Connected Places Catapult

Business Case for New Mobility Services:
Demand Modelling Tools

Executive Summary

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Introduction

The 'Business Case for New Mobility Services: Demand Modelling Tools' project was developed by the Transport Systems Catapult under the DfT-TSC Collaborative Research Programme April 2018 to March 2019.

The project looked at understanding priorities at removing the barriers for successful implementation of Mobility as a Service in UK cities. Specifically, the project looked at understanding the problem space from the perspective of multiple stakeholders and assessed if demand modelling tools can help to minimise the risk of introducing these new services and making them financially viable without disrupting the mass transit market.

The project has identified current market needs, industry capabilities and the problem space in the implementation of New Mobility Services and the adoption of Mobility as a Service schemes in the UK. Furthermore, current gaps in the transport modelling sector for modelling demand for New Mobility Services were investigated and an evidence base was provided to explore new tools and techniques to support the Department for Transport in the creation of new modelling tool to assess the investment case for introducing New Mobility Services.

Objectives

The main aim of the project is to identify the requirements for developing a new modelling tools to accelerate the adoption of a common methodology for modelling and appraising New Mobility Services in urban and rural areas.

In order to achieve this, the following tasks were required:

- Understand the analysis questions that transport operators and authorities need to answer around the introduction of new mobility services
- Understand the current state of international capability in modelling demand for New Mobility Services and Mobility as a Service
- Scope the availability and challenges around gathering the required data to populate such models, including the impacts on calibration and validation

The following sections provide an overview on the outcomes and recommendations on how to set up a demand modelling tool for assessing New Mobility Services.

This summary note also provides an introduction to the follow up work, which aims to develop a large-scale demonstrator of modelling demand in the assessment of New Mobility Services. The project, called Demand Modelling and Assessment through a Network Demonstrator (DeMAND), is currently advancing the data landscape and the model and results will be available in March 2020.

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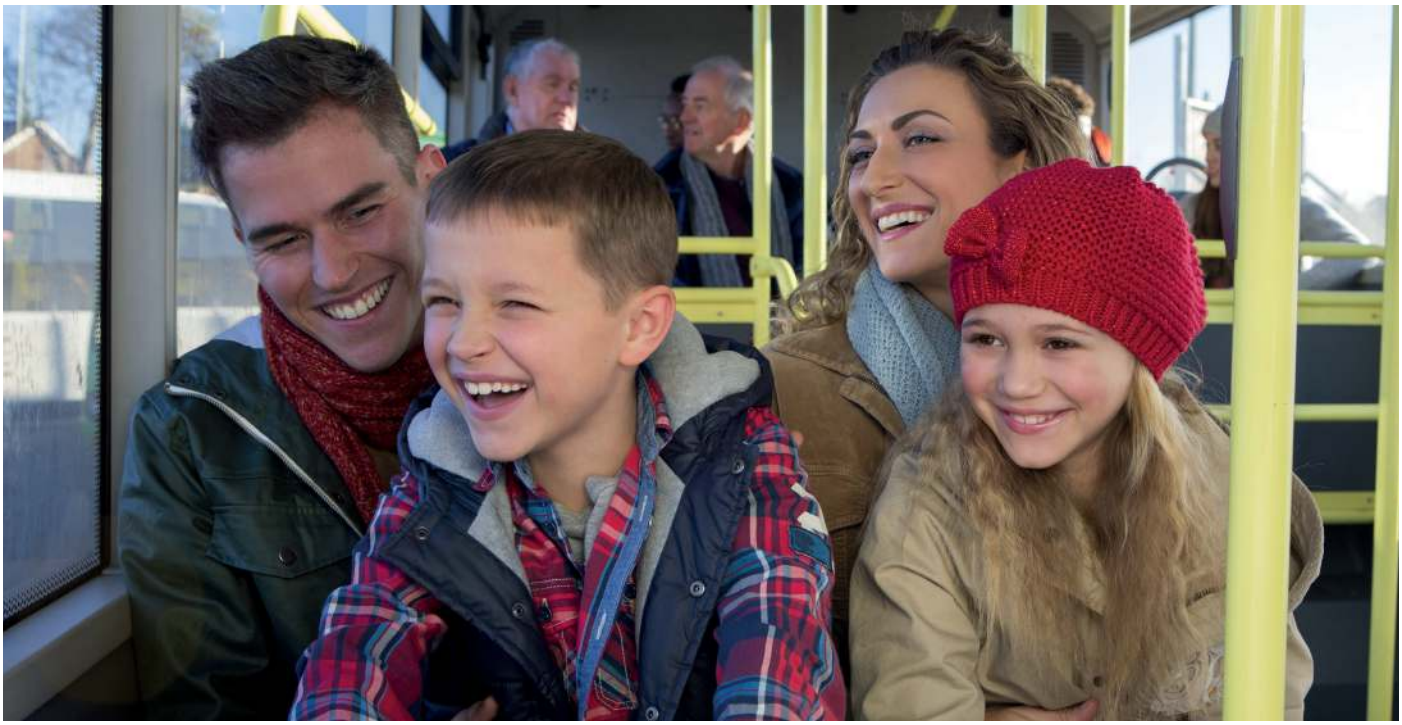

Results and outcomes

New Mobility Services and the introduction of Mobility as a Service schemes have been primarily promoted by a technology-driven market, leading to disruptions within the more rigid public transport system. Mobility service operators do not follow a consistent approach in the activation of these services. This can create barriers to sustainably introducing Mobility as a Service, which is a customer-centric seamless integration of multiple mobility services which ultimately aims to provide an integrated door-to-door service encompassing a one stop shop for planning, booking, paying for and taking multi-modal journeys.

Digitally enabled services are quick to set up but less visible to potential new users compared to conventional public transport, and often do not attract sufficient demand to be commercially viable in the long term. They may also not provide the necessary coordination with the wider public transport offer, leading to a suboptimum traveller experience. To maximise the positive transport (and carbon) benefits of this digitalisation trend, there is an emerging need to provide the Department for Transport, local authorities and mobility services operators with a tool to assess the introduction of these services before their launch and to evaluate their impact on the network and on the less adaptable public transport services.

Stakeholders from local authorities, transport authorities, transport modelling industry and data providers discussed the following aspects:

- Market needs for the introduction of New Mobility Services
- Current gaps in the transport modelling sector

Market Needs and Existing Capabilities

During the stakeholder engagement phase, representatives from academia, local authorities, the transport modelling industry (including both consultants and software platform vendors) and companies operating in the mobility sector provided insights into their priorities and needs and perceived barriers. Workshops and individual sessions were organised to gather the stakeholders' views on some key questions relating to current challenges in implementing Mobility as a Service and New Mobility Services, including how modelling could be used to assess the impact of New Mobility Services and what questions modelling tools need to be able to answer.

Each stakeholder expressed a different view on what Mobility as a Service is and what it should deliver. For New Mobility Services to reach their full socio-economic and environmental impacts, a degree of collaboration is essential. However, not unreasonably, all of the stakeholders were fully focused on the direct impact these services might have on them, making a holistic approach problematic.

Transport modelling and specifically demand modelling was identified as a way to de-risk the introduction of these services and support local authorities in the assessment.

Personal preference, accessibility and attitudes towards shared mobility play a big role in understanding demand. Estimating the effect New Mobility Services have on travel choices both on a short-term basis (e.g. planning and operational purposes) as well as on a long-term basis (e.g. development purposes) can be a challenge. Moreover, it is expected that New Mobility Services should meet demand for populations and geographical areas that are dispersed and/or low density, to reduce transport poverty and increase inclusion.

New Mobility Services are not expected to be used for long journeys but only to cover those first/last mile journeys during commuting. Integration at multiple levels with the more complex existing public transport ecosystem should be introduced to allow users to access Mobility as a Service through a single application. This should provide access to mobility, with a single payment channel instead of multiple ticketing and payment operations in integration of various forms of transport services into a single mobility service accessible on demand.

Stakeholders were particularly concerned about the right tool to use and which scenarios to implement in order to achieve the best combination of New Mobility Services to support a positive effect on the network congestion and improving air quality in urban areas. The main barriers identified were represented by data availability and the lack of collaboration to enable sharing of the data.

These barriers are more relevant in rural areas that, compared to urban environments, have availability of aggregated datasets, but do not have access to highly granular data coming from deployments of roadside sensors and Urban Traffic Management Centres.

Surveys that provide insights in travel behaviour can give a high level of insights into the travel patterns of a relatively small sample of the population. However, new sources of digital data that is location-based or draws on Mobile Phone Network Data provide much greater richness for significantly larger population sizes, therefore increasing their representativeness. They also give more accurate data on trip chains. They therefore are instrumental to represent the variability of journeys over a modelled 24-hour period.

New Mobility Services need sufficient demand for them to be viable. Demand Responsive Transport schemes have suffered from lack of demand in a number of cases. It was therefore recognised by stakeholders that a more thorough understanding of potential user needs is required so that value propositions can be designed. This requires a thorough understanding of the users' perspectives and needs, and the integration with the more complex public transport ecosystem, especially for longer journeys. However, there are no adequate tools that allow the use of the ever-growing big data source available on the market.

Local authorities are interested in the increase of accessibility and social inclusiveness that New Mobility Services can lead to. Mobility services have the potential to improve mobility conditions in areas that have high transport poverty or are newly redeveloped, where public transport is often inadequate or inappropriate to satisfy users' mobility needs. Local authorities are also concerned about the impact these services might have on short journeys (as they might lead to lower levels of active travel), and on medium length journeys (mainly bus services operations). Their potential impacts on congestion, the environment and health of population also need to be clarified. The possibility of creating mode shift away from private cars towards
shared rides and enhance the public transport in the local areas have already been proven by projects like MODLE **(https://gtr.ukri.org/projects?ref=102737)**, where a collaboration between stakeholders have enabled a better use of existing public transport resources. Transport operators are more concerned about the optimisation of fleet composition in order to satisfy demand and in the optimisation of travel times and empty runs.

However, all stakeholders agreed that using modelling tools to identify the demand for these services in advance can maximise the positive impact on transport and the environment, as well as the potential revenue for mobility on demand.

Modelling demand for mobility services is substantially different from the traditional four-stage trip-based modelling approach. If the objective is to provide a service that is fully inclusive of all users' needs, modelling the end-to-end users' journeys and the interdependence between one trip and another is pivotal. This requires a better understanding of travel behaviour, consumer attitudes to share in flexible on-demand services and the likely uptake of new trends in the mobility sector.

Modelling tools have been experimenting more on Mobility on Demand and Demand Responsive Transport with a specific focus on fleet operations and management without really considering demand modelling as an integral part of the business model.

Recommendations

Multimodality and attitudes towards sharing will affect how people will travel in the future and demand modelling tools need to move away from the traditional division of transport modes. Key changes to demand modelling approaches are needed at this stage since transport modellers dealing with New Mobility Services may have to move quite considerably away from the demand models used in the traditional way to model the capacity of infrastructures. Traditional transport modelling approaches, although still relevant for the remit they have been created, are not fit for the purpose of fully representing the complex dynamics present in New Mobility Services and their integration in Mobility as a Service enabled environments.

The main limitation of the traditional approach is their aggregate nature, which does not align well with the user-centric nature of NMS/MaaS. This arises from the commonly accepted belief that transport modelling in the era of NMS/MaaS should be tightly related to user preferences and customer NMS/MaaS experience factors generally neglected by the current approaches.

Key changes to the demand modelling approach:

- End-to-end users' journeys
- Multimodality
- Contribution that private on-demand services provide to a wider public transport ecosystem
- The ability to represent Mobility as a Service' integration with public transport systems
- The variability over 24 hours of all travel patterns to identify latent demand at different times of the day and for a large-scale area in order to capture all commuting patterns (even beyond the administrative boundaries of a council)
- **Data Ecosystem:**
  - **Urban context:** defined by a data-rich environment where legacy dataset will need to be integrated with new generation big datasets, coming from Mobile Phone Network Data and deployed sensors
  - **Rural context:** where all legacy datasets are present but often outdated and not reflecting the current travel patterns from users. In this case, location-based data, Mobile Phone Network Data and sensors can help to rapidly generate more recent travel patterns
- Integration with legacy models for strategic modelling and optimisation of the mobility service operations
- Transferability

Based on these characteristics, agent-based models are becoming a viable alternative solution to the traditional trip-based approach, because each person/agent is modelled and all trips occurred in a day are considered. A specific characteristic of this type of model is that they require a higher granularity of data and are computationally intensive. Data rich environment created in smart cities and cloud computing will be an advantage for this type of model.

Previous studies using Agent-Based Modelling for mobility

Agent-based modelling has been explored in a simplified version by commercial software vendors, often major results were achieved in other sectors, but not considering the implications on the transport sector. Agent-based models can be adapted to the transport sector and we have seen many examples flourishing around the world of bespoke agent-based models used in several case studies. One of the main barriers to a wider application of this type of model was the scalability and the great amount of data needed both to build the model and for calibration and validation purpose.

Among the platforms that provided large-scale applications in the transport sector, agent-based modelling can be developed further using the open platform MatSim and the commercial tool VISEM from PTV. The main advantages of these two platforms are the ability to receive support from bigger modelling communities and the integration with legacy software platforms. Both platforms can handle the use of disaggregated data input, and are quicker to use compared to other bespoke agent-based models and able to support the activity chains combined with socio-demographics characteristics.

The Transport Systems Catapult has already explored the use of agent-based modelling to model mobility solutions in Innovate UK funded projects "Mobility on Demand Laboratory Environments" (MODLE) and "Merge Greenwich". In these two projects agent-based models used a data-driven approach to test flexible Demand Responsive Transit, operated either with traditional vehicles or with automated vehicles. agent-based models can be developed either using a trip-based approach or an activity-based approach. The activity-based approach allows the representation of how each person is travelling over a day, combining trips and taking into account time bounded activities, for example going to work or school. In both projects, the agent-based model allows for the modelling of the complex interaction between flexible private mobility services and the more complex public transport ecosystem.

To model mobility on-demand, operators are interested in the latent demand and in understanding real travel patterns from users. In the MODLE simulation, demand and travel behaviours were informed by anonymised and aggregated Mobile Phone Network Data, which reveals real travel patterns from users using activity-chains.

Results showed that the traditional datasets based on the use of disconnected trips and origin-destination (O-D) matrices, in some circumstances can be misleading and do not provide useful insights in the behaviours of users. While the activity-based approach can differentiate between a higher number of trips linked together and generated by a single user (i.e. a high number of trips could be the results of activities linked to distribution centres) or generated by different users hence potential customers for a mobility service. Activity-based approach then can still generate traditional O-D matrices.

Agent-based models with activity-based approaches are sufficiently flexible to allow datasets to be used as a direct input to generate daily travel plans for agents. This allows the agent-based model to consider trip chains rather than disconnected trips. Moreover, in the absence of traditional datasets to inform demand or with outdated information, the methodology using Mobile phone Network Data (MND) can be available (e.g. for areas experiencing transport poverty conditions and rural areas more broadly).

However, agent-based models are subject to calibration and validation issues due to a lack of guidance and standardisation. These issues could be resolved by testing the methodology against a large-scale demonstrator and using data currently collected by local and transport authorities to enhance the integration between legacy data and new generation data sets.

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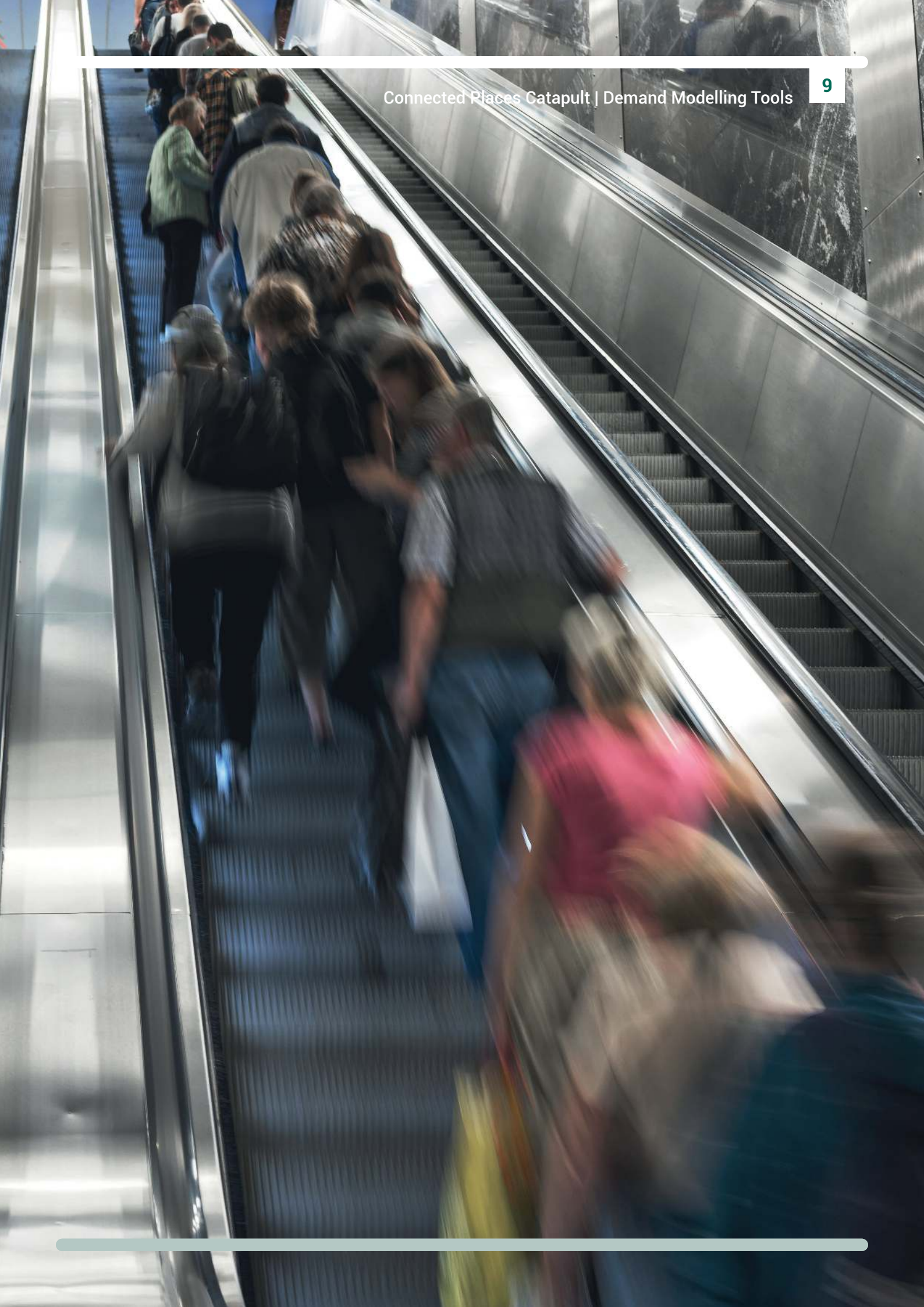
Requirements to create a large-scale demonstrator for modelling and appraising New Mobility Services'	
Model	Agent-based model with activity-based approach: • End-to-end users' journeys • Multimodality • Contribution of shared mobility towards increase in patronage in public transport • Microlevel approach to include new technologies, such as Connected Autonomous Vehicles, for ride-shared services running with autonomous and conventional vehicles using dynamic agents • Appraise impact on the network and the environment
Data Landscape	• Location based data (Mobile Network Data, GPS, satellite data, ...) as data input to generate daily travel patterns from users • Use of highly disaggregated data to make use of big data source coming from sensors and new technologies • Use of existing data centres, with consistent and long records of events for calibration and validation purpose of the model • Appraise the impact of New Mobility Service on the environment using a highly granular environmental data
Other factors to consider for shared mobility	Mobility Services and how the Mobility as a Service offering will be affected by this propensity • Changes in the value of time for ride-sharing mobility services and how this will affect the costs in the model • Understanding the willingness to pay when users are presented with a range of conventional and new transport options • The use of Artificial Intelligence to accelerate the procedure to automate the travel pattern recognition • Integration with legacy models for strategic modelling and optimisation of the mobility service operations



Next Step – Demand Modelling and Assessment through a Network Demonstrator (DeMAND) Project

The DeMAND project will provide a regional prototype transport model to identify a standardised methodology to assess the demand for the introduction of New Mobility Services and Mobility as a Service schemes. Funded by the Department for Transport (DfT) in 19/20 MOU, the main aim of the DeMAND project is providing the DfT with a new methodology to appraise Mobility as a Service schemes and the introduction of emerging on-demand mobility services.

Current transport models do not consider the contribution that these private services can provide to the wider public transport ecosystem because they are unable to represent door-to-door journeys. This shift will require a considerable investment from the transport industry and higher risks in developing the new tools.

Based on previous work by the TSC and others (literature review), the most appropriate methodology to pursue is that of a data-driven agent-based model which uses an activity-based approach. This methodology uses a "data rich approach to transport planning", as cited in the Future Mobility Report published by the Government Office for Science and can help mitigate the "unintended consequences of new transport modes, technologies and/or trends".

The implementation of a large-scale demonstrator will aim to support trialling of New Mobility Services in integration with a complex public transport ecosystem. Model outputs will support policy makers in the identification of the most sustainable and durable solution for the introduction of on-demand services.

For the large-scale demonstrator we propose to merge the data-driven approach developed using Mobile Network data with information coming from a stated preference survey which will focus on attitude to share and willingness to pay for shared mobility services, this will allow better understanding of the demand so that we can better model behaviour and tailor the demand modelling tools in the future.

DeMAND will be the first step necessary to enable DfT to shape the evolution of Mobility as a Service, to provide a suitable regulatory framework for Mobility as a Service, and practical support in updating existing modelling methods,. Currently, DfT has no tools to appraise Mobility as a Service schemes.

The DeMAND regional prototype transport model can then be used as the basis to further develop tools in other areas, to assess Mobility as a Service. As highlighted in the MODLE project, a key feature for the success of Mobility as a Service and New Mobility Service is the integration and co-existence with the more complex public transport ecosystem.

Sharing and openness of data between interested parties and the creation of standardised tools to minimise the effort required by transport modellers is a major barrier to the uptake of activity-based models as a viable alternative, hence a culture of sharing and collaboration has been one of the key elements to choose the location of the demonstrator.

The DeMAND project will provide a regional prototype transport model to identify a standardised methodology to assess the demand for the introduction of New Mobility Services and Mobility as a Service schemes.

The proposed area for the prototype will be Tyne and Wear in the North East of England. With the lowest rate of car ownership in the UK. Tyne and Wear users are already relying on an efficient public transport system, where the underground (Metro) is operating alongside a balanced presence of major bus operators in the metropolitan area. The DeMAND regional prototype will offer the perfect testbed, allowing Tyne and Wear to appraise Mobility as a Service schemes and emerging mobility services against unintended consequences (e.g. increase of transport poverty, reduction of active travel).

Specific project objectives are to understand the:

- Attitudes of people towards sharing, which provides understanding of potential uptake of New Mobility Services and how the MaaS offering will be affected
- Willingness to pay for shared modes
- Use of Machine Learning to increase the speed in processing the Mobile Network Data to generate activities
- Development of an agent-based model using an activity-based approach at large-scale.
- Fully document and appraise the methodology, data requirements and processes developed and evaluate them in line with industry needs and ways of working, which allow for scalability and transferability
- Provide recommendations for the next steps to allow the new method to be adapted into DfT'sTransport Analysis Guidance (TAG) and roll out to the transport modelling industry

Since we are moving towards smart and connected cities, there is a real need to consider and be able to use more easily these new data sets coming from mobile phone network data and location-based datasets within transport models. However, many of these data sets are currently collected for other industries. Hence, they require further processing and the use of techniques of data mining, data fusion and interpretation, before they can be used as an input for transport models.

Depending on the scale of the schemes to be assessed and the temporal horizon to be modelled, mobile phone network data and location-based data are ideal solutions to capture information on activity chains and real travel patterns on the network.

Each datasets has their own limitations, which can be overcome with data fusion techniques with other data sets to quantify:

- **Active travel in areas of interest:** cameras and image recognition techniques, pedestrian counting sensors and pedestrian tracking
- **Usage of public transport services:** surveys of users, smart ticketing information, tap in and tap out data)
- **Delays on the network:** UTMC centres managed by local authorities provide a good understanding of traffic flows and delays at junctions or along corridors through ANPR cameras usage
- Consumer data to identify users' preferences

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