Chairman Automotive Council Technology Group

Preface

This report was written by Corporate Value Associates and revised and produced by the Transport Systems Catapult's Customer Experience Business Unit.

This benchmarking report would not have been possible without the generous help and efforts of many. We would foremost like to thank **Innovate UK**, the **Department for Transport**, and the **Department for Business, Innovation and Skills** for their foresight in funding this ground-breaking study. We would also like to acknowledge the generous support received from: **Arup**, **BMW**, **Ford**, **Jaguar Land Rover**, **MIRA**, and **Nissan**. We are also very thankful for the Catapult support of the **Digital Catapult**, **Future Cities Catapult**, and **Satellite Applications Catapult**. We deeply appreciate the endorsement by the Chairs of the **Automotive Council Technology Group** and **IM-PACT UK**. We would like to express our special thanks to our **University Partnership Programme** and the Innovate UK Monitoring Officer **Brian Cumming** for their support to the study.

Thanks to our **Expert Panel** for their quality assurance on deliverables in this study and we are very grateful for the insights provided by all **Expert Interviewees**. Building on this we are also thankful for the large number of people who completed the questionnaire in our traveller research.

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Contents

Above:
The Transport Systems Catapult 'Virtual Reality' capability on a treadmill.

Above:
Capabilities for Intelligent Mobility.

Opp:
Five Traveller Types (Source: Traveller Research, CVA Analysis).

Executive Summary

INTELLIGENT MOBILITY IS CURRENTLY UNDERGOING RAPID DEVELOPMENT, PRESENTING A UNIQUE MOMENT FOR THE UK TO BECOME A MAJOR PLAYER.

Previous Transport Systems Catapult research has suggested that this global market will be worth around £900bn annually by 2025 [1], with the UK primed to be a hot-bed for Intelligent Mobility. This study was commissioned to help unearth the UK's innovation potential in the Intelligent Mobility space. It focuses on developing shared knowledge of what UK travellers need and value, acknowledging there needs to be an end user willing to pay for products and services. **10 specific Value Spaces for Intelligent Mobility with estimated £56bn of value (revenue opportunities) from the UK traveller have been identified**. The Transport Systems Catapult is helping the UK capture as much of this global market as possible – supporting businesses, creating jobs, and driving economic growth.

To help unlock this value whilst improving travel in the UK, this study utilised a large market research sample of 10,000 respondents as well as 100 expert and 50 company interviews. It has found the UK traveller to be progressive and ready for new developments in mobility:

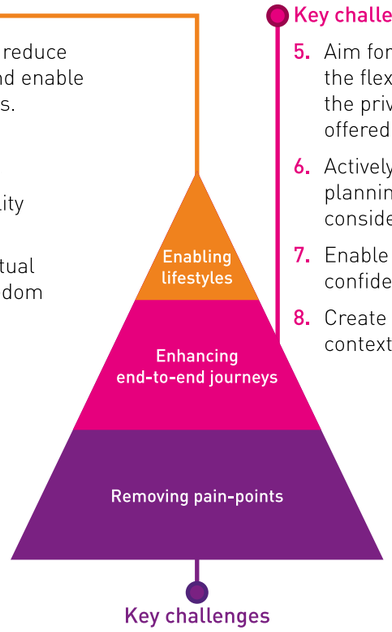
- 53% always look for ways to optimise their journeys.
- 72% have smartphones – 54% of which already consider it essential to their travel experience.
- 57% would not mind sharing their data for better services and 32% would share their possessions with others.
- 39% would consider driverless cars today.
- 31% of journeys made today in the UK would not have been made if alternative means were available that did not necessitate physical travel (i.e. 'virtual mobility').

At the same time, UK travellers are seeking significant improvements to the journeys they make. **75% of all journeys made in the UK are subject to negative experiences (i.e. pain-points)**. Above all, it is multi-modal journeys that are perceived as particularly troublesome, calling for significant improvements in end-to-end mobility. However, **currently only 12% of journeys involve active consideration of modal choice**. Therefore, activating travellers on the remaining 88% of journeys is fundamental to Intelligent Mobility.

Beyond improving today's journeys, **Intelligent Mobility also promises to address significant unmet transport lifestyle needs across a range of traveller types identified by the study**:

Traveller[1] Type	Description	Intelligent Mobility Opportunity
Progressive Metropolites	Living in the heart of the city, typified by the technology-savvy young professional, with significant amounts of personal and business travel. Want to reduce their transport footprint.	Leverage as lead users for new intelligent mobility solutions (shared, digital) in urban environments.
Default Motorists	High mileage drivers, with a mix of those who enjoy driving and many for whom it is a functional choice.	Remove the burden of driving – either through increasing productive time, or by providing viable alternatives.
Dependent Passengers	Dependent on others for their mobility needs, representing a mix of students, elderly, and those with impairments.	Develop solutions that can increase independence without relying on being driven in a personal vehicle.
Urban Riders	City dwellers, who travel less frequently than the Progressive Metropolites, making use of public transport available to them.	Well served today, although potential to improve access to national transport services.
Local Drivers	Mainly retirees or stay at home parents, making low mileage local journeys.	Their needs are currently well met. Possible opportunity to improve current experiences.

The most pertinent traveller needs and opportunities have been summarised as **12 key challenges** that need to be to be addressed to improve mobility in the UK. Developing solutions for these challenges will not only deliver on travellers' needs, but also unlock a number of Value Pools (revenue opportunities) for innovators in Intelligent Mobility.



Key challenges

1. Help the urban population reduce their transport footprint and enable digital, asset-light lifestyles.
2. Reduce the burden on the car-dependent population.
3. Provide independent mobility for Car Passengers.
4. Push the boundaries of virtual mobility to provide the freedom to not travel.

Key challenges

5. Aim for transport systems to offer the flexibility and convenience that the private car has traditionally offered.
6. Actively engage traveller in journey planning and transport modal consideration.
7. Enable faster journeys and increased confidence in arrival time.
8. Create relevant, personalised and context-aware information.

Key challenges

9. Solve the parking challenge.
10. Enable smoother drives.
11. Increase user experience and perceived value of public transport.
12. Improve and enable multi-modal journeys – reducing complexity, enhancing connectivity, and improving speed and reliability.

Opp: Overview of the 12 Challenges for Intelligent Mobility (Source: CVA Analysis).

To deliver on these challenges, Intelligent Mobility will require the integration of different technologies, products and services that will result in a step change in mobility. **Four Transformational Themes** were identified in the study that map out development paths towards Intelligent Mobility. They will deliver the greatest impact when combined, delivering seamless end-to-end mobility.

Transformational Theme	Description
Access	New mobility solutions (e.g. car sharing, ride sharing etc.) that offer more affordable, more convenient mobility.
Automation	Increased levels of automation in transport, for example the emergence of automated driving functionality, moving from assisted driving to fully autonomous drive.
Demand & Supply	Developments that seek to influence travel demand patterns and also better match supply to demand within transport systems.
Integration	The bringing together of disparate information, systems, and services, to provide travellers with a seamless end-to-end mobility experience.

Opp: Four Transformational Themes (Source: Expert Interviews, CVA Analysis).

Whilst many innovations in these four themes will occur naturally out of commercial interests, the study is recommending investments and interventions in three areas to establish the UK as a world leader in Intelligent Mobility:

1 Research and Development

Key technical capability areas need to be supported, ensuring the UK can hold IP[2] critical to the Intelligent Mobility supply chain. The study highlights **six Core Capabilities** for priority development (see table below).

2 Experimentation and Business Model Innovation

To successfully bring Intelligent Mobility products and services to market, a key focus needs to be on **experimentation, business model innovation, and real-life learning** as much as technical demonstration and validation.

3 Policy and Legislation

There is a need to put in place key policy measures and government initiatives that will enhance and enable the success of Intelligent Mobility. These include **providing ubiquitous connectivity, Open Data, multi-modal ticketing, standardisation of emerging technologies, and a focus (through KPIs) on multi-modal journey experiences**.

Capability	Description
HMI & Interaction Design	Technology, techniques and design methods that enhance the driver/ passenger experience, enable better driver/ passenger information and can help to influence traveller behaviour (e.g. Information and entertainment displays, voice and gesture recognition Human-Centred Interactive Systems Design).
Traveller Behaviour & Psychology	Techniques, methods and technologies used to improve the understanding of traveller decision making processes and behaviours (e.g. crowd behaviour modelling, heuristics, selection and decision-making models).
Connectivity & Networks	Ability to connect different systems, travellers, goods, infrastructure with the goal of establishing 'ubiquitous connectivity' (e.g. Cellular systems (e.g. 3G, 4G, and 5G), satellite connectivity, standards and communication protocols (e.g. V2I, V2V, and V2X).
Localisation & Mapping	Technologies enabling an understanding of the local environment (e.g. 'where you are and what is around you').
Data Privacy & Security	Secure flow of data (data security) as well as the safe storage of data (data protection) (e.g. encryption techniques, data anonymisation and protection techniques, cyber security measures).
Analytics & Simulation	Systems, algorithms and processes ranging from the handling and analysis of big data, predictive and prescriptive analytics, and machine learning (e.g. big data, predictive modelling, AI).

Opp: Six Core Capabilities (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

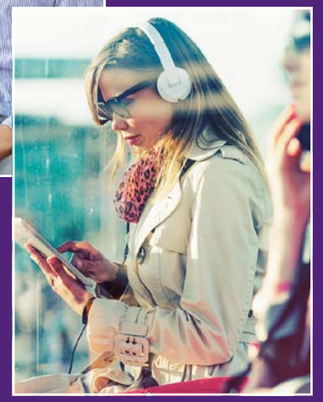
To drive UK global leadership in Intelligent Mobility there are a number of imperatives for different stakeholders as shown below:

Stakeholder	Imperatives
Central Government	• Fund **research and development activities and skills development** in the six Core Capabilities for Intelligent Mobility. • Focus on filling the gaps in provision of **reliable, fast, and ubiquitous connectivity**. • Establish a **data exchange mechanism and mandate open data** where appropriate (e.g. in rail franchises). • Create a **central ticketing platform and multi-modal marketplace** and encourage multi-modal integration to support expected advancements in dynamic pricing and timetabling. • Foster **cross-industry collaboration** to unlock value from Intelligent Mobility.
Local Government	• Encourage and support new business and **participate in experimentation** with new Intelligent Mobility solutions in private and public transport. • Shift focus towards **procuring against challenges** rather than procuring for solutions. • Push for **integration and innovation** in public transport (e.g. demand responsive services).
Infrastructure Operators	• Focus on **measuring progress against traveller needs and end-to-end journey experience** across transport modes. • Understand the extent to which potential investments in Intelligent Mobility can give **better value for money** than traditional infrastructure investments. • Encourage innovation by **opening up data streams**. • Set up mechanisms to **gather learnings and influence traveller behaviours** based on data insights.
Transport Operators	• Understand desired position in emerging Intelligent Mobility ecosystems, **focusing on multi-modal transport** and collaboration with new digital integrators. • Collaborate across the industry, by opening data and creating seamless end-to-end journeys (focus ticketing, pricing, integrated information, commercial models). • Actively **participate and collaborate with digital start-ups**, not least by opening up commercially non-sensitive data and start generating real-time data where missing (and consider how to monetise valuable data). • Reduce complexity of planning by **increasing availability of information** (in particular expected arrival time, expected level of personal space) and include every element of the journey (car parking, etc.)
Automotive Industry	• Continue developing **autonomous drive technology** and focus on market readiness, consider target segments. • Produce vehicles that are **suitable for a variety of new mobility modes**, such as autonomous taxis or dynamically timetabled and routed minibuses. • Consider the **role of the connected vehicle** in an integrated end-to-end mobility world. • Establish a presence in **new areas of the mobility value chain** beyond vehicles sales, finance and service. • Develop strategy for data generation and utilisation. • Take a leading position in **defining and implementing standards** in V2V[3] and V2I[4] communications.
Rail Industry	• Focus on traveller experience on multi-modal journeys, in particular **integration of 'new' modes** (bike share, car share, taxi apps, autonomous mobility) and **speed & reliability of interchange**. • Focus on **enabling productive time**: connectivity, seamless interchange, dynamic timetabling. • Focus on **accessibility of rail**: 'easy to get to' / first&last mile. • Enable digital lifestyles (e.g. journey experience personalisation) and **engage travellers with transport choices**.
Transport Systems Suppliers	• Prioritise **data generation and integration** from all possible sources. • Develop desired position in a world that focuses more on **decentralisation** than central 'command and control' traffic systems. • Consider **collaboration and integration** with new mobility providers and focus on how to deliver on end-to-end journey experiences.
Academia	• Prioritise **traveller behaviour understanding** as a core discipline to develop expertise in. • Focus on skills gaps in **algorithms and analytics** to educate tomorrow's Data Scientists. • Ensure technical degree programmes include a sufficient amount of **business and commercial understanding**.
Start-ups	• There is a significant opportunity for **innovative and agile** new entrants in Intelligent Mobility. • **Build strong relationships** with key players (e.g. automotive OEMs, transport operators, and local authorities) and **understand the different speeds** at which these players move.

Opp: Intelligent Mobility imperatives for the UK (Source: Expert Workshops, Expert Interviews, and CVA Analysis).

Opp/below: Progressive Metropolites.

Opp/below: Urban Riders.



Below: Default Motorists.

Below: Petrol Heads sub-group.

Opp: Local Drivers.

Opp/below: Car Dependents sub-group.

Opp/below: Dependent Passengers.

Introduction

Intelligent Mobility

INTELLIGENT MOBILITY IS THE **SMARTER, GREENER,** AND **MORE EFFICIENT MOVEMENT OF PEOPLE AND GOODS AROUND THE WORLD.**

A recent study into the business potential of Intelligent Mobility suggests that the **global market for this new sector will be worth around £900bn annually in just over a decade** [1]. As a growth market, it is expected to cut across and go beyond traditional transport modes and utilise emerging technologies to provide travellers with an improved end-to-end journey experience, but also increased transport systems efficiencies. As a result we are seeing a range of potentially disruptive developments and a number of initiatives have already been launched (e.g. the Transport Systems Catapult and UK Autodrive project). Indeed, Intelligent Mobility is becoming a top priority for the UK and the Automotive Council believes that this market has the potential "to increase mobility, improve safety, and enhance user benefits whilst simultaneously reducing pollution, consumption, and congestion" [2].

The underlying enablers of increased development in Intelligent Mobility have been the strong growth in mobile connectivity and smartphone penetration. Further benefits are expected from the emerging Internet of Things (including connected vehicles and infrastructure) and increased digitalisation and availability of data. Technology in itself will not, however, realise this value but its applications to meet the needs of travellers will. Intelligent Mobility not only seeks to deliver direct value to the traveller but also to provide sustainable benefits (e.g. social and environmental) for whole transport systems, such as mitigating congestion and emissions, and improving safety. A fundamental shift in how we realise the value in this new space is required and **there is a need to place 'users of mobility systems' at the heart of how the UK secures a substantial share of the global Intelligent Mobility market**.

Beyond technology, innovations in business models and user experiences (e.g. taxi hailing apps, car sharing schemes, and real-time traveller information) will be important. The range of potential innovators in this space is wide and **goes significantly beyond the traditional transport sector** – including digital start-ups, telecommunications providers, insurers, and many more. Intelligent Mobility solutions have the ability to significantly increase the capacity of transport systems and **deliver end-to-end journey experiences** that meet traveller needs (for both people and goods).

> "INTELLIGENT MOBILITY IS THE CONVERGENCE OF DIGITAL INDUSTRIES, TRANSPORT INFRASTRUCTURE, VEHICLES AND USERS TO PROVIDE INNOVATIVE SERVICES RELATING TO DIFFERENT MODES OF TRANSPORT AND TRAFFIC MANAGEMENT."
>
> MIRA [21]

> "HISTORICALLY, MOBILITY HAS BEEN VIEWED LARGELY AS A PRODUCT. [...] INCREASINGLY, HOWEVER, MOBILITY IS APPROACHED AS A SERVICE."
>
> Schneider Electric, ARUP, The Climate Group [22]

> "IT IS NOT REALLY ABOUT THE TECHNOLOGY," [TIM ARMITAGE] SAID. "IT IS ABOUT FINDING A COMMERCIAL MODEL THAT WORKS."
>
> Financial Times [23]

The concept of **'Mobility as a Service'** has emerged as a key trend within the Intelligent Mobility domain and represents the shift away from purchasing products (vehicles) towards instead purchasing the access (service) for the benefits of mobility. Increasingly, seamless on-demand and end-to-end mobility at the touch of a button is becoming a reality. As one might expect, these developments will result in **significant shifts in the mobility value chain**, and established transport players will have to think carefully about their desired position in these new ecosystems, with new players entering the transport sector.

Because Intelligent Mobility is an emerging market it is characterised by a search for new business models, which is something that start-ups and digital players traditionally excel at. As different sectors converge, realising the value of Intelligent Mobility will require collaboration between established players and new entrants that goes beyond the traditional borders of today.

Above all, the scale of the Intelligent Mobility opportunity should be appreciated.

Traveller Needs and UK Capability Study

TO CAPTURE A SUBSTANTIAL SHARE OF THE GLOBAL INTELLIGENT MOBILITY MARKET IT IS ESSENTIAL TO **UNDERSTAND FUNDAMENTAL ENABLERS OF VALUE** AND **PRIORITISE TARGETED INVESTMENTS** THAT BUILD SUSTAINABLE AND INNOVATIVE CAPABILITIES FOCUSED ON MEETING THE NEEDS OF THE UK TRAVELLER.

To this end, **Innovate UK**, the **Department for Transport**, and the **Department for Business, Innovation and Skills** jointly funded an Intelligent Mobility Special Project called **Traveller Needs and UK Capability Study**. The study was led by the **Transport Systems Catapult** between February and July 2015 – involving a combination of more than 70 organisations from different sectors, industries and transport modes.

The research conducted in the study comprised of 10,000 online and 100 offline questionnaire respondents, 50 company interviews, and 100 expert interviews. There are many studies that have analysed travel user sentiments. These studies are, however, most often specific to a transport mode or geography (e.g. analysing rail travel or transport in London) and tend to focus on short-term incremental improvements of current transport systems. Similarly, a number of studies have explored future mobility technologies but these tend to focus on technical innovations in a specific sector (e.g. rail or automotive). In contrast, this study attempted to take a holistic view of Intelligent Mobility across transport modes, sectors, UK geographies, and across all aspects of Intelligent Mobility.

In producing this study, a large number of cross-industry, cross-sector, and cross-modal stakeholders have been involved (please see the 'Acknowledgments' chapter for a full list). Corporate Value Associates designed the approach, delivered the research and analysis (with quality assurance from an Expert Panel), led the stakeholder workshops and developed the study's conclusions and recommendations.

The initiative was supported by the Automotive Council Technology Group. Also, an Industry Review Group comprising of three other Catapults and six companies played an instrumental role in the study's success.

In bringing together so many people and organisations, the first steps towards improved collaboration in, and understanding of, the Intelligent Mobility space have been made.

Understanding Traveller Needs

The study was designed to fill an identified existing gap in understanding what travellers value on their journeys, what pain-points they encounter and how they make decisions with regards to their travel options. The study achieves this by including all available modes in the research and taking travellers through an adaptive conjoint-based choice exercise which helped understand the relative trade-offs travellers make when deciding how to travel. Additional information, such as a journey diary, issues encountered and detailed information on needs, attitudes and behaviours, helped understand traveller segments and their needs on a detailed level. This has provided an understanding of the key challenges that the UK will need to overcome in order to develop and accelerate valuable Intelligent Mobility opportunities.

Identifying Value Spaces for Intelligent Mobility

This study does not attempt to value the Intelligent Mobility market as a whole (other studies exist [1]), or to quantify the socio-economic impact of meeting traveller needs (e.g. job creation). Instead, the value modelled in the analysis focuses on specific revenue opportunities that are available for players in this space by addressing the specific framed challenges.

Ultimately, value in mobility is derived from traveller spend, whether this means spend on travel tickets, vehicle ownership, or services and apps. There are other sources of value in the mobility value chain to consider, however, such as government spend on infrastructure and subsidies, as well as indirect value realised by making transport more efficient, safer and cleaner. In quantifying these, two types of calculations were performed:

1 Incremental Value

Estimates the additional amount travellers are willing to spend on their journeys for a better experience. This is modelled using conjoint data gathered during the traveller research. The suggested improvements (e.g. removal of pain-points) are compared to the current traveller experience. The result is measured against the traveller price elasticity (which was also obtained from the conjoint data modelling) to estimate the direct incremental value travellers assign to such improvements.

2 Redistributed Value

Estimates the portion of current transport spend that will no longer be required in its current form if the challenges are met and may be available for a new player offering new mobility services. This is modelled on a combination of the Office for National Statistics (ONS), National Travel Survey (NTS), Census, and the research data from this study.

The actual scale of incremental and redistributed value realised will depend on the extent to which the traveller challenges can be addressed. It should be noted that the numbers obtained are not predictions, but instead estimate the available 'Value Pools' for Intelligent Mobility within the Value Spaces.

As this study employs innovative approaches in order to identify potential areas of value, it is acknowledged that these approaches are different from traditional transport planning. This report is intended to supplement, not replace or re-work traditional transport planning models.

Describing Transformational Themes for Intelligent Mobility

There are a number of Intelligent Mobility products and solutions emerging and many ideas for further developments. This report describes the key emerging themes for Intelligent Mobility with an outlook towards 2030. This includes understanding the benefits that they can deliver in terms of meeting traveller needs and addressing pain-points – as well as the key enablers and capabilities required to make these developments successful.

Targeting Core Capabilities for Intelligent Mobility

Building a successful and profitable Intelligent Mobility sector in the UK will not be achieved purely with roadmaps and development plans, but by enabling and encouraging innovation both from existing players and new entrants. Increasingly, the speed of innovation in this emerging sector will be more akin to that of the Digital Revolution with fast growth and adoption of services (e.g. Uber and Citymapper) rather than traditional transport planning. This report aims to target the Core Capabilities that are both highly significant to enable Intelligent Mobility whilst also providing the UK with a competitive advantage.

Recommendations for Policy Interventions and Targeted Investments

This report is intended to benefit a number of stakeholders and help guide policy and investment decisions. As such, it is meant to stimulate activity and investment in Intelligent Mobility by identifying pertinent traveller needs and understanding the scale of targetable Value Pools.

Whilst a successful Intelligent Mobility industry should thrive with little policy intervention, many modes of transport are still reliant on and guided by central and local policy and support. Some level and type of intervention will be required in order to deliver step changes in traveller experience and ensure the success of Intelligent Mobility developments. This report aims to identify the key areas where such policy interventions would be beneficial.

The findings in this study will also support the Automotive Council Technology Group's Intelligent Mobility Roadmap and its broader objectives of increasing mobility, improving safety and enhancing user benefits, whilst simultaneously reducing pollution, consumption, and congestion. It will also provide an evidence-based baseline for policy planners, regulators, industry and funding bodies such as the Department for Transport, InnovateUK or the Intelligent Mobility Planning, Action and Coordination Team (IM-PACT UK), which the Transport Systems Catapult is chairing.

FINALLY, BEYOND THIS REPORT **THE STUDY HAS PRODUCED A LARGE DATASET OF TRAVELLER NEEDS AND PAIN-POINTS**. THIS DATASET IS A KEY ASSET THAT WILL BE AVAILABLE TO THE UK FOR FURTHER ANALYSIS TO HELP DIFFERENT STAKEHOLDERS UNDERSTAND THE IMPLICATIONS OF THE FINDINGS TO THEIR CONTEXT.

Key Findings

A Hot-bed for Intelligent Mobility

A SUCCESSFUL INTELLIGENT MOBILITY INDUSTRY IN THE UK REQUIRES **TRAVELLERS WHO WELCOME AND EMBRACE INNOVATIVE MOBILITY PRODUCTS AND SERVICES**, CREATING AN ADDRESSABLE MARKET FOR NEW BUSINESSES.

This study has found that the UK exhibits this trait. **From a traveller perspective, the UK has the key prerequisites to make Intelligent Mobility successful:**

Firstly, UK travellers express a clear need for travel improvements. 75% of all journeys made in the UK are subject to negative experiences (i.e. pain-points), many of which may be addressed with Intelligent Mobility solutions. Also, 53% of travellers (making up 57% of journeys in the UK) state that they actively look for ways to improve their journeys. This means that there is an audience willing and waiting for Intelligent Mobility to improve their lives.

> TRAVELLERS ACTIVELY LOOK FOR WAYS TO IMPROVE THEIR JOURNEYS.

Secondly, **UK travellers today exhibit progressive attitudes and are open to considering new approaches.** The study found that 57% of respondents would not mind sharing their personal data in order to get a better service. Considering frequently voiced concerns over data privacy, this number was unexpectedly high and significantly higher than prior research (equivalent values were about 40% in 2010 [3]). Instead of simply purchasing mobility products or consuming mobility services, they realise that transport as a whole can be improved if they actively contribute, not least with their personal data. In a similar vein, the lines between 'ownership' and 'access' are beginning to blur for UK travellers. Today, one third of UK travellers would consider sharing their possessions with others for money. The findings in this study resonate well with the 'Sharing Economy' concept [4] and indicate that the UK provides a critical mass for mobility services based on shared assets [5]. This trend is only expected to grow further, with asset sharing services becoming more mainstream (e.g. Airbnb, Lyft, and BlaBlaCar). In mobility, such services increasingly consider both the vehicle and journey as something that could be shared and better utilised. Furthermore, 39% of respondents say that they would consider using a driverless car – which is also a very high number for a product that does not yet exist (typically under 15%[5]). Indeed, this acceptance of autonomous vehicles is very encouraging for automotive OEMs[6] and other transport and logistics players who are innovating in this space, and there is an emerging acceptance of new transport modes that go beyond the traditional car and public transport.

Finally, **travellers are increasingly connected and can be easily reached through apps**. Smartphone penetration in the UK is 72% and growing (forecast to grow to 81% by 2017 [6]), with more than half of smartphone users already considering it essential to their travel experience. The combination of connectivity on the move, traveller attention and engagement, and a favourable digital distribution channel makes smartphones a priority access point for Intelligent Mobility solutions, ensuring that emerging value opportunities in Intelligent Mobility can be captured. In the future, this can be expected to extend to wearable technologies such as smart watches.

The most prominent recent innovations in the mobility space have come from digital start-ups such as Uber, Hailo, and Citymapper, who have already taken advantage of these trends. They deliver tangible improvements to the end-to-end journey experience by utilising existing infrastructure and vehicles and relying on consumer connectivity. There is consensus amongst the experts interviewed that the **UK is a leader in digital innovation**, with many exciting start-ups in London's 'Silicon Roundabout' and in other parts of the UK. These start-ups have a **large talent pool with the right skill-sets** to develop further innovations in the Intelligent Mobility space. The UK must not only continue to support this start-up scene, but also encourage developments in Intelligent Mobility through targeted funding. This includes giving start-ups access to public and local authority procurement and by encouraging new collaborations with traditional players in the mobility value chain.

THE UK IS A LEADER IN DIGITAL INNOVATION.

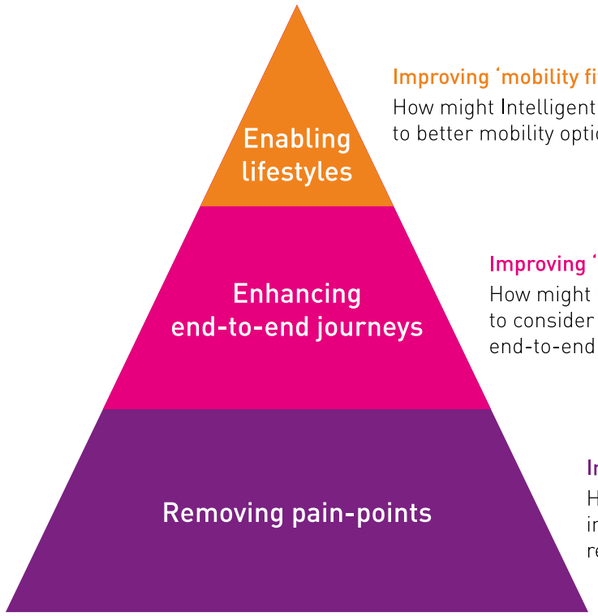
The UK is also seen as a **world leader in the more traditional transport systems space**. London's SCOOT[7] traffic control system is one of the most advanced in the world, and there is a thriving transport planning and consulting industry in the UK. The combination of this transport expertise and world-class digital innovation capabilities provides the **ideal blend of expertise for developing Intelligent Mobility solutions**.

Moreover, the UK is considered to be an **ideal testing and learning ground** for Intelligent Mobility due to its unique combination of densely populated cities and sparsely populated rural areas. A well-developed transport network that has to deal with significant demand peaks, yet at a manageable scale compared to some global mega-cities, provides the ideal basis to successfully develop Intelligent Mobility solutions. The UK's traveller readiness, digital innovation capability, traditional transport expertise, and a geography and infrastructure ideally suited for transport innovations positions the UK as a hot-bed for Intelligent Mobility – at the forefront of Intelligent Mobility development.

Hierarchy of Traveller Needs

THIS STUDY HAS IDENTIFIED A NUMBER OF **FUNDAMENTAL TRAVELLER NEEDS, PAIN-POINTS, AND ATTITUDES** THAT INTELLIGENT MOBILITY SOLUTIONS HAVE THE POTENTIAL TO ADDRESS.

Although what travellers experience is wide-ranging and often relates to specific circumstances, a number of key needs, pain-points, and attitudes have been identified in the study. These have been clustered into a '**Hierarchy of Traveller Needs**' consisting of three areas: Enabling lifestyles, Enhancing end-to-end journeys, and Removing pain-points.

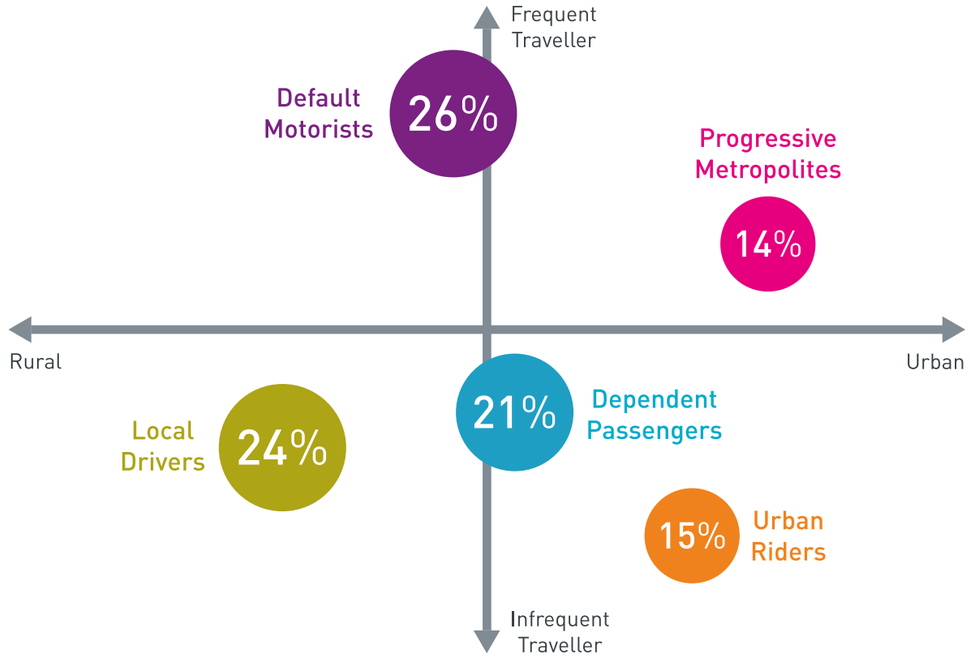


Opp: Hierarchy of Traveller Needs (Source: Traveller Research and CVA Analysis).

Enabling Lifestyles

Two core mobility-relevant dimensions were shown to influence the traveller's fundamental mobility needs, pain-points, and attitudes directly.

Firstly, how much they travel, for what purpose (e.g. work or leisure), and in which geographies (local, national, international) – their 'mobility lifestyle'. Secondly, what transport choices they have available, where they live and work, and whether they are restricted by personal or family situation – their 'mobility situation'. Across these two dimensions, five key traveller segments have been identified as shown below:



Opp: Key traveller segments as % of UK population (source: Traveller Research and CVA Analysis).

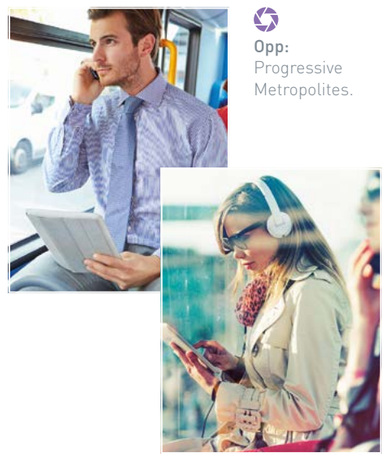
Progressive Metropolites

14% of UK population and 16% of journeys.

'Progressive Metropolites' live in large urban centres. They are heavy travellers both for work and for leisure, typically making 17% more journeys annually than the average UK adult. They are generally young professionals (57% are aged 35 or under) with high disposable incomes (twice as likely to earn more than £40,000 per year compared to average). They are very 'technology-savvy', with a 94% smartphone penetration – which they consider to be essential to their everyday lives. 70% state that they like to be the first to try new technologies and that they consider new digital services to be improvements in their lives – **making them early adopters and a clear target group for new digital products and services**.

This is equally true for mobility, as two thirds state that they are excited by new developments in transport and would consider driverless cars – significantly above the 39% population average. This transport innovation awareness, in combination with their digital affinity and their heavy travel patterns, make them the **ideal lead users for new Intelligent Mobility solutions**.

Travellers in this segment are regular users of public transport and in particular multi-modal transport (one third of their journeys). However, the private car still plays an important role in their lives as it is used for 48% of their journeys (33% in London).



Opp: Progressive Metropolites.

The car ownership experience is important to them (66%) yet **more than half of the car users in this segment (57%) could imagine giving up their car** if better alternatives were available. Solutions such as car sharing or ride sharing are likely to be successful in this segment, provided that they allow a **high level of personalisation and customisation** to re-create the benefits of individual car ownership. Travellers in this segment are also believers in the emerging 'Sharing Economy' concept, with 66% agreeing that services such as Airbnb improve their lifestyles. There could be a large opportunity to develop such services further in urban transportation, including **peer-to-peer sharing models and packaged mobility offers**. If such offers allowed shared access to different vehicles and transport services it would enhance their mobility options and mobility lifestyles significantly beyond that of the single car ownership experience.

This segment also aspires to live a sustainable mobility lifestyle with 55% trying to optimise their travel for the good of society (compared to the 30% average) and 53% trying to use transport modes that are good for the environment (compared to the 29% average). Clearly, with the remaining high level of private vehicle usage seen in this segment, there is an opportunity to develop solutions that help them live more sustainable lifestyles. However, at the same time, such solutions must also help these travellers optimise their transport costs (73%) and also enable them to use transport as a way to explore (83%).

Finally, this segment expresses a preference that **they would rather have completed the journey 'virtually'** (i.e. not travelling at all physically) for 60% of journeys made today, had they been able to.

This is a key opportunity for further innovation and to develop both enhanced video conferencing and goods delivery solutions that meet the needs of this traveller type.

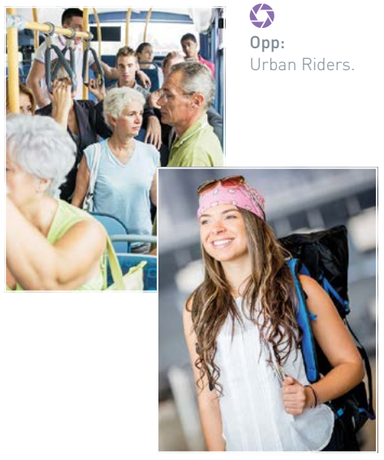
Urban Riders

15% of UK population and 10% of journeys.

The second urban segment are infrequent travellers, which is reflected both in leisure as well as in work journeys. Half of this segment do not work at all and include students, home keepers, retirees and unemployed people. This mix of demographics is also reflected in a typically low household income. The travel demand of this traveller type is low and focuses predominately on **local journeys within the urban environment**. As such, it is well supported with a multitude of mobility options available to meet their needs, which typically includes walking or taking the bus. Very few in this segment drive and in fact only 40% have a driving licence. Whilst there is little indication that this segment does not consider its mobility needs sufficiently met, opportunities would include provision of low cost transport services beyond buses (e.g. ride sharing services or shared taxis).

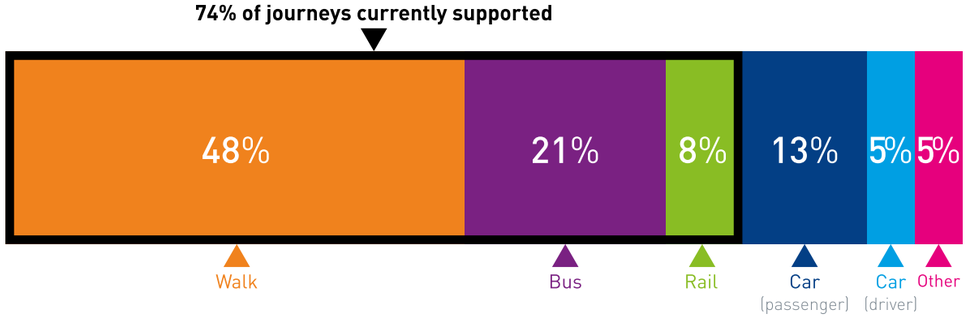
This segment is particularly unlikely to be travelling longer distances and the vast majority of them (79%) make non-local journeys less than once a month. Despite this, they are as likely to enjoy exploring new places (71%) just like other segments, which could indicate a latent need to have improved access to non-local travel at an affordable cost.

PROGRESSIVE METROPOLITES ARE EARLY ADOPTERS AND IDEAL LEAD USERS FOR NEW INTELLIGENT MOBILITY SOLUTIONS.



Opp: Urban Riders.

URBAN RIDERS INCLUDE MANY TYPES OF TRAVELLER IN URBAN ENVIRONMENTS WITH LOW TRAVEL DEMANDS.



Opp: Urban Riders transport modal segmentation (Source: Traveller Research and CVA Analysis).

Default Motorists

26% of UK population and 37% of journeys.

This is a segment of very frequent travellers who live in smaller urban centres or suburbs of larger cities. They make a significant number of journeys for work (twice the UK average) and also make a high number of leisure journeys (15% more than UK average). **The vast majority of their journeys are taken by private car**, which is their 'default' mode of transport. Other modes are either not accessible or are simply not considered. As such, this 'always on the road' segment makes up 46% of all car journeys in the UK. This is a 'working age' segment (typically 26 to 65) and the vast majority of them (three quarters) are employed, with middle household incomes (60% earn between £10,000 and £40,000 per year). As such, they represent a broad cross-section of the UK working population.

Interestingly, not all travellers within this segment enjoy driving privately. Two sub-groups have been identified based on their attitudes towards driving.

Opp: Default Motorists.

DEFAULT MOTORISTS MAKE UP 46% OF ALL CAR JOURNEYS IN THE UK, BUT TWO THIRDS OF THEM DO NOT VALUE CAR OWNERSHIP.

Default Motorists: Petrol Heads

9% of UK population and 13% of journeys.

The first sub-group, representing one third, actively enjoys driving and would even consider it their hobby. **Car ownership is very important to them and they cannot imagine relinquishing their car in the future.** They are very unlikely to consider mobility sharing schemes and are not excited about new technologies in transport such as driverless cars (only 25% are excited). Whilst there is limited scope to develop new mobility options for Petrol Heads, they will continue to be a target group for OEMs. Beyond selling vehicles to this sub-group there could be scope to offer additional mobility services which enhance their driving and ownership experience.

Opp: Petrol Heads sub-group.

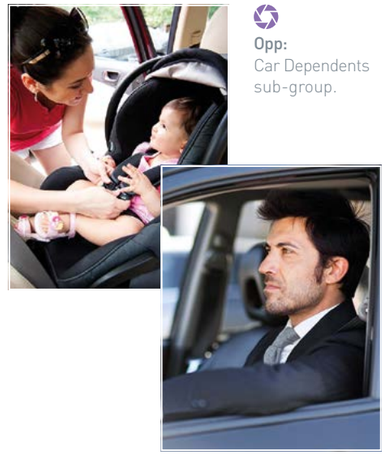
Default Motorists: Car Dependents

17% of UK population and 24% of journeys.

For this group, driving is purely a functional choice. They represent two thirds of the Default Motorist segment but do not identify with their car and do not value car ownership. In fact it is questionable whether they actually want to drive or whether it is simply the only sensible mobility option available to them (80% use their car every day). There is a sizeable opportunity to reduce their burden of daily driving.

Firstly, their **driving time could be made more productive**. 42% in this sub-group would consider autonomous vehicles – which is a clear opportunity for OEMs to consider and a direct benefit to these travellers in productive time.

Secondly, mobility options that reduce the active driving time might equally be of benefit for this sub-group – whether it is ride sharing, parking guidance to reduce time spent looking for parking, or multi-modal integration to reduce car dependency for longer journeys. Providing access to alternative modes would significantly enhance the mobility experience for this sub-group and **69% could imagine giving up their car**. New mobility alternatives would need to deliver the same flexibility and door-to-door convenience that private cars do. Dynamic timetabling and routing, seamless integration both at a local and national level, and sufficient space and connectivity for work would generally be of benefit to them.



Opp: Car Dependents sub-group.

Local Drivers

24% of UK population and 19% of journeys.

Local Drivers are a more suburban or rural, typically older segment (70% aged 55 or over and 60% are retired). They are non-working (either retired or have chosen to stay at home) and their travel demand is very much focused on local journeys. They own cars but tend not to be heavy drivers (half drive less than 5,000 miles per year). **As a whole, they do not appear to have any significant unmet lifestyle needs, and the private car is a complete mobility option for them**, with 63% making daily local trips for leisure or personal business. They are much less likely to state that they would rather not have travelled (22% compared to the 31% average) and many of their journeys (47%) are completed without any stated pain-points, which indicates that their needs are well met with private cars. Not only do they complete journeys without complaints, they also actively focus on enjoying their travel – with 55% often taking a slower route for a better experience (compared to the 45% average). **There could be an opportunity for Intelligent Mobility to enhance their journeys further through context-aware information services focusing on the driving experience.**

Whilst this segment shows average internet usage and is comfortable making payments online, there is a relatively low smartphone uptake (62%) and only 25% of smartphone owners consider it essential to their travel experience. Whilst this is a barrier for new app-based mobility services today this segment is expected to become increasingly more comfortable with mobile technology.

Opp:
Local Drivers.

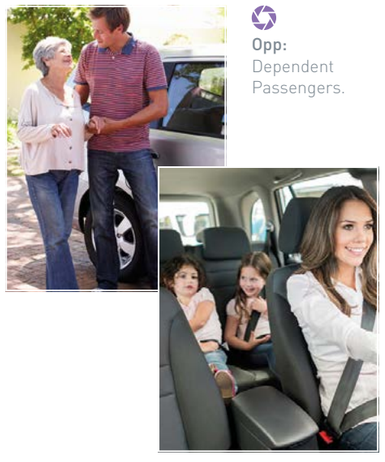
THE PRIVATE CAR IS A COMPLETE MOBILITY OPTION FOR LOCAL DRIVERS.

Dependent Passengers

21% of UK population and 18% of journeys.

'Dependent Passengers' is a segment that is dependent on others to meet its mobility needs. This traveller type consists of a number of groups, such as young people (who typically get driven by their parents), elderly people, and travellers with impairments. They take a majority of their journeys as car passengers and the remainder is typically covered by either bus or by walking, with journeys split representatively between work and leisure. In this segment, **Intelligent Mobility solutions could provide more independence and enable better access to travel**. This could include driverless mobility options that enable more journeys as a car passenger, dynamic bus services that offer greater flexibility, and digital navigation and assistance tools that enhance independent journeys. **The attitudes in this segment are generally supportive of Intelligent Mobility**, with 51% being happy to use increasingly automated services (compared to the 55% average) and 59% are happy to share their data for better services (compared to the 57% average).

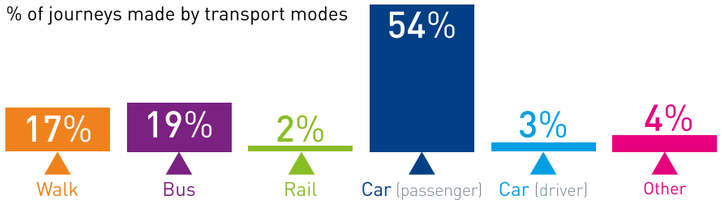
There are, however, a number of challenges to overcome. 74% within this segment do not have a driving licence and will not be able to access current car sharing solutions. Also, this is a low household income segment (50% earn less than £20,000 per year with almost half unemployed) and 70% of their journeys currently entail no cost to them at all (e.g. car passengers, walking or concessionary travel). Therefore any mobility services offered here need to be affordable and cost-effective. Where transport for this segment is subsidised, these services could potentially be made more efficient with Intelligent Mobility solutions (e.g. through dynamically routed buses).



Opp:
Dependent Passengers.

INTELLIGENT MOBILITY SOLUTIONS COULD PROVIDE MORE INDEPENDENCE AND ENABLE BETTER ACCESS TO TRAVEL.

% of journeys made by transport modes



Opp:
Dependent Passengers' modal split.

Improving 'Mobility Fit'

Enabling lifestyles is about more than just enabling and improving physical travel. **31% (19bn) of journeys made today would rather not have been made** if alternative means were available (e.g. online shopping). This includes 3.2bn journeys for shopping, 1.5bn for business travel, 1.8bn for education, and 0.5bn medical visits. Not wanting to travel could be for a variety of reasons, for example preferring to spend the travel time in other ways, or a particularly poor journey experience.

Those journeys that can be completed 'virtually' would be removed from the transport system, reducing demand and pressure at peak times. In the case of shopping trips this would, of course, result in an increased number of goods deliveries. The impact on traffic remains to be seen, especially where previous multi-purpose shopping trips are replaced by the delivery of many individual items as and when they are desired by the shopper. Whilst there is a risk of increased congestion, it is also an opportunity for innovation and Intelligent Mobility to help improve fast, reliable, and convenient delivery.

Intelligent Mobility has the ability to bring a significant step change to the lifestyles of many traveller types. In particular, the scale of unmet traveller needs is greatest in three segments (Progressive Metropolites, Default Motorists, and Dependent Passengers), constituting approximately 60% of the population and making up 73% of annual journeys in the UK. Together with enabling virtual mobility these three traveller types in particular might be more open to Intelligent Mobility solutions.

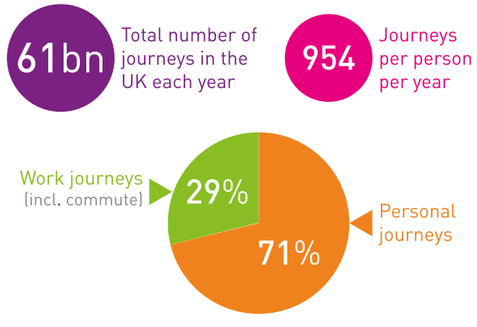
As such, four key challenges can be framed:

1. **Help the urban population reduce their transport footprint and enable digital, asset-light lifestyles.**
2. **Reduce the burden on the car dependent population.**
3. **Provide independent mobility for car passengers.**
4. **Push the boundaries of virtual mobility to provide the freedom to not travel.**

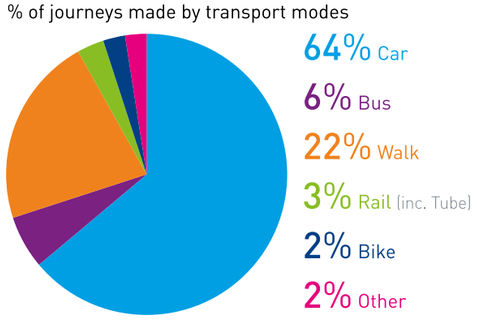
Enhancing End-to-end Journeys

This section investigates the key reasons for the choices that travellers make during their end-to-end journey, how to encourage transport modal shifts, and what other factors affect their journey experience.

The majority of travel in the UK is currently by road (64%) and the **key reasons that travellers use the car are flexibility and convenience**. Being able to travel when they want is the most important attribute to travellers (49%) and public transport is more likely to be chosen when it is easily accessed (47%). Therefore, public transport needs to offer the flexibility and convenience that the private car has traditionally provided to encourage some modal shift. Such public transport systems will need to include dynamically routed and timetabled transport, and seamless and fast interchanges between transport modes. Special consideration should be given to the 'first and last mile' where the private car currently provides the greatest convenience.

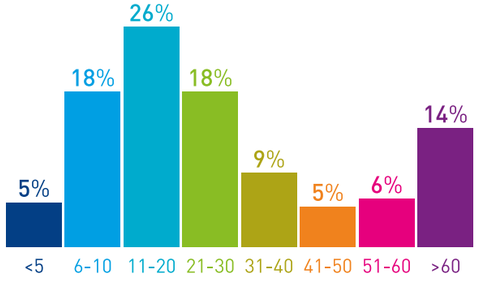


% of journeys made by transport modes

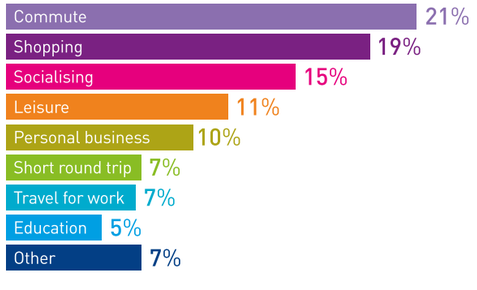


Opp:
Travel in the UK (Source: ONS, NTS, and Traveller Research - numbers may not add up due to rounding).

% of UK journeys by length (minutes)



% of UK journeys by purpose



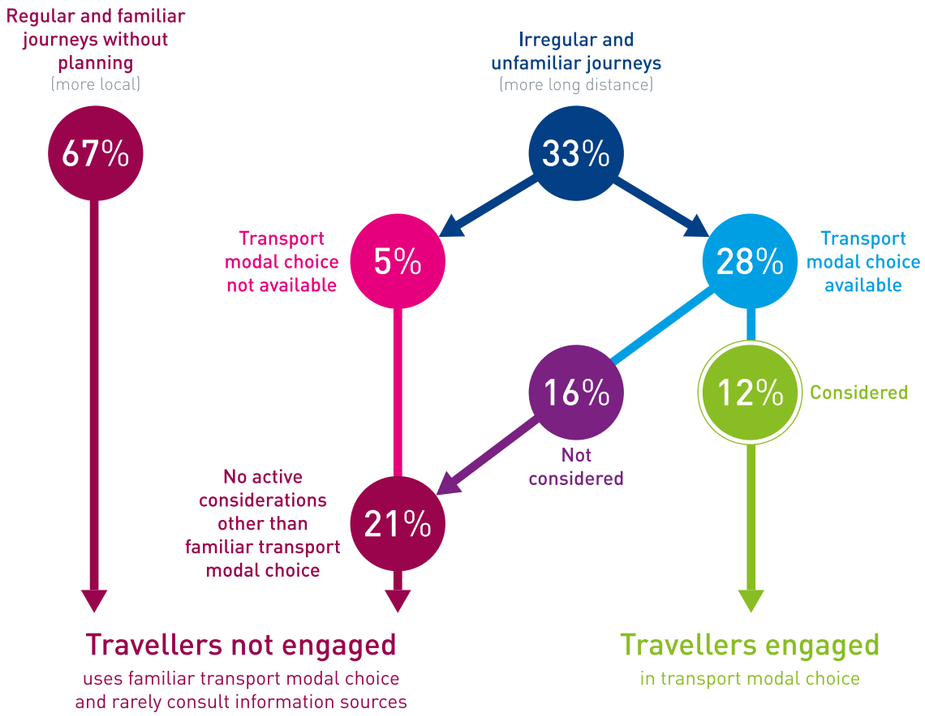
Another key challenge to overcome is the broader integration of multiple operators, which will increasingly also include providers of new transport modes of mobility such as car- and bike sharing schemes and ride sharing services. Offering integrated ticketing, traveller information, and dynamic timetabling (e.g. for infrequent transport services) would help give public transport the flexibility and convenience it currently lacks. Beyond this, the end-to-end journey for those who currently already travel multi-modally needs to be improved – as multi-modal travel is currently associated with a significant amount of pain-points (discussed further in the 'Removing Pain-Points' section).

Engaging Travellers in Modal Choice

For the vast majority of journeys (typically more local journeys), **travellers do not plan their journeys or consider what transport modal choices they have available**. **In fact it is only 12% of journeys that include travellers actively considering their transport modal choices** – as visualised below.

There are several important insights to note here. Firstly, the large number of journeys (67%) that are habitual and – from the traveller perspective – do not warrant any active planning or pre-journey consultation of information (e.g. routing, timetable or traffic information). For these types of journeys, it will be difficult to encourage travellers to consider their transport choices. As such, information services that enhance the traveller's experience but also encourage transport modal shifts or other behaviour change will not be actively considered on these journeys – which reduces the ability to enhance the overall efficiency and flow of the transport network.

The remaining 33% of journeys (typically longer ones) are irregular and are unfamiliar to the traveller such that some active planning is needed. Yet in the majority of cases when transport modal choices are available they are not considered. Instead, travellers default to their typically used transport mode, which in many cases is the car. As such, even those travellers who claim that they look for ways to improve their journeys only actively consider their mobility options for a small proportion of journeys. **Increasing this number should be seen as an imperative** and could be an important step in reducing private car-dependence, which would encourage uptake of both cleaner and congestion reducing transport modes. Potential end-to-end mobility options that span across transport modes and transport operators will depend on travellers actively considering their mobility options before and during every journey. This will require continued development of integrated planning and information tools with a view towards providing more personalised and prescriptive information.



Opp:
Journey planning and transport modal consideration (Source: Traveller Research and CVA Analysis).

Confidence in Arrival Time

Regardless of transport mode chosen, a critical end-to-end journey attribute for the traveller is the time spent travelling. This study found that in a choice exercise where travellers are offered the possibility of having journey time reduced or other journey attributes improved, journey time was identified as the most valued attribute. As such, this highlights the need for Intelligent Mobility solutions to provide overall transport flow improvements in a way that shortens overall journey times. In addition to the journey time, **travellers also value avoiding unexpected delays and having confidence in their arrival time**. In fact, these attributes are more 'top-of-mind' for travellers than the journey time itself, with 26% spontaneously stating these as important factors. 21% of road journeys (motorways and A roads) and 10% of rail journeys already experience delays today [7], and increased pressure on the transport network is forecasted [8]. As a consequence there will be increasing demand for mobility options to provide arrival time confidence. **Intelligent Mobility could help in a number of ways either through flow optimisation on the existing transport network (e.g. optimising traffic light flows and smart rail signalling), or through increasing network resilience to incidents (e.g. dynamic routing, dynamic timetabling).**

Journey Information

Irrespective of transport mode there are a number of factors that appear to consistently impact the traveller's perceived journey experience. Where travellers are on a time-critical journey (a journey which requires the traveller to arrive by a specific time, e.g. commute to work, school run) perceived 'journey quality' is impacted (with a particular focus on delays). When having to take responsibility for others (e.g. children) or luggage on a journey, travellers experience overall worse journeys. Conversely, when travelling with an adult companion, the end-to-end journey is perceived as significantly smoother. Counter to intuition, familiar journeys (i.e. those done on a regular basis) are more problematic. One plausible explanation is that travellers have an expectation baseline that has been set by prior experience – alternatively, travellers may be reducing their contingency buffer time and therefore are more sensitive to delays.

IN ALL OF THESE CASES BETTER END-TO-END JOURNEY INFORMATION CAN ENHANCE THE JOURNEY EXPERIENCE.

A 'virtual journey assistant' that takes the role of the adult companion could give travellers confidence in arrival time and a smoother end-to-end experience during time-critical circumstances that are demanding for travellers or where expectations are high. Such information would need to be personalised and context-aware to provide travellers with greatest value.

Improving 'Mobility Choice'

Enhancing end-to-end journeys has the ability to not only meet traveller needs but also to optimise transport flows and increase available transport capacity across the UK.

In delivering better end-to-end Journeys a number of key challenges need to be addressed:

5 **Aim for transport systems to offer the flexibility and convenience that the private car has traditionally offered.**

6 **Actively engage traveller in journey planning and transport modal consideration.**

7 **Enable faster journeys and increased confidence in arrival time.**

8 **Create relevant, personalised and context-aware information.**

Below:
A LUTZ Pathfinder Pod simulated journey.

Removing Pain-Points

Pain-points are key sources of frustration or desires for improvement that affect 75% of journeys in the UK. Whilst traveller pain-points are varied and include complaints such as pot-holes or dirty trains, there are a number of key pain-points that should be prioritised for Intelligent Mobility solutions. Improving these journey attributes not only positively affects the experience of travellers but can also represent a value opportunity for mobility operators.

Private Car Pain-Points

On car journeys **drivers often complain about the 'start-stop' nature of driving**, which includes queuing in traffic but also stopping for traffic controls and junctions. This affects 10% of all private car journeys in the UK (3.5bn journeys each year) and drivers would value having the continuity of their journeys improved. **Finding parking is another key pain-point**. Travellers struggle to find parking on 4.3bn journeys, which represents 12% of car journeys, rising to 14% if considering only urban journeys and 19% of journeys in London. Whilst parking could be a 'quick win' for Intelligent Mobility if live space availability data was to be generated, reducing the 'start-stop' nature of driving is likely to require more system-level change such as a better step change in traffic light phasing. More likely, it will require a combination of connected infrastructure and autonomous driving.

Public Transport Pain-Points

Public transport users experience twice as many pain-points as drivers. The pain-points expressed are often direct results of not delivering on the end-to-end journey and public transport is generally considered **poor value for money**, with the high cost of the journey being one of the most cited pain-points (17% overall and 25% for rail users). **Lack of personal space due to crowding** (20%) and an inability to sit down (12%) are common across all public transport modes at certain times of the day – along with lack of cleanliness (12%). Rail journeys in particular struggle with **limited internet connectivity** (14%).

Better management of supply and demand is one way that Intelligent Mobility might address many of the pain-points in public transport (this will be discussed more in the 'Four Transformational Themes for Intelligent Mobility' chapter).

Multi-Modal Pain-Points

Journeys involving modal interchanges are particularly prone to causing pain-points for travellers. With each additional transport mode in the journey, the number of pain-points experienced by the traveller increases, as shown below.

Multi-modal travellers find the planning of their journeys to be complicated and difficult. They are especially unable to rely on their estimated arrival time and are often delayed. Multi-modal travellers also complain that their journeys take an excessive amount of time and their data connectivity need is great. Improvements on multi-modal journeys are needed, such as providing simpler ticketing or reducing perceived complexity of planning (e.g. better planning tools and information before and during journeys). Providing better guidance and wayfinding during interchanges could prove to be a huge step forward. This would not only enhance the travel experience for those already making interchanges between transport modes but could also potentially encourage other travellers to consider multi-modal journeys.

Improving 'mobility experience'

Intelligent Mobility can help address many traveller pain-points across both private and public transport.

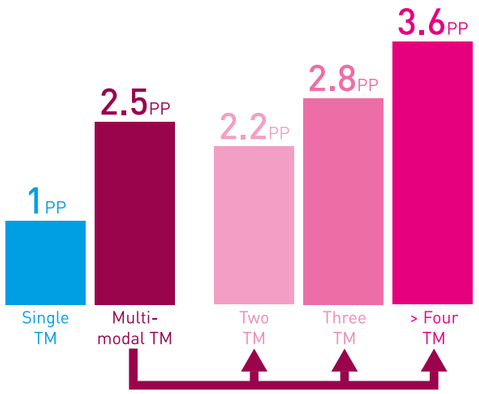
Four key challenges need to be addressed:

9 **Solve the parking challenge.**

10 **Enable smoother drives.**

11 **Increase user experience and perceived value of public transport.**

12 **Improve and enable multi-modal journeys – reducing complexity, enhancing connectivity, and improving speed and reliability.**



Number of Pain-Points (PP) encountered per Journey – Transport Modes (TM)

Opp: Pain-points in multi-modal travel (Source: Traveller Research and CVA Analysis).

Realising Potential Value from Intelligent Mobility

Traveller Needs Challenges

THE KEY CHALLENGES IDENTIFIED NOT ONLY REPRESENT **A GREAT LEVEL OF BENEFIT TO TRAVELLERS** IF SOLVED BUT ALSO **A POTENTIAL REVENUE OPPORTUNITY** FOR NEW OR EXISTING PLAYERS IN INTELLIGENT MOBILITY.

Within the 12 Traveller Needs challenges, **10 Value Spaces** that have the potential to create a profitable Intelligent Mobility industry in the UK have been identified. Challenges 5 and 6 have not been valued as the both act as fundamental enablers to many of the other challenges rather than as discrete opportunities in their own right.

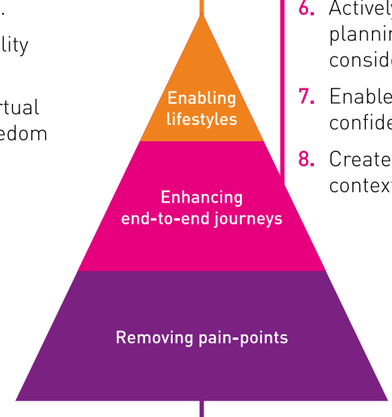
Challenge 5 is an enabler to Challenge 1 and 2, referring to car users utilising different modes, whereas Challenge 6 is a broad enabler of all Intelligent Mobility solutions that require traveller interaction and engagement.

Key challenges

1. Help the urban population reduce their transport footprint and enable digital, asset-light lifestyles.
2. Reduce the burden on the car-dependent population.
3. Provide independent mobility for Car Passengers.
4. Push the boundaries of virtual mobility to provide the freedom to not travel.

Key challenges

5. Aim for transport systems to offer the flexibility and convenience that the private car has traditionally offered.
6. Actively engage traveller in journey planning and transport modal consideration.
7. Enable faster journeys and increased confidence in arrival time.
8. Create relevant, personalised and context-aware information.



Key challenges

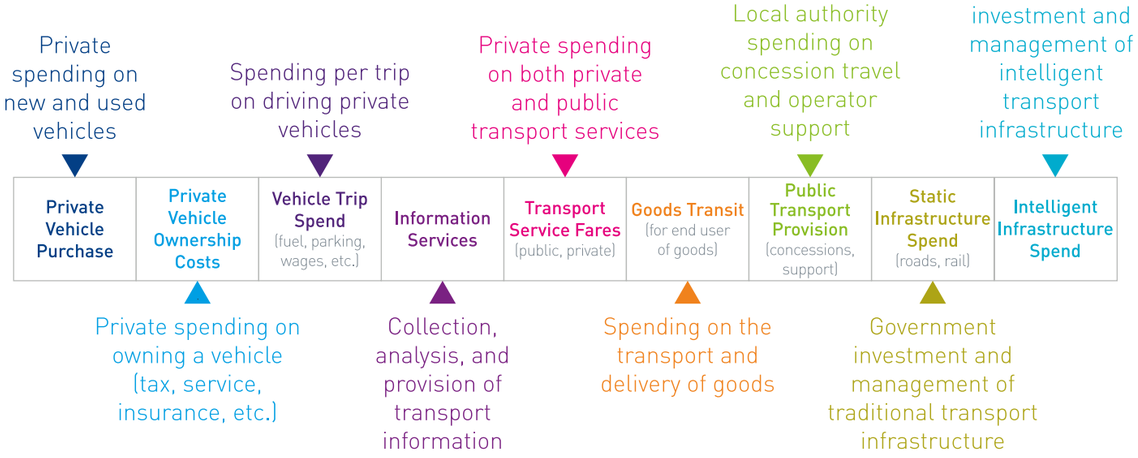
9. Solve the parking challenge.
10. Enable smoother drives.
11. Increase user experience and perceived value of public transport.
12. Improve and enable multi-modal journeys – reducing complexity, enhancing connectivity, and improving speed and reliability.

Opp: Overview of the 12 Challenges for Intelligent Mobility (Source: CVA Analysis).

Within each overarching Value Space, specific Value Pools (revenue opportunities) have been quantified. Two different types of value have been considered:

- **Incremental Value** is money that travellers are willing to spend on top of their transport spend today. Incremental value can be realised through:
  - New personal vehicle features – making car use easier, smoother, and less burdensome
  - Information to help travellers during their journeys – across all modes
  - Enabling journeys that were not previously possible
  - Other journey improvements (e.g. meeting pain-points) that travellers will pay extra for
- **Redistributed Value** is money currently spent on transport today that travellers would rather have spent on different mobility solutions or where government spend could be more efficiently spent otherwise. Redistributed value can be realised through:
  - 'Mobility as a Service' – removing the need for ownership and/or removing the burden of driving
  - 'Virtual mobility' – shifting trip spend to alternative solutions (online shopping, video conferencing)
  - Efficient public transport – optimising demand and supply across all modes of transport

The Value Pools have been considered across a number of different aspects of the transport sector:



Below: Areas of the transport sector considered in value analysis (Source: CVA Analysis).

Identified Value Spaces

VALUE SPACE: PROGRESSIVE METROPOLITES

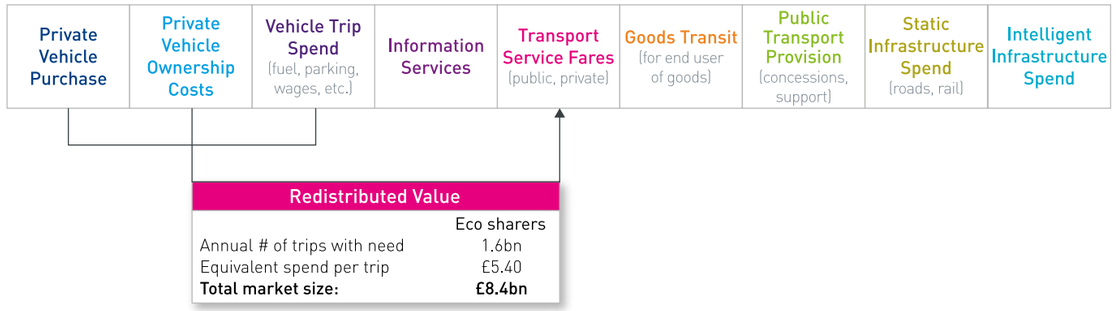
CHALLENGE 1: HELP THE URBAN POPULATION REDUCE THEIR TRANSPORT FOOTPRINT AND ENABLE DIGITAL, ASSET-LIGHT LIFESTYLES.

Description

Progressive Metropolites epitomise the emerging opportunity for Intelligent Mobility. They have high disposable household incomes, are tech-savvy early adopters, aspire to lead sustainable lives, and have to deal with congestion in the urban environment. 48% of their journeys are still made by private car but they are open to replacing their car ownership with alternative mobility options that meet their needs.

Value Pools

Addressing this challenge will cause a shift in value from private vehicle ownership and operation to transport services (e.g. ride sharing or shared vehicles). These travellers also represent a key lead market for potential future driverless taxis, due to their high degree of acceptance of autonomous developments and desire to move away from ownership. Being highly engaged in transport this value shift may happen quickly with the right mobility options, as they are eagerly looking for ways to improve their travel. The total Value Pool is £8.4bn and includes current spend on private car ownership and usage by those who would give up their car if they could. These people make a total of 1.6bn journeys each year with their cars and spend the equivalent of £5.40 per journey. In the short- to medium-term, unless Intelligent Mobility solutions deliver across all their journeys, they are likely to retain their car ownership but replace individual trips with new mobility options. In the longer term, however, this Value Pool may be fully captured where private ownership is replaced by flexible and shared mobility solutions.



Below: Progressive Metropolitans – Value Pool (Source: CVA Analysis).

Implications

Shared and environmentally friendly transport solutions already exist in the UK but these have not made significant inroads into the urban travel mix despite these needs being present in urban environments. Further insights are required to fully understand why uptake has been limited, what can be done to successfully design and implement mobility solutions with significant uptake, and what would trigger the Progressive Metropolites to actually give up car ownership. It is likely that different types of mobility solutions need to be tested to understand travellers' mobility patterns and preferences. Local authorities should encourage trials of innovative solutions with an expectation that they may fail. Acceptance of experimentation should include the type of vehicle that is offered, price structure and mobility 'packages' available, level of multi-modal integration, and the digital user experience. Structured learning and understanding will be important so that successful Intelligent Mobility solutions can be deployed.

VALUE SPACE: DEFAULT MOTORISTS

CHALLENGE 2: REDUCE THE BURDEN ON THE CAR-DEPENDENT POPULATION.

Description

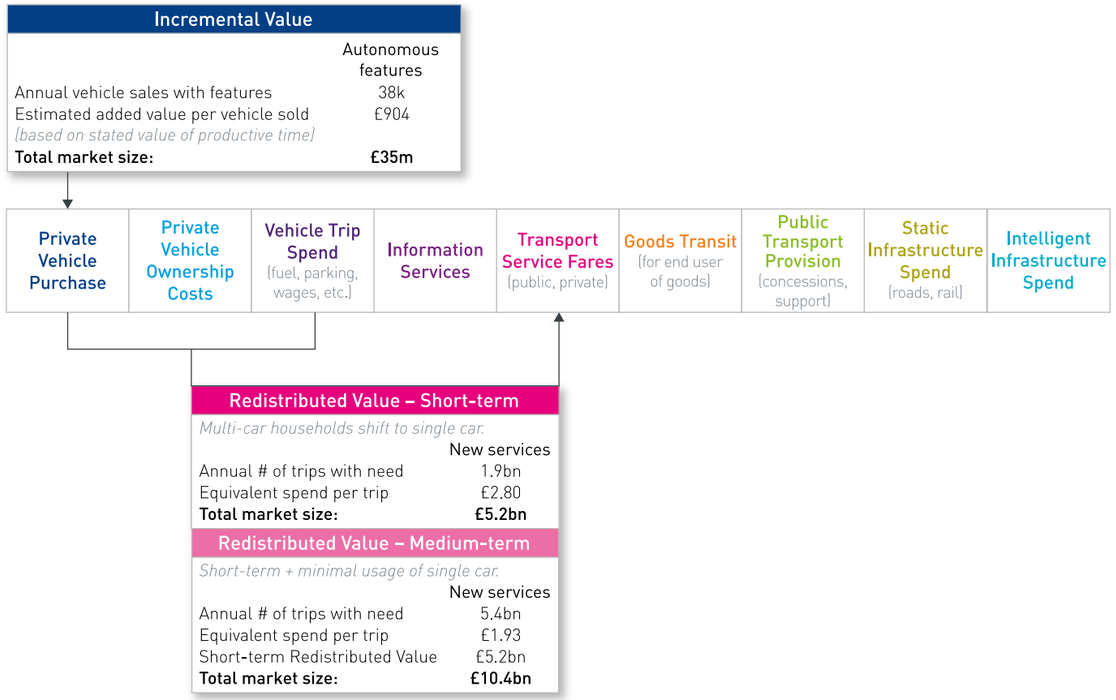
The Default Motorists segment is divided into two groups: Petrol Heads and Car Dependents. The latter see the car as a means to an end and are burdened by their car ownership. They are interested in using autonomous vehicles and would be willing to give up their car if viable alternatives were available.

Value Pools

Two separate Value Pools are considered:

- **Autonomous Features**: providing **autonomous driving features** can relieve drivers from the chore of daily driving. This could range from active cruise control to full autonomous driving without the need for driver intervention. In the long-term autonomous features could become mainstream if new vehicles become available with this functionality as default (e.g. Google's autonomous car).
- **New Services**: providing **new transport solutions** to those who reluctantly own a vehicle could result in their current spend on the traditional automotive value streams being redistributed. To fully realise this would require transport that can fulfil all of their current journeys. In the short-term this is likely to represent a shift from three and two-car households to one-car households or will simply replace some of their journeys.

Below: Default Motorists – Value Pool (Source: CVA Analysis).



Implications

Similar to Challenge 1, **delivering new services will require experimentation** to understand and refine offerings. Because Default Motorists are more habitual travellers with less progressive attitudes compared to the Progressive Metropolites, experimentation in this segment could prove to be more difficult. A possible approach would be to **utilise employers** to encourage transport modal shifts on commuter and business journeys or to help raise awareness of new Intelligent Mobility solutions. As this is a segment of existing car buyers, delivering autonomous features should be possible once market readiness has been reached. Here, the constraint is the slow speed at which the UK 'car parc' turns over. It could take many years before a large penetration is reached and benefits at scale such as vehicle platooning can be realised.

VALUE SPACE: INDEPENDENT MOBILITY

CHALLENGE 3: PROVIDE INDEPENDENT MOBILITY FOR CAR PASSENGERS.

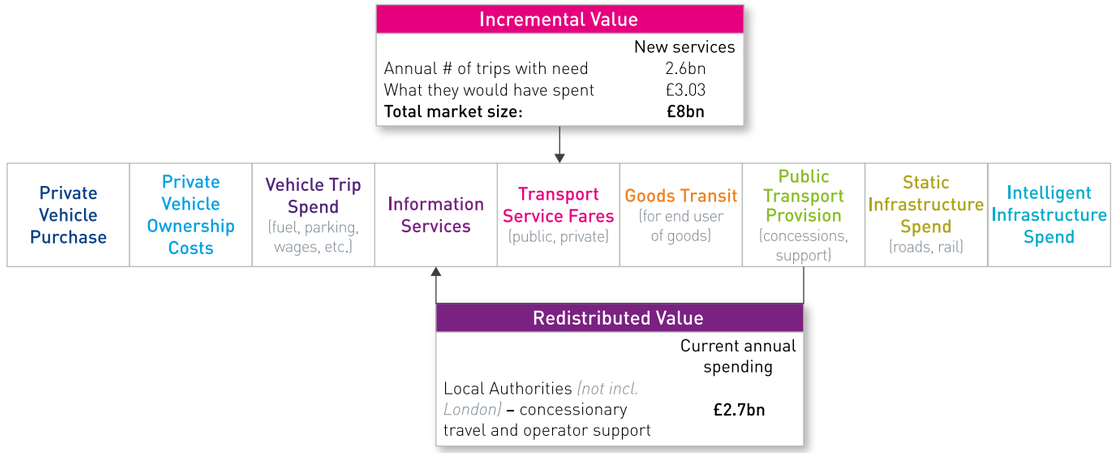
Description

The Dependent Passengers segment includes those who are too young to drive, too old to drive, and those with mobility impairments. Currently, 54% of their journeys are made as a car passenger. Whilst assisted journeys are undoubtedly necessary and valuable, there is a traveller opportunity to enable more independence, which could also lessen the congestion and environmental impact of too many return escort journeys.

Value Pools

Dependent Passengers stated that they would be willing to **spend an average of £3.03 on each journey that is currently free for them**. This presents an opportunity for traditional players and new entrants alike to provide mobility options that can deliver independence at this price point (although it is likely less than the price of a typical taxi journey). Beyond this, Dependent Passengers represent a significant segment of concessionary travel users and Intelligent Mobility is a potential **source of efficiency savings**. This could be achieved by aggregating demand and dynamically running services to respond to this demand, which would increase the utilisation of services that run primarily for concessionary travellers.

Below: Independent Mobility – Value Pool (Source: CVA Analysis).



Implications

Despite traditionally utilising free transport these travellers would in fact be willing to spend on improved independent journeys. This is an opportunity for new and existing players in this space, including private enterprise, local authorities or other funding bodies. However, the needs and expectations in this segment might be different from other travellers, which needs to be considered when developing new solutions.

VALUE SPACE: VIRTUAL MOBILITY

CHALLENGE 4: PUSH THE BOUNDARIES OF VIRTUAL MOBILITY TO PROVIDE THE FREEDOM TO NOT TRAVEL.

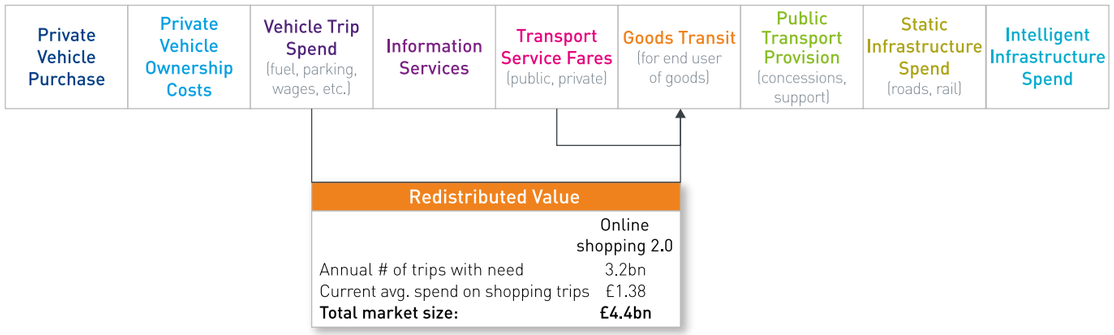
Description

31% of journeys made by travellers today are journeys they would have rather made virtually if it was possible. For example, online education and video conferencing would take many of these journeys out of the transport system. The potential opportunity in providing such communication solutions is not considered as an Intelligent Mobility Value Pool here. However, 5% (3.2bn) of journeys are shopping journeys that travellers would rather have made virtually. Increasing online retailing would see a shift from personal travel to goods delivery. The value associated with this shift is discussed below.

Value Pools

Online retailing has already become a major part of mobility and the UK leads Europe with 15% of retail spending now online [9]. There are still 3.2bn annual shopping journeys in the UK that travellers would rather have completed virtually. These include both car and public transport journeys with an average cost per journey to the traveller of £1.38 (including e.g. public transport fares, petrol, and parking). In replacing these journeys with online retailing, there is additional value available for everybody in the traditional goods delivery value chain – such as warehousing, haulage, last-mile delivery, and routing optimisation. There are also many opportunities for new and disruptive players to deliver new business models (e.g. Uber, Peership, Amazon Lockers, and 'direct to vehicle boot' delivery services). Further investigation is required to size this market and determine the opportunity for different players but, as a proxy, current spend on shopping journeys that travellers would rather not do amounts to £4.4bn per year in the UK.

Below: Virtual Mobility – Value Pool (Source: CVA Analysis).



Implications

Aside from the experience of online shopping itself, new goods delivery solutions will be successful if they offer an experience that matches traveller lifestyles in terms of delivery flexibility and are also cost competitive for the traveller. Many players are innovating around the delivery experience and further developments are expected to be funded by private investment.

The ability to deliver cost-effectively depends mainly on the network density and delivery vehicle utilisation of the deliverers. Local authorities and road operators need to be aware that increased goods delivery can potentially have a negative impact on local traffic flows. Intelligent Mobility has the ability to mitigate this impact through road traffic management and smart parking solutions that enable delivery vehicles to stop close to their destination without impacting other road users.

Beyond online shopping, broadening the appeal of virtual mobility will require a good understanding of the potential use-cases that need to be built (e.g. work and education), so that targeted solutions can be developed.

VALUE SPACE: JOURNEY TIME

CHALLENGE 7: ENABLE FASTER JOURNEYS AND INCREASED CONFIDENCE IN ARRIVAL TIME.

Description

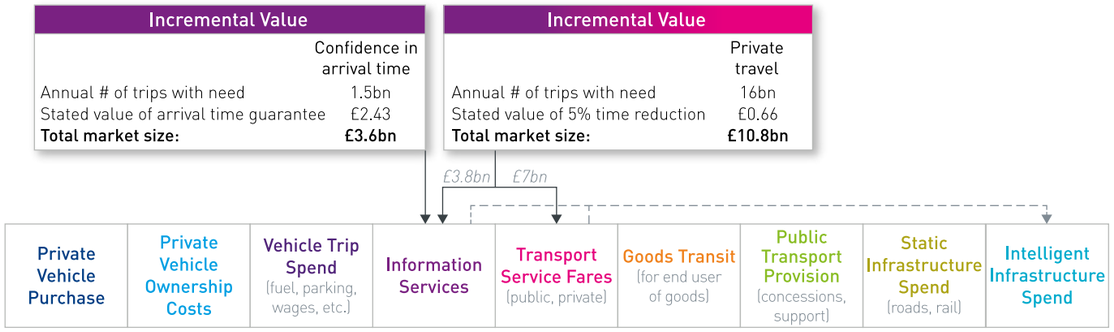
Minimising the time allocated for a journey is a key functional need for travellers in the UK. This can be approached on two levels: simply reducing the time journeys take or by minimising the contingency time allocated for journeys by improving confidence in arrival time.

Value Pools

84% of travellers state that they would be willing to pay for faster journeys. Intelligent Mobility can help reduce journey times through better traffic flows. Empirical studies show that the expected impact of Intelligent Mobility solutions is 2%-15% in terms of time savings [10]. This realistically implies that benefits would only be noticed by the traveller on journeys above 30 minutes or 18% of journeys made. Assuming a 5% time saving can be achieved, on average travellers state they would spend an additional £0.66 per journey. Most of this available Value Pool relates to journeys that are greater than one hour in length, with the equivalent per journey spend of £1.31.

The need for higher confidence in arrival time is expressed on 1.5bn journeys per year. On these journeys travellers state that they would be willing to pay £2.43 per journey for having a guarantee of not being delayed and knowing the precise arrival time before setting off. This Value Pool could be made available by being able to integrate and aggregate information sources in real-time to provide accurate and reliable arrival times.

Below: Journey Time – Value Pool (Source: CVA Analysis).



Implications

Improving system-level flows to decrease journey times can either be achieved by using Intelligent Mobility solutions to increase capacity at key bottlenecks or by shifting demand to less congested routes and times. There are a number of solutions that could prove fruitful in this endeavour (discussed in the 'Four Transformational Themes for Intelligent Mobility' chapter).

Providing confidence in arrival time can be achieved through providing accurate and predictive information. Making transport data readily available will enable the private sector to innovate and it will be necessary to share the right information that allows developers to make meaningful inferences (e.g. passenger loading compared to train capacity and differentiating between cars per minute compared to general vehicles per minute).

VALUE SPACE: PERSONALISED JOURNEY INFORMATION

CHALLENGE 8: CREATE RELEVANT, PERSONALISED AND CONTEXT-AWARE INFORMATION.

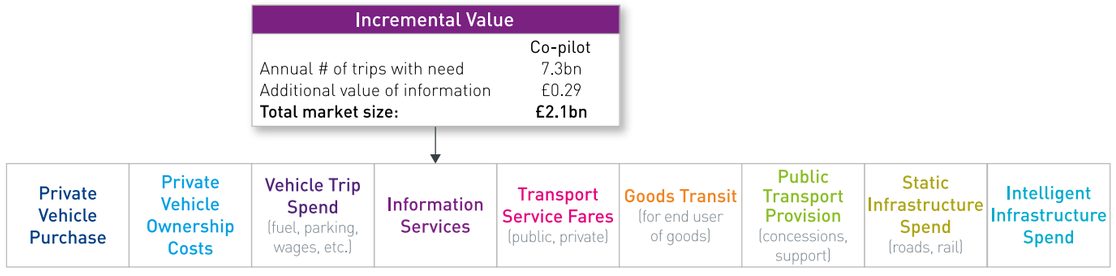
Description

Journeys are affected by situational factors such as familiarity with the journey, the level of time pressure, and responsibility for others. These are key factors affecting the journey experience. Intelligent Mobility can deliver an improved experience through relevant, personalised, and contextualised information. A 'virtual journey assistant' can be envisaged where personalised contextual information is proactively delivered to the traveller at key moments.

Value Pools

Travellers place an average value of £0.29 per journey on the negative experiences that could be alleviated with journey assistance. Whilst this may add up to an amount per traveller per month that suggests that subscription or premium mobility services may be feasible, it is questionable how many travellers will actually pay this amount in the future. Increasingly, such journey assistance experiences are being delivered through apps like Citymapper and Google Now on smartphones and through wearable technology. These apps are typically free to the traveller but with scale they have the opportunity to derive value in other ways, such as commission from selling transport fares or through providing analytics services of traffic flows or traveller choice behaviours. Value for new entrants is likely to come from data capture and information processing rather than delivery. This Value Pool is not quantified as part of this study, as there are many different business models in which transport data could be monetised – the value opportunity directly from the traveller, if obtainable, is shown instead.

Below: Personalisation – Value Pool (Source: CVA Analysis).



Implications

The ability for journey assistant solutions to support travellers depends on their ability to provide relevant data in a contextualised and proactive way. It is therefore critical to enable innovators in this space to access as much transport data as possible (i.e. open data) and to continue to generate increasingly granular data. Examples of next development steps include indoor location and navigation for travellers in train stations or underground stations, integration with the traveller's other applications (e.g. calendar, social media accounts, and preferences), and increasing levels of proactivity in helping travellers throughout their journey (e.g. re-routing depending on weather, congestion, and ticket booking).

VALUE SPACE: PARKING

CHALLENGE 9: SOLVE THE PARKING CHALLENGE.

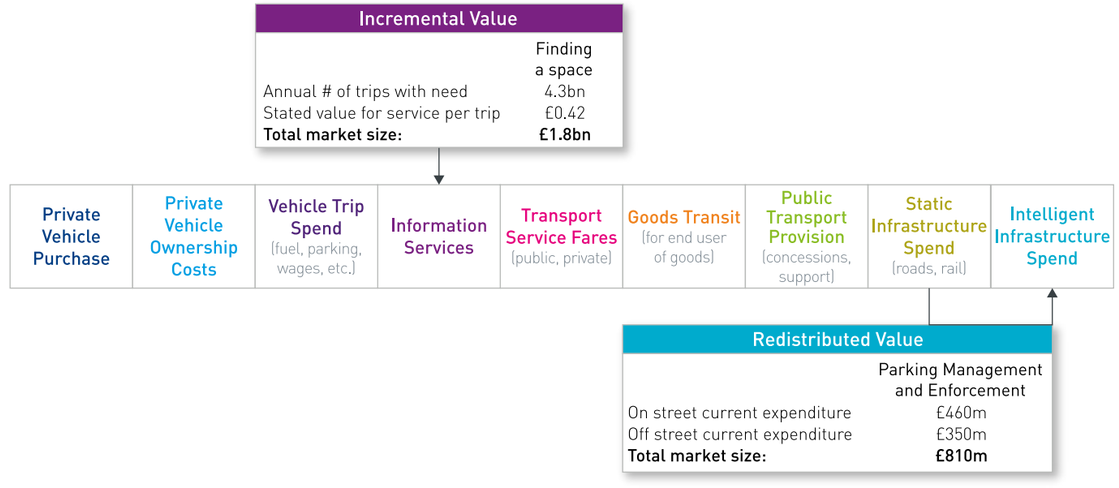
Description

On 12% of journeys in the UK, drivers find parking a significant pain-point (14% in cities and 19% in London), which cumulatively represent 4.3bn annual journeys. Other research in the UK has found that the average driver spends over 6.45 minutes searching for a parking space on each journey [11].

Value Pools

Drivers on these journeys would be willing to pay £0.42 per journey to be able to reserve a parking space and be guided to it. Two thirds of this value is from being able to guarantee the space and one third from the routing element. In the short-term this value can be directly realised by charging drivers for parking guidance and reservation. In the future, however, it is likely that travellers will come to expect routing to empty parking spaces to be free (e.g. as with road traffic data). In deploying smart parking solutions there are also opportunities to simplify enforcement and increase management efficiencies. The current spend in the UK on this is £810m, – constituting a potential Value Pool for players who can bring about efficiencies. Smart parking may also offer significant incremental value through increasing utilisation and multi-purpose use of existing paid bays when they are not in use (e.g. freeing up restricted bays). These additional opportunities have not been quantified here as they are highly dependent on the specific parking situation in the area and the level of space utilisation.

Below: Parking – Value Pool (Source: CVA Analysis).



Implications

To achieve traveller acceptance and tangible reduction in time spent searching for parking, a sufficiently high coverage of 'smart parking bays' would be required – particularly in areas of high demand (e.g. urban areas). There is a plethora of different technologies and applications available in this space, including road sensors, CCTV (image recognition), vehicle connectivity, and crowd-sourcing of information. These will vary significantly in terms of the capital and operating costs, but will also offer different levels of accuracy and adjacent benefits. It is likely that a blend of technologies will be used and integrated eventually. Local authorities should be encouraged to allow trials and experimentation with different systems to ensure that learnings are captured and shared.

Successful solutions will deliver seamless traveller experiences and desirable benefits, such as integrated payment. Space reservation is the most valued aspect and should be offered where possible. There is, however, a need to understand the impact this will have on achievable space utilisation and to measure how traveller parking behaviours change once the ability to reserve space becomes more widespread. Finally, integration with enforcement will ensure not only back-end cost savings but also a reliable user experience for travellers.

VALUE SPACE: SMOOTH DRIVES

CHALLENGE 10: ENABLE SMOOTHER DRIVES.

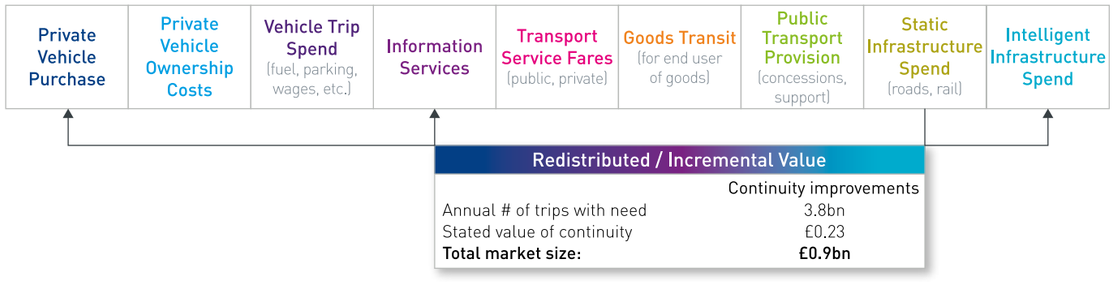
Description

The start-stop nature of journeys is another significant pain-point for drivers being held up by congestion or traffic signals. This affects 10% or 3.8bn journeys and is most prevalent in cities where 19% of journeys are affected.

Value Pools

On the 3.8bn journeys affected, travellers would value improvements in journey continuity at £0.23 per journey – amounting to a total Value Pool of £0.9bn per year. This Value Pool is not directly realisable at the moment because there is no mechanism for car drivers to pay such an amount and in return receive a smoother journey. The exception is through toll roads where an amount is charged for a less congested journey. Technical innovation may, however, be able to solve this by utilising autonomous drive technology and connectivity that enable smoother journeys through co-operative driving and vehicle platooning. The £0.9bn Value Pool could be seen as additional traveller spend for such features and there are further opportunities that could be monetised (e.g. dedicated lanes for vehicle platoons). Also, system-level developments are likely to be of benefit, such as improved traffic light phasing and actions to reduce congestion. There are also opportunities for the private sector to provide drivers and vehicles with relevant information (e.g. optimal speed to approach and awareness of delays). Both of these are, however, unlikely to result in a revenue stream for the traveller but would bring benefits to traffic in the UK as a whole.

Below: Smooth Drives – Value Pool (Source: CVA Analysis).



Implications

Research and Development should continue in autonomous drive, V2V and V2I communications – along with traveller information. Connected and autonomous vehicles are likely to bring significant traffic flow improvements and information-based solutions should be considered as part of future vehicle design – in order to safely and seamlessly provide information to the traveller. To deliver benefits across the UK, it is important that relevant standards are developed and that lessons learned concerning flow improvements are shared and disseminated.

VALUE SPACE: IMPROVED PUBLIC TRANSPORT EXPERIENCE

CHALLENGE 11: INCREASE USER EXPERIENCE AND PERCEIVED VALUE OF PUBLIC TRANSPORT.

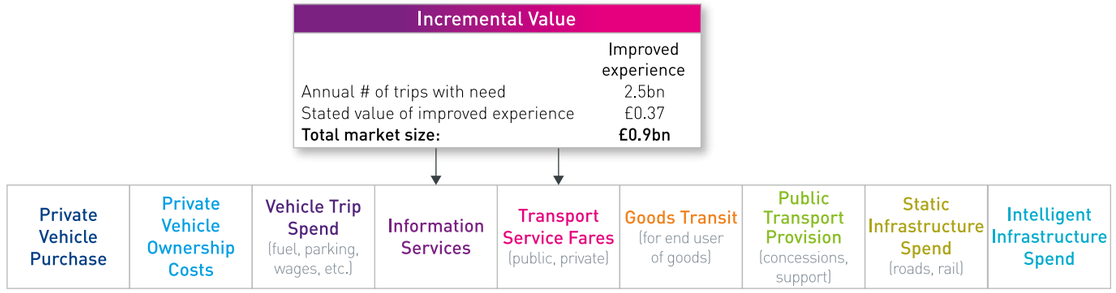
Description

2.5bn public transport journeys per year generate a number of pain-points including lack of personal space, lack of connectivity, and a perception of poor value for money (in particular on rail).

Value Pools

When given the choice between today's experience and a pain-point free journey, travellers put an average incremental value of £0.37 per journey on having a better experience. This incremental value rises to £1 for journeys that are more expensive and longer than one hour – representing a total Value Pool of £0.9bn and 4% of total traveller spend on public transport each year [12]. An approach to addressing the lack of personal space is to better dynamically manage demand and supply: with loading information, travellers would then be able to make value trade-offs using earlier or later services to avoid congestion. Going beyond this, supply can be managed to be more responsive to traveller demand through, for example, dynamic timetabling and routing of buses and potentially for public rail transport in the future. Better and more even utilisation of public transport assets would meet key traveller needs in terms of decreasing congestion and increasing personal space, but also allow for a more efficient use of the public transport network as a whole – helping to reduce operating costs and fares. If pain-points can be removed or mitigated without any increases into public transport fares the perceived value of public transport will increase significantly.

Below: Perceived Value – Value Pool (Source: CVA Analysis).



Implications

Increased availability of real-time data, including loading information, would be a catalysts for innovation in demand management. This can help to better distribute demand across the public transport network. Operator contracts and franchises should be used to ensure that this data is made available as Open Data and more granular data is generated using emerging technologies. The travel experience could be further enhanced by integrating ticketing to provide travellers with the flexibility of switching between operators and transport modes. Supply management innovations should also be encouraged, such as innovative train and bus interiors that allow more flexible space utilisation (e.g. modular activity-based environments), especially at peak times. Progress in these areas needs to be measured and confirmed, for example by including a focus on traveller value and experience alongside operational performance metrics.

VALUE SPACE: MULTI-MODAL JOURNEYS

CHALLENGE 12: IMPROVE AND ENABLE MULTI-MODAL JOURNEYS – REDUCING COMPLEXITY, ENHANCING CONNECTIVITY, AND IMPROVING SPEED AND RELIABILITY.

Description

Multi-modal travel represents a key opportunity to increase the efficiency of travel in the UK, which could include the 'first and last mile' of a journey being delivered by personal mode (e.g. car, bike and foot) and the long bulk of the journey being shared (e.g. buses, coaches, rail and shared rides). Multi-modal travel is, however, fundamentally more complex for the traveller and introduces a number of pain-points to alleviate. These include the perceived complexity of the journey, connectivity, and delays when travelling or interchanging.

Value Pools

Travellers on 700 million multi-modal journeys value removal of their pain-points at an average of £0.76 per journey, giving a total Value Pool of £0.5bn. Removing pain-points related to connectivity and delays would also impact other public transport journeys that are not multi-modal, which would provide an even bigger Value Pool of £1.3bn. As with previous Value Pools, it is unlikely that these can be realised directly by transport operators. Providers of information services and generators of necessary primary data should be able to access this value if they can provide solutions that genuinely improve multi-modal journeys.

There are 9bn journeys that are currently completed by car that might be possible to complete multi-modally instead. Traveller spend on these journeys is relatively low (£0.49) but amounts to £4.4bn, which could be redistributed to public transport operators. Travellers will have to pay more to give up their car for part of the journey and travel multi-modally in situations of heavy road congestion or very limited parking availability. As the UK's transport network becomes increasingly congested the need for multi-modal travel to assist travellers in avoiding bottlenecks might increase – increasing the size of this Value Pool.

Below: Multi-modal Journeys – Value Pool (Source: CVA Analysis).

Incremental Value	Multi-modal journeys	Public transport
Annual # of trips with need	0.7bn	1.6bn
Stated value of improved experience	£0.76	£0.85
Total market size:	**£0.5bn**	**£1.3bn**

Private Vehicle Purchase	Private Vehicle Ownership Costs	Vehicle Trip Spend (fuel, parking, wages, etc.)	Information Services	Transport Service Fares (public, private)	Goods Transit (for end user of goods)	Public Transport Provision (concessions, support)	Static Infrastructure Spend (roads, rail)	Intelligent Infrastructure Spend

Redistributed Value	New multi-modal
Annual # of trips with need	9bn
Equivalent spend per trip	£0.49
Total market size:	**£4.4bn**

Implications

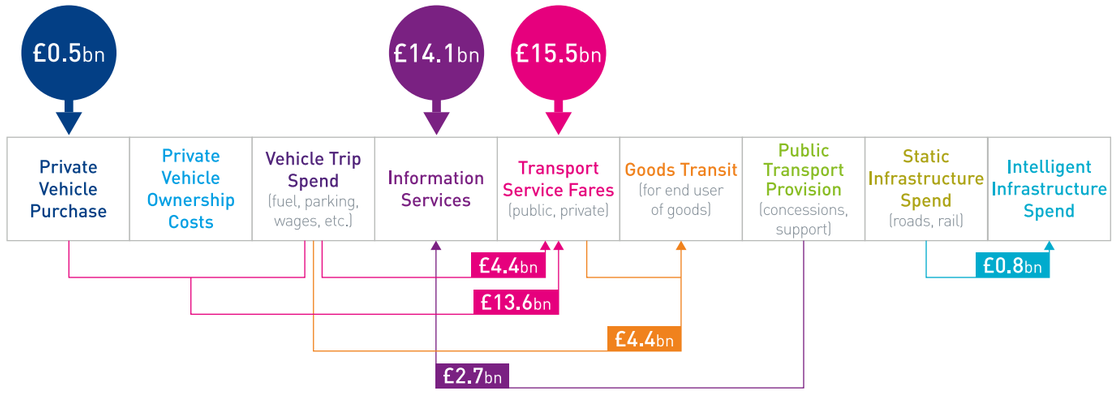
One of the main barriers in multi-modal travel is the fragmentation of multi-modal services in terms of ticketing and payment. There is a need to integrate systems across transport modes (e.g. ticketing, booking, and scheduling) but also to develop the business models underpinning integrated multi-modal journeys. How revenues get distributed between transport operators and service providers will be an important barrier to overcome if packaged end-to-end fares are charged to travellers. Immediate improvements in multi-modal journeys could be made through delivering relevant information before and during journeys. If interchanges can be made shorter, smoother, or more reliable there is also the opportunity to provide travellers with shorter end-to-end journeys for which they are willing to pay.

Summary of Value Spaces

EXPLORING THESE 10 IDENTIFIED VALUE SPACES FOR INTELLIGENT MOBILITY HAS THE POTENTIAL TO **UNLOCK A NUMBER OF VALUE POOLS** AND BRING ABOUT A **SIGNIFICANT SHIFT IN SPENDING** IN THE TRANSPORT SECTOR AS A WHOLE.

By defining and developing Intelligent Mobility solutions to meet these challenges within the Value Spaces a total Value Pool of £56bn (revenue opportunities) can be unlocked.

Below: £56bn of total Value Pool identified in value analysis (Source: CVA Analysis).



In particular, the following five areas of interest are worth noting:

Private Vehicles

Already, a large proportion of drivers do not value private car ownership and view it merely as a means to an end. This does not, however, exclude short- to medium-term opportunities to provide additional vehicle improvements (e.g. connectivity, autonomous driving and clean powertrain) – which would represent a £0.5bn annual source of value for e.g. automotive OEMs and their research, development and supply chain. This value is calculated on the annual value of autonomous feature sales to Default Motorists (taking into account the typical vehicle replacement rate) and does not include the value of selling autonomous features to other segments or the value of autonomous taxi services.

The shift in value from vehicle ownership to sharing and other vehicle based transport services (estimated long term potential 15% shift of revenue today) is also not necessarily a loss of value for the automotive sector. For instance, car sharing has been shown to have minimal impact on total vehicle miles (and actually an increase was observed in Germany)[13]. Given vehicle lifetime is strongly dependent on miles driven, there would be minimal decline in total vehicle sales.

However, the value shift prompts a number of critical actions for OEMs:

- Become the vehicle of choice for these new service solutions.
- Maintain the service, parts, and finance revenue from these vehicles.
- Understand their place in emerging intelligent mobility markets: new transport and information services.

New Transport Services

New transport services can range from standalone solutions (e.g. car sharing and dynamic bus services) to 'Mobility as a Service' mobility options that leverage multi-modal transport solutions. Although this represents a £33.5bn value opportunity in the UK and many solutions exist in this space there has been little uptake to date. To unlock this value there would need to be a step change in our understanding of both traveller behaviour and new business models. In the expected value chain for this market there will be significant value in key activities such as manufacturing and servicing vehicles, operations, insurance, data collection and analytics and user experience design. Data analytics will be a key enabler in this space and provide optimisation of demand and supply and enable better asset utilisation. This will result in cost reductions for travellers and hence data analytics is expected to command a significant share of the value available.

Information Services

Information services focus on the utilisation of data to deliver value to the traveller, influence traveller behaviours, and optimise transport systems. This data can come from transport services (e.g. bus, rail, and taxi), connected vehicles, transport planning services (e.g. on smartphones, sat-navs, and computers), and non-transport sources (e.g. social media and weather stations). This is emerging as a significant source of value in the UK transport sector with £14.1bn of incremental value and a further £2.7bn of redistributed value. To unlock this value, data collection, integration, processing, and visualisation will be key – along with the information infrastructure to deliver this. The uniqueness of the assets held (e.g. skills, IP, access to travellers, type of data) will govern the value distribution – along with the ability to deliver exceptional user experiences. As a whole, the value of data is expected to be significant, with data quality being a major driver as it provides the input for delivering meaningful information to travellers that is personalised and contextual. Beyond the direct value of this data, it can also help to deliver a better relationship with travellers.

Intelligent Infrastructure

Intelligent infrastructure connects and integrates existing physical infrastructure (e.g. traffic lights, road sensors, parking bays, and rail signals) with vehicles and travellers to optimise flows and utilisation – more effectively than investing in new traditional infrastructure. The major transport systems suppliers and smaller enterprises can help achieve this aim through systems and data integration. Demonstrating value of intelligent infrastructure, compared to traditional infrastructure investments, will be key and parties involved will need to work closely with local and central government to deliver convincing business cases.

Goods Transit

There is an opportunity for innovation in delivering goods to consumers. 27% of shopping trips currently being made would rather have been made 'virtually'. Improved offers will require a clear understanding of customer lifestyles and a focus on business model innovation to offer viable alternatives. Operational efficiency attained by this will help reduce costs by leveraging optimisation engines and information services to provide real-time system flexibility. Also, customers will benefit greatly from improvements in time, reliability, and efficiency made possible by Intelligent Mobility.

Opp: Exploring the future of Intelligent Mobility at the Transport Systems Catapult.

Four Transformational Themes for Intelligent Mobility

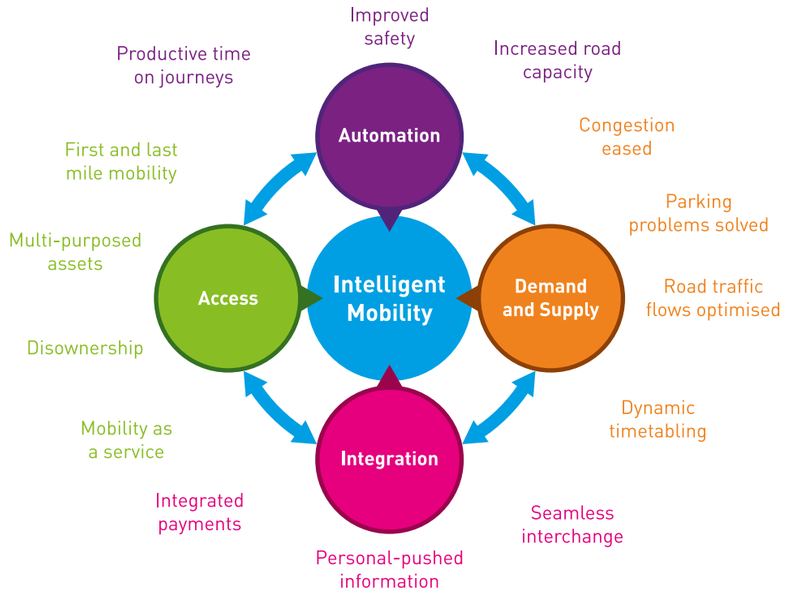
THE FUTURE TRAJECTORY OF INTELLIGENT MOBILITY FOCUSSES ON FOUR THEMES, WHICH IN COMBINATION HAVE THE **POTENTIAL TO TRANSFORM HOW WE TRAVEL**.

Across the framed challenges and identified Value Spaces for Intelligent Mobility a number of technologies, products and services have been highlighted (e.g. shared mobility solutions, autonomous driving features, and data-driven services). Whilst some of these are already market ready others are being developed and will enter the market in the coming years. This chapter explores Intelligent Mobility themes through to 2030.

Experience in other sectors shows that it is often the integration of many developments along with a superior customer experience and innovative new businesses models that lead to step change in customer benefit. As an example, in the telecommunications sector there had been many early innovative developments (e.g. WAP[8] in the late 1990s/early 2000s [14], touch screens as early as 1992 [15], push email from 1999 [16], and mobile applications from the late 1990s [17]) that incrementally brought value to consumers.

It was only, however, when hardware, software, content and services got integrated in the iPhone that Apple would revolutionise the way we engage with mobile communication and connectivity.

Analogously, Intelligent Mobility will require the integration of different technologies, products and services that will result in a step change in mobility. **Four concurrent Transformational Themes** have been explored in the study that explore development paths towards Intelligent Mobility: **Access**, **Demand and Supply**, **Integration** and **Automation** – as shown below. On their own, the long-term visions for each will revolutionise how we move people and goods, but they will exhibit even greater step change when they are combined.



Opp: Four Transformational Themes for Intelligent Mobility (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

Access Theme

Description

The Access theme includes many developments that extend the way travellers can use mobility products and services. This future is characterised by seamless user experiences, new business models, and access to mobility assets. Privately owned cars and traditional public transport are no longer the only mobility options available to travellers. New mobility services and innovations within existing mobility options are broadening their access to different types of mobility.

> THE MAJORITY OF DEVELOPMENTS IN THE ACCESS THEME ARE RELATED TO BUSINESS MODEL INNOVATIONS, RATHER THAN TECHNICAL INNOVATIONS.

They rely on existing or slightly modified vehicle types and smartphone connectivity to enable access to these mobility assets. A critical success factor is the user experience, making it quick and simple for travellers to access mobility, but also enabling a personalised and context-aware experience while moving.

The Access theme has the potential to deliver on many of the Value Spaces identified. In particular, **access to new and different mobility modes is critical in meeting the lifestyle challenges of the Progressive Metropolites, Default Motorists and Dependent Passengers**. Additionally, the Access theme can also be a key enabler and accelerate low emission vehicle uptake. With shared vehicle services, ownership and depreciation of the battery no longer needs to be a traveller concern and a more seamless integration with charging infrastructure is possible. Developments within the Access theme include:

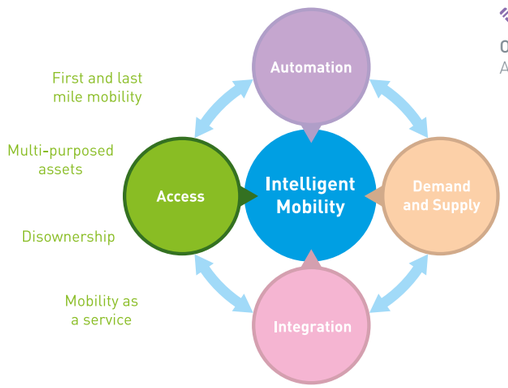
- Shared mobility assets (e.g. car and bike sharing schemes).
- Multi-purposing of assets (e.g. peer-to-peer car sharing or private-vehicle based freight delivery).
- 'Mobility as a Service', where end-to-end journeys are available to travellers at the touch of a button (e.g. taxi hailing apps and demand responsive buses).
- 'Democratisation' of mobility, customising and personalising elements of the mobility value chain (e.g. telematics insurance) to make them more affordable for specific traveller types.
- Virtual mobility, removing the need to travel altogether (e.g. video conferencing and goods delivery solutions).

Development Path

A continuous development path is expected in the short-term (2015-2020), refining the traveller experience, exploring different commercial offers, and focusing on broadening the appeal of these offers across different types of journey and use cases. Many solutions have already reached significant size in major cities, such as Uber, ZipCar, and Santander Bikes in London. To reduce costs and get high utilisation of vehicles, these players will have to grow their scale and in achieving this, it is likely that offers will be extended to user groups beyond the private traveller (e.g. commercial travel or delivery services). Other short-term developments are likely to include those focused on private vehicles, such as insurance telematics or peer-to-peer vehicle sharing.

In the medium term (2020-2025), new forms of access solutions are likely to emerge. The greatest opportunity is in dynamic shared transport (e.g. shared taxis and demand responsive buses), becoming widely available and accepted by the traveller. Additionally, there is likely to be further integration between transport modes and services, allowing the concept of 'Mobility as a Service' to be fully realised. Combinations of alternative transport modes and public transport are able to provide the equivalent convenience and flexibility of private car ownership.

In the long-term (2025-2030), a rapid introduction of autonomous shared mobility solutions is conceivable (e.g. combining Access and Automation themes), when business models and user experiences have been validated and optimised.



Opp: Access Theme.

Enablers

Whilst enabled more by business model innovations than by technology developments, mobility solutions in this area rely on connectivity. Providing ubiquitous connectivity (i.e. seamless and reliable coverage of mobile data) is therefore a fundamental enabler. Car and bike sharing have not yet enjoyed high uptake in the UK and it is likely that there are simply not enough use cases where using these types of services is convenient and cost-effective for travellers. It is important that local authorities are engaged and support new access schemes, by enabling on-street parking, considering the portion of the population that are not able to use smartphones, and potentially with further measures such as special lane access for shared vehicles. Cross-sector collaboration is also important, giving access to off-street parking for instance or placing shared vehicles at train stations. Multi-modal integration will be a further driver of increased uptake and the objective should be to encourage travellers to consider these new mobility options (either for full journeys or as part of a multi-modal journey). As such it is important that these are integrated both physically (e.g. interchanges) as well as digitally (e.g. journey planning apps). Opening up data and providing 'Application Program Interfaces' (APIs) are key to accelerate uptake (e.g. live vehicle availability). Reaching travellers beyond the urban segments, however, will be more difficult. Here, employer initiatives (e.g. cycle to work employee schemes) are likely to be more successful and shared mobility solutions based upon private car ownership (e.g. peer-to-peer car sharing or ride sharing) should be encouraged.

Demand and Supply Theme

Description

This theme encompasses developments that seek to balance demand and supply within transport systems more effectively.

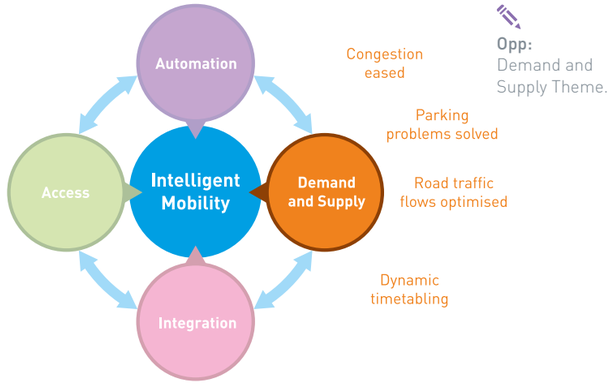
> GEO-SHIFTING DEMAND, TIME-SHIFTING DEMAND, AND DYNAMIC SUPPLY MANAGEMENT TO OPTIMISE ASSET UTILISATION.

This involves shifting flows to less congested routes, reducing peak demand, and reducing downtime of mobility assets with spare capacity. Currently, congestion is confined to specific routes and times of day – even on the London Underground, congestion is 'highly regular' and 'concentrated in rather short time periods' [18]. The goal should be to reduce these demand peaks that cause crowding of public transport, delayed drives, and other traveller pain-points. This would ensure that the existing mobility assets can be fully utilised where spare capacity is available.

Matching transport demand and supply can have a significant impact to transport systems, increasing flows, opening up capacity, and improving resilience – equivalent to the effect of physical infrastructure investments (e.g. road widening). The benefits of tackling congestion with Intelligent Mobility solutions, rather than traditional investments needs to be demonstrated on a case-by-case basis. The Demand and Supply theme will, equally, be a major contributor to the success of the Access theme, where the provision of access in a cost efficient way can fundamentally change the value proposition. Effective flow and capacity management will significantly contribute to the success and profitability of shared vehicle schemes and 'mobility on demand' services.

Development Path

For this development path a critical enabler will be to **understand traveller behaviour**. For example, in time-shifting demand it is important to understand how travellers will react to information and pricing, accounting for the traveller type, mobility lifestyle and mobility situation. Until autonomous mobility is available, geo-shifting demand to less congested routes will rely on various types of traveller information delivered for example through smartphones, in vehicle or electronic message signs to encourage travellers to take different routes. Predictive analytics (and prescriptive analytics in the long run) can provide a higher granularity to understanding traveller journeys and optimally match transport supply. With a fundamental traveller understanding opportunities will emerge for a range of Intelligent Mobility solutions that seek to act on both the demand and supply side. To manage the demand and supply balance across multiple modes a degree of transport systems development and integration is required first.



Opp: Demand and Supply Theme.

There are short-term (2015-2020) opportunities in better presenting transport information to travellers that effectively 'nudges' their behaviour. A key challenge is how to engage the traveller if only 12% make an active choice about their travel. Without reaching a significant number of travellers the benefits will centre on the individual. This could provide significant value for travellers that are more flexible in how and when they travel – being able to avoid congestion throughout their end-to-end journeys.

In the medium-term (2020-2025), transport systems are expected to become increasingly connected, including V2V and V2I communications. This will give a step change in the ability to dynamically manage demand and supply in real-time. With live information from vehicles (e.g. their destination, expected routing, and time to the next traffic light), traffic management systems will be in a much better position to manage flows. Further measures such as dynamic road pricing could be introduced and a direct feedback loop to the vehicle allows for much better traveller interaction and guidance.

In the long-term (2025-2030), this could culminate in city 'central flow' optimisation with every vehicle participating in the system. However, such a 'command and control' scenario is unlikely with a significant number of legacy vehicles still on the road and no requirement to participate. It is more likely that 'localised' optimisation algorithms are in place and that advanced measures such as dynamic lane allocation or flexible one-way systems are implemented. Furthermore, dynamic and predictive timetabling of public transport will enable significantly better supply management. This will not only address many traveller pain-points, but also boost the overall efficiency of the transport network – delivering cheaper journeys for travellers and more efficient public spending for government.

Enablers

The fundamental enabler of the Demand and Supply theme is the availability of **open, reliable, and highly granular data**. Transport systems will be able to manage travel flows significantly better if real-time data can be aggregated (e.g. congestion levels and incidents on road and rail). Currently unavailable data that would significantly enhance capabilities include data on the types of vehicle (e.g. differentiating between cars, taxis, buses and cyclists on the road), intended destinations, and live loading or capacity data of all public transport vehicles. This could be further enhanced by integrating predictive and prescriptive capabilities, but significant analytical capabilities will be required (both in terms of computational power as well as algorithm design and data visualisation).

> THERE IS SIGNIFICANT VALUE IN MAKING DATA OPEN TO ENCOURAGE THIRD PARTY DEVELOPERS TO CREATE INTELLIGENT JOURNEY SOLUTIONS.

There is significant value in not just using this data for centralised traffic control systems but also in making it open to encourage third party developers to create intelligent journey solutions. To ensure demand can be adequately managed (e.g. incentivising traveller behaviour) a good understanding of traveller psychology and behaviour is necessary. Understanding how travellers react to guidance or to dynamic pricing is important, as is the ability to predict behavioural changes when incidents occur in the transport network. There is both a role for academic research to understand the fundamentals but also to conduct business experiments to validate and refine their theories. Demand and Supply developments will radically change entire transport systems.

There is a requirement for more active engagement from local and central government to support developments in this area. This increased involvement should be leveraged as an effective means to collate and disseminate behavioural and psychological understanding. Also, a city or national approach to Demand and Supply could prove fruitful and, in doing so, would provide travellers with a consistent traveller experience. Finally, a step change in the effectiveness could be achieved in combination with autonomous mobility. A connected and autonomous vehicle will be able to better follow central guidance, adjust its speed in real-time to enable smoother flows, and provide better throughput of more vehicles on the road (e.g. platooning). With a fleet of autonomous taxis that are always on the move, parking infrastructure could be minimised and the right vehicle for the right traveller type and journey could be provided (e.g. smaller pods for individual travellers).

Opp:
The Demand and Supply of future mobility options will both have to be considered for Intelligent Mobility.

Integration Theme

Description

The Integration theme brings together disparate information, systems, and services to provide travellers with a seamless end-to-end experience within the transport network. This integration covers three key areas: information, ticketing, and interchanges. For the purposes of this report Integration refers to the integration between the different transport modes and operators that travellers may encounter on their journeys. Integration in the traffic management sense (e.g. flow control through V2I communications) is considered as part of the Demand and Supply and Automation themes.

> INTEGRATION FOCUSES ON IMPROVING THE EXPERIENCE OF END-TO-END JOURNEYS – REMOVING MULTI-MODAL PAIN-POINTS AND PROVIDING RELEVANT INFORMATION TO MAKE JOURNEYS BETTER.

Integrated information is relevant to all transport modes, which allows travellers to better plan their full journeys and make an increased number of informed transport modal choices – even adjust their journeys as they take place. A lack of integrated ticketing and booking across transport modes and geographies is currently a key barrier to multi-modal travel. Improving the interchange experience through enhanced indoor navigation or more dynamic platforming and timetabling will further encourage multi-modal journeys and remove key pain-points. However, integration is perhaps most valuable in combination with the previous themes discussed. For Access, it unlocks 'Mobility as a Service' where travellers can seamlessly travel across all transport modes without having to think about payments and ticketing. It also brings new transport modes for the first and last mile of travel – significantly broadening the appeal of multi-modal travel by making it convenient and flexible. For Demand and Supply, the integration of data sources is a key means to system-level optimisations but also provides the ability to engage with travellers on their journeys.

Development Path

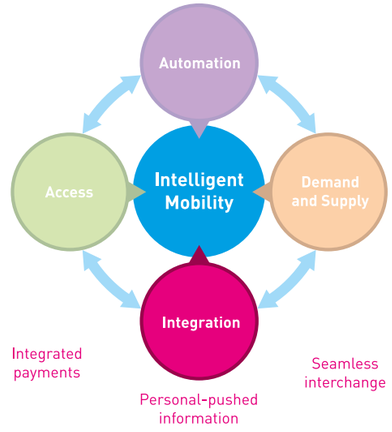
More and more information is already being integrated and there are several players who have taken great strides in providing integrated travel information – notably Google, Citymapper, ITO World, TransportAPI, and TrapezeGroup in the UK. This has been enabled by open data initiatives such as TfL in London, through purchasing of commercial data, and through integration of non-traditional transport data sources (e.g. smartphone data). There will be continued evolution in the coverage and quality of traveller information across all transport modes, including integration of information beyond transport such as restaurant or theatre bookings.

How this data is presented and interacted with by the traveller will also continue to evolve with expected next steps being the proactive, dynamic, and context-aware presentation of information across devices – including wearable technologies such as smart watches.

> DEVELOPING INTEGRATED TICKETING IS AS MUCH A COMMERCIAL CHALLENGE AS A TECHNICAL ONE.

Different ticketing systems need to be integrated, including those of new transport service providers such as car or bike sharing schemes and app-based taxi services. Whilst the Oyster and contactless system in London is world-leading in ticketing systems, this could be extended towards nation-wide multi-modal travel if commercial arrangements can be made to integrate all possible transport providers. In the short-term it is likely that third party providers currently focusing on end-to-end traveller information will attempt to integrate ticketing and act as an intermediary. In the medium-term, standardised end-to-end ticketing could be achieved, with a long-term vision of a full ticketing system for mobile devices that does not require physical payment and optimises costs for the traveller.

Developments in physical interchange are highly situational and continuous development is expected in the short- and medium-term. Step change can be achieved once dynamic timetabling and routing is common place in public transport.



Opp:
Integration Theme.

Enablers

In the short-term, connectivity becomes a fundamental enabler to provide reliable delivery of information to travellers at important stages in their journeys. This connectivity needs to be able to provide seamless coverage (both on and off the transport network) and have sufficient speed to deliver the information. The availability of transport data will be pivotal and open data has proven to be an effective means. Whilst TfL is seen as the leader in this space there are a large number of transport operators across the country who do not yet provide adequate live data and APIs to access their data. Collaboration between players, such as transport operators, vehicle manufacturers, and traveller information providers would help to establish workable standards and ensure that learnings are appropriately disseminated to stakeholders.

Facilitating end-to-end ticketing and pricing is a significant technical, commercial, and political challenge that spans multiple stakeholders. There will be a need for government interventions to help overcome this, both to define the national approach and to stimulate change throughout the sector. It is key to establish a mechanism that allows fair distribution of revenues between operators on a multi-modal journey. To measure the success of continued integration multi-modal key performance indicators (KPIs) measuring the end-to-end journey experience need to be established. This will provide a better understanding of which elements of a multi-modal journey need to be prioritised for improvements and how lack of integration impacts travellers.

Automation Theme

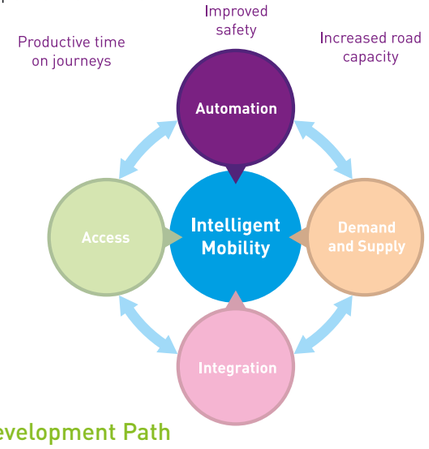
Description

This theme is the most dependent on technology and the types of autonomous functions on the horizon range from increasingly sophisticated driver assist features to fully autonomous drive.

Drivers who use autonomous features could benefit from reduced fatigue, additional productive time, and specific use case benefits such as automated valet parking – not to mention the increased safety of autonomous drive technology. A shift in operating costs (e.g. driver salaries, insurance) is conceivable as well for transport service operators (e.g. taxis) if they adopt fully autonomous vehicles. When sufficient penetration is reached, there is a significant opportunity to boost overall transport efficiency (with autonomous V2V and V2I communications), which would deliver faster flows and greater capacity (e.g. through vehicle platooning).

> AUTOMATION ON ITS OWN ONLY BRINGS LIMITED TRAVELLER AND TRANSPORT SYSTEMS BENEFITS.

Combining Automation with Access (assuming connectivity) will bring a step change in benefits. When travellers can rely on shared autonomous transport to provide their end-to-end mobility needs, there will be a declining demand for private vehicle ownership – providing a change to the automotive industry.



Opp: Automation Theme.

Development Path

Full technology readiness for autonomous driving is difficult to predict but it is likely that in the short-term (2015-2020) there will be incremental developments in driver assist features and use-case specific applications of autonomy (e.g. motorway platooning). In the medium-term (2020-2025) it is expected that the first consumer-ready autonomous vehicles could be launched. Automotive OEMs are developing increasingly sophisticated driver assist systems that will eventually lead first to partial and then full autonomy. At the same time digital players (e.g. Google, Apple, and Uber) are aiming to leap-frog many of the initial stages of Automation development by focusing on fully autonomous vehicles first. Much of the required underlying technology is principally ready but it is the real-life testing and validation that is needed (e.g. autonomous vehicles building experience in how to deal with real road situations). With increasing consumer acceptance and technical sophistication, it is expected that autonomous services will emerge in the long-term (2025-2030). Looking beyond 2030, as autonomous vehicles become sufficiently common, system-level optimisation will emerge and make travel smoother and quicker for all.

Enablers

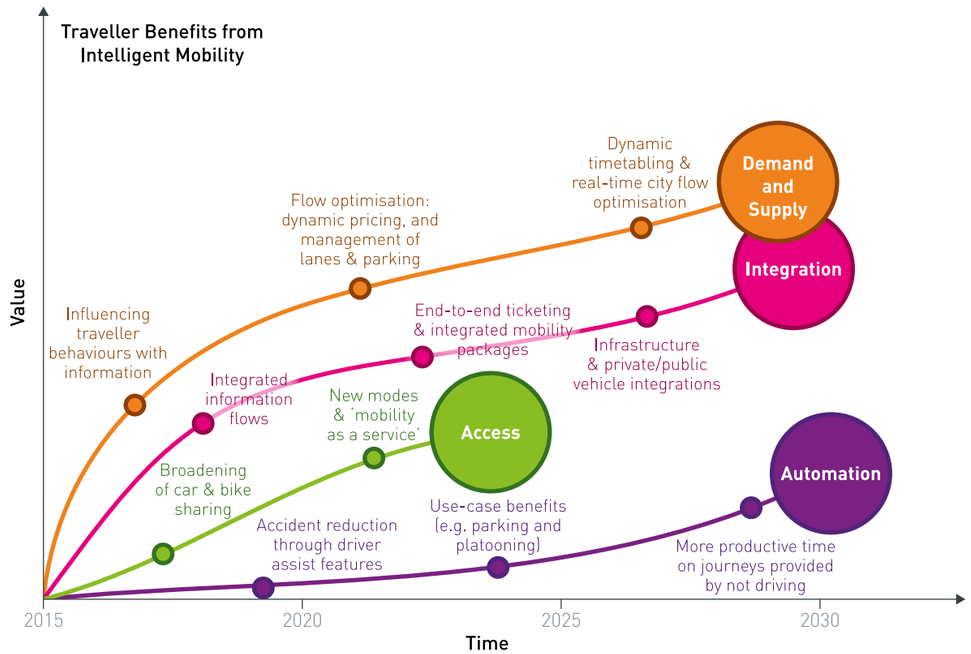
Key to successfully bring autonomous cars to market readiness is validation and real-life learning. The underlying technology is largely ready and only requires cost reduction through scale production. **Significant progress needs to be made, however, with on-road testing to understand vehicle behaviour in different conditions** (e.g. road types, traffic situations, and weather) and how people interact with different levels of autonomous vehicles. The USA is ahead in this area with Google's driverless cars having driven over a million miles already [19].

It is critical that similar activities are supported in the UK. **To accelerate the market readiness of autonomous cars legislative and insurance barriers regarding accident liability need to be fully resolved**. Physiological issues around motion sickness will need to be fully understood as well. Finally, the UK has an opportunity to accelerate adoption and benefits delivered from Automation (e.g. by mandating minimum automation standards and connectivity levels).

Combining the Four Transformational Themes

The expected development paths of the four themes will all help to realise some level of traveller benefits. The Demand and Supply theme, however, is expected to offer the greatest potential benefits in meeting traveller needs from now until the considered 2030 time horizon for this study. The reason for this is because the theme is expected to address system-level benefits at scale across all transport modes, whereas the other themes will only deliver benefits to a portion of the Intelligent Mobility market. Whilst each of the themes delivers traveller benefits, when they are combined a much greater impact is attainable. There are a number of key synergies between the themes that can deliver a step change in end-to-end journey and traveller experience.

Integration can play an important part in broadening the ability for the Demand and Supply theme, as traveller flows and capacity across modes can be more efficiently matched. In the long-term (2030 and beyond) there will also be large synergies with the Automation theme when autonomous vehicles reach a significant scale in the UK – providing an opportunity to optimise the flows of these vehicles when they are fully autonomous. When combined with the Access theme, Integration enables the traveller to make use of 'Mobility as a Service' – the seamless access to different mobility options for travellers. This will make alternative transport modes an increasingly viable option for travellers and allow them to forego private vehicle ownership completely.



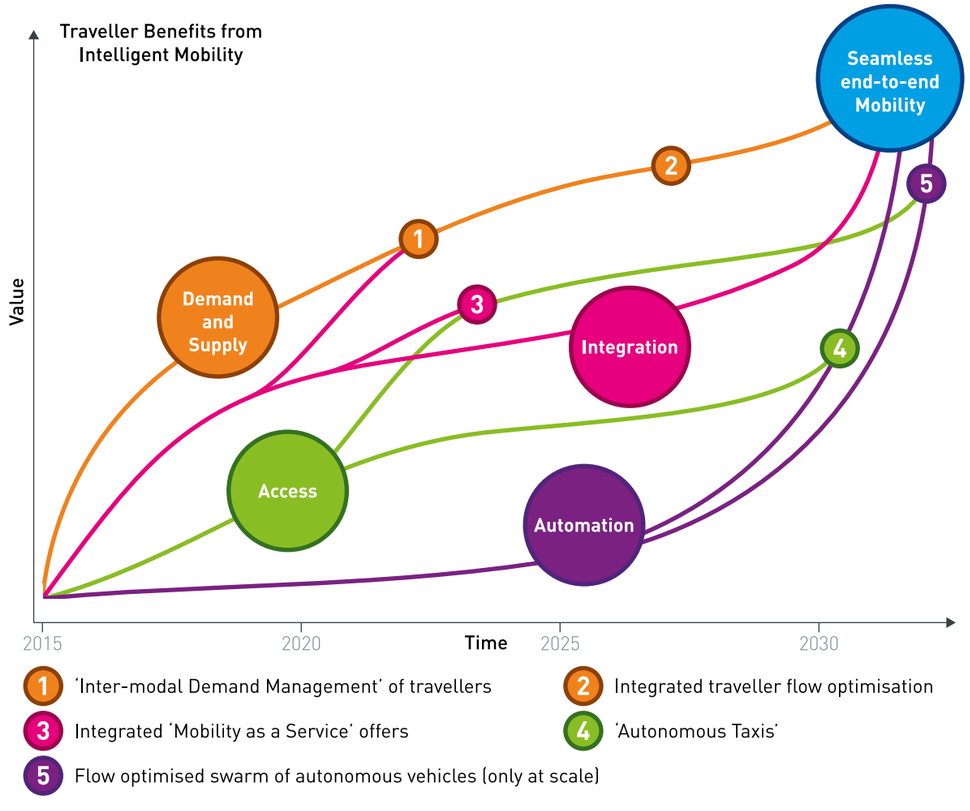
Opp: Four Transformational Themes (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

The combination of the Access and Automation themes will enable 'Autonomous Taxis' – leading to dramatic cost reduction by eliminating the labour cost associated with the driver and reducing insurance costs. This would bring significant value to all travellers as they are freed from the pain-points and costs associated with private car ownership.

> WHEN ALL FOUR TRANSFORMATIONAL THEMES ARE COMBINED A STEP-CHANGE CAN BE ACHIEVED FOR TRAVELLERS IN THE UK BEYOND 2030.

When all four themes are combined beyond 2030 a step change would be achieved for travellers in the UK. Such a future would conceivably include multi-modally integrated, flow-optimised, zero emissions fleets of driverless vehicles. Travellers would be able to seamlessly move between transport modes, utilising cost-effective public transport with individual first and last mile autonomous taxi solutions. Such a future would deliver significant value to the traveller, optimise capacity, improve safety, and lower emissions across UK transport systems. Whilst this future is unlikely to be fully realised by 2030, the development paths towards this vision create a significant opportunity for improving the end-to-end journey of travellers and improve the UK transport systems more generally.

Across the four themes there are individual short-term enablers that warrant attention to help accelerate their development paths. In the medium-term, however, there is a need for Intelligent Mobility (by means of combining the themes) to become a cornerstone of transport policy. Continuous innovation and structured learning will be important especially in three Core Combinations (Mobility as a Service', 'Inter-modal Demand Management', and 'Autonomous Taxis'), which will ensure that new developments reach investment, market, and business readiness quicker and meet traveller needs.



Opp: Combined Transformational Themes (Source: Expert Panel Workshop, Expert Interviews, and CVA Analysis).

Capabilities for Intelligent Mobility

THE FOUR TRANSFORMATIONAL THEMES FOR INTELLIGENT MOBILITY WILL REQUIRE **A NUMBER OF KEY CAPABILITIES TO BE TARGETED AND DEVELOPED**.

In the study, several capabilities have been identified that act as fundamental enablers for Intelligent Mobility. Here these capabilities are explored and prioritised for development in the UK. The following table represents a summary of each capability as well as examples.

Capability	Description	Examples
DATA COLLECTION, STORAGE AND MANIPULATION		
Sensing Capability	Sensing capability across environmental, count and classification (e.g. vehicles and people), to detection, tracking and vision.	• Laser-based sensors • Radar • Infrared • Ultrasound • Weather and emissions sensors
Localisation & Mapping	Technologies enabling an understanding of the local environment (e.g. 'where you are and what is around you').	• Satellite Imaging and Earth Observation • GNSS[9] • Integrated positioning • SLAM[10] • High resolution local mapping • Computer vision
Data Privacy & Security	Secure flow of data (data security) as well as the safe storage of data (data protection).	• Encryption techniques • Data anonymisation and protection techniques • Cyber security measures
Information Processing	Processing and storage of information. Usually involves the processing of large volumes of data.	• Data centre and storage • CPU[11] technologies • Cloud computing • Data compression • Quantum computing
VEHICLE EFFICIENCY		
Low Emissions Propulsion	Low emission propulsion systems and associated technologies.	• FCEV[12] • BEV[13] • PHEV[14] • ICE[15] • Unconventional / Other
Material Science	Set of technologies involved in the creation and development of new materials.	• Lightweight materials • Multifunctional Materials (e.g. conductive and negative emissions) • Nanotechnology
Manufacturing Techniques	Advancements in manufacturing technology and processes (e.g. rapid prototyping).	• Additive Manufacturing and 3D Printing • Advanced robotics (e.g. collaborative robotics) • Platform modularisation involving design technique

Opp: Capabilities for Intelligent Mobility (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

Capability	Description	Examples
DATA UTILISATION		
Real-time Control	Technologies and processes that enable real-time intelligent control of vehicles or systems.	• Complex event processing • Decision-making algorithms • Motion stabilisation
Navigation & Path Planning	Systems and processes enabling routing, path planning, image processing and analysis and obstacle detection.	• Path planning algorithms • Image processing and analysis • Obstacle detection and avoidance
Analytics & Simulation	Systems, algorithms and processes ranging from the handling and analysis of big data, predictive and prescriptive analytics, and machine learning.	• Big data • Predictive modelling • AI[16]
Data Visualisation	Ways of structuring and displaying large amounts of data or information in a consumable and meaningful way that can be used to inform stakeholders, decision makers, operators or the traveller.	• Visual perception understanding • Image generation and rendering
TRAVELLER INTERACTION		
HMI & Interaction Design	Technology, techniques and design methods that enhance the driver/passenger experience, enables better driver/passenger information and can help to influence traveller behaviour.	• Voice and gesture recognition • Augmented reality • Eye tracking • Human condition monitoring • Information and entertainment displays • Computer brain interfaces • Human-Centred Interactive Systems Design
Traveller Behaviour & Psychology	Techniques, methods and technologies used to improve the understanding of traveller decision making processes and behaviour.	• Crowd behaviour modelling • Choice modelling • Price elasticity modelling • Heuristics, selection and decision-making models
INFRASTRUCTURE ENABLERS		
Energy Storage & Distribution	Technologies and methods that enable efficient storage, distribution or recovery of energy.	• Battery chemistry • Hydrogen storage and distribution • Charging (e.g. fast charging and inductive charging) • Energy recovery • Smart grid
Connectivity & Networks	Ability to connect different systems, travellers, goods, infrastructure with the goal of establishing 'ubiquitous connectivity'.	• Cellular systems (e.g. 3G, 4G, and 5G) • Satellite connectivity • WiMAX[17] Systems • NFC[18] • Fibre optic • Mesh networks • SDN[19] (e.g. Radio and Network) • Television white-space • Standards and communication protocols (e.g. V2I, V2V, and V2X)

Capability Assessment

To establish a prioritisation amongst the capabilities for development in the UK, two dimensions were considered:

1. **Importance for Intelligent Mobility**: expected ability to enable Intelligent Mobility developments both in terms of bringing new solutions to market as well as realising value.
2. **UK Competitive Positioning of Capability**: an assessment of UK strengths compared to other countries, including potential for future development in the UK.

Bringing these two dimensions together creates a Capability Priority Matrix for Intelligent Mobility. Core Capabilities are those that provide substantial benefits to delivering Intelligent Mobility where the UK is comparatively strongly positioned. Whilst all the capabilities shown in the table below are relevant to Intelligent Mobility, some are more important than others in the context of the four Transformational Themes. As an example, Real-time Control is very important for enabling autonomous driving but is much less important to enable new forms of car sharing services or integrated ticketing.

Below: Capability Assessment (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

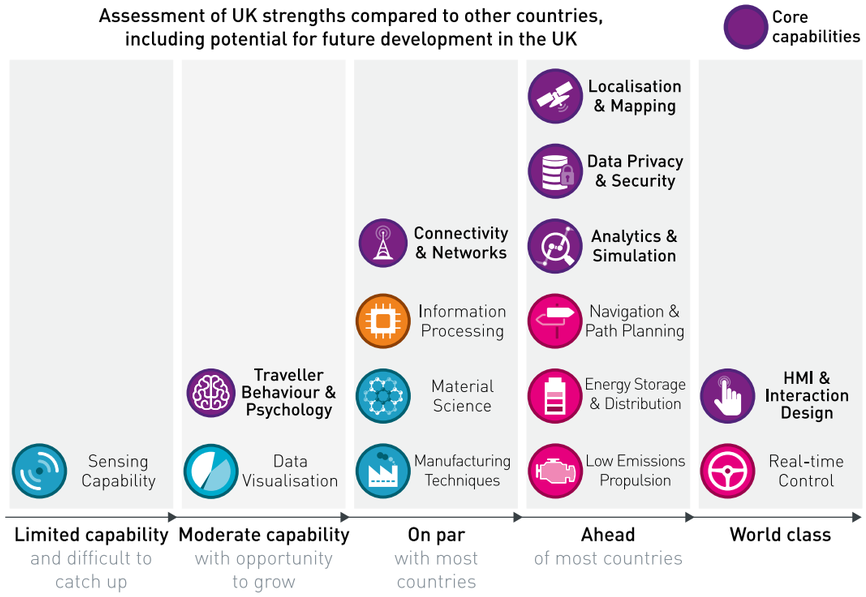
	Access	Automation	Integration	Demand & Supply	
Connectivity & Networks	High	High	High	High	• Connectivity is a key enabler to all revolutions as most Intelligent Mobility functions require some form of basic connectivity.
HMI & Interaction Design	High	High	High	High	• High quality HMI & Interaction Design is crucial for all themes.
Traveller Behaviour & Psychology	High	Medium	High	High	• Understanding traveller behaviour is crucial to better manage Demand & Supply, provide better access and integrate different transport modes (Integration). It also requires a good understanding of how drivers interact with Automation.
Localisation & Mapping	Medium	High	Medium	High	• Localisation & Mapping is particularly important to enable the Automation theme as well as better management of Demand & Supply.
Data Privacy & Security	Medium	High	Medium	Medium	• Although most themes could be enabled by a basic level of functionality, Data Privacy & Security are often crucial to build the required level of traveller trust and ensure system security – in particular for the Automation theme.
Analytics & Simulation	Medium	Medium	Medium	High	• Analytics & Simulation is the backbone behind many Intelligent Mobility functions and therefore is important throughout most themes – in particular for the Demand & Supply theme.
Information Processing	Low	High	Medium	Medium	• Information processing operates in the background of most revolutions. • Most likely it would be most heavily relied upon for automation as well as to a lesser extent for integration (for functions such as dynamic timetabling) and supply demand management (i.e. traffic flow optimisation).
Sensing Capabilities	Low	High	Low	Medium	• Sensing Capabilities are key enablers of the Automation theme but it can also improve the Demand & Supply theme through better counting and classifying vehicles.
Data Visualisation	Low	Low	Medium	Medium	• Data Visualisation is not key to enable any of the themes but is often a valuable addition.
Real-time Control		High		Low	• Real-time Control is mostly needed to improve autonomous vehicles.
Navigation & Path Planning		Medium		Low	• Navigation & Path Planning is predominately required for autonomous vehicles.
Material Science	Low	Low			• Material Science provides advanced materials that enable the Access theme and improved vehicle builds.
Manufacturing Techniques	Low	Low			• Advanced Manufacturing Techniques provide improved manufacturing for new types of vehicle.
Energy Storage & Distribution		Low		Low	• Energy Distribution & Storage is not an essential enabler of Intelligent Mobility.
Low Emissions Propulsion		Low		Low	• Low Emissions Propulsion is not an essential enabler of Intelligent Mobility.

The ranking in the previous table shows how important Connectivity & Networks is to deliver Intelligent Mobility, which reflects that a basic level of connectivity is a fundamental underpinning to most Intelligent Mobility applications (ubiquitous more so than speed of). Most applications of Intelligent Mobility also contain some form of HMI & Interaction Design and Traveller Behaviour & Psychology to be successful. At the other end of the spectrum, Energy Storage & Distribution as well as Low Emissions Propulsion capabilities were assessed as being less central to enable most Intelligent Mobility functions. Indeed, very few Intelligent Mobility applications require these capabilities. Few Intelligent Mobility applications for example require a clean powertrain or sufficient coverage of charging points as fundamental enablers (e.g. autonomous vehicles can be run on conventional powertrains). It is important to stress that this ranking is not a reflection of the overall potential market size for these capabilities (current or future) but merely a ranking based on the importance of a particular capability as an enabler for Intelligent Mobility. It equally does not negate the important contributions that both of these capabilities are likely to make to reduce overall emissions.

UK Competitive Positioning

The assessment of the UK's competitive positioning is based on qualitative information provided during 100 Expert Interviews with senior stakeholders in areas related to Intelligent Mobility.

The results were then further validated through Expert Panel workshops and reviewed by the study's Industry Review Group and Project Steering Board. This section outlines the rationale behind the ranking for each capability.



Opp: Assessment of UK strengths compared to other countries, including potential for future development in the UK (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

'World Class'

HMI & Interaction Design

The UK's leading position is represented by a mature UK design industry and the 'Silicon Roundabout' in London continues to grow along with world leading expertise in app and high-tech solutions. The UK as a whole benefits from great diversity. Static and non-static information displays is an area where the UK has traditionally also excelled in with the information displays during the London 2012 Olympics being frequently cited by experts. Other examples include some of the UK's success in app design with transport apps such as Citymapper, Hailo, and Kabbee. Whilst the UK is positioned on a world class level, strong contenders exist in some of the Nordic countries as well as the USA.

Real-time Control

The UK is at the forefront of Real-time Control research through Oxford University and many other universities. The UK is positioning itself as a leader in this capability through autonomous vehicle trials such as the 'UK Autodrive' project but the USA, Sweden and Germany are also contenders for a top position in this field (e.g. DARPA Robotics Challenge, Google Car, Volvo Drive Me, and Audi RS7). The UK focus has generally been towards autonomous vehicle navigation without dependence on communicating with the environment (e.g. V2I).

'Ahead of Most Countries'

Analytics & Simulation

The UK has a clear strength in the analytics involved in Urban Traffic Control. The London SCOOT system is widely regarded as leading system and was frequently cited by the experts interviewed in this study. The UK is equally well regarded for the scientific analysis involved in UTC and train/air/marine systems. The UK also has a significant capability in machine learning at University level, although much research and innovation is being carried out by large multinationals with mostly a US focus (Microsoft, IBM, and Google).

Localisation & Mapping

In the mapping space the UK is strongly positioned with a world leading mapping institution (Ordnance Survey). In addition to static mapping, the UK is strongly positioned in academia with world class research being conducted at several universities on simultaneous localisation and mapping (SLAM).

Navigation & Path Planning

Many of the future and current GNSS location-based services will be driven by international initiatives, such as the European Galileo project. The UK has key strengths in path planning on a research and academic level.

Energy Storage & Distribution

Several UK universities are undertaking world class battery chemistry research, though the expertise around battery assembly, integration and manufacturing is largely concentrated in Asia-Pacific (e.g. Korea and China).

Low Emissions Propulsion

The UK leads Europe in the design and manufacture of advanced powertrains, with the UK being the second biggest producer of ICEs in Europe (2.5 million per year). The UK is also continuously acquiring skills in BEV and PHEV, in addition to the UK's strong legacy in low emissions ICE. Other countries such as Germany and Japan were cited as being equally advanced if not slightly ahead with hybrid and electric vehicle powertrains.

Data Privacy & Security

The UK has key strengths in cyber security but, due to national security and defence, these capabilities are often less publicised. The UK's Academic Centres of Excellence in Cyber Security Research (ACE-CSRs) are driving continuous further development. Whilst there are key data privacy and security skills in the UK outside of transport, V2V communications security is less well developed.

'On Par with Most Countries'

Information Processing

The UK does have some strengths in this capability with a large number of semi-conductor businesses in the UK, most notably ARM. However, a large proportion of these businesses are under foreign ownership. The UK is conducting advanced research in this field at many universities but in the private sector most players are global with a USA focus (e.g. Intel) – which prevents the UK from being ahead of most countries in this space.

Material Science

The UK is at the forefront of research in many advanced materials, in particular lightweight materials (e.g. aluminium, magnesium, polymeric composites, nanotechnology, and graphene).

Several expert interviews noted, however, that the UK is lacking behind in the commercialisation of the research and supply chains must be established to support this endeavour (e.g. as for carbon where demand from aerospace and Formula 1 has supported steady growth).

Manufacturing Techniques

Whilst the UK was cited as having a leading position in fundamental technology research (TRL[20] 1-3) it is seen as weaker in the latter stages of technology development (TRL 4-7). Additive Manufacturing and 3D printing capabilities were described as broadly on par with other countries such as China and the USA. Formula 1 and its low volume and high quality SME[21] manufacturing industry was mentioned as a great example of the UK excelling in a highly technical niche of the manufacturing space.

Connectivity & Networks

Although the UK was seen as conducting leading research and development in this space (e.g. 5G Innovation Centre in Surrey) similar basic research is being conducted in Japan, Korea and China – along with other European countries. The UK was seen as behind most countries when it came to the commercialisation of new telecommunications and networking technologies, as most of the valuable IP in this area is owned and created by large telecommunications equipment providers abroad (e.g. Nokia, Ericsson, and Huawei).

'Moderate Capability with Opportunity to Grow'

Data Visualisation

Although SMEs (e.g. ITO World) and academia (e.g. University College London's CASA[22]) in the UK have key capabilities, the UK as a whole was seen to be not quite on par with other countries. The UK has potential to catch up in this field, especially when leveraging its strong capability in HMI & Interaction Design.

Traveller Behaviour & Psychology

The experts see the UK as having some expertise and noteworthy research (e.g. the Behavioural Insights Team, Nottingham University's HFRG[23], and University of Leeds's CMC[24]) but as being somewhat behind other countries leading in this field – in particular some of the Nordic countries such as Sweden and Finland.

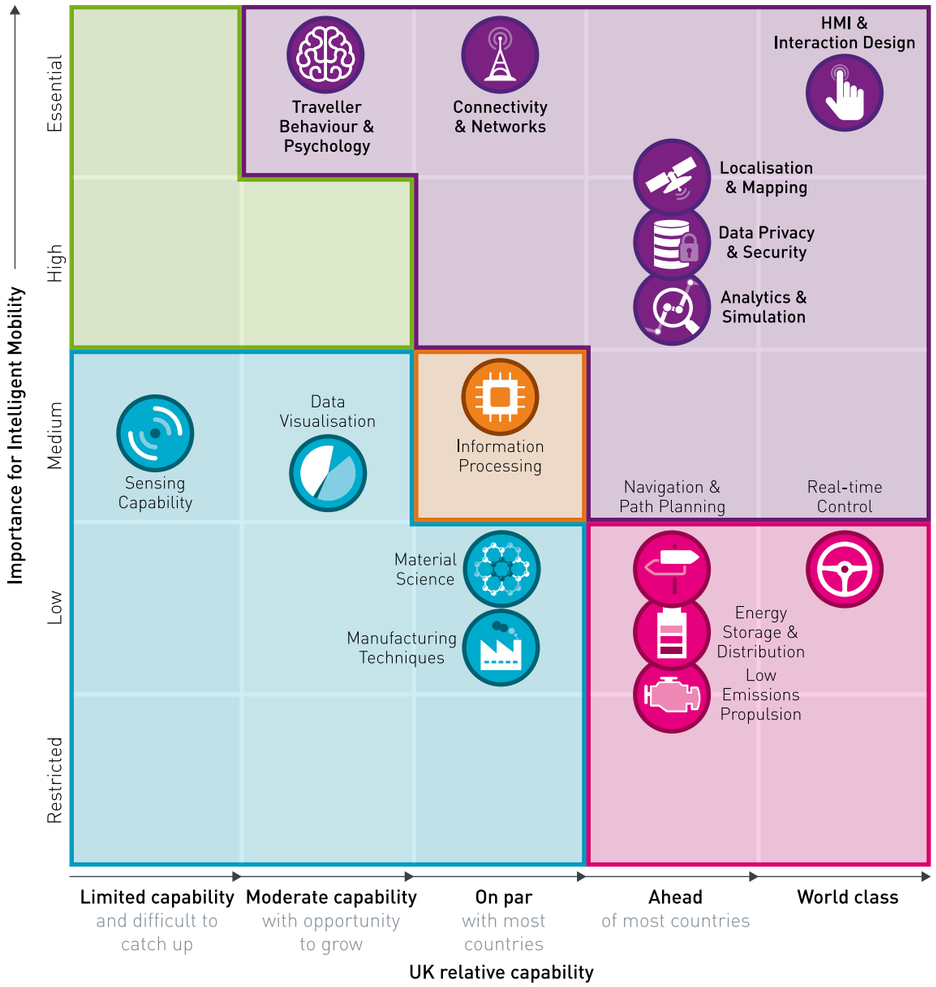
'Limited Capability with Difficulty to Catch up'

Sensing Capability

Although the UK is comparatively academically strong, particularly in vision-based sensors, the UK has not developed a strong 'tier one' capability that can deliver the scale required for the automotive and transportation sectors. UK universities also face tough competition from other universities in Europe and elsewhere. A centre of excellence for sensor technology has so far not emerged and the UK faces competition on the commercial side from 'tier one' automotive suppliers from abroad. Improvements in the manufacturing process and production of larger volumes will increasingly commoditise the sensor market and drive down prices.

Capability Priority Matrix

The Capability Priority Matrix is a useful graphical tool for presenting the relative benefits capabilities provide to delivering Intelligent Mobility value.



Opp: Capability Priority Matrix (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

High benefit capabilities are in the top right of the Capability Priority Matrix, where the capabilities will potentially have a high impact and the UK shows competitive strengths. The value of the Capability Priority Matrix lies in focusing the discussion on where the UK should target its efforts to drive global leadership in Intelligent Mobility. It also provides a snapshot of key investment areas for the UK that can most effectively further Intelligent Mobility developments. In particular, it is a useful framework for making explicit judgments about the potential benefits of capabilities and their functions and applications – with the ability to benchmark against other capabilities and countries. The vertical axis looks at the potential benefit of the capability to Intelligent Mobility, rated as either essential, high, medium, low, or restricted. The horizontal axis groups capabilities in accordance with the UK's competitive strength.

A cluster of six Core Capabilities emerged as priority development areas. With four of these the UK was assessed as being at least ahead of other countries in their development (HMI & Interaction Design, Localisation & Mapping, Data Privacy & Protection, and Analytics & Simulation). The UK was judged to be on par with other countries and having moderate capability with opportunity to grow with the two remaining Core Capabilities (Connectivity & Networking and Traveller Behaviour & Psychology). Because these two are critical enablers of Intelligent Mobility (and many other sectors of the economy) they were considered priority development areas as well. In fact, developing expertise and experience in Traveller Behaviour & Psychology will be a key competitive advantage in delivering Intelligent Mobility solutions globally. Information Processing is located at the centre of the Capability Priority Matrix and investment in this space should be carefully considered.

Another cluster of four capabilities emerged that are important to transport more generally and specifically to autonomous vehicles (Real-time Control, Navigation & Path Planning, Energy Storage & Distribution, and Low Emissions Propulsion). These have the potential to also provide value outside of transport (e.g. energy storage) but not specifically to Intelligent Mobility (compared to some other capabilities). The UK's relatively strong positioning in these areas makes them nevertheless capabilities that should be further developed. However, the business case for further investment is likely to require value from other areas than Intelligent Mobility and will have to be assessed in a more general transport or other context.

Below: Transport Systems Catapult bringing the UK together to support innovation in smart infrastructure.

Investing in Intelligent Mobility (Recommendations)

A NUMBER OF **KEY ACTIONS** ARE REQUIRED TO **ESTABLISH THE UK AS A LEADER IN THIS HIGH GROWTH SPACE.**

The study has identified many ways in which Intelligent Mobility can bring benefits to the traveller and players investing in this space. It has also described possible trajectories on how this emerging market can develop in the UK. Intelligent Mobility is also expected to become a valuable export market for the UK. To capture the value identified in this study investments and interventions should be targeted in three areas:

1. **Research and Development**: in key technical capability areas ensuring the UK can be a world leader in IP critical to the Intelligent Mobility supply chain.
2. **Experimentation and Business Model Innovation**: experimentation, technical demonstration and validation, business model innovation, and real-life learnings in important application areas of Intelligent Mobility.
3. **Policy and Legislation**: putting in place key policy measures and government initiatives that will enhance and enable the success of Intelligent Mobility.

Opp: The Transport Systems Catapult 'Manchester Table' helps decision-makers invest in Intelligent Mobility.

Research and Development

Six Core Capabilities have been identified as priority development areas to position the UK as a global leader in Intelligent Mobility. Across these capabilities there are key development needs and actions to focus targeted investments and policy interventions on.

Capability	Development Needs	Actions
HMI & Interaction Design	• Need for continuous learning rather than sudden step change. • Design choices that incentivise optimal travel behaviour on a system-level. • HMI aiding transition towards fully autonomous vehicles.	• Focus on establishing UK as brand to attract key talent. • Foster collaborative environments that bring industry talent together. • Establish centres of excellence.
Traveller Behaviour & Psychology	• Better understanding of crowd dynamics and response to incentives (elasticities). • Tools to understand implications for business propositions.	• Target funding for UK demonstration projects (mitigating first mover disadvantages). • Creation of a common knowledge base of traveller behaviour insights.
Connectivity & Networks	• Reliable and ubiquitous connectivity (moving and stationary). • Compatibility across technologies (e.g. cellular, satellite, Wi-Fi, and NFC). • Demonstrate the business case for infrastructure investments in connectivity.	• Opportunity to merge existing technologies into innovative new systems. • Increase funding and support for demonstrators from central and local government. • Focus on patenting and protecting key developments and develop models and frameworks for securing IP for UK industry.
Localisation & Mapping	• Predictable and affordable high precision positioning and tracking down to centimetres, both indoors and outdoors (acknowledging the current European Galileo project). • Aim to develop high resilience and reliability (e.g. weather and low connectivity). • Need for a common UK map containing highly detailed 3D mapping data for virtual validation of technology performance.	• Investment should be focused at university level with a view to spinning out opportunities. • Encourage collaboration for location-based data exchanges between private sector suppliers (e.g. mobile phone data, fleet management, and logistics) and public sector infrastructure operators.
Data Privacy & Security	• Focus on V2V and V2I communications cyber security as well as system-level security (e.g. traffic control centres).	• Continue investments in existing UK centres of excellence in cyber security. • Provide guidelines and standards for protecting individual private data. • Ensure travellers right to anonymity where appropriate.
Analytics & Simulation	• Support skills development and where possible protect IP in this space. • Understand transferability of algorithms across sectors and use cases.	• Consider establishing centre of excellence. • Develop relevant skills throughout education.

Opp: Six Core Capabilities (Source: Expert Panel Workshops, Expert Interviews, and CVA Analysis).

Experimentation and Business Model Innovation

Developments in Intelligent Mobility depend not only on technical innovation but also on innovations in business models and user experiences.

Gathering real-life learnings on traveller behaviours through structured experiments is considered vital to achieve an evidence-based approach to innovation. Experimentation is already a widely used approach by many, including in areas such as policy development [20]. In doing so, Intelligent Mobility solutions can be prototyped and developed with real users to understand what drives success based upon validated and falsified hypotheses. As such, experimentation differs from pilots and technical demonstrations, where expectations are more focused on successful validation rather than allowing failure for the sake of learning. The entrepreneurial approach of "fail fast and fail early" has demonstrated that it encourages learning and accelerates innovation.

> EXPERIMENTATION DIFFERS FROM PILOTS AND DEMONSTRATIONS, WHERE EXPECTATIONS ARE MORE FOCUSED ON SUCCESSFUL VALIDATION RATHER THAN ALLOWING FAILURE FOR THE SAKE OF LEARNING.

Looking across the four Transformational Themes there are some key considerations for experimentation. For the Access theme, experimentation will naturally focus on business model innovation and personalised customer experience. It is fundamental to the success of new Intelligent Mobility solutions (e.g. for Progressive Metropolites and Dependent Passengers). The Demand and Supply theme is heavily dependent on influencing traveller behaviours and gaining a fundamental understanding through in-market experiments will be key. Whilst it is relatively easy to isolate sections of roads for experimentation there are regulatory barriers to overcome when considering options such as dynamic pricing in public transport. Automation is the most technical theme and testing and learnings on real roads will be a critical next development step in order to make autonomous drive technology market ready. Additionally, understanding how travellers behave in semi-autonomous vehicles and translating that into interior design features require an element of experimental learning. In relation to the Integration theme the level and depth of integration that travellers' desire needs to be established in experiments, especially when combined with other themes.

Funding and supporting Intelligent Mobility therefore needs to cover in-market experimentation on top of traditional R&D. 'Traditional funding' aligns to an overall roadmap and targets specific technical incremental developments to increase technology readiness levels. 'Innovation Funding' is different and focuses on real-life learning activities rather than discrete technology demonstrators – supporting iterative scaling of investment, market, and business readiness levels. This type of funding also focuses on removing barriers for experimentation, ensures national dissemination of learnings, and encourages local authorities to procure for innovation (i.e. the Value Space) rather than the finished product or service.

Ultimately it comes down to a difference in the measurable unit of progress – with the former being 'execution' and the latter being 'learning' whilst scaling towards a successful business.

Policy, Legislation and Regulation

Whilst many innovations in Intelligent Mobility will emerge naturally from market forces because of the significant value available, there are a number of actions that the UK stakeholders might consider. As mentioned several times throughout the report, there are fundamental enablers to Intelligent Mobility:

- **Connectivity**: providing reliable and ubiquitous connectivity.
- **Open Data**: encouraging and even mandating open data.
- **Multi-Modal Ticketing**: facilitating multi-modal ticketing and integration between different transport operators.
- **Standardisation**: establishing standards in a number of emerging areas such as V2V and V2I communications.
- **Multi-Modal Journey KPIs**: progress against meeting the identified traveller needs in this study should be measured and incentivised by establishing multi-modal journey KPIs across transport systems.

In particular, open data and multi-modal ticketing represent two fundamental enablers that government interventions could help to accelerate.

Open Data

Throughout this study, data has been shown to be a fundamental and key enabler for the majority of Intelligent Mobility solutions. Opening up transport data is one way of encouraging data-driven innovation with positive results from a traveller perspective. Currently, TfL[25] are seen as the 'champions' of open data. Through the publication of static/live transport data, and the provision of APIs for developers they have stimulated a wealth of innovation with many different apps presenting this data to travellers. This has enabled travellers in London to use the network with increased confidence and reassurance and has brought significant benefits to multi-modal travel information.

There is a need to further open data and there is a significant lack of live data beyond TfL that is holding back progress in journey information (e.g. from rail operators or local authorities). As the Internet of Things revolution and crowd sourcing continue to grow the volume and granularity of data, information will grow exponentially.

Currently, the value of data and commercial interests to protect it are key barriers to overcome. Many of those who generate data are keeping it closed, with a view to monetise it in the future. Additionally, there is a view that open data providers should be entitled to some of the behavioural insights generated by the users of their data (e.g. which choices travellers make, under which circumstances). This could include gaining access to processed and analysed traveller behaviour insights of their transport users.

> ESTABLISH A MARKET PLACE FOR TRANSPORT INFORMATION INCLUDING BOTH OPEN AND CLOSED DATA THAT COMPANIES WANT TO MONETISE.

These issues could be tackled by **creating a carefully designed and managed 'transport data exchange'**. Such a platform would define licencing permissions and reward mechanisms – establishing a market place for transport information including both open data and transport data that companies want to monetise (not personal data). It would also allow the development of service layers with the provision of analysed and enriched data that help achieve transport systems benefits (e.g. preferred traffic routing for flow optimisation and supply of key traveller behaviour insights). Some players may decide to provide their piece of the 'data puzzle' for free in return for access to some of the learnings that are being generated.

Such an exchange would encourage new mobility entrants to participate and allow transport operators to benefit from the learning and insights of the development community.

Multi-modal Ticketing

Another key barrier to overcome is to establish a means for travellers to have more integrated end-to-end and multi-modal journeys – including the means to seamlessly and spontaneously change between the different modes of transport available. This not only benefits existing multi-modal travellers but will encourage increased adoption and provision of new and alternative transport modes (e.g. city bikes). The key to delivering this is integrated ticketing that spans across transport operators and geographical boundaries. Whilst there is already a shared vision of an 'Oyster card' equivalent integrated ticketing system across the UK, there is a serious need to not only implement an appropriate payment mechanism but also to design a multi-modal ticketing interchange that allows all possible mobility players to participate (including new modes such as shared car, taxi or bike) and enables future developments, such as dynamic timetabling and pricing.

> DESIGN A MULTI-MODAL TICKETING INTERCHANGE THAT ALLOWS ALL MOBILITY PLAYERS TO PARTICIPATE.

Two interventions should be considered:

- **Mandating Interoperable Payment and Ticketing Standards**: for example, smart card payments or universal APIs that allow travellers to purchase multi-modal tickets during journeys with route components from any service provider.
- **Creating a Central Ticketing Platform and Multi-Modal Marketplace**: for example, where transport operators provide live times and capacity into a common platform. This could eventually extend to establish a transport operator 'bid system' for end-to-end journeys or portions of it. This would provide travellers with the freedom to switch between transport operators – for example allowing travellers on overcrowded trains to get off and complete the last portion of their journey on a dynamically timetabled bus.

Such a ticketing interchange could deliver a step change in multi-modal travel experience and deliver system-level efficiencies.

Conclusions and Stakeholder Implications

The UK has the opportunity to take advantage of the emerging Intelligent Mobility market, driving significant value to travellers, but also establishing a strong domestic and export industry. Key findings include:

- The Intelligent Mobility market has a large potential market size with a significant value opportunity in the UK alone.
- There is strong traveller 'pull' for innovations in mobility, including the large Progressive Metropolite and Default Motorist segments.
- Engaging travellers with modal choice and enabling better end-to-end multi-modal journeys need to become key objectives
- Four key Transformational Themes in Intelligent Mobility have been identified, focusing on access, integration, demand/supply management and automation.
- Many of these require capabilities from the digital and adjacent sectors, rather than the traditional transport space.
- The UK is well positioned from a skills, experience and capability perspective to realise value from this market.
- There is a healthy appetite for innovation and experimentation in the UK which needs to be fostered and could become a core strength, along with a collaborative culture between different players in mobility.
- To bring these to market successfully, a number of key interventions are required, specifically focusing on open data and multi-modal integration.

The transport landscape is, however, changing rapidly and to drive UK global leadership in Intelligent Mobility there are a number of imperatives for different stakeholders as shown below:

Stakeholder	Imperatives
Central Government	• Fund **research and development activities and skills development** in the six Core Capabilities for Intelligent Mobility. • Focus on filling the gaps in provision of **reliable, fast, and ubiquitous connectivity**. • Establish a **data exchange mechanism and mandate open data** where appropriate (e.g. in rail franchises). • Create a **central ticketing platform and multi-modal marketplace** and encourage multi-modal integration to support expected advancements in dynamic pricing and timetabling. • Foster **cross-industry collaboration** to unlock value from Intelligent Mobility.
Local Government	• Encourage and support new business and **participate in experimentation** with new Intelligent Mobility solutions in private and public transport. • Shift focus towards **procuring against challenges** rather than procuring for solutions. • Push for **integration and innovation** in public transport (e.g. demand responsive services).
Infrastructure Operators	• Focus on **measuring progress against traveller needs and end-to-end journey experience** across transport modes. • Understand the extent to which potential investments in Intelligent Mobility can give **better value for money** than traditional infrastructure investments. • Encourage innovation by **opening up data streams**. • Set up mechanisms to **gather learnings and influence traveller behaviours** based on data insights.
Transport Operators	• Understand desired position in emerging Intelligent Mobility ecosystems, **focusing on multi-modal transport** and collaboration with new digital integrators. • Collaborate across the industry, by opening data and creating seamless end-to-end journeys (focus ticketing, pricing, integrated information, commercial models). • Actively **participate and collaborate with digital start-ups**, not least by opening up commercially non-sensitive data and start generating real-time data where missing (and consider how to monetise valuable data). • Reduce complexity of planning by **increasing availability of information** (in particular expected arrival time, expected level of personal space) and include every element of the journey (car parking, etc.)
Automotive Industry	• Continue developing **autonomous drive technology** and focus on market readiness, consider target segments. • Produce vehicles that are **suitable for a variety of new mobility modes**, such as autonomous taxis or dynamically timetabled and routed minibuses. • Consider the **role of the connected vehicle** in an integrated end-to-end mobility world. • Establish a presence in **new areas of the mobility value chain** beyond vehicles sales, finance and service. • Develop strategy for data generation and utilisation. • Take a leading position in **defining and implementing standards** in V2V[5] and V2I[6] communications.
Rail Industry	• Focus on traveller experience on multi-modal journeys, in particular **integration of 'new' modes** (bike share, car share, taxi apps, autonomous mobility) and **speed & reliability of interchange**. • Focus on **enabling productive time**: connectivity, seamless interchange, dynamic timetabling. • Focus on **accessibility of rail**: 'easy to get to' / first&last mile. • Enable digital lifestyles (e.g. journey experience personalisation) and **engage travellers with transport choices**.
Transport Systems Suppliers	• Prioritise **data generation and integration** from all possible sources. • Develop desired position in a world that focuses more on **decentralisation** than central 'command and control' traffic systems. • Consider **collaboration and integration** with new mobility providers and focus on how to deliver on end-to-end journey experiences.
Academia	• Prioritise **traveller behaviour understanding** as a core discipline to develop expertise in. • Focus on skills gaps in **algorithms and analytics** to educate tomorrow's Data Scientists. • Ensure technical degree programmes include a sufficient amount of **business and commercial understanding**.
Start-ups	• There is a significant opportunity for **innovative and agile** new entrants in Intelligent Mobility. • **Build strong relationships** with key players (e.g. automotive OEMs, transport operators, and local authorities) and **understand the different speeds** at which these players move.

Methodology

THIS REPORT IS BASED ON **A RIGOROUS METHODOLOGY** DESIGNED TO GIVE AN **OBJECTIVE ASSESSMENT** OF TRAVELLER NEEDS, PAIN-POINTS, AND ATTITUDES AS WELL AS KEY CAPABILITY NEEDS AND COMPARATIVE UK POSITIONING.

Fundamentally, the methodology is designed to derive investment priorities by understanding the linkages between Intelligent Mobility capabilities and the impact these will ultimately have on meeting traveller needs and addressing pain-points.

The analysis in the study relied on data and insights derived as follows:

- **Market Research**: Traveller needs, pain-points, and attitudes from the traveller research.
- **Expert Interviews**: Transformational Themes for Intelligent Mobility alongside UK Capabilities were determined through interviews with experts and stakeholders in this space.
- **Expert Panel**: Analysis and development of conclusions were shaped by an Expert Panel.
- **Desktop Research**: Literature reviews were also conducted to add depth to the study.

Analysis of the research outputs followed a structured process to determine investment prioritisation and other recommendations. Throughout this analysis process, detailed analytical frameworks were used to answer specific questions (e.g. to prioritise capabilities for Intelligent Mobility). An Expert Panel provided quality assurance through regular review of findings and input to conclusions and recommendations being made. Just like the Expert Interviews, the Expert Panel was made up of a number of representatives from across academia, industry and government.

Opp: Intelligent Mobility imperatives for the UK (Source: Expert Workshops, Expert Interviews, and CVA Analysis).

Below: Gathering insights during one of the study's Expert Panel workshops.

Market Research

Typical market research exercises have samples of 1,000-2,000 respondents. This study employed a large scale market research exercise, which comprised of a UK-representative sample size of 10,000 travellers. This provided high confidence in the results and allowed analysis of a number of sub-groups (e.g. travellers using specific transport modes, particular geographies, or specific traveller types).

Core to the research design was the need to understand:

- The **fundamental attributes** that are important in a traveller's decision on how to travel from A to B (including e.g. cost, time taken, comfort, privacy, and productive time).
- The actual **pain-points experienced** once a specific transport mode was chosen (which Intelligent Mobility might be able to address).

Traveller needs, pain-points, and attitudes – were assessed using market research. Conjoint modelling was used to determine the monetary value that travellers put on having their fundamental journey attributes met and their pain-points addressed. Using the Hierarchy of Traveller Needs framework (Enabling Lifestyles, Enhancing end-to-end journeys, and Removing Pain-Points), the research data was analysed on a number of dimensions (e.g. traveller types, mobility lifestyles, mobility situations, and journey types).

This resulted in a set of 12 key challenges. The size of the Value Pools unlocked by addressing these challenges was then modelled based on the conjoint data.

To ensure that the findings can be extrapolated to travel in the UK as a whole, the questionnaire relied on a journey diary exercise from which one random journey was selected for each respondent. All analysis was weighted towards the National Travel Survey to ensure full representation of travel in the UK.

The dataset itself represents a core asset for the UK and allows for deep exploration of traveller needs, pain-points, and attitudes in much greater detail than possible to summarise in this report.

Moving forward, such analysis can be performed on the dataset to answer specific questions or derive specific insights that different stakeholders may have.

Below:
With a focus on the 'users of mobility systems', traveller needs and UK capabilities have been explored in this study.

Expert Interviews

100 expert interviews were conducted with the aim to understand:

1. **Transformational Themes for Intelligent Mobility** that are expected between now and 2030.
2. **The requirements** to enable the development paths within the themes.
3. **The UK's comparative position** and potential to drive further development in Intelligent Mobility.

The types of experts selected for interview were representative of different stakeholder groups across the Intelligent Mobility spectrum and included academia, industry and government – along with special interest groups and social scientists. For each type of expert a specific interview guide was developed, allowing for both structured understanding of the space and enough loose conversation to discover new learnings.

Literature Review

As part of an extensive desktop research conducted in the study, a number of reports were reviewed in order to compile an appropriate overview of existing insights. This included, for example:

- Travelling in a Changing World: Key Findings report from the 'Ideas in Transit' (2012).
- The COMPASS Project's 'D3.2 key trends and emerging traveller needs' (2012).
- The AECOM Report on 'Integrated Passenger Information: Delivering the Rail End to End Journey' (2010).
- Several research documents referenced in the Transport Direct research compendium and research projects, reports, and papers from CTS at UWE.
- McKinsey's report on 'Open data: Unlocking innovation and performance with liquid information' (2013).
- Arthur D. Little's reports on 'the Future of Urban Mobility 2.0: Imperatives to shape extended mobility ecosystems of tomorrow' (2004) and 'Creating a Better Journey' (2013).
- The Market Analysis of the Intelligent Transport Systems and Services (ITSS) Sector (2008).
- KPMG's reports on 'self-driving cars: the next revolution' (2011) and 'self-driving cars: are we ready?' (2013).
- Roland Berger's report on 'SHARED MOBILITY: How new businesses are rewriting the rules of the private transportation game' (2014).
- Institution of Mechanical Engineers' report on Intelligent Transport: Intelligent Society (2012).
- The European Commission's report on 'Intelligent Transport Systems in Action' (2011).
- 'The Intelligent Transport Systems (ITS) for sustainable mobility' report by the United Nation's Economic Commission for Europe (2012).
- Transport Focus' (former Passenger Focus) reports on 'bus passenger views on value for money' (2014), 'transport integration in Scotland – what passengers want' (2014), and 'the Future of Transport' (2012).
- Chartered Institute of Logistics and Transport report on 'Logistics and transport: VISION 2035' (2011).
- DfT's 'Door to Door: a strategy for improving sustainable transport integration' (2013).
- The European Automotive Partners Research Association Future Road Vehicle Research (FURORE) R&D Technology Roadmap (2005).
- Ricardo's reports on 'UK Automotive Industry in 2020: Focusing on Supply Chain and Skills & Technology' (2006) and 'Automotive technologies: the UK's current capability' (2010).

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- **Suzie Hunter** and **Carl Sanderson**, BMW
- **David Skipp** and **Graham Hoare**, Ford
- **Helen Finch**, **Antonis Michailidis** and **Anthony Harper**, Jaguar Land Rover
- **Chris Reeves** and **George Gillespie**, MIRA
- **David Moss** and **Simon Fraser**, Nissan

Expert Panel

Name	Organisation
Hazel Collier	BVRLA
Andree Woodcock	Coventry University
David Skipp	Ford
John Stanger	Ford
John Lynch	Future Cities Catapult
James Hardy	Future Railway, RSSB
Nicolas Zurlinden	Heathrow Pods
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Paul Blakeman	Imtech Traffic & Infra UK and Ireland
Antonis Michailidis	Jaguar Land Rover
Helen Finch	Jaguar Land Rover
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Anthony Baxendale	MIRA
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Kate Armitage	Route Monkey
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Kieran Arnold	Satellite Applications Catapult
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Erik Thomasson	University of Leeds
Adele Wearing	University of Leicester
Maria Teresa Raventos	University of Leicester
Lyudmila Mihaylova	University of Sheffield
Daniel Chick	Zipabout

Expert Interviewees

Name	Organisation
Rahim Tafazolli	5G Innovations Centre, University of Surrey
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Alexander Jan	Arup
Alex Burrows	Atkins
John McCarthy	Atkins
Philip Woods	BAE Systems
Alastair Scott	BMW
Carl Sanderson	BMW
James Cover	BMW
Richard March	BMW
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Andy Pitt	Crossrail
Daren Wood	DeltaRail
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Richard Brown	Ford
Graham Hoare	Ford
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Manjeet Kumari-Lal	Highways England
Meg Downing	Highways England
Daniel Ruiz	Imtech
Marc Roberts	Imtech
David Elson	Innovate UK
Dan Mercer	Iridium Communications
Mike Jacklin	ITO World
Peter Miller	ITO World
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Chris Holmes	Jaguar Land Rover
Mick Cameron	Jaguar Land Rover
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Anthony Townsend	New York University
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Jasdeep Sawhney	Nissan
Mark Pagett	Nissan
Richard Picton	Nissan
Robert Farmer	Nissan
Simon Fraser	Nissan
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Sarah Sharples	Nottingham University
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Paul Priestman	PriestmanGoode
Richard Westgarth	QinetiQ
Xavier Quayzin	QinetiQ
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David Keene	RDM Group
Colin Ferguson	Route Monkey
Simon McBeth	Sanef ITS Operations
Kieran Arnold	Satellite Applications Catapult
Tim Sherwood	Satellite Applications Catapult
Nick Burrett	SES Satellites
Stephen Skippon	Shell
Paul Brookes	Siemens
David Wong	SMMT
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Peter Warman	Transport Associates' Network
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Glynn Barton	Transport for London
Kuldeep Gharatya	Transport for London
Leon Daniels	Transport for London
Rosie Trew	Transport for London
Vernon Everitt	Transport for London
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Greg Marsden	University of Leeds
Jonathan Paragreen	University of Sheffield
Friederike Ziegler	University of Sheffield
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Martin Phillips	Virgin Trains
Claire Lewis	Visteon
Richard Dashwood	Warwick Manufacturing Group
Paul Jennings	Warwick Manufacturing Group
David Jones	Xerox
Daniel Chick	Zipabout

References

Note: Where no sources are provided in the report, this indicates findings from the traveller research or expert interviews performed as part of this study.

Ref No	Source
[1]	Transport Systems Catapult, "Market Breakdown," [Online]. Available: https://ts.catapult.org.uk/market-breakdown. [Accessed 22 07 2015].
[2]	Automotive Council UK, "Intelligent Mobility: a National Need?," 2011.
[3]	EY, "The Big Data Backlash," 2013.
[4]	K. Stokes, E. Clarence, L. Anderson and A. Rinne, "Making Sense of the Collaborative Economy," NESTA, 2014.
[5]	D. Wosskow, "Unlocking the sharing economy," 2014.
[6]	Statista, "Share of mobile phone users that use a smartphone in the United Kingdom from 2010 to 2017," [Online]. Available: http://www.statista.com/statistics/257051/smartphone-user-penetration-in-the-uk/. [Accessed 22 7 2015].
[7]	Network Rail, "Performance," [Online]. Available: http://www.networkrail.co.uk/about/performance/. [Accessed 22 7 2015].
[8]	Department for Transport, "Road Traffic Forecasts 2015," 2015.
[9]	Centre for Retail Research, "Online Retailing: Britain, Europe, US and Canada 2015," [Online]. Available: http://www.retailresearch.org/onlineretailing.php. [Accessed 27 7 2015].
[10]	innovITS, "Impact Study on Intelligent Mobility," 2013.
[11]	The Telegraph, "Motorists spend 106 days looking for parking spots," [Online]. Available: http://www.telegraph.co.uk/motoring/news/10082461/Motorists-spend-106-days-looking-for-parking-spots.html. [Accessed 22 7 2015].
[12]	Office for National Statistics, "Family Spending, 2014 Edition," [Online]. Available: http://www.ons.gov.uk/ons/rel/family-spending/family-spending/2014-edition/index.html. [Accessed 27 7 2015].
[13]	McKinsey&Company, "Mobility of the Future," 2012.
[14]	M. J. Calvin Chan, "Introduction to WAP," [Online]. Available: http://webdocs.cs.ualberta.ca/~zaiane/courses/cmput499/work/presentations/wap/. [Accessed 23 7 2015].
[15]	Mashable, "The Touching History of Touchscreen Tech," [Online]. Available: http://mashable.com/2012/11/09/touchscreen-history/. [Accessed 23 7 2015].
[16]	The Telegraph, "The history of BlackBerry," [Online]. Available: http://www.telegraph.co.uk/technology/blackberry/11347347/The-history-of-BlackBerry-in-pictures.html. [Accessed 23 7 2015].
[17]	Encyclopædia Britannica, "Palm OS (Operating System)," [Online]. Available: http://www.britannica.com/technology/Palm-OS. [Accessed 23 7 2015].
[18]	I. Ceapa, C. Smith and L. Capra, "Avoiding the Crowds: Understanding Tube Station," in ACM SIGKDD Intl. Workshop on Urban Computing, 2012.
[19]	Google Plus, "Google Self-Driving Car Project," [Online]. Available: https://plus.google.com/+SelfDrivingCar/posts/iMHEMH9crJb. [Accessed 23 7 2015].
[20]	Ofcom, "Using experiments in consumer research," 2010.
[21]	MIRA, "Intelligent Mobility".
[22]	Schneider Electric, ARUP, The Climate Group, "Urban Mobility in the Smart City Age," 2014.
[23]	Financial Times, "Bus and train operators wary of jumping on driverless bandwagon," 2015.

Endnotes

Additional information about text in the report (as denoted by superscript numbers after the text) can be found below.

Ref No	Source
1	Travellers encompass all types of travel including local and long distance journeys across all modes of transport
2	Intellectual Property
3	Vehicle to Vehicle
4	Vehicle to Infrastructure
5	CVA prior research
6	Original Equipment Manufacturers
7	Split Cycle Offset Optimisation Technique
8	Wireless Application Protocol
9	Global Navigation Satellite System
10	Simultaneous Localisation and Mapping
11	Central Processing Unit
12	Fuel Cell Electric Vehicle
13	Battery Electric Vehicle
14	Plug-in Hybrid Electric Vehicle
15	Internal Combustion Engine
16	Artificial Intelligence
17	Worldwide Interoperability for Microwave Access
18	Near Field Communication
19	Software Defined Networks
20	Technology Readiness Level
21	Small and Medium-sized Enterprises
22	Centre for Advanced Spatial Analysis
23	Human Factors Research Group
24	Choice Modelling Centre
25	Transport for London
26	Vehicle to Vehicle
27	Vehicle to Infrastructure

Your Thoughts...

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