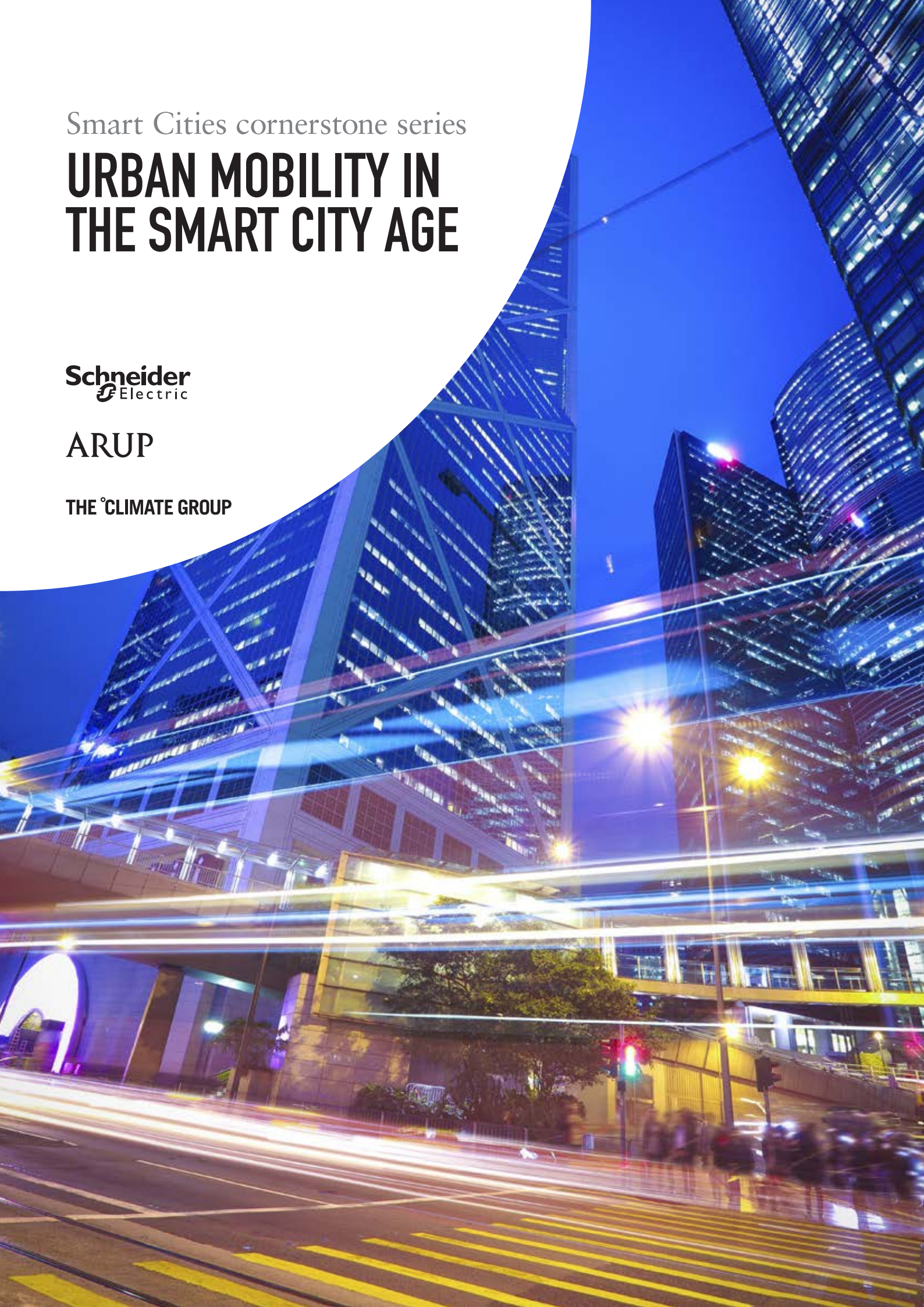Smart Cities cornerstone series

URBAN MOBILITY IN THE SMART CITY AGE

Schneider Electric

ARUP

THE °CLIMATE GROUP

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FOREWORD

A smart city is an efficient city, a liveable city, as well as an economically, socially and environmentally sustainable city. This vision can be realised today, using innovative operational and information technology, and leveraging meaningful and reliable real-time data generated by citizens and city infrastructure.

However, an unprecedented scale of change is needed for cities to become more efficient, attractive, inclusive and competitive. This change will require a new paradigm, which looks at the fabric of cities in a totally new way. This, in turn, requires a breakthrough in how cities, businesses, citizens and academia think and work together. The transition towards smarter cities is about reinventing cities, such that:

- **citizens** are no longer considered as users, but as **key stakeholders**;

- **technology** is no longer looked at as a static asset, but as a **dynamic enabler**;

- **business** is no longer viewed as a provider, but as a **partner**;

- the notion of urban evolution is replaced by one of transformation.

EFFICIENT, SAFE AND SUSTAINABLE MOBILITY IS A CORNERSTONE OF A SMART CITY

Urbanisation is accelerating at pace, placing new, intense pressures on city resources and infrastructure. Urban Mobility will be one of the toughest challenges for cities around the globe. In many cities, existing mobility systems are already inadequate, yet urbanisation and increasing populations will increase demand still further. Cities have traditionally sought to solve such challenges by adding new capacity to match demand. However, a capacity-building approach alone is neither efficient nor sustainable.

On top of the growing demand, mobility needs are changing and evolving, and travellers' expectations of seamless movement are becoming ever greater. Many new mobility solutions are emerging, which leverage technology to improve service provision and manage demand. A holistic response to urban mobility optimises both supply and demand solutions to facilitate more sustainable outcomes.

FROM SMART CITY TO SMART MOBILITY

In the technological era, we are facing the emergence of a new market, in which new business models and creative thinking are required to design contemporary systems based on hard infrastructure working together with operational and digital technologies; to develop the service relationships between existing and new actors; and to finance a robust and future-proof mobility system. Mobility infrastructure has been identified as the number one priority for cities seeking to attract investors, and as such it is high on the agenda for many growing cities.

As we talk to cities and experts around the world, we hear mobility articulated both as a critical difficulty and a potential source of hope to transform city operations. What is becoming clear from our conversations is the need to invest in infrastructure with a view to it serving long-term needs of 50 years or more, and not only immediate or short-term needs; the need to treat mobility as one tool to enhance economic, social and environmental wellbeing. There is a common agreement that significant investment and creative financing will be required, if mobility infrastructure is to cope with growing pressures. But, there is a consensus that we already have sufficient technologies available today to take positive steps to transform mobility systems. So what is holding us back?

This paper explores how we will move from a reactive approach to mobility services, to a proactive model that anticipates future change and takes advantage of new opportunities. We have a need for better assembly and integration of components to manage continuously changing demand and supply. Leadership, innovative finance, policy support, and citizen engagement will be essential to drive change.

This is the first paper in our series on the cornerstones of a smart city; a series which considers how we need to look at cities differently, understand the stakes and the stakeholders, to invent tomorrow's cities - together.

With the release of this study, 'Urban Mobility in the Smart City Age', our aim is to provide city and mobility decision-makers with reflections and guidance on developing and adopting sustainable strategies that meet current and evolving challenges. We also hope to engage a wider audience in this discussion.

We hope you will find this study useful, and we would be pleased to discuss its findings, conclusions and the implications for your city. Schneider Electric is working with cities around the world to deliver safer, more efficient, and more sustainable mobility in their cities.

GLOSSARY

APPLICATION PROGRAMMING INTERFACE (API)

An interface between software developers and digital infrastructure that allows software to speak to software, helping to unlock the value of large datasets and lower transaction costs for developers, cities and businesses.

DIGITAL INFRASTRUCTURE

The operational, information and communication technologies that contribute to effective management and operations of human environments, including the sensors, actuators, transmitters and cables that collect and distribute data.
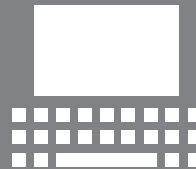
INFORMATION TECHNOLOGY

The use of computers to store, retrieve, transmit and manipulate data.

MOBILITY

Mobility describes the ability of people and goods to move around an area, and in doing so to access the essential facilities, communities and other destinations that are required to support a decent quality of life and a buoyant economy. Mobility incorporates the transport infrastructure and services that facilitate these interactions.
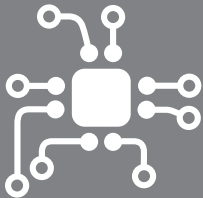
OPERATIONAL TECHNOLOGY

Hardware and software that detects prevailing conditions and enables changes in conditions, through direct monitoring or control of devices, processes and events. Intelligent Transportation Systems (ITS) are the operational technologies used in mobility systems.
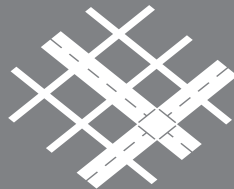
PHYSICAL INFRASTRUCTURE

The physical 'hardware' of human environments, which includes engineered assets like roads, railways and transit hubs, as well as natural assets. In this report, our focus is on the engineered assets related to mobility.

SMART

In the context of cities and urban infrastructure, 'smart' (or 'intelligent') implies a connected, technology-enabled environment, where the creative power of digital assets and information is leveraged to manage city services and improve citizens' quality of life. Smarter cities can offer a range of benefits to progress urban sustainability goals.

SUSTAINABILITY

In the context of urban mobility, sustainability refers to a system that supports social connectivity and economic prosperity in a fair and equitable manner, without presenting risks to local or global environmental quality and resource use.

CONTENTS

THE CHALLENGE OF URBAN MOBILITY

This chapter establishes the challenge of urban mobility in today's cities. It sets out why mobility is such an important element of the urban sphere, and identifies the drivers which define the need for a new approach to mobility.

Mobility underpins everything we do as individuals; as communities; as regional, national and international economies. People need to move around to secure basic human needs, but mobility is also a luxury, contributing to quality of life by enabling exploration, leisure and recreation. In the city, high quality mobility is a necessity for the success of other urban sectors and the creation of jobs, and plays a key role in cultivating an attractive environment for residents and business.

Yet mobility is widely cited as one of the most intractable and universal challenges faced by cities the world over. As urban populations increase, existing and emerging cities face the challenge of meeting rising demands for efficient mobility within limited physical infrastructure capacity. Simultaneously, citizens' expectations are changing continually, influenced by ongoing innovations around low carbon and efficient vehicle technologies and improvements in infrastructure management.

Increasingly, cities are the focus for regional, national and international economic activity and social development, drawing growing business and resident communities. The combined influence of population growth, demographic change and changing urban form leads to increasing demand for travel in city centres, suburbs and between the two. Demand for improved intercity mobility is also growing, to create faster and more direct connectivity between settlements. As demand rises, so too do concerns about transportation as one of the leading contributors to global greenhouse gas emissions, congestion, noise and poor air quality in cities.

This growing demand converges with an inadequate supply of physical transport capacity in many cities, which can result in crowding, congestion, and an unpleasant experience of the city. In established cities, this problem is attributed to spatial constraints - which inhibit additional growth of transport networks – together with budgetary limitations on physical infrastructure maintenance and renewal. Meanwhile, in many developing cities investment in infrastructure construction is struggling to keep pace with the rapid rate of urban growth.

Historically, mobility has been viewed largely as a product, which includes the vehicles, physical infrastructure and fuels required to move people around. Increasingly, however, mobility is approached as a service: the method by which we procure food, engage in economic activity, access entertainment or meet with friends and family, all through seamless movements from place to place. Already, the ways in which we fulfil these tasks are changing radically as we use mobile phones, web and video to manage our lives on the go.

These new capabilities rely on physical and digital infrastructure whose potential is only beginning to be realised. By supplementing urban planning and management practices with digital technologies, there is an opportunity to improve mobility services for citizens, while managing demand on physical transport networks and generating wider economic and environmental value

In the move towards a more sustainable transport, demand will be addressed as part of a package of long-term strategies to eliminate the negative health and environmental consequences of mobility per se. In this way, strategies will be able to bring measurable economic and environmental sustainability benefits and improve traveller experience in terms of:

- Lower fuel and power consumption by vehicles and infrastructure, leading to:
  - reduced transport-related greenhouse gas emissions; and
  - improved local air quality and related environmental conditions.
- Reductions in congestion and traveller frustration;
- A more streamlined, efficient and cost effective system to operate and maintain, leading to;
  - greater affordability for transport providers and travellers; and
  - reduced requirement for unsightly hard infrastructure in dense urban environments.

THE PROBLEM OF THE PEAK

Mobility demand in cities is highly variable over time, leading to a continual disparity between the level of service supply and demand. Cities need to be built to accommodate peak travel demand, whereas every night the demand plummets and a huge surplus of capacity is created in the network. This dynamic ebb and flow in the system is a major challenge for infrastructure and service management, as well as wider city planning.

Considering the daily cycle of transport demand set out above, an urgent challenge in the delivery of mobility is addressing the peak demand. This is a question of either increasing capacity (limited potential in many cities, as explored earlier), or redistributing demand over time and across different transport modes or routes.

One of the key challenges of urban sustainability is to maintain economic vitality while reducing resource use. While many growing cities respond to increasing peak travel demand by building new physical infrastructure (roads, rails, bike paths, etc.), this cannot be the whole solution. Indeed, new capacity may serve to perpetuate growth in peak demand. Even 'clean' capacity may not lead to the behaviour change and modal shift that cities are looking for, unless strongly supported by sufficient information, education and awareness. The key is to maximise the utility of existing and planned infrastructure by distributing demand across modes, routes and time, allowing cities to do more with less.

A holistic response will look at both the supply of and demand for mobility services, by:

• Actively managing capacity over time to make the most efficient use of existing physical infrastructure (operational efficiency); and

• Distributing reliable information to travellers about the relative costs and benefits of different travel options, thereby promoting behaviour change.

Together, these two approaches will help to reduce the peak demand for travel on any single mode or route and distribute the overall demand over time and across modes. Smart solutions can facilitate both of these objectives, especially when supported by wider policy measures that promote changes in travellers' behaviour (such as flexible or staggered working hours).

It is important to acknowledge that these two approaches do not address the fundamental need for mobility in a city. Reducing the overall need to travel remains a vital objective of urban planning practice. The approach presented here addresses the management and distribution of demand – allowing for reduced peak hour congestion and improved operational efficiency of transport infrastructure.

"The next big challenge for mobility in Vienna is to shift commuter travel on to more sustainable modes. However, the capacity of our mass transit network is already under pressure. So we need new additional approaches."
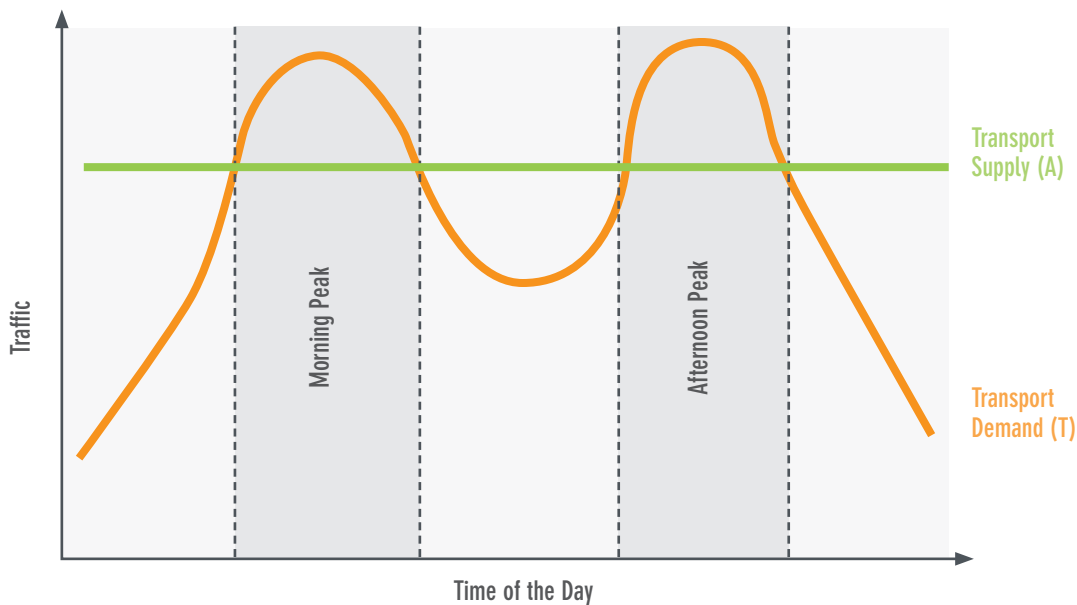
MANFRED MÜHLBERGER, CITY OF VIENNA.

THE DAILY CYCLE OF MOBILITY DEMAND

- The majority of city residents, commuters and visitors want or need to travel during short (peak) periods of the day. This places pressure on the transport system at peak times, which leads to overcrowding, congestion and a negative user experience. The supply of urban transport capacity is static over time, and must therefore be designed to absorb the peak demand as far as possible.

- However, travel demand outside peak hours is dramatically lower, creating surplus capacity in the system for long periods of the day and night. While this may provide a more comfortable and reliable experience for off-peak travellers, surplus capacity implies an over-engineered transport system and under-utilisation of physical infrastructure. This is not conducive to efficient operations. It is a costly outcome for cities - who must finance redundant operating capacity - and for the environment, which must absorb higher average emissions per traveller.

Average urban transport demand over 24 hours

(Source: Hofstra University, New York).

Traffic

Morning Peak

Afternoon Peak

Transport Supply (A)

Transport Demand (T)

Time of the Day

SUMMARY

Urban mobility is one of the most intractable challenges faced by city governments, presenting economic, social and environmental implications. The provision of physical infrastructure is fundamental to enable mobility, yet there is a tipping point at which additional supply will no longer provide an efficient means to service demand. Patterns of mobility in many cities mean that there is significant under-utilised capacity on existing infrastructure for long periods of the day. As part of a package of measures, smart solutions can help to improve the efficiency of the system and redistribute demand across modes, routes and time. The following chapter discusses some of the existing solutions available to support these objectives.

On a 15-mile stretch of the U.S. 75 highway corridor in Dallas, Texas, a groundbreaking integrated corridor management project is being unveiled with the objective to mitigate the chronic traffic congestion that has plagued the route. Integrated management takes advantage of multiple transport modes, including automobiles, buses, light rail, and even walking, to manage the movement of people more efficiently across modes. Information from all modes is consolidated through data analytics and a single platform, to maximise the total flow of people over time. This relies on a wide range of data collected from sensors along the roadway and rapid transit systems, smartphone Global Positioning Systems (GPS), and real-time information feeds about road closures, maintenance works and weather conditions. By assimilating these data feeds, travellers can be provided with instant information via the Dallas-Fort Worth 511 service provided by Schneider Electric, about the optimal route to their destination, whether by car, another mode, or a combination.

The project is projected to cost around $8 million in capital expenditure, from which an estimated $80 million can be expected in travel time savings, fuel savings, emissions reductions and enhanced quality of life. This testifies to the huge economic, environmental and social benefits that can be reaped through improved use of digital solutions.

THE PROMISE OF
SMART MOBILITY →

2

THE PROMISE OF SMART MOBILITY

This chapter explores the potential for smart mobility to meet the challenges set out in Chapter 1. It explains how smart mobility can lead to more efficient use of transport infrastructure, and alter the way people use transport services by equipping them with more and better information.
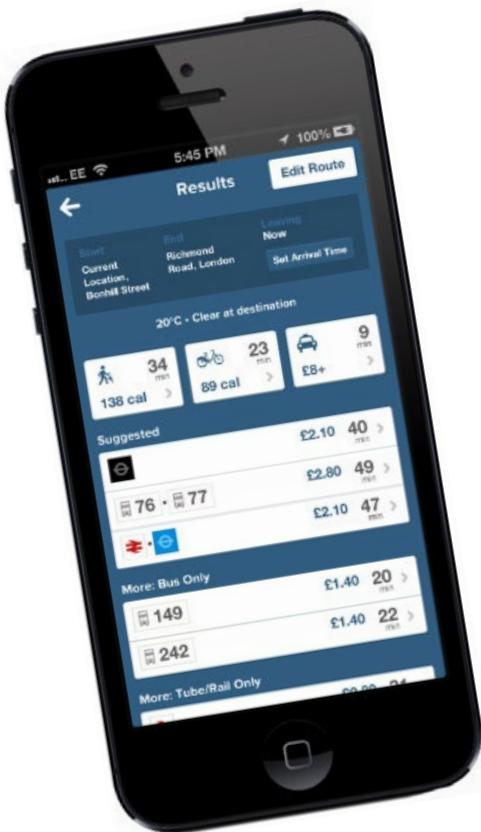
Smart mobility services and user groups

Service type	User groups		
	Travellers (citizens and businesses)	Transport operators	Urban planners
Smart parking e.g. SFpark	Improved ability to locate best available street parking, based on price and proximity.	Improved ability to manage street parking, reduce congestion and enforce fines.	Use data to plan parking provision based on demand.
Smart ticketing e.g. Oyster card, Suica	Easier payment for transport services across modes.	Benefit from faster payments and greater integration of payment systems across modes.	Use data to plan future infrastructure and service provision based on demand.
Real time journey planner e.g. Citymapper, moovit	Ability to plan A to B (to C) travel in real time.	Use data to plan future operations. Use as a mechanism to influence traveller behaviour and distribute travellers across modes.	Use data to plan future infrastructure and service provision based on demand.
Command & control centre e.g. Minnesota Urban Partnership Agreement.	Receive in-journey information via Variable Messaging Systems (VMS) to help manage travel expectations and route plans.	Improved ability to actively manage traffic and travel in real time based on prevailing conditions and predictive analytics.	Use data to plan future infrastructure based on past travel patterns under different conditions.
Bicycle sharing service e.g. Barclays Cycle Hire, Vélib', Bicing.	Availability of 'grab and go' bikes throughout the city, providing an alternative mode of travel as well as linking modes, especially for 'last mile' connections.	Ability to distribute travellers across more modes, reducing excessive demand on a single mode.	Use data to plan future provision of cycle infrastructure (bike locations, bike lanes, etc.).
Car sharing service e.g. Lyft, Zipcar	Availability of 'grab and go' cars throughout the city, providing an alternative mode of travel as well as linking modes.	Use traveller data (if available from private actors) to guide service management.	Use traveller data (if available from private actors) to guide infrastructure planning.
Taxi booking service e.g. Hailo	Convenient access to taxi services, perhaps providing a choice of fuel type, at any place or time.	Use data to inform taxi fleet management and influence other public transit services.	Use data to inform infrastructure planning and public policy.

SMART MOBILITY PRODUCTS AND SERVICES

The technologies and services that enable smarter mobility have a range of capabilities that benefit travellers, service providers and urban planners alike. Many of these products rely on real time data to offer integrated information services (such as real time journey planning or command and control facilities).

Individual travellers and service providers are already taking advantage of smart technologies and services in many major cities, albeit on a piecemeal basis and in a marketplace largely formed of small private actors. In few cases have city governments and urban planners sought to maximise the economic potential of the data and services that these private actors are creating.

The table outlines the types of services that are increasingly becoming available, and the benefits that different users can access.

WHO BENEFITS?

Illustrated by a few existing examples, this section outlines four key benefits available to the main potential user groups for smart mobility solutions:

1. **Travellers:** Enhancing the travel experience in urban areas and improving the reliability of journey times and costs for citizens and businesses, to create a more liveable and humane city;
2. **Transport operators:** Balancing demand and supply to secure improved functionality, allow more efficient use of transport resources, promote alternative modes of travel and secure a more environmentally sustainable outcome for urban transport systems;
3. **Urban planners:** Improving future infrastructure planning and transport service provision on the basis of real and modelled data about traveller demand and behaviours;
4. **City governments:** Generating economic growth from the development of an economic sector focused on technology, data and information.

Together, these benefits contribute to the advancement of an urban sustainability agenda based on principles of functionality, ecology, humanity, politics and economics.

CITIZENS: ENHANCING THE USER EXPERIENCE

New citizen facing solutions are appearing that enable people to:

- access real time information about their journeys;
- share resources (cars, lifts, parking); and
- pay for multiple stages of a journey at once, without cash.

These services are helping people to manage their use of transport more effectively, and contributing towards better modal integration. This section explores in more detail what each of these services means for citizens, investigating examples of where they have already been deployed around the world.

Real time journey information

Information services have the potential to improve the traveller experience substantially:

• Users can select travel options based on personal preferences, such as cost or convenience.

• Travellers can re-gain control over their own journey time and make adaptive choices to avoid system failures.

• Overcrowding and congestion can be avoided, which improves traveller comfort.

• Travellers can make productive use of journey time by accessing online services as they travel.

Information also helps service providers to raise awareness about the range of alternative travel modes available, thereby promoting lower carbon and more active options to conscientious travellers. Awareness is recognised as a key driver of modal shift.

These benefits depend on the capabilities to monitor and assimilate real time system performance data, and distribute personalised travel information. Real time information across all transport modes and services can be aggregated with city maps, pricing information, calorie counters and personal calendars to enable instant evaluation of the best route from A to B at any time of day. By accessing this information, individuals can manage their own 'personal peak demand', by choosing to travel by modes or routes with greater capacity, or at times when journeys will be faster (assuming lifestyle routines are flexible to allow this). Journey planning services therefore help to shave the peak demand for any transport mode through rational decision making by individuals.

"Life changing. This app really changes the way you travel through London."

"Absolute genius! What I've been waiting for. A 'take me home' function which scans every mode of transport from where you are! I'm writing this from a bus I've never heard of that picked me up from a bus stop I've never been to and it's taking me to my road!"

CITYMAPPER APP STORE REVIEWS, 2013.

Citymapper is an integrated real time journey planning application which has successfully launched in London and New York. The online and mobile service incorporates routes across the city using all public transit modes, bike share programmes, pedestrian routes, real time service updates, together with pricing information and estimated calorie use. Citymapper not only enables instantaneous evaluation of the optimal route of travel from A to B, but it improves people's travel experiences and increases their confidence in public transport services. It makes travelling through cities easier and more efficient than ever before. In August 2013, Citymapper was the third most popular free navigation app in the iTunes store, after Google Maps and NavFree, despite only covering one city in the UK. Reviewer comments demonstrate the improved travel experience that the service facilitates.

$28 million

Moovit offers a similar service to Citymapper, though it augments public transport information with crowd sourced data, collected anonymously from users. Users can receive and share live data, improving the accuracy of the route and location information offered by the application. Moovit recently closed a $28 million funding round, demonstrating investor confidence that the application will continue to grow its user base[1].

Sharing resources

The popularity and effectiveness of resource sharing is already being demonstrated through the success of familiar car sharing and bicycle sharing initiatives internationally. A significant decrease in car ownership amongst car sharing users in the United States[2] demonstrates the confidence people have in such schemes, and the benefits available from resource sharing. Studies in the United States show that each car-sharing vehicle replaces 9-13 privately-owned vehicles[3]. The average car-sharing participant reduces his or her driving by 27-56 per cent[4].

Peer-to-peer lift sharing schemes based on social media platforms are becoming more widespread, for example Zimride linking intercity drivers with passengers in the United States, and BlaBlaCar in Europe.

Car sharing service provider, Zipcar, partnered with Croydon Borough Council, London in 2012 to provide car club services to council employees. This programme successfully helped the Council to reduce car travel costs by 42 per cent, and also cut employee business miles by 42 per cent per year[5].

In a similar initiative, ride sharing service network operator, Zimride, has expanded its service network by partnering with over 100 universities and corporations in the United States, and helped its registered users to save over £50 million in vehicle operating costs such as fossil energy, insurance and maintenance[6].

Both of these models utilise real time data as part of an online booking service for users. Partnerships provide start-up mobility providers with stability and consistency in their future customer base, to support ongoing business growth.

Payment

Smart payment and ticketing services also contribute to the user experience and the convenience of sustainable travel decisions. Smart ticketing offers benefits in reduced queuing time for travellers and a more convenient way to hop from one mode to another.

Smart solutions are becoming widely adopted as the way to pay for multi-modal mass transit systems in many parts of the world. It is also becoming common to widen the use of smart cards to include electronic payments in retail outlets, thereby further embedding the ticketing solution as a convenient urban payment system. The Octopus card in Hong Kong, Easycard in Greater Taipei, and Suica in Greater Tokyo have all adopted this model and are now used by a high proportion of their respective city populations. Each time a card is swiped for payment anywhere in the city, new useful data is generated about user demand.

With the maturity of Near Field Communication (NFC) technology, mobile payment via smart phone is emerging as the next generation of smart payment and ticketing solution. Beijing has been using NFC mobile payment since June 2013, enabling citizens to store payment cards on their NFC enabled smart phone. Travellers need only swipe their smart phones to make a payment on the public mass transit systems, taxi and in many retails outlets in Beijing.

Taxi hailing apps such as Hailo or Uber also allow passengers to pay for cars through their online platforms. The platform owner makes sure that the drivers get paid, minus a transaction fee. The experience for the passenger is seamless.

"Integrated real time transport information services can improve the reliability and the user experience of public transport services. Through making transport service information easy to access and in real time, it can encourage more citizens to travel through cities by using public transport as much as possible"

MR TSE–YING LIN, FORMER COMMISSIONER OF TAIPEI CITY TRANSPORT AUTHORITY.

TRANSPORT OPERATORS: BALANCING TRANSPORT DEMAND WITH SUPPLY

Command and control centres have the capability to aggregate real time operational data from across the transport system, interpret current conditions and predict the future on the basis of past trends. These capabilities enable rapid response to sudden increased demand in the system and avoidance of excessive peaks.

For example, where severe congestion inhibits traffic flows along a road, command and control centres distribute advice about alternative routes to avoid back-up of vehicles in the surrounding road network. Or, where a major event causes high demand for bus travel, command and control centres direct operators to increase capacity by adding more vehicles into the system.

Demand-responsive strategies can also advise service providers to adjust the types of vehicle in use according to estimated or detected public transit needs, enabling optimisation of fleet and costs together with emissions reduction according to daily variations, without affecting the perceived quality of service.

This dynamic management of transport systems means that supply can be matched with demand in real time, improving the functionality and environmental sustainability of the system.

Service providers also make use of demand-responsive pricing as a different type of management solution. Demand and supply information is used by operators to adjust the price of mobility services at different times of the day or in different areas of the city. This creates economic incentives to travel outside of peak hours or by alternative modes/routes where possible, therefore helping to distribute the peak demand.

As tools become more sophisticated, transport operators will be able to communicate predictive information to travellers, to influence passenger demand. A project in Paris is already seeking to use predictive modelling to give people better information about their journeys and influence their overall use of the system.

£4.4 million

Could be saved if the TCC were to be established permanently

During the 2012 Olympic Games in London, the Transport Coordination Centre (TCC) facilitated active sharing of information and coordinated incident response procedures between multi-modal transport providers (Transport for London, Highways Agency and London Emergency Services Liaison Panel), existing Traffic Control Centres in London, Games Organisers and their stakeholders.

The value of the TCC was demonstrated during an incident on the London Underground during the Games, which caused complete closure of a section of the Central Line for around five hours. It took 11 minutes for a re-routing recommendation to be planned by the TCC and broadcast across the remaining network and in the Olympic Park. Based on this incident, it was estimated that £86,000 in time savings benefits may be attributed to the TCC for an incident of that scale. If the TCC were to be established permanently, its intervention in one such incident of similar scale each week could contribute around £4.4 million in time savings benefits annually [7].

The approach taken by the TCC is replicable to handle many smaller everyday challenges, either scheduled or anticipated by analytics.

An initiative of the City of San Francisco, SFpark uses sensor technology (smart parking meters) and wireless communication technology to collect and distribute real time information about the number and location of available parking spaces in San Francisco. SFpark operates both as an information service in its own right, and also makes its data available as an API for use by public and private developers. SFpark uses demand-responsive pricing to open up parking spaces on each block and reduce circling and double-parking in congested areas. Parking fees may vary by block, time of day or day of the week, fluctuating by no more than 50 cents per hour down or 25 cents per hour up. Rates are determined based on the lowest possible hourly rate to achieve the right level of parking availability; San Francisco set a target occupancy rate of 60-80 per cent. In areas and at times where it is difficult to find a parking space, rates will increase incrementally until at least one space is available on each block most of the time. In areas where open parking spaces are most plentiful, rates will decrease until some of the empty spaces fill. Pricing changes are calculated on the basis of a transparent policy[8].

"Occupancy data in the first year of the program suggest that SFpark has made considerable progress toward solving the important problems of severe overcrowding on some blocks and very low occupancy on others"[9]

SF PARK PRICING REVIEW.

Snips is a contextual modelling company which is engaged in a project with the French national rail company SNCF. The project focuses on public transport management in the Paris region, using apps to help people in Paris decide when and how to travel in order to achieve a more comfortable journey. Apps give information about how many people are expected to be using a particular train and whether a passenger is likely to get a seat, or if it is better to wait for the next train. This capability is useful for travellers and also provides better prediction for service providers like SNCF.

The app uses contextual modelling to enable prediction of behaviour during specific conditions and combinations of conditions. Variables such as the day of the week, weather, current events in the city and network disruptions can be combined in a single model. This is then used to create an understanding of different dynamics and how they work together to influence travel patterns.

Snips is also developing a project which will help users find parking spaces in Manhattan. The project will rely on contextual modelling to make predictions about parking availability, requiring no additional sensor hardware.

URBAN PLANNERS: IMPROVING PLANNING
THROUGH PREDICTIVE MODELLING

Planners have the opportunity to use the vast amounts of data generated by public and private actors to improve the planning and delivery of transport services and facilities to citizens, by using data to identify and address problems. The full range of opportunities available to planners is only beginning to be recognised, and is moving gradually from the research forum to become an integrated part of urban planning practice.

Mobile phones, parking sensors, congestion charging zones and smart card ticketing all yield valuable data about how and when people are moving around the city, and how these patterns are affected by variables like traffic, weather or public events. Supplemented by social media, aggregated data can also provide details of citizens' thoughts and feelings about places and experiences[10]. Personal privacy is ensured through anonymisation of the data, before it is made available for use.

Increasingly, mobile phone data is being used to improve transport modelling practice. Mobile phone datasets comprise anonymous information on users' origin, destination, route and mode of transport, and journey time. In the developed world, these data are being used to validate models, to confirm that they are replicating real-world behaviour. As confidence grows in their reliability, they can replace expensive and disruptive road-side interview surveys as the primary data source. They can also be updated more regularly, meaning that base year models can be kept current.

In the developing world, there is often very little reliable travel demand data available, so mobile phone data can revolutionise the analysis of travel patterns and planning of urban transport systems. For example, in 2012 Orange Telecom initiated a project called 'Data for Development Challenge', which provided a mobile phone dataset for five million of its customers in the Ivory Coast. These data were used by a research team to build 'the best possible' transport model of the Ivory Coast using only the mobile phone data and publicly available mapping (e.g. OpenStreetMap).

The outputs provide an insight into travel patterns across the country and have the potential to provide a modelling tool to test the effects of infrastructural changes in the relatively short term. The project showed that, in developing countries where the `conventional' data required for transport planning is virtually non-existent, new sources of data can be exploited to provide insight into travel behaviour that would otherwise have been impossible to achieve[11].

With the right skills and software capabilities, this massive anonymous data bank can allow urban planners to understand the detailed use characteristics of city facilities and services, and to create places that are tailored to the people who use them. Simulation and parametric design tools are becoming increasingly sophisticated and user friendly, allowing predictive modelling to inform future design. Using sensor-derived real time data, different planning conditions can be quickly tested and simulated.

By utilising data in planning, planners have the opportunity to create a more humane and functional urban environment, which responds to the evolving needs and expectations of its populace.

Singapore's Land Transport Authority (LTA) plans and manages transit systems, roads and related facilities in Singapore. In response to the rapid growth in public transport data available to inform urban planning, the LTA — together with business and technical partners — has created a large central data warehouse, called Planet. Planet pools data from various business sources and supports queries based on three years' worth of public transport transactions. Planet provides new ways to view the data collected from across the system, and allows predictive analysis. The transaction data that feeds into Planet includes information about ridership and journey times, which enable users to:

- Formulate, validate and refine land transport policies.
- Locate transport facilities, such as seats and shelters.
- Optimise operations, such as passenger loading and frequency.
- Support the LTA's metrics-based regulatory framework.

Use of the system expanded to analyse areas of congestion in the land transport network with spatial analytics. Intermodal data can be analysed with advanced predictive algorithms of travelling patterns, whether by car, bus or train, to understand the impact of traffic on commuting.

Planet is allowing the LTA to set strategic plans for the future via a more complete view of the land transport planning model[12].

CITY GOVERNMENTS: GENERATING JOBS AND ECONOMIC GROWTH

Economic growth can be derived from every aspect of a smart mobility system. At the most basic level, the improved functionality, user experience and environmental sustainability of the system serve to create a city that is more attractive to business investors and new residents, and which supports the smooth running of local and regional economies. For governments, smarter systems imply greater control over operations, improved monitoring and targeting of maintenance investments, with consequent cost savings. In London it has been estimated that real time mobile transport applications could save end users £15 to 58 million in terms of time saved per year, due to reductions in traffic congestion and improved functionality of transport systems[13].

Furthermore, it is estimated that global economic value of $720 to 920 billion per year could be generated by utilising open data to develop new digital transport applications[14]. These economic benefits rely on the collection of increasingly accurate and comprehensive real time data via operational technologies, and the ability to distribute that data via state of the art information and communications technology (ICT) networks. Continual innovation in these sectors promises ongoing growth in software applications and the proliferation of economic activity related to data processing, analytics and simulation. New private and public-private business models are emerging around information services, which would not have been possible without big data.

San Francisco is beginning to collect transport data from a range of sources, including the network of private taxi cab operators and increasingly prevalent corporate buses. The taxi data will be used in the short term to improve taxi dispatch, and there is an ambition to incorporate more modes in the city to take advantage of the potential for innovation.

"You can see innovation that has happened as a result of data. Just from looking at patterns. It's a no brainer."

SAN FRANCISCO DIRECTOR
OF TRANSPORTATION POLICY,
GILLIAN GILLETT.

SUMMARY

The rise of new technologies and information based services in the mobility sector offers a range of valuable responses to the challenges of operational efficiency and personal travel demand in cities. Benefits can accrue to travellers, transport operators, urban planners and city governments, who together can enable improved system functionality, environmental sustainability, traveller experience and new economic value. The following chapter describes the components of a smart mobility system, which enable this value to be created.

"Live information about every detail of the transport system means that users don't have to guess when the next bus will arrive or what is the most efficient route from A to B, a development that has been estimated to generate a value of £15–58 million per year in time saved for users of Transport for London[15]."

SHAKESPEARE REVIEW,
AN INDEPENDENT REVIEW OF
PUBLIC SECTOR INFORMATION, 2013.

"Someone's commute is always seen as the worst part of their day and a negative experience. We're trying to change that… We're interested in the experience with the individual and the city, and how the smart phone empowers an individual to experience their city."

CITYMAPPER FOUNDER, AZMAT YUSUF[16].

THE PROMISE OF
SMART MOBILITY →

3

THE STRUCTURE OF SMART MOBILITY

Chapter 2 considered some of the services that arise from a smart mobility system, and the value that these products can create for travellers, transport operators, urban planners and city governments. Here, we consider the toolkit for building a smart mobility system, which enables the creation of smart services.

The smart mobility system can be conceived as a number of 'layers', each of which depends on and adds value to those beneath and above it.

PHYSICAL INFRASTRUCTURE

The whole system is underpinned by the physical infrastructure of urban mobility; that is the roads, railways, bike paths, footpaths and other physical assets that enable transport to operate. The data and information that support smart mobility are generated continuously from dynamic patterns of human behaviour as people navigate the city using the available infrastructure.

OPERATIONAL TECHNOLOGY

Operational technologies generate the raw material required for smart solutions: the data. They allow real time collection and communication of raw data from physical infrastructure and services, and rapid adjustment of infrastructure management to create additional capacity where it is needed. Such technologies are already installed in many cities to direct traveller behaviour and maintain traffic flows, therefore contributing to increased operational efficiency on the network.

Intelligent Transport Systems (ITS) encompass the range of operational technologies used for transport management, including the sensors, payment and ticketing infrastructure, surveillance, remote controls and display equipment that are employed along transport routes to monitor and manage travel conditions. Increasingly, ITS also utilises the mobile monitoring technologies installed in vehicles or carried by individuals. Every smart phone in the city is a roaming source of information and private actors such as INRIX, TomTom and NAVTEQ are already using crowdsourcing techniques to capture real time travel data for use in operational controls. TomTom's MapShare, Google's Waze and NAVTEQ's Trapster features harvest information from the user community to provide live information about traffic congestion to their customers, and to inform updates and fixes to their base maps used for navigation and location-based control platforms.

ITS equipment continuously generates new data and information about the transport network, and allows transport operators to make immediate interventions to manage traffic and travel.

COMMUNICATIONS TECHNOLOGY

Wi-Fi, 3G, 4G and Bluetooth channels are fundamental for real-time communication of location-based data from machine to machine (the 'internet of things'), and between human operators, data processors and information consumers. For example, data is communicated from operational technologies to command and control centres, where it can be used to enable instant responses via remote controls.

There are over 6 billion mobile phone subscriptions in the world[17], held by customers who are already using cellular technologies to give and receive information. More than 1 billion of these are smart phone owners, and this number is growing by 42 per cent each year[18]. In many countries, the speed and extent of wireless network coverage, together with the protocols governing wireless use, are major limitations to the quality of data available from operational technologies. Hard-wired communications will play a role in some cities, where existing fibre installations are more effective than wireless channels.

INFORMATION TECHNOLOGY

Data is collected and aggregated by public and private sector actors engaged in data processing, anonymisation, analytics, contextual modelling, simulation and software programming. These specialist data handlers take advantage of the vast supply of city data and information from operational technologies to create innovative software applications and interfaces for users. These applications are pushed out to users via communications networks, providing useful information to influence network operations and demand. The software response to urban mobility is currently the more dynamic area for growth in the mobility market, with many new players proposing innovative ideas to influence travel management. While operational technology is already well understood and adopted by many city governments and transport operators, its role in supplying data for software innovation is only just being recognised. Many cities are only just beginning to embrace the potential of software solutions. Some of the existing applications were outlined in Chapter 2.

SUMMARY

The smart mobility system requires a variety of infrastructure types, including physical infrastructure, operational technologies, and communication and information technologies. Without any single component of this system, smart mobility products cannot meet their full potential to manage operational efficiency and user demand. Coordination and integration between different layers in the structure allow improved operational efficiency, as well as new products for demand management.

The structure of smart mobility
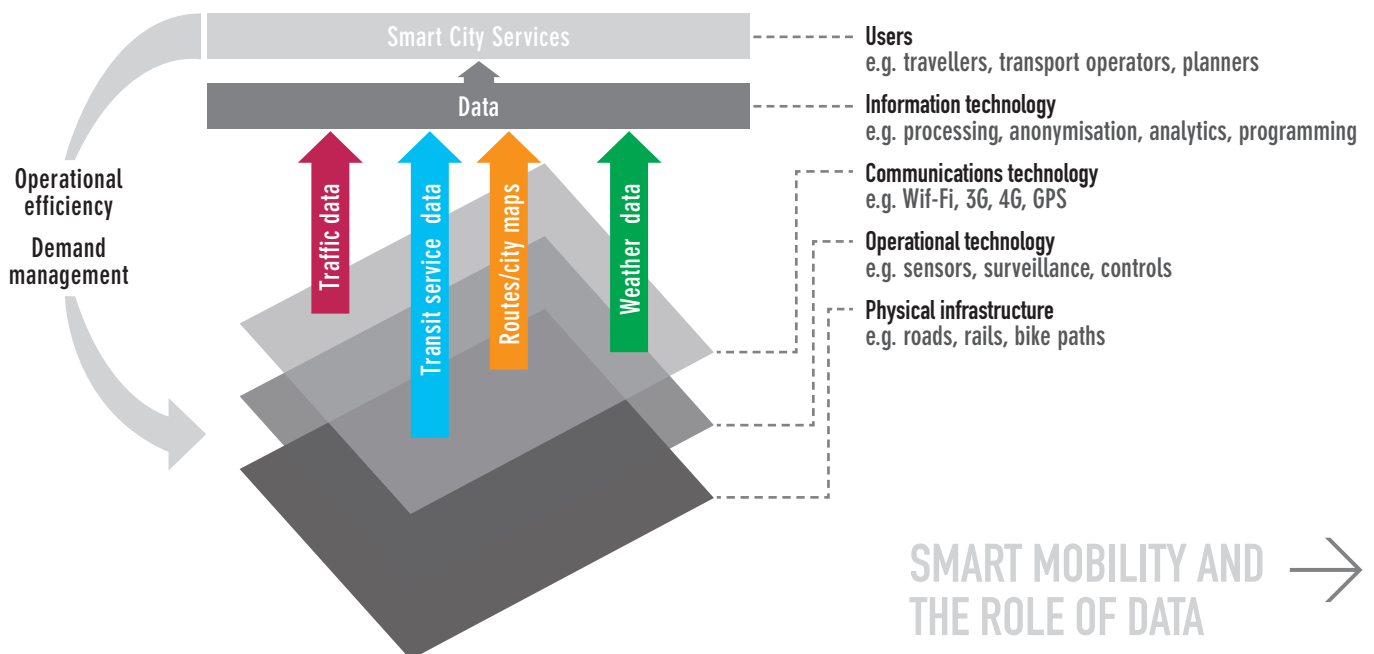
SMART MOBILITY AND THE ROLE OF DATA

Chapter 3 described the technology foundations of smart mobility solutions, and introduced the concept of data as the raw material for new mobility services. This chapter describes how smart mobility services are made, focussing on the role of data. This chapter explains how data is used and services are created through an information value chain that brings together stakeholders from across different sectors and verticals. This will help city government, transport operators and industry understand how they need to start thinking about data and operational technologies when commissioning new services—either infrastructure like control centres, or transport modes such as new bus contracts—to allow additional economic and social value to be created.

Value chain for sustainable urban mobility

Data source	Raw data	Information component	Information services
Public transport service providers	Location and time of use Journey time Routes Passenger flow Service status Cost Potential delays	Live departues for public transport services Time delay of public transport services Passenger flows of public transport service by time, location, route, service Mapping vehicle flow by time and area Usage patterns of bike sharing service and car park by time and area Usage patterns of and EV charging network by time, area, type of EV and type of charge point	Real time transport information and journey planning service: eg. - Citymapper - DB Navigator
Private transport service providers	Location and time of use Service status Availability Journey time Cost Number of vehicle Routes	Usage patterns of car sharing by time location and area Supply and demand on taxi, car sharing and ride sharing by time, location and route	Command and control centre: eg, - Barcelona - Dallas - London - Madrid - Rio de Janeiro
Citizens	Real time location Date / time Movement Communication pattern Service accessed	Mapping or virtualising traffic movement in cities Mapping traffic congestion patterns in cities Traffic control and route modelling Road traffic and emergency analytics	Access to travel choices: - Taxi, e.g. Hailo, Uber etc. - Bike sharing e.g. Barclays cycle, Ubike etc - Car sharing, e.g. Zipcar, DB Navigator - Ride sharing, e.g. Zimride, Blabla car etc.
City areas and maps	Weather data Environmental data Usage patterns Demographics Routes Geospatial information	Demographic of mobile internet usage Spatial usage of streets and neighbourhoods by time and date People movement patterns	Parking / charging point service with dynamic pricing: - SFpark - Park Right
Police, borough, public and other stakeholder	Faults of traffic control equipment Emergencies / incidents		

DEFINING THE INFORMATION VALUE CHAIN

The information value chain describes how an actor or series of actors takes raw data and adds value through various processes to produce information products and services. The value chain starts from the implementation of operational technologies, through the processing of raw data and development of information services. This chain generates value not only from the end product, but at each stage and through each flow of information in the process. An understanding of the value chain helps to recognise the business models for the activities that make up a smart mobility solution, to see what gaps in provision there might be, and to understand how the various actors can work together.

The stages of this simplified value chain are:

• Data sources
• Raw data
• Information components
• Information services

The next section explains each stage and the business models associated with them in more detail.

STAGES IN THE INFORMATION VALUE CHAIN

DATA SOURCES

Data comes from the public and the private sector. The technologies to collect this data will include Intelligent Transport Systems (ITS), mapping systems, social media such as Twitter and Foursquare, and so on. Citizens may also choose to allow their location data to be crowdsourced to provide alternative sources of passenger or traffic data. Alternatively, their data may be collected by other actors (e.g. telecoms or satnav system operators) and anonymised to preserve privacy. This data may be owned by city governments, by the transport operators or by private operators of sensors and data platforms.

Public data sources

A key enabler of the value chain for smart mobility services is a city's upfront investment in ITS and other intelligent infrastructure that generates key raw data. Developing cities are likely to incorporate ITS in the process of building out their transportation infrastructure, meaning that the specification of intelligent infrastructure could present little additional cost to the city. Developed cities are already seeing ITS as a cost effective way to improve the management of existing infrastructure, and they are increasingly incorporating intelligent assets as part of system maintenance and renewals. The business case for these systems should include the potential economic benefits available from data.

The specification and procurement of intelligent assets not only promotes growth of a new technology manufacturing industry, but also the development of new data and information services. The availability of public data provides greater certainty in the value chain, enabling new industry to grow up around the promise of robust and comprehensive data.

Private data sources

Useful data will also come from telecoms operators, satnav operators and private operators of sensors.

In particular, GSM (Global System for Mobile Communications) location data retrieved from mobile phones, provides information on the location of a phone throughout a journey, giving the origin, destination, route and time of travel. This has great value for those interested in planning for the mass movement of people, such as transport modellers and transport operators, to inform model development and service planning.

Inrix is a company which specialises in real-time traffic data. Inrix collects location data anonymously from Global Positioning System (GPS) enabled mobile phones via telecoms operators, cars via satnav operators, and service vehicles equipped with GPS locators. The location data is used to produce real time traffic information, and to inform forecasts of traffic levels. The scale and volume of data collection is impressive, with an estimated 100 million devices providing data on 1.8 million miles of road network. Inrix data is utilised by Google Maps for its traffic and travel times predictions, as well as the majority of the top navigation apps in the Apple App store.

Navigant Research estimates that global investment in smart transportation systems, between 2012 and 2020, will total

$31.1 billion

Most of this investment will be in intelligent traffic management systems[19].

Crowdsourced data

Crowdsourced data can be private or public. An example of public crowdsourced data is OpenStreetMap, a collaborative map which is now being used by many applications and services worldwide.

Waze is a routefinding app for drivers, which relies on data crowdsourced from its user community. Real time traffic information is collected from users as they drive, and used to optimise routes for other drivers. The app allows users to report incidents hands-free while driving. Suggested routes can be automatically adjusted in real time to reflect changes in conditions or traffic incidents. Waze is a good example of a community of users willing to opt-in to anonymous data collection in order to receive and improve a service.

RAW DATA

The raw data generated by intelligent infrastructure provides a rich raw material resource, encompassing information about journey time, usage patterns, service availability and other transport system characteristics. Data generated through ITS and other investments in operational technologies are generally a by-product of the primary purpose of that investment—to operate and control transport assets. This raw data may be owned directly by the city, by their agencies, or by the commercial organisation operating infrastructure on behalf of the city or directly for citizens. Therefore there will be different business models associated with the raw data.

Public agencies, including city government, are seeing the economic value in making their data available at no cost. In the UK, the value of public sector information to consumers, businesses and the public sector in 2011-2012 is estimated between £6.2 and 7.2 billion (including social value). Governments around the world are seeking to encourage private enterprise by making data available as a raw material for information services. Transport agencies are also seeing benefits in avoided cost by making data available. Third party developers create apps and services for citizens based on their raw data, which means they no longer have to build or maintain these services. Transport for London is one public agency that has made transport data available for public use, which has helped to kick-start the value chain for information services in London's mobility sector.

For private data owners, this raw material may be a saleable asset in its own right. The market for raw data comprises private enterprises engaged in data processing, analytics and Application Programming Interface (API) development, together with academic and research organisations. ITO World is one private enterprise specialising in transport data management, virtualisation and analysis, which provides solutions to transform raw data into meaningful information packages. Private data owners such as telecoms operators are seeking to monetise the data they hold in various ways. Telefonica recently set up a data analytics division to sell insights about its customers' movements to retailers. Many telecoms operators also sell anonymised raw data to satnav operators.

Government and public agencies will not control all the relevant data, some raw data will be held by private organisations. Business models around sharing of private data are nascent. One example is Motionloft, a private operator of location sensors, which is sharing certain datasets with the San Francisco datastore[21].

The European Commission estimates the potential economic value of reusing public data in the European Union at [20]

€27 billion

INFORMATION COMPONENTS

While raw data alone may have few direct applications on the ground, the information components derived from data analysis have substantial value in guiding urban planning, transport system design and service management both in real time and for the future.

Information components are generated through data processing, which may be completed by the infrastructure owner or by a third party. Where a third party is involved, economic value is created by the purchase and supply of a processing service. For example, Google has turned its proprietary Google Map API into one of the most widely used components of mobility information services. In turn, the information component itself generates value through its direct application in urban planning and service provision, or through its transfer and use by another entity. Open Cage Data in the UK markets customised geodata packages extracted from the crowdsourced OpenStreetMap, making it easier to use and solving issues of quality and duplication.

Transport API is the UK's first open platform dedicated to transport solutions. The private company draws on open data feeds from key industry sources, such as Traveline, Network Rail and Transport for London, including national timetable, departure and infrastructure information for schedules, live departures and archived service running across all transport modes. Real time insights are generated through analytics across the full range of available data. Transport API sells information packages via monthly subscription or a 'Price Per Hit' plan to web and app developers like Citymapper and the Greater London Authority, and a transport widget for use in travel portals, local websites and business planning[22].

INFORMATION SERVICES

Information services are the final product in the value chain, and have the greatest potential to generate value directly for individual travellers (citizens and businesses) and transport operators. Information services may be developed through the acquisition of private, purchased or freely available information components. Various smart mobility services were described in Chapter 2. But how do they make money?

Business models for the newer services are still developing, but there are six main categories. Many services depend on a mixture of several revenue streams.

- App sales
- Venture capital funding
- Transaction fees (paid by transport operator)
- Transaction fees (paid by transport user)
- Sponsorship
- Consultancy fees.

Open data enhances the value of information services by allowing developers to access a greater number and range of useful information components, without major start-up costs. Many information services are, in turn, freely available either in whole – where finance is provided by investors or advertisers – or to a specified level of service, with enhanced service chargeable by user subscriptions. Thus, economic value is created for the developer. Ultimately, developers may sell shares in their business to generate additional revenue, or otherwise sell the whole company.

In August 2013, Uber, an app-based taxi booking service, raised a new round of financing at a $3.5 billion valuation.

Uber is growing 18% month over month and is this year[23] reportedly generating

$125 million

While services like Citymapper allow individuals to select travel based on the end to end journey cost (therefore offering a cost saving potential for the user), others have a more significant revenue generation potential. The peer to peer car sharing scheme, RelayRides, enables individuals to offer their personal vehicle for shared use by others in the RelayRides community, with a rental fee charged to the borrower. The RelayRides app for smart phones is the centrepiece of the service, enabling borrowers to find lenders in their local area, request a rental and pay the charges. Monthly fees have been estimated to generate up to $600 per month in additional income for those who offer their vehicle for use.

> "Mr. Santos uses his Toyota RAV4 only about 15 hours a month for grocery shopping and other errands. At other times it is available for rental at $10 an hour – $1 less than a Zipcar parked nearby, he said. RelayRides takes a 15 per cent share of the rental fee. 'I'm making some cash from the car,' said Mr. Santos, who has been earning $200 a month, more than enough to cover his insurance, fuel and other costs."

RELAYRIDES, REVIEWED BY THE NEW YORK TIMES, 2010[24].

ACTORS

The value chain for information services connects actors who each play a part in generating value[25] and who also benefit from different types of value creation. Each actor moves in and out of the value chain in a fluid way, taking different roles at different stages in the process. For example,

- Travellers (citizens and businesses) contribute data through their use of city infrastructure, mobile technologies and information services. They also benefit from the use of these facilities by gaining improved access to city services, employment, friends and family.

- Regional, national and international organisations establish standardisation of procedures, data generation and interaction, to assure best practices, interoperability and productisation, aimed to improve efficiency and reduce costs.

- City governments set policy and regulations around data collection and data sharing, invest in digital infrastructure, collect data from citizens and city activities, and use that data to inform urban planning, design and operation.

- Transport operators include public sector agencies and their suppliers, which specify, install and operate digital infrastructure, collect and analyse data, and use that data to inform service planning and delivery.

- Private businesses include those that own and operate digital assets on their own property and gather data from those assets, as well as organisations that create economic value from their activities in data processing, analytics and information service development, both international corporations and start-ups.

Each individual role is essential to the creation and multiplication of value. A key challenge in the delivery of smart systems comes in enabling actors to fulfil multiple roles effectively, and capturing the added value generated by each new contribution. Challenges also exist in bringing together the contributions of public and private sector actors on a common platform, which removes the disincentives and barriers to data sharing and enables the full wealth of data from across the city to be made available to all who can use it.

Taipei City Transport Authority has launched a real time transport information service built on open transport data and APIs. As a public transport provider, data holder, developer and city manager, the Authority specifies, installs and operates physical infrastructure; generates, processes and analyses data; develops publicly available APIs; and creates an integrated information service for travellers. The Authority therefore contributes to value generation at every stage in the value chain.

"We recognise the potential values of releasing public transport data and open APIs, because we believe business opportunities can be created for developers and small enterprises by using our open data and APIs. We also developed a real transport information service based on our open data in order to make transport more accessible in Greater Taipei, and to encourage the wider public to use our data service to create more value added information services."

MR. TSE-YING LIN, FORMER COMMISSIONER OF TAIPEI CITY TRANSPORT AUTHORITY.

SUMMARY

The development of information services relies on a sequence of actions, from the installation of intelligent infrastructure to the collection and processing of data and final development of information services. Value is created by and for different actors at each stage in the sequence, such that the overall value of an information service exceeds the total sum of its constituent pieces. Value can be described in terms of the economic and financial benefits accruing to stakeholders throughout the value chain, as well as the efficiency, user experience and environmental benefits that can also be realised.

Value chains will emerge messily or explicitly depending on the available raw data and information components. Cities may not always be able to predict the services that are possible or that will be delivered. Identifying where to intervene will require expertise in navigating this new technology space, but equally in managing relationships with third parties such as citizens, app developers and the private sector, with an interest or control over any part of the chain.

The value chain analysis shows clearly that multiple data streams from multiple sources are required to build these smart mobility services. The implications this has for governance, technical architecture and commercial models will be explored in the next chapter.

BRINGING THE VALUE
CHAIN TO LIFE →

5

BRINGING THE VALUE CHAIN TO LIFE

New mobility services, building on operational technology and data, are starting to address problems related to peak hour travel demand, while also offering the potential to make cities more liveable and successful. Delivering the benefits of these services to a wide range of actors requires multiple data streams from multiple data sources and technologies. This requires an ecosystem approach, in which commercial, organisational, social and technical components are aligned.
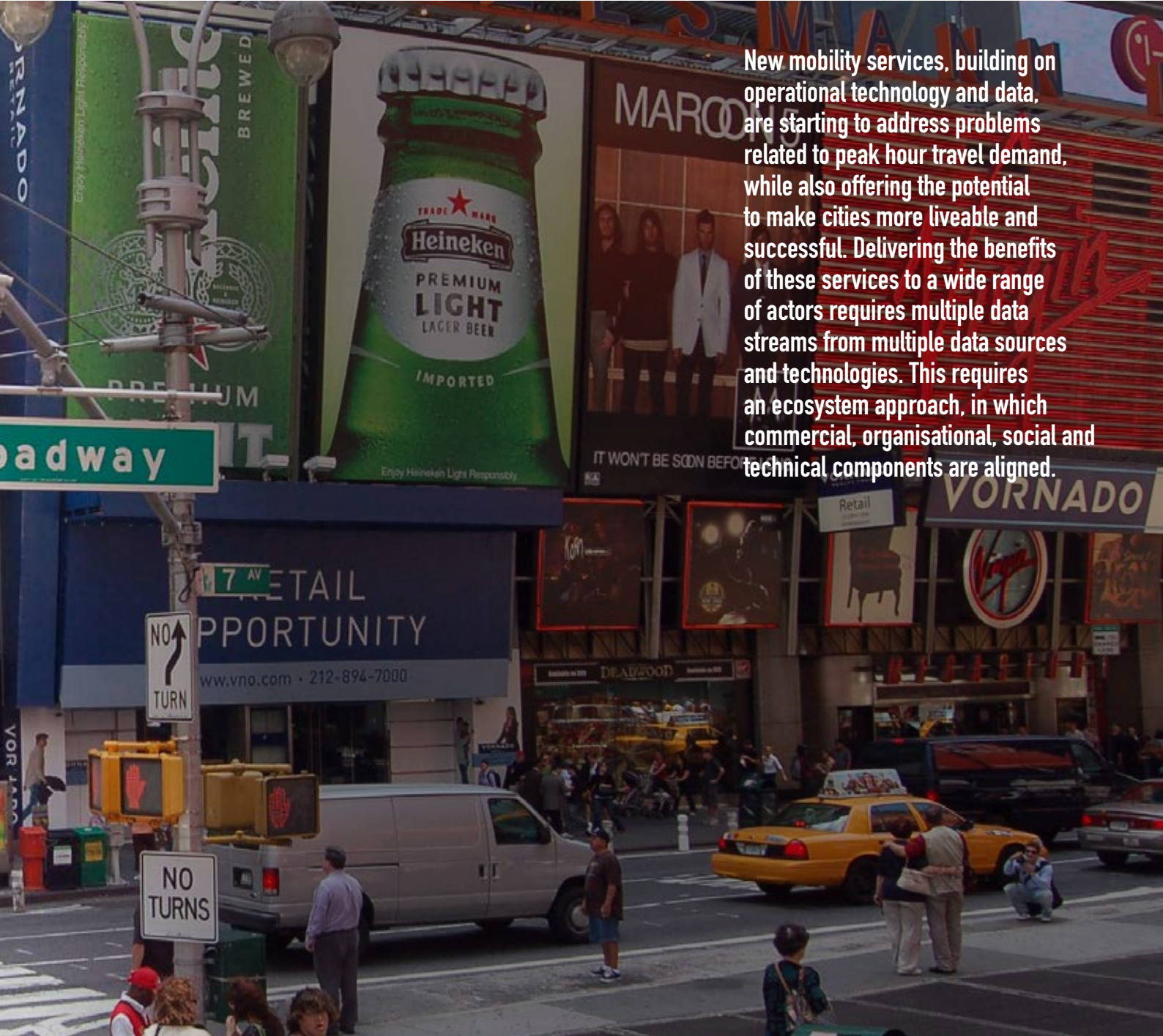
Cities, government, industry and citizens need to consider four aspects:

1. City government has an important role to kickstart new services by releasing as much data as possible, both static and real time data.
2. Cities and transport operators should consider how projects and services can be scaled up across districts and stakeholders by considering business models, standards and architectures.
3. Cities need to work with businesses and citizens to create the ecosystem around data.
4. Political leaders need to engage with the debate around data and transport services to ensure that the wider implications of the new ecosystem are managed correctly.

This chapter discusses the requirements and next steps.

"We meet developers and private companies every year to get their feedback on our open data, in terms of the data quality and type of data. We want to encourage more people to use the city's open data, and think providing the right data with high quality is important to our users"

MR TSE-YING LIN, FORMER COMMISSIONER OF TAIPEI CITY TRANSPORT AUTHORITY.

MAKE DATA AVAILABLE TO THOSE WHO CAN GENERATE VALUE

As we have seen in Chapter 4, transport data can come from many sources: public, private and crowdsourced from travellers. City government has an important role to kick-start activity in their cities. Three essential steps are:

1. Release data
   Cities should adopt the mantra 'done is better than perfect' and release data, in any format, in a simple datastore. The original London datastore cost £15,000. Cities should then expect to iterate and work with users to make it better. In particular, city actors should engage directly with software developers (or civic hackers) to find out what data they need, uncover problems and build demand for datasets. This demand can be used as a lever to encourage other departments or transport operators to release data too.

2. Reflect city objectives in pricing models for data
   To date, more than 1 million open datasets have been made available by governments worldwide[26]. Static data is generally fairly easy to make available at no cost since it is usually held by government for its own purposes. However, real time data may have a cost associated with it, particularly if held by private transport operators. Cities should consider options for value-added services, but recognise that business models are nascent and the private sector may be more experienced and effective. Membership models are also being trialled, but it is not yet clear whether they enable innovation or limit interoperability between modes and providers. Currently, the business case for making transport data available should focus on benefits to travellers, system wide benefits around congestion, and the economic value brought to businesses.

3. Consider how transport and urban planners could use data analytics
   City governments should convene interested parties from different departments to explore city challenges and the ways in which data could assist. Furthermore, cities should collaborate with citizens and private businesses to source missing data, and consider how investment in additional operational technologies (e.g. smart parking projects) could yield useful data. Collaboration should be encourage between government, transport operators and businesses (e.g. telecoms companies) to explore the opportunities that big data can bring, for example to help city authorities develop lower cost, more accurate and responsive transport models.

THINK ABOUT HOW TO SCALE NEW INNOVATIONS

Useful data will come from many public and private sources, and from multiple projects run by cities and their partners. Cities should think about how data can be brought together to produce new services and drive operational efficiency across the city. This will require coordination across technical, organisational and commercial axes.

TECHNOLOGY

In the UK's Future Cities Demonstrator Programme, the three infrastructure types most frequently proposed by cities as essential to their future cities programme were:

- Sensors;
- Wi-Fi networks; and
- Smart card/NFC payment systems.

8 of the 30 cities involved in the programme prioritised data collection from citizens and organisations via GPS or satellite facilities, and 6 of the cities proposed to invest in 4G broadband services[27].

Data can be contributed by a variety of infrastructure assets and communication services. A city's intelligent infrastructure assets will be wide in variety and can contribute to many aspects of mobility management.

Understanding the various options for intelligent infrastructure, identifying appropriate applications and specifying infrastructure components are essential for smarter city governments. Where external service providers and infrastructure operators are procured by government, contracts should outline the need for digital infrastructure and the requirement for operators to supply the output data to government.

Cities should also consider the opportunity to create a reference architecture – such as the National ITS Architecture already in place in North America - and specific technical standards around city projects so that projects can integrate. For example, a smart parking project implemented in one part of the city should have the ability to integrate with other smart parking projects in terms of payment and access to information. Cities could consider introducing information brokers to collect data from operational technologies as part of this architecture.

Through an integrated approach, cities would be able to support private businesses to scale up individual projects from the project level to the city and beyond, to drive incremental growth in the value of project investments and to allow public and private sector innovations to 'plug and play' as part of an integrated ecosystem.

> "It's dead simple to prototype version one of a smart city app. Getting it to version 7, where an entire city's population can use it, is another story. But both scaling and evolving software are exactly the kind of tasks that big companies and private enterprises are particularly good at."[28]
>
> ANTHONY M. TOWNSEND.

ORGANISATION

City governments can establish the structure that brings all of these projects together in an integrated way. This will require coordination of different actors and assignment of specific roles and responsibilities, such as data sharing across mobility services, interoperability of assets and collaborative service management. Government has a unique opportunity in the value chain to create the right stakeholder relationships and roles through regulation, policy, procurement and service contracts. Integration across all city infrastructures will allow actors to collaborate with each other, share resources, integrate similar projects and take advantage of economies of scope and scale. With this approach, command and control and real time information services can be extended across multiple sectors and jurisdictions. Scaling projects from individual applications to city level could be conceived as three levels:

- Project level, which limits the collaboration and system integration to local applications, and restricts the opportunities for wider value creation.
- Functional level, which achieves the collaboration and system integration across multiple projects within one or more verticals (e.g. transport and energy) to increase opportunities for maximising economic and functional value; and
- Positive Externalities, which achieves the collaboration and systems integration across multiple projects within one or more verticals (e.g. transport and health) as well as within shared infrastructures to maximise economic and functional value across industries.

COMMERCIAL

New commercial models are required to bring together the private and public sectors to engage in data-sharing. Compelling business cases are needed that articulate the value of data-sharing to public, private and non-profit stakeholders. This is no easy task. Large IT vendors have been investing in the smart city market for several years, recognising the value of implementing and operating city data platforms alongside smart grid networks. However, there has been a slower-than-hoped for adoption of smart city technologies and the private-public partnerships that have emerged to deliver data-sharing platforms have predominantly been limited to pilot projects.

There is scope to export more innovative, longer-term partnerships for smart city initiatives. City governments can leverage their public profile and physical assets to attract private sector investment. For example, the City of Barcelona's regeneration of an ex-industrial district into a cluster of technology start-ups and demonstration sites (Living Lab) for new smart city solutions has attracted private investment and support. Dublin City Council adopted an alternative model, involving the leasing of public assets and sale of advertising spaces around the city to an advertising company, JCDecaux, to fund the city's public bicycle rental scheme in a 15 year deal. In a time of financial uncertainty, cities can leverage their relatively long-term and low-risk investment profile to attract the private sector through shared joint investments and projects.

City governments also need to make the case internally for spending on smart initiatives. However, many cities do not track their IT expenditure, either within departments or within their sub-contracts. Recognising their embedded technology spend will help city governments to realise the cost savings of integrated smart technologies.

IMPROVE LEADERSHIP OF THE DIGITAL ECOSYSTEM

Implementing smart city solutions means that city government is no longer the top down driver of development in the city, but is one actor in an ecosystem. As we have seen, many successful citizen facing smart mobility solutions are developed by start-ups and small companies, using open data from city government. Cities need to develop smart city strategies that represent the needs and capabilities of a variety of city stakeholders, including community groups, the private sector and universities.

If cities are to capture the full value available from smart mobility projects, they must create the policy, procurement and regulatory framework for a holistic urban digital system.

Development and implementation of effective smart city governance relies on clear leadership from government. Leadership requires a sophisticated understanding about the value of digital infrastructure, the appropriate technical specifications, and the principles of holistic system design. Leading cities in this field are already appointing Chief Information Officers and Chief Technology Officers to own and coordinate the city's response across all sectors, to forge partnerships and to enable government to be responsive to technological change on a project, sector or city scale.

Some city governments have established groups and roles to work directly with start ups and citizens to co-create services. San Francisco has a Chief Innovation Officer. The European Union has a focus on Public-Private-People-Partnerships which offer a way of integrating citizens' desires and behaviours into the design of services. The cities of Philadelphia and Boston each have a Mayor's Office of New Urban Mechanics, which focus on delivering civic innovation and transformative city services for residents.

GOVERNANCE OF THE SMART CITY INVOLVES FOUR PARTNER GROUPS:

- Mayoral leadership, informed by greater exposure to new fields, organisations and ideas;

- City departments, with the purview to pilot, invest in and initiate new programmes and take strategic risks to advance their work;

- Business innovators, from whom the most disruptive and system-changing ideas often arise and who have the greatest capacity to stimulate growth of a digital economy; and

- City residents, whose behaviour and choices will be the overall determinant of sustainable outcomes.

E-mobility Berlin is a joint initiative between Daimler, RWE and the German federal government, to provide electric vehicles for the city. Daimler will provide more than 100 electric smart cars and services. RWE is handling the development, installation and operation of the charging infrastructure by providing 500 charging points, supplying the electricity and maintaining central control of the system. The government is encouraging investments from the private sector, gathering stakeholders to explore issues and solutions, and setting up a supportive policy framework. The project is a good example of how different sectors can work together towards the same goal and realise sustainability and financial benefits[29].

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TAKE ACCOUNT OF THE WIDER IMPLICATIONS OF DATA-SHARING AND NEW MOBILITY SERVICES

As we have discussed, smart mobility services have the potential to deliver benefits to citizens and to the operation of the city. However, we need to ensure that the opportunities are equally accessible to all. Ongoing access to services should be monitored to make sure that everyone who needs to access them can do so, and that those without a smartphone or digital skills are not marginalised.

City and national governments also need to be mindful of the impact of some smart mobility services on employment, both positive and negative, and that individuals who offer services through platforms are not disadvantaged. For example, there is a live debate and ongoing litigation between Uber and several states over the implications Uber has on the casualisation of the workforce. The controversy centres on whether the legal definition of a taxi and limousine includes an operator such as Uber that provides a reservation arrangement service to customers[30].

Privacy implications of location and other personal data need to be considered. Citizens need to be able to trust that their data is not going to be misused or shared without their permission. Industry and government should consider principles related to 'opt-in' and 'right to be forgotten', where practicable. Government should also consider whether data protection laws are fit for purpose, both as a protection for citizens and as an enabler of new services.

MOBILITY: A CORNERSTONE OF THE SMART, SUSTAINABLE CITY →

6

MOBILITY: A CORNERSTONE OF THE SMART, SUSTAINABLE CITY

This report has considered the opportunities available for cities to improve the operational efficiency and traveller experience of their mobility systems, while generating new economic value. Smart technologies offer incredible potential for sustainable mobility. However, the key messages of this report can also be applied to other urban sectors.

Cities are designed to meet the everyday needs of citizens and to cope with peak demands, not just in the mobility sector but in energy, water, public services, buildings and homes, and in ICT services. Each one of these systems faces similar challenges in balancing peak demand against a limited but sustainable level of supply.

But fundamentally, cities are self-organising systems. With an appropriate combination of physical infrastructure, operational and information technologies, cities can be guided towards a more efficient level of operation over time. This transformation can generate huge value for urban economies, while enabling behavioural change, securing a more reliable service for citizens, and reducing negative environmental externalities like greenhouse gas emissions.

This paper has shown the potential benefits for the mobility sector. But cities are made up of a complex web of overlapping systems, of which Mobility is just one. Energy, Water, Public Services, Buildings & Homes, and Information and Communication Technologies to name but a few are all part of the essential fabric of cities.

The balance between demand and supply is a central challenge for every city system. Growing urban populations place increasing strain on basic city services and resources, which should be served through a balance of increased system capacity and demand management solutions. Constrained urban areas find it hard to support the continuing expansion of physical capacity in any single system, leaving demand management as an unavoidable alternative.

> "In growing cities, the pressures of growth are so intense that we need drastic change to the standard way of doing things. Growth will out-grow the efficiency of physical technologies alone — we will need operational change too."
>
> FLORIAN LENNERT, INNOZ / LSE CITIES.

Schneider Electric have partnered with Mobility Tech SAS Green to create an integrated system for managing the firm's electric car-share fleet while simultaneously managing electricity supply to the Bouygues office complex in Paris. Using a sophisticated algorithm, the system ensures that the right amount of power is distributed to meet demand from the building and from the vehicle charge points, and that sufficient power is supplied to each car as required. The system is based on a software package called e-Colibri, which is installed in the cars and connected to a central computer using General Packet Radio Service (GPRS) and Global Positioning Systems (GPS).

The use of this technology demonstrates how buildings and mobility may be managed simultaneously through a single software platform. Integrated energy management systems can help to secure overall efficiencies in energy use between points of consumption, suggesting the added value that smart solutions can bring in complex, cross-sector urban management situations.

Smart solutions can address efficiency both within and across sectors. Some examples of integration between mobility and other systems include:

- Mobility / Street lighting: each system optimises itself, but they collaborate during events and incidents, for example to provide increased lighting when needed for emergency services, or security lighting as needed around bus stops.

- Emergency / Mobility: the so-called 'Golden Minutes' effect is created when transport corridors are proactively managed to allow emergency vehicles to pass through quickly.

- Weather / Mobility: the capacity and safety of roads and streets is highly depend on weather conditions. Special response plans may be needed, using smart devices to activate maintenance services and optimise the use of resources.

- Environment / Healthcare / Mobility / Buildings / Industry: indoor environmental quality can be managed to protect health, including through restrictive actions, notifications about conditions, and staged levels of alert.

These examples show that the integration of systems through technology has the potential to increase efficiency and address safety and sustainability. Technology also has the potential to make our cities more humane and liveable. We need to make sure that citizens are at the centre of our efforts by combining top down and bottom up approaches to governance of projects: top down through city leadership and bottom up through citizen engagement and transparency. By mainstreaming smart technologies in this way, we will be able to dispense with the 'smart' tag and revert to 'cities'.

150Mb/s

the download speed offered on LTE–Advanced 4G network by South Korea's SK Telecom in 2013 — more than 10 times the rate of its 3G service and twice the speed of the UK's existing 4G network.

89%

the increase of smart phone users in urban India, from 27 million in 2012 to 51 million in 2014.

326 million

the estimated machine–to–machine (M2M) connections globally by 2016, compared with 104 million in 2011.

500 million

tweets per day are sent by 200 million regular users worldwide. 60% of users are also active via mobile phone.

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