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Deriving transport benefits from Big Data and the Internet of Things in Smart Cities

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Context

With the rapid advancements in technologies that can be applied to deliver transport differently, we are on the cusp of something exciting, with the potential to revolutionise the way we travel and how we deliver transport services in the future. The DfT is currently examining the use of sensing, and other IoT sources, to collect and generate large amounts of transport related data, the analysis of this data, and its use to deliver more joined up and 'smarter' transport. Coupled with this: the move towards automated systems; changes in demographics, use and ownership; new innovations in business models and the drive to decarbonise the transport sector – all will shape future transport and raise their own challenges. At the heart of this transport revolution, Big Data and the science underpinning the analytics of the data are beginning to re-shape our thinking and the potential for service delivery for future transport. Fundamentally, we better need to understand the potential for big data in making transport services smarter in cities.

Introduction

This paper will describe how the department is addressing the above fundamental question and through summarising a variety of current actions and will provide an insight into how the DfT is exploring the deployment and enhancement of Big Data technologies in transport, and the challenges to delivering Smart Cities.

This will include:

- Potential barriers to benefits realisation
- Insights from a scoping study on deriving transport benefits from Big Data
- Encouraging innovation to make our cities smarter
- Exploring Systems Thinking in the context of a Smart City
- Next steps

The direct transport benefits and wider societal benefits of using Big Data and the Internet of Things in Smart Cities could be vast. Data from across the transport system, in particular from sensor connectivity, has the potential to create a truly integrated inter-modal transport system that maximises efficiency gains, improves asset management and enhances the customer experience of a city.

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A Smart City uses data and technology to monitor, manage and improve key infrastructure and services for citizens. Utilising data to enhance transport can bring huge benefits to the system and the user. The DfT has placed Smart Cities at the centre of its Big Data activities.

In order to realise the potential of Big Data in Smart Cities it is important for government and the wider transport community to understand the breadth and scope of these transformative technologies, and the likely changes to data analytics, business models and connectivity that will be generated as a result. However to date, although many cities claim to be 'smart' there are few tangible examples of this been successfully implemented in practice. Moreover, we really are at the beginning of this revolution, so most important for the Department is to understand, what is the vision, what is the potential, what is needed to enable the technologies, services and data analytical tools to be available to fulfil the promise of Big Data for smart cities and transport.

Once that is understood, the regulation, guidelines or other enablers to foster this can be considered by the Department.

Potential barriers to benefits realisation

Big Data is already transforming the way we conduct research, deliver healthcare, improve performance, run cities and operate businesses. However, in the transport sector benefits exploitation is at a much lower level of maturity.

Many UK cities have made good progress in implementing smart initiatives. However, they have faced common challenges which need to be overcome if smart is to have a lasting and meaningful impact.

The DfT is leading a project to identify the impact of smart initiatives upon transport, and the role of Government to support city leaders and local authorities deliver the smart agenda.

The Department has been engaging with a wide range of stakeholders to better understand what those key barriers are and how they can be mitigated.

Our initial research and engagement has highlighted a number of potential barriers to Big Data benefit realisation:

- *Commercial sensitivities* mean that companies often do not want to share "their" data as they believe it has commercial value and/or gives them a competitive edge. This was a particular barrier to realising the benefits of smart ticketing investment as operators did not want their competitors to have access to "their" data.
- *Building the business case* for innovative approaches can be difficult as there is limited evidence of the likely benefits.
- *Market failures* may take different forms. For instance, early innovators may not be able to secure a return for their upfront investment. Asymmetric information is likely to be a problem as suppliers know much more than public sector customers in terms of costs, benefits and risks.

- *Data collectors/owners are not necessarily those that would benefit from any exploitation of the data by 3rd parties*, creating a disincentive to share, and the need to create different types of business models.
- *Public trust and public acceptability* will influence uptake of smart technologies and sharing their data.
- *Capability* within public authorities to understand the likely data, data analytics and integration techniques, potential business models and data access to enable their exploitation.
- *The variability in the quality around IoT sensors* may be an issue as poor quality products could provide misleading results. Sensors need to be fit-for-purpose for the activity and local environment. It is therefore important to have the correct standards in place. The British Standards Institute has already started to develop standards around Smart City technologies. The quality of data may also be poor negating its use or providing misleading conclusions.

Scoping study into deriving transport benefits from Big Data

The scoping study conducted by DfT will explore the existing trends and technologies in transport connectivity in Smart Cities and the challenges preventing the wider use of Big Data technologies. The study will include a review of the existing evidence base of Big Data and IoT around transport applications in smart cities, including relevant UK, European and international studies covering:

- data generation;
- data sharing;
- data linking;
- data analytics;
- data exploitation;
- open data architectures and platforms;
- business models.

The scoping study will be an analysis to identify research gaps and recommend actions that can enhance transport benefits using existing 'big' datasets. The data the research will be built on will not solely be confined to "transport" datasets (e.g. traffic data) but any datasets that could be potentially exploited for transport purposes now or in the future. For example, the DfT is interest in learning more about:

- Mobile computing and smartphones which generate very large volumes of data in near real time on where individuals are, where they are going and how they feel about the experience. When mined, this allows more targeted services that reduce costs by making better use of the existing infrastructure.

- Data generated through existing and emerging technological developments (i.e. Intelligent Transport Systems, Mobility as a Service, and Connected and Autonomous Vehicles) could be integrated and used to deliver tangible outcomes.

- Data sources which could be combined to derive a fuller picture of travel demand, factors that influence provision and wider trends. Such an approach can often be cheaper than manual counts or bespoke computer models. Could

Big Data replace the need for travel surveys and/or manual traffic counts? And feed into transport models?

- Wireless sensor networks combined with ultra-low power sensors to develop intelligent infrastructure, to monitor our transport networks, to facilitate conditioning monitoring of a wide range of structures such as bridges or tunnels, alerting authorities to weaknesses or disrepair; and building resilience in the transport system, e.g. sensor technology combined with algorithms could help predict and manage flooding more effectively.

- Using data analytics to understand driver behaviour to find creative ways to persuade drivers to take public transport or to reduce roadway and parking lot congestion.

The DfT expects the research to provide description that can clarify quantity, ownership and availability/accessibility of existing data sets as well as identify and describe the benefits, barriers and enablers around Big Data use.

The research will also examine why data is often not shared. For instance is it due to market practices/behaviours or are there genuine market failures that are impeding the delivery of the benefits. In addition to this the research will provide;

- An assessment of the feasibility of open architectures and innovation platforms - that allow the integration of multiple datasets from different sources – to deliver tangible transport benefits in a smart cities context. This should include: the challenges, barriers to their use and opportunities these could deliver.

- An assessment of whether there are any skills shortages, in both the public and private sectors, that are impeding benefits realisation; and what measures could be undertaken to address these.

- The identification of new business models that would address the issues/challenges identified above.

- What government needs to do to encourage the use of these new business models e.g. addressing market failures, and raising local authority and industry awareness, and give considerations of the differing levels of intervention required to achieve benefits.

These findings will help Identify the areas where there is potential for connectivity between policy agendas across government, including: how transport smart initiatives in our cities could support the policies of other government departments (e.g. health; access to education, training and employment; service provision and the environment); and how different systems could be integrated.

The scoping study will conclude this spring so we will be able to present the key findings and outcomes at the ITS Congress.

Encouraging Innovation to make our cities smarter

In addition to the scoping study, the Department for Transport have launched a Transport Technology Research Innovation Grant (T-TRIG) on enhancing the digital transport agenda (Big Data). T-TRIG is a scheme that enables the DfT to fully fund

early-stage research projects in support of innovative ideas or concepts that facilitate a better transport system.

This competition call is being run to stimulate ideas generation and test initial concepts around how accessible and existing datasets can lead to tangible transport benefits. For example reducing congestion, improving mobility or improving the customer experience. These projects will also help to inform the Department's future thinking in this area.

The competition calls for applicants to put forward proposals that take the next step in using Big Data by utilising Artificial Intelligence4 and Machine Learning5 to enhance value gained from data analysis in transport, including predictive capacity. The Department will be supporting projects designed to deliver transport benefits from the following areas:

- ML to enhance data analysis;
- Using AI in transport;
- Data linking and bring together disparate data sets to demonstrate benefit;
- Using enhanced computing to process existing transport or transport-related data.

Results of the T-TRIG competition will be announced at the ITS Congress in detail.

Exploring Systems Thinking in the context of a Smart City

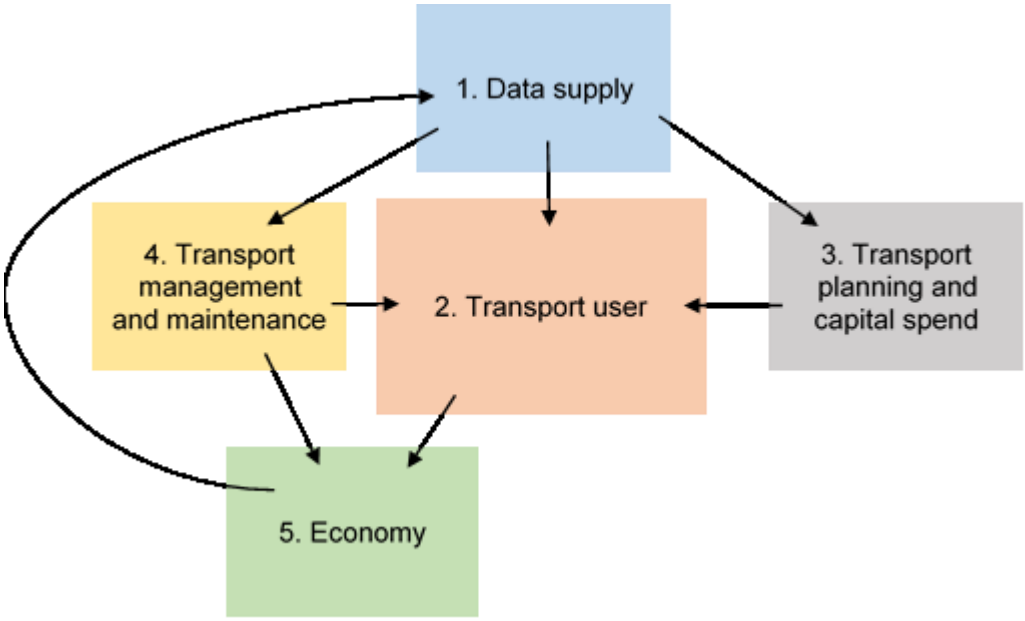
In order to develop a greater understanding of Smart Cities, and in particular the way that Smart Cities affect and are affected by transport policy, the DfT have produced a Systems Thinking model of how Smart Cities work. The model was built in workshops involving a range of stakeholders, both from DfT and external organisations.

Smart Cities present many opportunities to deliver transport benefits. However, a Smart City is driven by its use of data and technology: without a strong underpinning of data, analytics and communication in the right environment, the full potential of Smart Cities cannot be realised.

The high-level model, below, shows the complex landscape that exists in developing Smart Cities and the key elements that are related to making transport smarter. The model broke down the system into submodels that relate to the data side of smart cities, detailing the factors associated with data collection, storage, processing and usability.

[4] AI allows a system to exhibit human-like intelligence in its responses through use of rational reasoning and deductive solutions.

[5] ML is a form of AI that allows a system to learn from results and amend itself accordingly.



Two key variables within the submodels are the quality of data and the quality of data analytics. It is recognised that Smart Cities are dependent on the data gathered, and having data of high quality is necessary for their functioning. This submodel was also recognised as an area where DfT's input could be useful in effecting positive changes throughout the system.

The key findings from the project showed how using data and having a systems approach will enable better decisions for now and the future. For example:

- Journeys can be improved through better decisions being made by transport users and operators in real time.
- Transport planners can also use data to design better infrastructure to meet needs for the longer term.
- Transport safety can be improved through better planning, user decisions, and maintenance of infrastructure.
- The economy could grow through sector expertise and increased mobility of people and goods.
- Transport can become more environmentally sustainable through more efficient maintenance schedules and planning that enables services to be better co-located.

Alongside this the findings helped identity risks to security (of both infrastructure and personal security against fraud). As more data becomes available and combined to create new insights, more understanding is needed to effectively manage this risk.

Coupled with this: the move towards automated systems; changes in demographics, use and ownership; new innovations in business models and the drive to decarbonise the transport sector – all will shape future transport and raise their own opportunities and challenges.

Next steps

The scoping study will help to inform DfT's work programme in this area. There are likely to be a number of technical challenges of Big Data and analytics that will need examining, for instance combining diverse datasets in real time, scaling-up given the emergence of connected vehicles, cybercrime prevention, and real-time modelling for decision-making.

A key element to making our cities smarter will be public acceptability and DfT in its forward work programme will be exploring public attitudes towards the use of Big Data and smart technologies.

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