

Networked Society Lab



ERICSSON

# ICT & THE FUTURE OF TRANSPORT

PART 2/8  
INDUSTRY TRANSFORMATION  
– HORIZON SCAN

# STRUCTURE OF THIS REPORT SERIES

This report is one in a series of seven investigating industrial transformation in the Networked Society.

The impact of technology on our everyday lives and economic interactions is undeniable. In conjunction with megatrends such as globalization, climate change, urbanization and aging populations, ICT is helping to transform our society and the economic structures that have formed the basis of industries since the industrial revolution.

Digital technologies allow new organizational forms to emerge within and outside of industrial boundaries, thereby challenging our traditional notions of economic organization in markets. Where once size was an important driver of success, now many smaller companies are able to compete both locally and globally. Where firm, strongly defined boundaries and clearly defined economic roles were necessary, now the ability to dynamically participate in a variety of networks is key to a resilient corporate strategy. ICT is transforming the rules of our world's economic value systems, and industries are being transformed as a result.

It is not possible to provide a deep dive into every industry covered within this series. Instead each report investigates the role of ICT in creating productivity improvements and industrial disruption with a view to gaining a broad perspective on the overall transformation the world is undergoing. Six industries are investigated and across them general themes are identified that form the basis of the final report, the "Economics of the Networked Society", which outlines some of the broad economic principles that may help us understand the era we are entering.

These reports represent the culmination of several years' work investigating the changing economic structures of the world in the digital age. We hope our small contribution helps to further not just the vision of a Networked Society, but also its implementation – a society where dynamic, digitally enabled strategic networks allow us to build an economically, environmentally and socially sustainable world.

# METHOD

The reports in this series are developed using systems analysis to identify the operating boundaries of each industrial structure. Through analyzing the boundaries and their associated thresholds, a stronger understanding of capacity for change within an industry is possible to achieve. This method combines systems analysis with traditional measurement methods as well as extensive interviews across various parts of an industry's value chain in order to try and understand the possible emergent characteristics of industrial structures and the role that digital technologies may play in creating innovation, disruptive or otherwise. Many boundaries may be affected by a number of different aspects. Within these reports, however, we focus solely on how these thresholds can be adapted by ICT. Each report outlines the following:

1. **The industrial boundaries and associated thresholds**
2. **The role of data within those boundaries and the emerging information value chains**
3. **An overview of the industrial archetypes / organizational forms of start-ups in the industry**

Each of these industrial analyses has then been further analyzed to understand the emerging characteristics of the Networked Society, which is covered in the final report.

For further information, contact Dr Catherine Mulligan:  
[c.mulligan@imperial.ac.uk](mailto:c.mulligan@imperial.ac.uk)

# TABLE OF CONTENTS

Structure of this Report Series	2	3.3 Industrial Disruption Due to ICT	23
Method	3	Ride Sharing	23
Scope and Introduction	5	Carpooling	24
Executive summary	6	Disrupting Last Mile Logistics	24
1. Introduction	7	Autonomous Vehicles	26
2. Industrial Structures	9	<b>4. Thresholds of Transport Systems</b>	<b>27</b>
3. Role of ICT	10	4.1 Traditional Thresholds	28
3.1 ICT and Large-Scale Transport Systems	11	Demand	28
Intelligent Transport Systems	11	Increasing Urbanization and Urban Sprawl	28
Information Marketplaces for Intelligent Transport Systems	12	Energy	28
Inputs	15	Regulation	28
Processing	15	Financing	29
Examples of the processing that are required here included	15	Environmental Thresholds	29
Packaging	16	4.2 Emerging Thresholds	30
Distribution/Marketing	16	Digitally Empowered Citizens	30
Increased Efficiency Cross Industry Information Value Chains	16	Ratio of licensed drivers to cars	30
Logistics	19	Insurance Models for a Digital World	30
3.2 Small-Scale Transport Services – the App Economy	20	Data	30
Transport Data Brokers	20	<b>5. Emerging Roles for ICT in Transport Systems</b>	<b>31</b>
Car and Bike Rental	21	Citizen Centric Transport	31
Taxi Services	22	Data-Driven Driving	31
		Social Logistics	31
		<b>6. Conclusions</b>	<b>32</b>

## ICT & the Future of Transport

### Scope

The scope of the transport industry is extremely broad. Within this report, we focus road logistics and commuter travel (within cities) as two of the most important sectors for economic growth and productivity. The transport industry is perhaps also the sector that requires the most transformation as Transportation accounts for more than 13 percent of CO<sub>2</sub> emissions worldwide, with road freight transport representing the largest – and growing – portion.<sup>1</sup>

Transport is one of the most interesting industries from the perspective of industrial disruption due to the amount of disruption that the industry is undergoing at the moment. Transport is therefore indicative of the emerging issues that may face other industries, from the use and application of data to the development of autonomous vehicles based on sensors and wireless connectivity, leading to numerous regulatory complexities.

Many technological advances are being developed within the transport industry covering chemistry, physical engineering and nanotechnology. This report focuses solely on the ICT aspects that create industrial disruption, and these other material science aspects are beyond the scope of the report.

**Imperial College  
London**

Sustainable  
Society Network 

### AUTHOR

Dr Catherine Mulligan  
Research Fellow, Innovation and Entrepreneurship,  
Imperial College Business School

### DISCLAIMER

All care has been taken in the preparation of this document, but no responsibility will be taken for decisions made on the basis of its contents.

---

<sup>1</sup> IPCC (2007) Intergovernmental panel on climate change, Working Group III, Report May 2007.



# EXECUTIVE SUMMARY

Transport is a fundamental part of every nation's economy, allowing people to travel to and from work, and ensuring that goods and services are effectively delivered. Since the early 1960s, the transport infrastructures of many nations in the world have been formulated around personal vehicles and expanding road infrastructures. This has often come at the expense of public transport services such as railways, and severely congested roads have been the result.

At the same time, rising relative prosperity and a variety of new service models in air travel have meant that people are often travelling more, and over longer distances. Transport and Logistics are now responsible for up to 40% of air pollution, and regulation is being implemented to reduce transport's impact on CO<sub>2</sub>, NO<sub>x</sub> and other emissions. The transport infrastructures of many nations are now coming under significant and multiple pressures due to urbanization, rising global populations and environmental challenges. The manner in which transportation is 'delivered' needs to be transformed.

ICT plays both a fundamental and a transformative role in the industry today. In fact, **the use of technology may be as effective as doubling or tripling the physical road capacity in some cities.** Digital technologies, from modern control systems to sensor technologies, can create more capacity without requiring additional physical infrastructure. In a situation where more and more land in cities is lost to road building and other types of transport infrastructure, this can avoid major costs associated with building new infrastructure.

ICT has a critical role to play in facing these challenges and, with proper implementation, may help to significantly reduce congestion. Well-established concepts such as Intelligent Transport Systems are only one part of the ICT picture as integration between various parts of transport infrastructure becomes a competitive advantage for companies, cities and nations. Other examples include:

- > Embedded technology to create connected cars and integrate them into the transport infrastructure
- > Streamlined project management tools that enable better use of workforce on construction sites and dramatically reduce the costs of getting transport infrastructure up and running
- > Increased use of sensors and other technologies to enhance understanding of maintenance and wear and tear of transport infrastructure

In addition, ICT is already having a transformational impact on the transport industry, destroying existing relationships between actors in the value chain and creating space for new entrants. Such applications of ICT have led to the emergence of several new organizational forms, which allow for the creation of dynamic, strategic networks among individuals and small firms. As subsequent reports will illustrate, these organizational forms repeat across the emerging "Networked Society" and represent a fundamental shift in how our world is organized.

# 1. INTRODUCTION

Transport and logistics are key enablers of social and economic activities in human society. As a result of ICT and economies of scale and scope, they have become globalized, streamlined organizations. This has had a “cascade effect”<sup>2</sup> across supply chains, driving greater consolidation of transport and logistics between and across value and supply chains. Urban transport, meanwhile, has evolved significantly over the last 50 years and has an ever-increasing and active role to play in a globalizing economy. Significant technical improvements in the transport sector, e.g. building of road, rail, shipping, and air infrastructure provide scale, volume and efficiency to satisfy the demand for moving goods internationally.<sup>3, 4</sup>

In the context of expanding international logistics, digital technologies have thus far facilitated increasing city traffic and congestion.<sup>5, 6, 7</sup> Production and distribution practices in urban freight are based on low inventories and just-in-time delivery.<sup>8</sup> Business-to-consumer electronic commerce born out of the internet has created an explosion of freight traffic for personal deliveries in residential areas and office districts previously dominated by personal transport.<sup>9, 10, 11</sup> Questions have been posed

in both logistics and in personal<sup>12</sup> transport about how to reduce the impact of increasingly motorized movements without penalizing social and economic activity.

The pressure to develop and deliver socially, economically, and environmentally sustainable transport systems is pressing in urban areas. The World Bank<sup>13</sup> estimates that 1.5 million people die from the combined impact of air pollution and crashes worldwide each year, more than the number of deaths caused by HIV/AIDS, tuberculosis, malaria, or diabetes. The urban population in the developing world is nearing 50%; in the developed world, where designing sustainable transport systems has long been a pressing issue with little success, it is above 75%.<sup>14</sup> The vehicle fleet has increased across all vehicle classes and contexts resulting in vehicle emissions, congestion, and the reduction of the quality of life in many cities. It is critical in many countries, therefore, not just to find sustainable transport solutions, but also to investigate how to redefine urban supply chains themselves in order to reduce the requirements for transporting goods and services in the first place, while reducing waste and providing for the re-use of goods across an urban environment. Digital technologies can play a key role in co-ordinating such efforts.

<sup>2</sup> Nolan, P., Zhang, J. and Liu, C. (2008), “The global business revolution, the cascade effect, and the challenge for firms from developing countries”, *Cambridge Journal of Economics*, Vol. 32 No. 1, pp. 29–47.

<sup>3</sup> Hamilton, A., Waterson, B., Cherrett, T., Robinson, A. and Snell, I. (2013), “The evolution of urban traffic control: changing policy and technology”, *Transportation Planning and Technology*, Vol. 36 No. 1, pp. 24–43.

<sup>4</sup> Lakshmanan, T.R. (2011), “The broader economic consequences of transport infrastructure investments”, *Journal of Transport Geography*, Vol. 19 No. 1, pp. 1–12.

<sup>5</sup> Lyons, G. (2002), “Internet: investigating new technology’s evolving role, nature and effects on transport”, *Transport Policy*, Vol. 9 No. 4, pp. 335–346.

<sup>6</sup> Wang, D. and Law, F.Y.T. (2007), “Impacts of Information and Communication Technologies (ICT) on time use and travel behavior: a structural equations analysis”, *Transportation*, Vol. 34 No. 4, pp. 513–527.

<sup>7</sup> Zanni, A.M. and Bristow, A.L. (2010), “Emissions of CO2 from road freight transport in London: Trends and policies for long run reductions”, *Energy Policy, Energy Security – Concepts and Indicators with regular papers*, Vol. 38 No. 4, pp. 1774–1786.

<sup>8</sup> Ruigrok, W. and Tulder, R. van. (1995), *The Logic of International Restructuring: The Management of Dependencies in Rival Industrial Complexes*, Routledge, London; New York.

<sup>9</sup> Clarke, G., Johnson, A., Nankivell, J. and Turpin, M. (2014), *Van travel trends in Great Britain, On the Move: Making sense of car and train travel trends in Britain*, London: Royal Automobile Club, available at: [http://www.racfoundation.org/assets/rac\\_foundation/content/downloadables/van\\_report\\_aecom\\_100414.pdf](http://www.racfoundation.org/assets/rac_foundation/content/downloadables/van_report_aecom_100414.pdf) (accessed 30 April 2014).

<sup>10</sup> Edwards, J.B., McKinnon, A.C. and Cullinane, S.L. (2010), “Comparative analysis of the carbon footprints of conventional and online retailing: A ‘last mile’ perspective”, *International Journal of Physical Distribution & Logistics Management*, Vol. 40 No. 1/2, pp. 103–123.

<sup>11</sup> Fernie, J. (2009), *Logistics and Retail Management: Emerging Issues and New Challenges in the Retail Supply Chain*, Kogan Page Publishers.

<sup>12</sup> Kennedy, C., Miller, E., Shalaby, A., Maclean, H. and Coleman, J. (2005), “The Four Pillars of Sustainable Urban Transportation”, *Transport Reviews*, Vol. 25 No. 4, pp. 393–414.

<sup>13</sup> Cohen, A., Brauer, M., Shahraz, S., Leach-Kemon, K., Freedman, G., Bhalla, K., Shotten, M., et al. (2014), *Transport for health: the global burden of disease from motorized road transport* (No. 86304), The World Bank, pp. 1–39.

<sup>14</sup> Hall, P. (1998), *Cities in Civilization*, Pantheon Books, New York.

## 1. INTRODUCTION

Enhancing mobility while reducing congestion, accidents and pollution is a challenge common to all major cities. According to the European Commission, transport congestion in and around urban areas costs nearly 100 billion euro each year – or 1 % of the EU's GDP – due to delays and pollution. Urban mobility accounts for 40% of all CO<sub>2</sub> emissions from road transport and up to 70% of other pollutants.<sup>15</sup> Cities therefore face dramatic challenges in the coming decades with the management of transport systems, as travel continues to increase in parallel with the development of new technologies and increasing relative affluence, human capital, and innovation. It is estimated that 180,000 people move into cities each day and that soon there will be nearly 6 billion cars on the planet, placing pressure on already stretched transport infrastructures. The migration of city dwellers to the suburbs leads to settlement structures with long travel distances. This phenomenon of urban sprawl goes hand-in-hand with an increase in car ownership and commuter traffic.

Transport underpins a nation's economic growth and is a fundamental prerequisite for an economy's overall success.<sup>16</sup> Without transport and logistics solutions, the supply chains that form the basis of the global economy would not be possible. Many transport solutions, both for logistics and for public transport of citizens around cities, are coming under increasing pressure for a variety of reasons including rising global populations, growing urbanization and the globalization of trade supplies as well as aging or poorly developed infrastructures. Ensuring the continued functioning of the world's transport systems is therefore critical. Without transport and logistics the world, as we know it today, would not exist. As the global trend towards megacities continues, as well as the propensity of people to travel more, the requirements to deal with congestion increase due to its possible impedance on growth.

At the same time, however, the burden of financing transport infrastructure development is something that both developed and developing nations are struggling with. The maintenance of existing infrastructure is often as problematic and expensive as building completely new infrastructure. The OECD estimates that new road construction requirements vary between US\$ 200–300 bn each year. In the UK alone, McKinsey

estimates that the cost of maintaining, renewing and expanding transport infrastructure will be around £350 billion over the next two decades.<sup>17</sup> Railways, meanwhile, require another \$US 50–60 bn each year. “By 2030, it is estimated that more than \$US 41 trillion will be required on a global level for infrastructure development and maintenance over the next two decades”.<sup>18,19</sup> Even with massive investments in transport infrastructure, it is unlikely that all infrastructural bottlenecks will be fixed by 2030, and as a result, there is a dire need for transformation of how transport and logistics are delivered across cities as well as the broader economy and society. ICT will play a critical role in this transformation as industrial thresholds are reached and crossed. Integrated and intelligent transport systems are fundamental to economic success in the future.

### Interacting Infrastructures

As transport infrastructures have evolved over the past decades, they have become more complex and now often have deeply interwoven interdependencies on other infrastructures. For example, most large-scale infrastructure assets are increasingly relying on flows of information and other communications technologies.<sup>20</sup> For instance, the electricity network is moving towards smart meters, active traffic management systems using real-time information are increasingly common, and water companies now use remote sensors to identify leaks. At the same time, the transport sector itself has a strong impact on living environments, in particular in urban environments. Transport also affects, and is affected by, the structure of work in the country in question as well as land management and housing stock management.

As an example, in a country with a growing casual or freelance economy, fewer overall journeys might be made by commuters each week, but those journeys may be much longer as a result of workers taking advantage of cheaper housing further out from the centers of towns and cities. In addition, as covered in our report on the retail sector, the manner in which consumers decide to purchase and consume goods and services has a dramatic impact on both the urban infrastructure and logistics services they require.

<sup>15</sup> EU Commission, 2007, Green Paper on Urban Mobility

<sup>16</sup> HM Treasury, National Infrastructure Plan, 2011

<sup>17</sup> McKinsey UK strategic transport infrastructure model, February 2011

<sup>18</sup> OECD. (2007). Managing Urban traffic congestion.

<sup>19</sup> PriceWaterhouse Coopers Transportation & Logistics 2030 Volume 2, 2013

<sup>20</sup> HM Treasury, National Infrastructure Plan, 2011

# 2. INDUSTRIAL STRUCTURE

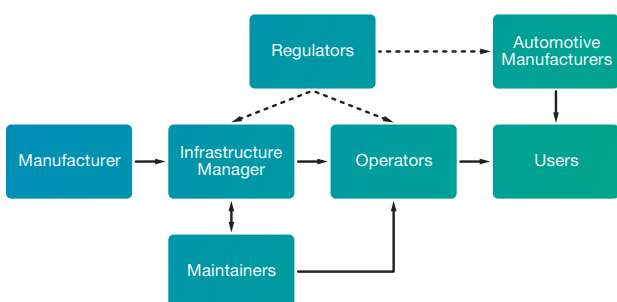
“Transport” generally corresponds to the delivery of people and goods via road, rail, air, and sea (classifications 49,50,51,53 in the United Nations Statistics Division’s International Standard Industrial Classification of All Economic Activities). “Transport infrastructure and services” refers to all infrastructure and services that support transport (classification 52) as well as the manufacture of vehicles and equipment for monitoring and servicing transport.

These sectors are those that deliver day-to-day travel and delivery services in and around cities for home, work, and leisure activities. For the sake of simplicity, these are collectively called “intraurban” transport to distinguish it from long-distance intercity transport.

While there are significant national differences in how transport systems are implemented, today’s modern transport infrastructure industry has often been split up into several areas of control. Generally, these fall into the broad categories outlined briefly below and illustrated in Figure 1.

- > **Manufacturers:** Manufacturers build and sell infrastructure and transport assets such as trains, tracks, and buses.

Figure 1: High-level industrial structure for Transport Industries – Rail and Road



- > **Infrastructure Managers:** Infrastructure managers buy infrastructure from manufacturers and implement, manage and maintain the infrastructure on behalf of a city or a government. Examples include the rail networks in the UK or the road infrastructure authorities responsible for building and maintaining national road infrastructure.
- > **Operators/Maintainers:** Operators are those companies that run the actual services on the infrastructure. These companies often set timetables and are the ones that most enduser consumers know and have customer relationships with. Maintainers, meanwhile, are responsible for the day-to-day running of different transport infrastructures and for ensuring that maintenance is carried out appropriately, e.g. ensuring that road surfaces are kept serviceable. In many countries, these are outsourced operations paid for by the Operators.
- > **End Users:** End users are the people who are actually using the services, such as train or bus passengers. Alternatively, end users purchase their own vehicles and drive them on the infrastructure provided.
- > **Automotive Manufacturers:** Automotive manufacturers design, build and distribute personal cars to end users via a variety of sales mechanisms.
- > **Regulators:** A key aspect of the transport infrastructure in any nation is the regulator, who provides regulations that companies need to abide by in a variety of situations. Examples include anti-monopoly regulations, anti-price setting, management of timetabling information as well as setting health and safety standards for end users and staff working on the infrastructure itself.

# 3. ROLE OF ICT

ICT has played an increasingly influential role in Transport systems since the 1960s, mainly in improving efficiency of operations by being embedded in business processes. With recent advances in cloud computing, along with the increasing ubiquity of mobile devices and cheaper sensors, however, the role for ICT within the transport sector has expanded dramatically and is now a source of industrial disruption, creating new linkages between economic actors and providing entry points for smaller companies as well as players from adjacent markets.

Within this section, we cover the three main ways ICT is being implemented within the Transport sector:

## 1. Large-Scale Transport Systems

These solutions are implemented within corporations (logistics) and across cities (ITS) in order to streamline and improve efficiencies within existing systems

## 2. Small-Scale Transport Systems

These solutions have often been implemented at “app” level, based on open data from cities, in order to help commuters connect with existing transport solutions in a more convenient manner

## 3. Industrial Disruption

These solutions are implemented either on “app” or large-scale level and disrupt the established industrial structure, either through the introduction of new players or by completely redefining the transport system itself

# 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

Technology has been applied in the transport sector for many decades to help improve safety and efficiency. Firstly, permanent inductive loops and temporary pneumatic road tubes were implemented in the 1960s and are still the most commonly used instruments for collecting traffic data.<sup>21</sup> Many of these technologies are still in use, as in the State of California, which has over 25,000 permanent traffic sensors, 90% of which were inductive loops in 2010.<sup>22</sup>

Other ICT innovations within this space include cheaper versions of these older technologies that aim to fill an urban planning information gap, such as Tomorrow Lab's DIY Traffic Counter, which claims to deliver the functionality of a \$1000-plus traffic counter for around 10% of the cost.<sup>23, 24</sup>

The increasing processor speeds of sensors will enable a more dispersed network of counters, near-field communication, light sensors, sound sensors, wifi device sensors (such as in smartphones) and video cameras that can be used to not only track transport patterns,<sup>25</sup> but also to create significantly more 'intelligent' traffic systems. Intelligent traffic systems assist in reducing congestion, increasing safety and creating a more enjoyable transit experience for commuters.

Some moves in this direction have been made in the guise of the 'connected car', where end users' cars are connected via the cloud to a variety of actors they were previously unconnected to.<sup>26</sup> Through these sorts of applications, the Internet of Things (IoT) allows drivers and passengers to access applications from a screen within their vehicle that provides them real-time information regarding traffic, congestion, possible parking spots and tailored navigation services. Sensors in the car may transmit information to the car manufacturer to improve product development and provide tailored maintenance schedules for the drivers. City officials can also hook into these data streams in order to gain a more detailed understanding of driver behavior, areas of the city that need more planning in order to reduce blindspots, etc. In this way, an end user's car may be viewed not just as a rolling hotspot providing connectivity and entertainment to its passengers, but also as a fundamental part of the transport infrastructure itself. Without connectivity between cars and between a car and the broader transport infrastructure, truly efficient transport infrastructures will not emerge. We briefly investigate these 'intelligent' transport systems (ITS) in the next section.

## Intelligent Transport Systems

The EU defines an ITS as a system in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport.<sup>27</sup> These systems "aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more

<sup>21</sup> Klein, L.A., Mills, M.K. & Gibson, D.R. (2006) Traffic Detector Handbook: -Volume II. [Online]. Available from: <http://trid.trb.org/view.aspx?id=814752> [Accessed: 18 July 2014].

<sup>22</sup> Lu, X.-Y., Kim, Z., Cao, M., Varaiya, P.P., et al. (2010) Deliver a set of tools for resolving bad inductive loops and correcting bad data. [Online]. Berkeley, Calif., USA, California PATH Program, Institute of Transportation Studies, University of California at Berkeley. Available from: <http://www.its.berkeley.edu/publications/UCB/2010/PRR/UCB-ITS-PRR-2010-5.pdf> [Accessed: 18 July 2014].

<sup>23</sup> Ullrich, T. (2012) Traffic Counter Case Study. [Online]. 2012. Issuu. Available from: [http://issuu.com/shriya/docs/traffic\\_counter\\_case\\_study](http://issuu.com/shriya/docs/traffic_counter_case_study) [Accessed: 22 August 2014].

<sup>24</sup> Goodyear, S. (2012) This DIY Traffic Counter Could Change Everything About Transportation Planning. [Online]. 8 November 2012. CityLab. Available from: <http://www.theatlanticcities.com/commute/2012/11/diy-traffic-counter-could-change-everything-about-transportation-planning/3846/> [Accessed: 22 August 2014].

<sup>25</sup> Somasundaram, G., Sivalingam, R., Morellas, V. & Papanikolopoulos, N. (2013) Classification and Counting of Composite Objects in Traffic Scenes Using Global and Local Image Analysis. IEEE Transactions on Intelligent Transportation Systems. [Online] 14 (1), 69–81. Available from: doi:10.1109/TITS.2012.2209877.

<sup>26</sup> <http://www.ericsson.com/ourportfolio/transport-and-automotive-industry/connected-vehicle-cloud>

<sup>27</sup> EU Directive 2010/40/EU

### 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

coordinated and ‘smarter’ use of transport networks”.<sup>28</sup> A core part of this is providing standardized interfaces between different parts of the infrastructure. ETSI notes that there are a large number of possible technologies involved in ITS including “telematics and all types of communications in vehicles, between vehicles (e.g. car-to-car), and between vehicles and fixed locations (e.g. car-to-infrastructure)”.<sup>29</sup>

#### Information Marketplaces for Intelligent Transport Systems

As described in the previous section, a significant number of data sources in the Transport industry are slowly becoming available, many of which make it possible to measure a variety of different aspects of a nation’s or city’s transport infrastructure. However, these information sources – from sensors,



Currently, however, the transport sector is held back by the difficulties in sharing information quickly and easily between multiple systems. In the next section we investigate how to create an information marketplace for transport and logistics by addressing what inputs are required, as well as the combination of data sources needed to produce the information products required.

satellites, cars, social media, etc. – are often currently held in data silos, meaning that the various actors within the value chain do not share information in a coordinated fashion. In some cases, they are also prevented from doing so, as in the case of operators, who are not allowed to share timetabling information without the approval of a government-appointed regulatory board. For a truly functioning ITS to reduce congestion, an integrated approach to using this data is necessary.

<sup>28</sup> *ibid*

<sup>29</sup> <http://www.etsi.org/index.php/technologies-clusters/technologies/intelligent-transport>

### 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

Table 1 below illustrates the data sources and information requirements of the transport industry.

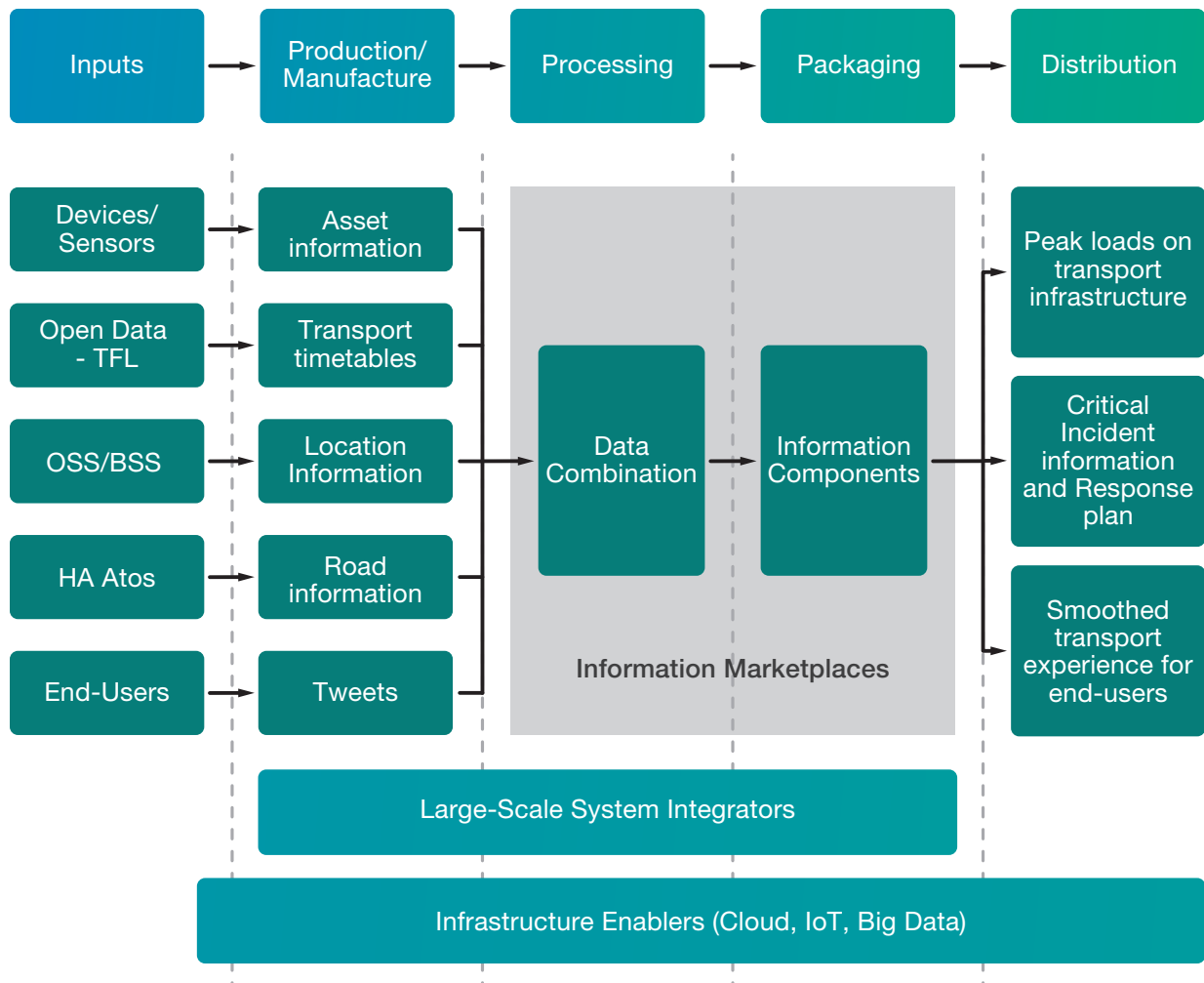
Table 1: Data Sources and Information Requirements of Actors within Transport (Source Holler et al, 2014)

Actor	Information	Example Data Sources
<b>Manufacturer</b>	<ul style="list-style-type: none"> <li>Where is my equipment?</li> <li>How is it being used?</li> <li>How is it performing?</li> <li>How is it being maintained?</li> <li>Does it need redesign? Data feeds for redesign</li> <li>What are the new markets for my product?</li> <li>What needs replacing and where?</li> <li>What are the levels of utilization it is seeing?</li> <li>What other systems is it interacting with (that I don't know about)</li> <li>What is the present state of the equipment (accidents)</li> <li>Management of recalls, safety notices</li> </ul>	<ul style="list-style-type: none"> <li>Sensors and aggregated data readings</li> <li>Customer relationship databases</li> </ul>
<b>Infrastructure Managers</b>	<ul style="list-style-type: none"> <li>State of infrastructure</li> <li>How are maintainers performing?</li> <li>How are manufacturers doing (change them? Recall or buy different product from them?)</li> <li>Are needs of Operators (customers) being met?</li> <li>Infrastructure maintenance (with operators) maintenance scheduling to minimize disruption and maximize maintenance</li> </ul>	<ul style="list-style-type: none"> <li>Sensors on tracks</li> <li>Switches (rail)</li> <li>Maintenance schedules</li> </ul>
<b>Maintainers</b>	<ul style="list-style-type: none"> <li>What needs fixing next?</li> <li>Meeting targets for service levels?</li> <li>Prediction of failures/maintenance needs</li> <li>Manufacturers' knowledge of emerging maintenance issues (globally)</li> <li>New maintenance patterns as a result of changes in timetable?</li> <li>Maintenance databases</li> <li>Customer relationship databases</li> </ul>	<ul style="list-style-type: none"> <li>Sensors on assets, for example on trains, tracks</li> <li>Maintenance databases</li> <li>Customer relationship databases</li> </ul>
<b>Operators</b>	<ul style="list-style-type: none"> <li>What quality level is infrastructure providing?</li> <li>Is the infrastructure degrading – does this affect future operations?</li> <li>What is the demand for operations from users?</li> <li>Usage demand for period when there is maintenance?</li> </ul>	<ul style="list-style-type: none"> <li>Customer feedback</li> <li>Driver communication systems</li> <li>Sensors in internal sections on an asset</li> <li>Timetabling information</li> </ul>
<b>Regulators</b>	<ul style="list-style-type: none"> <li>Timetabling</li> <li>Competition regulation</li> </ul>	<ul style="list-style-type: none"> <li>Timetabling</li> <li>Competition regulation</li> </ul>
<b>Users</b>	<ul style="list-style-type: none"> <li>Actual service delivery</li> <li>Service problems</li> </ul>	<ul style="list-style-type: none"> <li>Tweets</li> <li>Facebook</li> <li>Mobile apps</li> <li>Connected cars</li> </ul>

### 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

In order for the transport infrastructure to respond appropriately to increasing demands, the sharing of its information needs to be expanded to provide an integrated transport solution that brings together all the actors involved in a city, including the citizens as users, who often know more about the real-time performance of the transport infrastructure than operators and maintainers. In the next section, we provide an overview of an example Information Value Chain (IVC) within Transport. As with all IVC, these value chains require governance mechanisms for privacy and security.

Figure 3: Information Marketplace for Transport in Cities (Adapted from Höller et al, 2014)



## 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

### Inputs

Devices/Sensors: the devices and sensors here include the sensors on e.g. rail tracks that provide information from a variety of sources about the following:

- > Traffic: Amount and weight of traffic over the road or on a rail track
- > Subsidence: Whether the infrastructure in question has moved or changed. These sensors can help indicate when a critical infrastructural problem might cause a major incident.
- > Temperature and operating conditions for the infrastructure: These sensors measure heat, humidity and other environmental parameters that may affect the asset's performance or longevity
- > Open data: Open data may be used as an input into a transport information value chain in the form of maps, transport data, timetable data and the current performance of the transport network in question
- > OSS/BSS: The Operational Support Systems and Business Support Systems of mobile operator networks are also important inputs to information value chains. Within a transport scenario, they may be used to measure how many people walk between different modes of transport, e.g. between metro and tram or bus. Also, they may be used to understand crowding and congestion in particular areas of a city.
- > Corporate databases: A significant number of corporate databases are available within a country's transport networks. These include the manufacturers' corporate databases, which register the operators they have sold to and how the transport asset has performed. Operators in particular have quite large customer relationship management systems that contain a significant degree of detail about customers' preferred travel plans, the performance of their assets, etc.
- > End users: Perhaps the most significant input for travel in the new era of IoT is the end user. End users now have the ability to contribute to the Information Marketplace for transport by, for example, tweeting or otherwise reporting about the performance of the transport infrastructure. In addition, a significant majority of smartphones now enable end users to act as their own transport directors; instead of relying solely on the information from

operators, they are able to connect together to gain understanding of what their optimal route might be. Moreover, many smartphones now contain NFC and other sensor-type technologies that allow the end user to interact with the transport infrastructure in new, more complex manners. Many end users will be able to pay for their transport via near-field technologies in the future. Some transport apps are also allowing end users to create 'connected journeys' using multiple modes of transport in one city, rather than having to search a number of timetables.

### Processing

During the processing stage, data from various sources is mixed together. Making use of data analytics, these data sources are combined together to create the insights and information necessary for transport decision-making, which is often tremendously complex. Some examples include:

- > Understanding how to best deliver public transport services to lower-income communities
- > Providing appropriate coverage of public transport during peak commuting hours
- > Understanding how to re-route traffic during a major incident
- > Prevention of major rail incidents through deep knowledge of how the transport infrastructure is actually working

### Examples of the processing that are required here included

- > Combining the number of mobile subscribers on a bus at a particular time of day with the timetabling information for local bus services
- > Combining sensor track information owned by the maintenance teams together with the data from train or car manufacturers. This allows a more detailed understanding of how a product is actually performing in use, rather than in the laboratory test environments that manufacturers have traditionally relied upon
- > Combining detailed demographic information together with maps and environmental sensors, allowing city officials to understand how transport routes are affecting the health of different inhabitants in different areas of the city

## 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

### Packaging

After the data from various inputs has been combined, the packaging section of the information value chain creates information components. These components could be produced as charts or other traditional methods of communicating information to end users. Within the transport scenario, the packaging of information would be shared between a broad group of end user actors. Due to the sensitive nature of the information being shared, it is likely that this information marketplace would be a private one – one that, at least initially, makes only a minimal amount of data publicly available. The actors would therefore be able to package and share the data amongst one another within an established set of design patterns and data sharing rules. One difficulty with the packaging of transport information in a city context is the broad number of actors that will need to be able to view and understand the data quickly. Everyone from urban planners to transport professionals will need to be able to view and understand the data quickly in order to make decisions. The human interface is therefore one of the most important aspects of this information value chain.

### Distribution/Marketing

The final stage of the Information Value Chain is the creation of an Information Product. These products fall into two main categories:

- Information products for improving internal decision-making: These information products are the result of detailed information analysis that allows better decisions to be made. For the transport scenario, cities will be able to create more detailed and streamlined urban planning systems that incorporate IoT data with the vast array of other ICT assets across a city. Information about how a city is actually used by its citizens will give cities the ability to understand how best to deliver transport services while enhancing quality of life for their citizens.
- Information products for re-sale to other economic actors: These information products have high value for other economic actors and can be sold to them. While these products may not be directly re-sold, the ability to share information across the value chain may provide significant value to the eco-

economic actors in question. Operators may be able to reduce customer dissatisfaction, and city officials may be able to provide transport services that are envied by other cities. Infrastructure managers and maintainers, meanwhile, will be able to provide a higher quality service for lower cost while ensuring the safety of passengers and employees alike.

### Increased Efficiency Cross Industry Information Value Chains

It is not just within the ITS realm that the information value chain may benefit the transport industry, however. There are significant gains to be made by incentivising companies and both national and local governments to share data and work together. This will help companies achieve the required savings across the entire construction value chain for transport infrastructure.

From a corporate perspective, sharing data can help reduce the day-to-day costs of extremely complex project management. Many transport construction projects are comprised of a large variety of sub-contractors and temporary staff. This can lead to overly complex reporting and working procedures for both companies and staff: “Second- and third-tier suppliers are not always effectively integrated at an early enough stage [although they] are often providing the bulk of the construction capability.” It is common to see front-line staff being supervised by several different managers, who spend much of their time trying to resolve complex interfaces between separate organizations: “We found that front-line staff were working productively for only around 10 percent of their shift. They spent most of their shift waiting for tools, specialist colleagues, and access to the site, or walking to collect missing items.”<sup>30</sup>

Properly integrated ICT systems can help construction staff work more effectively, providing real-time updates of the state of projects, which sub-contractors should be on site at which time, and which parts of the site they are supposed to be working on while supplying up-to-date records of any critical path dependencies for the project in question. This will allow staff to only

<sup>30</sup> McKinsey, 2011 Keeping Britain moving

### 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

be called in on those days that they are required, and more importantly, the correct equipment and materials can be delivered correctly and at the correct time for the project schedule. Overall project management could be enhanced, costs reduced and lead-times shortened: “Better supervision and front-line planning can, on average, cut total labor costs by 20 percent or more. Such a saving would shrink the unfunded investment gap by between £25 billion and £35 billion.”<sup>31</sup>

An example of shared facilities across the construction industry can be seen, for example, in the creation of the London Construction Consolidation Centre (LCCC), which was developed to reduce the number of deliveries going directly to construction sites in order to reduce congestion and CO<sub>2</sub> emissions. By the end of the two-year pilot period, the following benefits were identified:

- An estimated 60–70 percent reduction in the number of vehicles delivering to the four sites being served
- Two hours average reduction in supplier journey times
- Increased productivity of the labor force on the construction sites by up to 25 minutes per person day as a result of the delivery reliability from the LCCC

From a planning perspective, ICT can help to reduce the lengthy process of achieving planning permissions. This is particularly useful in countries such as the UK that struggle with extended planning processes, which often are complicated by legal processes, meeting the environmental requirements for sustainability targets and protecting the habitats of protected wildlife. ICT could, for instance, be applied to properly map and update the locations of protected species. Also, many of the current government regulations could be put into electronic formats that could be automatically integrated into project management and planning systems.

One example could be the creation of digital tools that help to assess a project’s environmental impact “in a global approach (from materials to structure) as a component of lifecycle analyses.”<sup>32</sup> Such systems could help shorten the application, planning and implementation time for infrastructure projects, thereby significantly reducing costs:

“At each stage, infrastructure providers incurred significant legal fees and other costs, sometimes stretching into hundreds of millions of pounds. If the typical four-year planning process could be shortened by just 6 or 12 months, the funding gap would fall by between £1 billion and £2 billion.”<sup>33</sup>

There are several areas where such integrated systems could be successfully applied, including option appraisal, in order to maximize the value of overall infrastructure spending. Ideally, these should ensure that the wider impacts of spending are included, such as possible broader regional impacts, while also identifying where infrastructure assets could effectively be shared.<sup>34</sup> More importantly, the overall costs of the infrastructure could be properly assessed, including both initial costs as well as “maintenance costs including the economic loss of traffic jams due to maintenance work,<sup>35</sup> which can be more properly integrated and assessed with data shared across sub-contractors, open data sources and local and national governments”.

Integrated transport infrastructure planning systems will therefore be a critical component in ensuring that countries meet their infrastructure requirements without significant overspending on such projects. This is equally important for aging infrastructure. In many European countries, for example, existing infrastructure dating back to the “1970s and 1980s are thus reaching the end of the serviceability.” Knowledge about their condition is therefore essential for planning the expenses involved in maintenance and

<sup>31</sup> ibid

<sup>32</sup> NR2C New Road Construction Concepts Towards reliable, green, safe&smart and human infrastructure in Europe

<sup>33</sup> McKinsey, 2011, Keeping Britain Moving

<sup>34</sup> HM Treasury, 2011 National Infrastructure Plan

<sup>35</sup> NR2C New Road Construction Concepts Towards reliable, green, safe&smart and human infrastructure in Europe

### 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

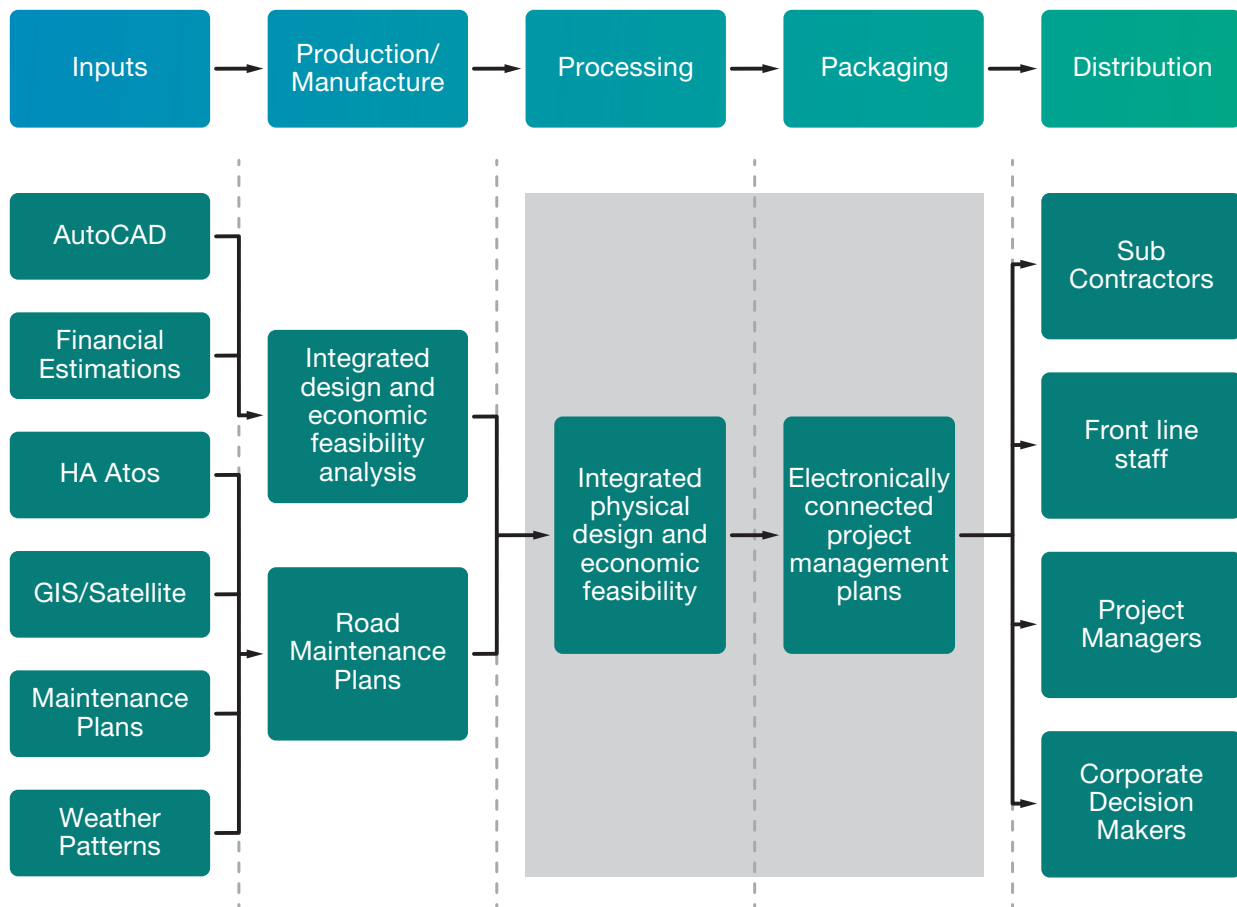
rehabilitation of this infrastructure. Such planning requires the development of monitoring systems to quickly establish the condition of the infrastructure, performance models for structures, materials and maintenance techniques to forecast the maintenance required year by year.<sup>36</sup> Such systems require the integration of a variety of information sources between economic actors within the entire transport value chain.

Figure 4 provides an example of such an information value chain, which would be private and shared only between trusted parties actively working on projects.

Additionally, logistics operators and other actors in the logistics supply chains could increase both operating and cost efficiencies by “developing research projects along the supply chain, or sharing resources with competitors – options could include sharing warehousing, transport networks, or last mile delivery solutions in crowded urban centers.”<sup>37</sup>

Integration of data sources is only one area where ICT can help create efficiency improvements. Another important area is that of physical goods deliveries – i.e logistics.

Figure 4: Cross industry value chain



<sup>36</sup> ibid

<sup>37</sup> PriceWaterhouse Coopers, Transport and Logistics Volume 1, 2013

## 3.1 ICT AND LARGE SCALE TRANSPORT SYSTEMS

### Logistics

Logistics is an area where ICT has been successfully applied for many decades in managing the flow of goods between end points. ICT has “already led to substantial improvements in real-time monitoring of the flow of goods. Tracking and tracing systems allow an exact view of location of different products, be they at the supplier, distributor, salesman, or already delivered to the end-customer”. These systems have been successfully applied to reduce theft, pinpoint route tampering, provide equipment tracking, reduce delays in production and increase the security of products and staff.<sup>37</sup> Delivery processes have been improved by providing detailed information on temperature, air quality and – for fresh produce – by monitoring the rate of decay. Decision makers now “receive a broad picture about the condition and location of individual goods as well as components across the entire supply chain.”<sup>38</sup> IoT holds significant promise for logistics in creating increasingly efficient and effective supply chain processes. Strong ICT capabilities are a core competence and often a core differentiator in this industry.

For many manufacturing companies within, for example, the FMCG industry, products have short sales lives and are fairly low value. As a result, companies look to minimize stock and optimize the value of their logistics networks. Logistics can have a significant impact on such a company’s margins and companies are therefore often trying to understand how to best integrate flows to minimize so-called “empty running”.

Paradoxically, existing investments in supply chain management technologies have to some extent delayed the uptake of innovative and potentially industrially disruptive ICT applications in the logistics industry. For example, some systems (e.g. IsoTrak) have allowed companies to know the rough locations of drivers and trucks along their routes. However, since companies were charged ‘per ping’ for knowing the driver’s exact location, many companies did not use these services extensively as the actual ongoing IT costs of multiple transactions would affect margins.<sup>40</sup> Companies instead used systems such as IsoTrak to maximize fuel efficiency and to attempt to reduce empty runs by drivers and

trucks, rather than to fully streamline their operations. As the costs of sensors, smartphones and other tracking technologies have fallen, many companies have decided it is time to invest in such innovations.

Logistic operations that rely heavily on trucking or other forms of road transport are perfectly suited to the usage of smartphones, GPS and other forms of sensor technologies. Many companies have already implemented GPS and smartphone applications to track the performance of truck drivers across delivery fleets. This allows more fine-grained control over both delivery routes and the performance of individual drivers. Aggregated trucking patterns allow companies to fine-tune regular delivery routes as well as schedule proper maintenance of vans and trucks based on actual wear and tear, rather than on prescribed maintenance schedules outlined by manufacturers. In addition, companies may book driver safety training where it is required.

Even smaller logistics companies are able to take advantage of the reduced costs of digital technologies, with many studies showing carriers and owner-operators placing greater dependence on devices including smartphones, tablets and apps, to run their businesses, find freight or improve load management.<sup>41</sup>

Integrated transport solutions will become critical to the competitive success of a broad variety of logistics operations and as a result, this sector of the industry is likely to provide opportunities for industrial transformation for new entrants.

In addition to enabling ITS and enhancing information value chains within transport infrastructures, ICT has begun to be applied in a wider variety of ways within the transport industry due to the broadscale consumerization of technology. This gives consumers much more control over the ways in which they interact with and use transport services. Some of these services hold the potential for industrial transformation. We cover these in sections 3.2 and 3.3.

<sup>38</sup> PriceWaterhouse Coopers, Transportation & Logistics 2030 Volume 1, 2013

<sup>39</sup> ibid

<sup>40</sup> Author interviews with logistics specialists

<sup>41</sup> <http://about.uship.com/post/media-coverage/opinion-transportation-techs-tipping-point/>

# 3.2 SMALL-SCALE TRANSPORT SERVICES – THE APP ECONOMY

Recent decades have seen a proliferation of small-scale consumer technology such as smartphones and tablets as well as an increasing availability of cheap computational capacity in the form of cloud computing. These technologies have now reached a point where they are able to reshape industrial structures as they permit the creation of new organizational forms. Within this section, we investigate these small-scale developments and identify several patterns, or organizational archetypes, that exist within the transportation. We focus on the following: Data Brokers, Transport Asset Rental and Taxi Services.

## Transport Data Brokers

Within the transport industry, there has been a proliferation of smartphone apps that are based around increased interactivity and networking among transport users.<sup>42, 43</sup> The increase in smartphone users has spawned many mapping services, from general-use maps made by Google to specialized transport mapping services in different cities around the world.

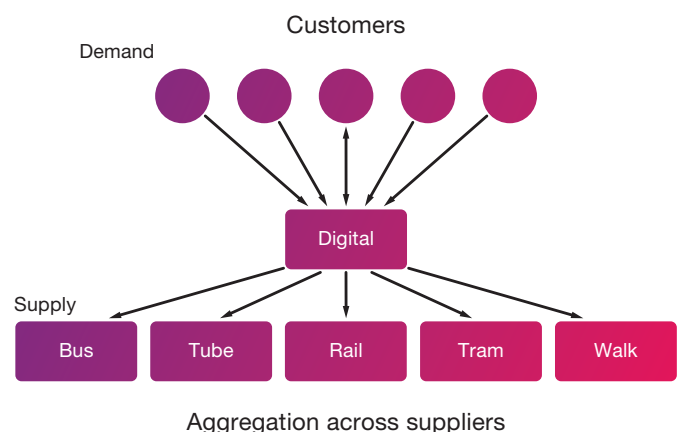
Some services, such as the UK Transport API,<sup>44</sup> provide aggregated developer services towards transportation APIs by collating open data feeds from a variety of sources such as Network Rail and Transport for London (TfL). Developers are able to build quite sophisticated transport services for their end users, for example Citymapper, which provides on-demand route information for smartphone users in real-time.<sup>45</sup>

Through integrating these mapping services with social media and cloud computing, Transport API are also able to provide analytic services to developers showing how people ‘feel’ about their commutes and related travel services.

These sorts of services are digitally aggregating suppliers’ services and information. Commuter demand is also aggregated in order to provide developers of transport services with sufficient demand for their products and services.

Through these solutions, therefore, a large variety of transport platforms are brought together, providing a larger aggregation of transport information to support both the developer and commuter communities, facilitated by an API and data broker as illustrated below in Figure 5.

Figure 5: Transport Data Brokers



<sup>42</sup> Boyd, M. (2014) How Smart Cities are Using APIs: Public Transport APIs. [Online]. 22 May 2014. ProgrammableWeb. Available from: <http://www.programmableweb.com/news/how-smart-cities-are-using-apis-public-transport-apis/2014/05/22> [Accessed: 19 August 2014].

<sup>43</sup> Ishida, T. (2002) Digital City Kyoto. Commun. ACM. [Online] 45 (7), 76–81. Available from: doi:10.1145/514236.514238 [Accessed: 19 August 2014].

<sup>44</sup> <http://transportapi.com/>

<sup>45</sup> Jaconi, M. (2014) The ‘On-Demand Economy’ Is Revolutionizing Consumer Behavior – Here’s How. [Online]. 13 July 2014. Business Insider. Available from: <http://www.businessinsider.com/the-on-demand-economy-2014-7> [Accessed: 19 August 2014].

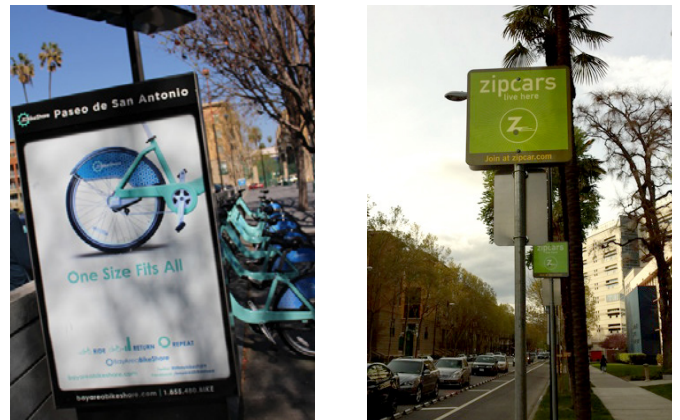
### 3.2 SMALL-SCALE TRANSPORT SERVICES – THE APP ECONOMY

These services are also being delivered to a broad variety of customers via the increasing use of electronic signage at bus stops and other transport connection points. Through interactive interfaces, cities are able to provide access to these aggregated transport information services to all citizens – not only those with a smartphone:

Image: Electronic Signage and Aggregated Transport Information



Image: Bike and Car Collection Points in San Jose



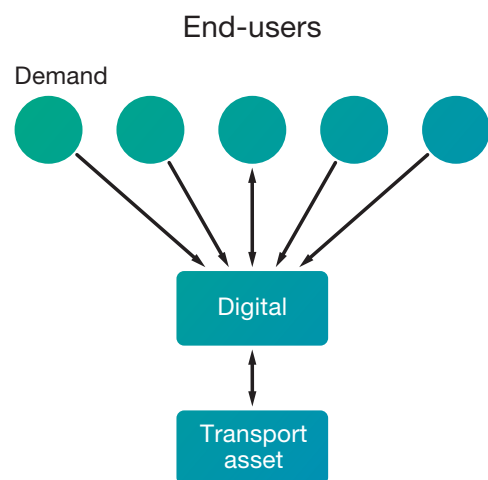
In these cases, a range of technologies are used to create new methods of organization and coordination of supply and demand between end users and asset owners. While there are several different forms of asset ownership – bikes are often owned by cities, whereas cars are typically owned by private companies – the organizational archetype is the same: demand is aggregated and supply of an asset is coordinated by digital technologies, as illustrated in Figure 6.

#### Car and Bike Rental

Another organizational archetype that has become common across many cities is the use of digital technologies to provide more efficient access to physical transport assets. A form of transport asset rental, users are able to “pay per use” of a bike or a car, while asset owners are able to ensure that assets are in use a greater proportion of the time.

This pattern is repeated in a variety of transport sub-sectors, from bikes (e.g. Boris Bikes in London) to car rental (e.g. Avis) to car sharing (e.g. RelayRides). In addition to digital interactions, however, this organizational structure also requires new methods of access to the asset in question. Public bike rental services, for example, need both the real estate for bike pick-up sites as well as digital technologies.

Figure 6: Digitally Enabled Transport Asset Rental



## 4.2 SMALL SCALE TRANSPORT SERVICES – THE APP ECONOMY

New forms of this organizational archetype also hold promise for more significant industrial transformation, such as the use of car kits that allow people to use mobile apps to access and open cars parked on the street, rather than requiring additional real-estate for new car lots.

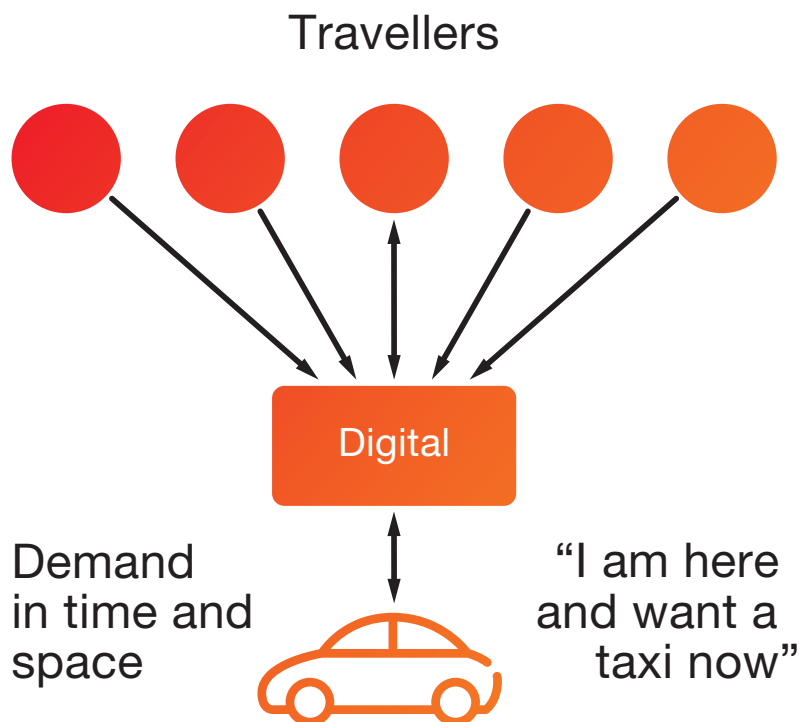
These forms of car-sharing are already having an impact on the industrial structure. For example, it has been estimated that for each car-sharing vehicle in a large city, 32 personal vehicle purchases are avoided.<sup>46</sup> In addition, some traditional car rental service providers are starting to adopt similar methods of providing access to cars, as it reduces the costs of real estate management for traditional car rental services. Avis' acquisition of ZipCar is one such example, and several car manufacturers, including BMW and Daimler, are investigating how to provide "as a service" methods of car provision to their customers.

### Taxi Services

An adaptation of this organizational form can also be found among taxi services. Using a simple app installed on their smartphone, end users are able to request a taxi at their exact location, rather than relying on an available taxi happening to pass them on the street. Nearby taxi drivers receive the request and are able to decide whether or not they will pick up the passenger. This type of technological intervention has been created to aggregate demand for access to taxis. Examples of this include Hailo, which is used in a variety of cities around the world. This organizational archetype is illustrated in Figure 7.

In section 4.3, we investigate the next stages of disruption for the transport industry, which will not only challenge the regulatory environment, but will also potentially have greater impact on our urban environments and the manner in which end users approach their transport requirements.

Figure 7: Aggregating demand for Taxis



<sup>46</sup> Alix Partners, 2014

# 3.3 INDUSTRIAL DISRUPTION DUE TO ICT

The potential for disruption of the current structure of the transport industry through the interaction of digital technologies and transport systems can be seen on a variety of levels. In this section we focus on two of these organizational forms: digitally-enabled ride sharing and the use of digital technologies to create autonomous vehicles.

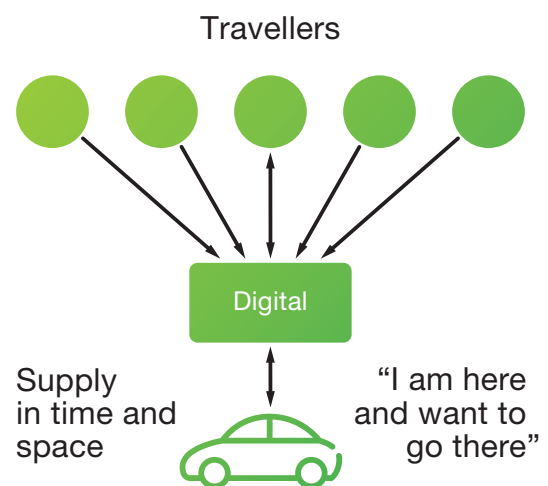
## Ride Sharing

Both Uber and Lyft have received a great deal of press attention due to their use of digital technologies to innovate within the field of transport. Sometimes referred to in the context of the “sharing economy” and sometimes regarded as competing with taxi services, both of these services apply a combination of cloud computing and mobile applications to allow travellers to rent time, space and a driver in someone else’s car. Anyone who owns a car can register as a driver and, as long as they pass through the security checks, are able to rent out space and time in their car. In comparison to car rental services, a traveller is able to rent solely the exact amount of space and time that they actually need in a car. These digitally enabled solutions therefore allow for the aggregation of time and space in cars across a large variety of travellers. This form allows for the creation of a type of taxi service, but one that is fully digitally enabled. Rather than maintaining a fleet of cars, mechanics, drivers and the associated real estate of a taxi company, Lyft or Uber allow cars to return to the possession car owners when not in use for a job.

Companies such as Lyft and Uber are therefore able to collect fees by assisting the allocation of these resources effectively across the economy and, in effect, from other peoples’ fixed assets.

It also means that a driver is able to allocate their time more efficiently – when they are not driving, they are able to do something else entirely. For example, there are emerging examples of people working a variety of small jobs via a multitude of digitally-enabled “sharing economy” platforms in order to make ends meet.<sup>47</sup>

Figure 8: Digitally Enabled Ride Sharing



<sup>47</sup> Check App. Accept Job. Repeat, In the Sharing Economy, Workers Find Both Freedom and Uncertainty, NY Times, August 16th 2014

### 3.3 INDUSTRIAL DISRUPTION DUE TO ICT

This model, however, challenges the regulatory environment for taxis and the manner in which passenger safety is addressed. Traditionally, taxis have been heavily regulated in terms of motor vehicle safety and the background checks required for drivers. Both Uber and Lyft now require driver background checks and regular checks of driver vehicles, as well as insurance and driver safety education. Uber, however, has nonetheless been banned in Germany due to failing “to meet safety regulations by using ‘unverified drivers in unlicensed vehicles’, and leaving passengers uninsured in the event of an accident or injury.”<sup>48</sup>

This is perhaps the most disruptive force that the taxi industry has seen in several decades, as seen in the 2014 protests by London’s Black Taxis, which were directed toward Uber’s lack of regulation in comparison to traditional licensed black cabs.<sup>49</sup> Several cities in the United States have also attempted to curb the use of ride sharing apps by having police pose as riders in order to impose fines on drivers.<sup>50</sup>

#### Carpooling

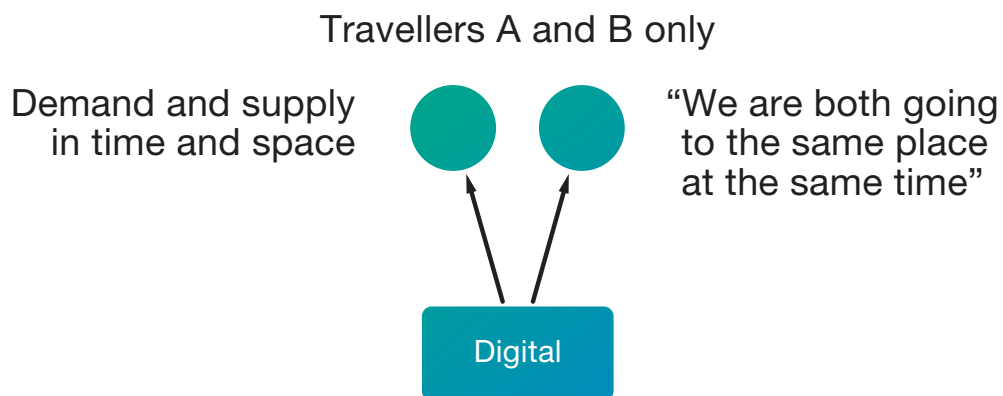
In an expansion of a more traditional style of sharing cars, start-ups such as RideJoy are now offering a

digitally mediated carpooling service. End users are able to enter their travel requirements into the platform to find other people travelling to and from similar points. Rather than renting space, time and a driver – with the passenger playing the role of ‘customer’ – these organizational structures instead allow end users to share travel costs. This is illustrated in Figure 9.

#### Disrupting Last Mile Logistics

Perhaps one of the most interesting organizational patterns now emerging within transport is the digitally enabled model of ‘last mile’ logistics within urban areas. As many people work increasingly in a free-lance or short-contract capacity within many modern economies, the time available for visiting shops, collecting items or waiting for home deliveries can either diminish or become less predictable. At the same time, many smaller stores in local areas suffer due to competition from online and large-scale retailers. One response to this has been the creation of localized ‘last-mile’ delivery brokers within a variety of urban areas, allowing people to buy items from local stores or restaurants and have them delivered by local drivers to the home or office location that is most convenient at the moment.

Figure 9: Digitally Enabled Car Pooling



<sup>48</sup> <http://www.ft.com/cms/s/0/cad1f9c4-2391-11e4-8e29-00144feabdc0.html#axzz3Bgfg9QTQ>

<sup>49</sup> <http://www.bbc.co.uk/news/uk-england-london-27799938>

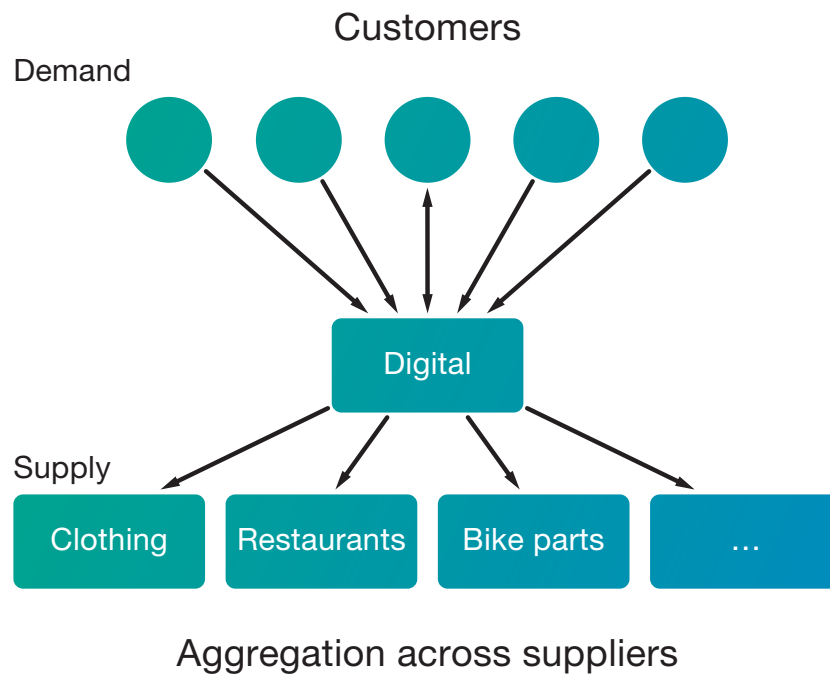
<sup>50</sup> <http://www.fastcompany.com/3029754/most-innovative-companies/undercover-police-are-targeting-uber-and-lyft-drivers-to-send-a-me>

### 3.3 INDUSTRIAL DISRUPTION DUE TO ICT

While this model is often used within the restaurant industry to deliver lunches and catering from local restaurants to offices, companies such as PostMates in the USA now offer delivery of anything from designer clothes to bike parts.

from the off-the-shelf SaaS providers that enable smaller companies access to everything from routing shipments to accounts receivable and payable. Small-scale applications that can be installed on a smartphone, such as PostMates, enable a degree

Figure 10: Aggregation across suppliers for last mile logistics



While it is unlikely that the globalized supply networks of large companies will be destroyed, many local transport and logistics suppliers will be required as supply networks are re-established at a local level, in particular to help overcome the issues associated with congestion and last mile logistics in urban areas. These aspects will be covered in a more in-depth fashion in our upcoming report on the retail sector.

Transport and logistics solution providers will rely heavily on a broad range of technical innovations

of coordination between suppliers, brokers and end users that was previously only available to large-scale corporations with the money to invest in large-scale ICT systems.

Such delivery systems could incorporate the use of drones or other forms of autonomous vehicles as they become integrated into transport systems, but the coordination mechanisms can only be provided by ICT systems, many of which are increasingly available to smaller players, not just multinational corporations.

### 3.3 INDUSTRIAL DISRUPTION DUE TO ICT

#### Autonomous Vehicles

Autonomous vehicles have been a hot topic of discussion within the transport industry during 2014. These are vehicles that apply a range of technologies including sensors, lasers, satellites and car-to-car communication, to automate the task of driving. While full-scale adoption of such vehicles is still a relatively distant prospect, a variety of pilot studies are in progress, the most famous of which is perhaps Google's 'driverless car'. A variety of car manufacturers are also investigating the role of driverless car technologies, including integrating concepts such as platooning of autonomous vehicles, which would allow cars to effectively travel much closer together, thus reducing congestion.

There is likely to be a long period of overlap in which manual and connected/driverless cars will co-exist on roads, which will limit platooning to designated roads or lanes. When the number of cars that are able to use digital technologies to form platoons, reaches critical mass, however, it will become possible to reverse the lane restrictions. The available space on roads through platooning autonomous vehicles be increased by 2 times in urban areas and 10 to 20 times on high-speed roads. Vehicle manufacturers that are developing their own driverless car technologies and government regulators<sup>51</sup> believe that car-to-car communication is vital for ensuring that such vehicles are able to navigate small-scale changes and effectively reroute.<sup>52</sup> This type of communication must be real-time with extremely low-latency in order to provide the security and safety mechanisms required for road and traffic systems.

In theory, with effective autonomous vehicles and appropriate regulation, fossil-fuel-based technologies can also be more rapidly phased out in urban areas if the autonomous vehicles are designed as electric vehicles. In the UK, for example, more than half of all urban trips under five miles are still done in a car. 40% of all CO<sub>2</sub> emissions in the UK transport sector come from movements of less than 10 miles. Effective autonomous vehicles for short trips or for use in last-mile logistics can therefore significantly reduce emissions and fossil fuel dependency through the development of business models in which endusers can share autonomous vehicles for local journeys.

Finally, autonomous vehicles may help challenge the 'mission ubiquity' of traditional personal vehicles sold to consumers.<sup>53</sup> Currently, most cars are designed to do everything from short-distance errands to the supermarket and commutes to work to long-distance trips between cities. But with extensive use of autonomous, vehicles for local trips within cities, this may no longer be necessary. Personal vehicles could instead be reserved for longer-distance trips, and if electric vehicle technologies become prominent within autonomous vehicles for short distances within cities, fossil fuels could be saved for those industries and transport applications that are prohibitive to electric vehicles or other renewable forms of fuel sources.

<sup>51</sup> <http://www.nhtsa.gov/About+NHTSA/Press+Releases/2014/USDOT+to+Move+Forward+with+Vehicle-to-Vehicle+Communication+Technology+for+Light+Vehicles>

<sup>52</sup> Madrigal, A.C. (2014) The Trick That Makes Google's Self-Driving Cars Work. [Online]. 15 May 2014. The Atlantic. Available from: <http://www.theatlantic.com/technology/archive/2014/05/all-the-world-a-track-the-trick-that-makes-googles-self-driving-cars-work/370871/> [Accessed: 1 August 2014].

<sup>53</sup> Parry-Jones, R. (2014) Imperial Business Insights - Richard Parry-Jones, Chairman, Network Rail. [Online]. 2014. Eventbrite. Available from: <https://www.eventbrite.co.uk/e/imperial-business-insights-richard-parry-jones-chairman-network-rail-tickets-11604432169> [Accessed: 1 August 2014].

# 4. THRESHOLDS OF TRANSPORT SYSTEMS

The transport industry exists within a certain ‘thresholds’ that keep the industrial structure functioning in a stable manner. Once a threshold<sup>54</sup> is crossed, the industrial structure is likely to re-adjust as new entrants are able to enter the market. Existing actors within the established industrial structure will be forced to adjust their strategies as a result. In today’s transport industry, digital technologies are creating ‘space’ for new entrants that over the long term may cause a restructuring of the industrial structure and the methods by which transport is provided to end-users.

In this section, we present an overview of some of these main thresholds, and in Section 6, we investigate how the transport industry might be reshaped through the continued application of ICT. We split these thresholds into two main sections: long-term thresholds that have always been part of the transport industry, and new thresholds, some of which have been introduced due to technological advancements.

---

<sup>54</sup> For example, when semiconductor speeds in mobile handsets reached the same computational capacity as desktop computers, the ‘smartphone’ was developed, which eventually led to the restructuring of the mobile industry as new entrants from the computing industry were able to compete within this restructured market

# 4.1

## TRADITIONAL THRESHOLDS

### Demand

One of the key thresholds within the Transport System is demand, i.e. the number of people that wish to use the service, the number of cars on the road or the number of passengers that wish to use public transport. Demand is set to increase dramatically, in particular in urban areas, due to rising populations and increasing levels of urbanization. For example, by 2030, the average UK resident is expected on an annual basis to drive an added 1,100 kilometers, take more long-distance trains and “take one more flight than he or she does at the moment ... which will increase passenger numbers on the roads by almost 30 percent, rail travel by 50 percent and the number of flights originating in the United Kingdom by as much as 75 percent.”<sup>55</sup> On average, for each kilometer of motorway, 113 million passenger vehicle kilometers are driven nationally each year, versus 47 million in Germany, 39 million in France and 36 million in the United States.<sup>56</sup>

### Increasing Urbanization and Urban Sprawl

In most urban areas, faster journeys will not cause a long-term reduction in travel time. Instead, commuters often select cheaper housing located further away in order to take advantage of the increased travel speed. Individuals are not primarily interested in travel distance, but rather in the social, economic, and environmental costs of bridging that distance: namely, time, money, and effort.<sup>57</sup> Commuters generally act within certain transport boundaries – roughly a total commute time of around one hour per day and costing around 10-15 percent of total personal expenditure.<sup>58, 59</sup>

Increasing travel speeds will therefore more than likely create broader urban sprawl as a result of increasing urbanization.

### Energy

Energy supply and demand represents one of the most significant issues for transport. Fuel prices and their volatility are significant issues. The cost of energy relates directly to the forms of transport selected by companies for logistics and the options selected by people for daily transport. If prices increase dramatically, there is likely to be a re-territorialization of supply chains and a relocation of manufacturing closer to the sources of demand. Studies show that if the “oil price soared to a four digit figure, regionalization of supply chains and relocation of production sites would be the consequence. If oil prices stay in the three digit figure range, global sourcing and transportation are still expected to provide reasonable cost advantages.”<sup>60</sup>

The electrification of existing fleets may address certain emissions and energy security issues but, taken in isolation, offers no positive impact on other issues of urban space planning and traffic alleviation.

### Regulation

Regulation is one of the main processes that set thresholds within the transport industry. For example, in 2007, the EU set a target of 20 percent renewable energy usage within transport by 2020. Many emerging nations have also implemented similar plans, with the Chinese government targeting 20 percent of its energy capacity to be renewable by 2020.

<sup>55</sup> McKinsey, 2011, Keeping Britain Moving

<sup>56</sup> McKinsey, 2011, Keeping Britain Moving

<sup>57</sup> Maat, K., Van Wee, B. & Stead, D. (2005) Land use and travel behaviour: expected effects from the perspective of utility theory and activity-based theories. *Environment and Planning B: Planning and Design*. 32 (1), 33–46.

<sup>58</sup> Marchetti, C. (1994) Anthropological invariants in travel behavior. *Technological Forecasting and Social Change*. [Online] 47 (1), 75–88. Available from: doi:10.1016/0040-1625(94)90041-8 [Accessed: 28 October 2013].

<sup>59</sup> Schafer, A. (1998) The global demand for motorized mobility. *Transportation Research Part A: Policy and Practice*. [Online] 32 (6), 455–477. Available from: doi:10.1016/S0965-8564(98)00004-4 [Accessed: 9 February 2014].

<sup>60</sup> PriceWaterhouse Coopers, 2013, Transport and Logistics 2030, Volume 1

## 4.1 TRADITIONAL THRESHOLDS

Regulation also has a strong impact on the ability of a nation to generate revenue for the building of transport infrastructure. Fossil fuel taxes, for example, help to pay for infrastructure investments in many EU countries. The resulting loss of tax revenues from the implementation of renewable energy sources within the EU needs careful assessment with regards to how countries will source funding streams for new infrastructure investments.

### Financing

Financing of transport infrastructure is a major issue for many nations, in particular for those faced with upgrading existing transport infrastructure.<sup>61</sup> A significant rate of investment is required in order to keep pace with the global requirements for infrastructure.

The funding gap, however, may be the most significant issue for a number of countries. This is the gap between the estimated costs for the upgrade and upkeep of transport infrastructure and the actual tax revenues available to pay for it. This challenge will need to be addressed by a variety of funding mechanisms from Public-Private Partnerships, by privatizing certain parts of infrastructure or possibly by investigating different tax revenues streams.<sup>62</sup>

### Environmental Thresholds

Pollution from fossil-fuel-based transport has been a threshold for the transport industry for many years. CO<sub>2</sub>, pollution levels, NO<sub>2</sub> and fine particulate matter (PM10) create significant health problems and it is estimated that, in the UK alone, poor air quality costs the economy up to £17 billion each year through increased health problems and reduced life expectancy.

Road transport is responsible for 66% of particulate emissions and 42% of NOX emissions in London. 100,000 EVs could reduce emissions of particulates by 70–90 tons per year and emissions of oxides of nitrogen by 350–400 tons per year.

---

<sup>61</sup> HM Treasury, 2011, National Infrastructure Plan

<sup>62</sup> *ibid*

# 4.2 EMERGING THRESHOLDS

As illustrated through this document, the role of ICT is increasing within the transport industry and as a result, a new set of thresholds are emerging that relate to the application of digital technologies. Several related thresholds are emerging:

- > The number of consumers using click to collect and online delivery mechanisms
- > The ratio of licensed drivers to cars. As endusers use digital technologies and autonomous cars, there may be a reduction in the number of licensed drivers. Crossing this threshold may mean that the number of service business models will increase dramatically
- > Data – the amount of data captured from sensors and smartphones will restructure the industry once a critical number of data sets are collated.

## Digitally Empowered Citizens

The increasing ubiquity of digital technologies has created a redistribution of transport patterns over recent years as customers have become better able to communicate with one another about transport issues via a variety of social media.

From a broader perspective, however, consumers are also intervening in the delivery patterns of logistics companies as they demand greater control over delivery processes. Many consumers are also starting to demand locally delivered produce and other local goods.

As will be discussed in our Retail report, these logistics thresholds are also connected to the manner in which companies reshape their existing operations as a result of online shopping and mCommerce. The number of

people shopping for items online and using solutions such as “click to collect” will continue to have dramatic impacts on transport infrastructures.

## Ratio of licensed drivers to cars

As a larger number of people use digital technologies to coordinate and access transport solutions, the ratio of licensed car drivers to actual cars may fall. Transport infrastructures would need to be flexible and responsive to these changes, which may be triggered by the increased use of ride sharing, car sharing and autonomous vehicles.

## Insurance Models for a Digital World

Insurance within the emerging digital world is an increasingly difficult topic. Under current laws, it is unclear who is liable for an autonomous vehicle during an accident: Is it the owner, the passenger or the company that developed the software? Does a passenger need to be sober in a driverless car? A key boundary that needs to be addressed within the transport industry is therefore the liability and associated risk models for the range of new technology solutions proposed for rail, road and air. Without appropriate risk models, it is very difficult for insurance companies to set premiums.

## Data

The increasing use of sensors and smartphones across all aspects of transport infrastructure leads to rising amounts of data, which needs to be collected, analyzed and applied appropriately within the transport sectors. These data sets are likely to be the focus of some of the upcoming transformations of the transport sector and, as a result, the sheer quantities of data available is a critical threshold: When is it safe to assume you have enough data to make a decision that may have significant real-world impacts?

# 5. EMERGING ROLES FOR ICT IN TRANSPORT SYSTEMS

## Citizen Centric Transport

As discussed, ICT has a strong role to play in transforming the transport industry. In this section, we turn to the emerging future roles that ICT may have in redefining transport. We take two simple examples: data-driven driving, which could potentially change the nature of insurance and commuting; and social logistics, which may transform the ways in which last-mile logistics are handled within cities.

## Data-Driven Driving

Thanks to the rising numbers of sensors and communications technologies embedded into vehicles, it is starting to become possible to collect significant amounts of data about the performance not just of the vehicle in question, but of the actual drivers themselves. Usage patterns of internal systems can be stored and assessed, as can decisions taken and response times made in instances such as inclement weather. Data profiles can be built and constructed around a driver's pattern of use and overall driving style.

A few examples of this type of solution already exist within the trucking industry. Volvo's I-See,<sup>63</sup> for example, makes it possible to control the truck in real-time when it is approaching a hill, leading to overall fuel cost reduction.

In personal vehicles, data collected from an individual's driving performance could, for example, be used by insurance companies to raise or lower someone's insurance premium in response to their actual driving record. This can be seen in start-ups such as ZenDrive,<sup>64</sup> which recently received funding to create a data-driven transport solution.

As such solutions become the norm, a transformative impact will be felt as the transport and insurance industries struggle to cope with the privacy issues associated with managing the data generated by personal vehicles and their drivers.

## Social Logistics

A somewhat more dramatic transformation of the transport industry can be seen in the use of social tactics within the last-mile logistics sector. By applying the logics of social networking<sup>65</sup> to freight, a set of preferred networks could be established between companies allowing local producers to coordinate their deliveries for greater coverage areas. The network might also allow larger brokers and shippers to make use of the many thousands of small logistics companies, many of whom have specific regional knowledge regarding how best to deliver across the last mile in a particular city.

Such solutions would rest on the notions of dynamic strategic partnerships and the ability to identify those within a network who can be trusted to deliver one's parcels. Service providers would serve as an extension of the network partner's company as and when required while offering micro-payment options for delivery. We cover these issues in more detail in subsequent reports in this series, in particular the final report.

<sup>63</sup> <http://www.volvotrucks.com/trucks/uk-market/en-gb/trucks/volvo-fh-series/key-features/Pages/i-see.aspx>

<sup>64</sup> <http://www.zendrive.com/>

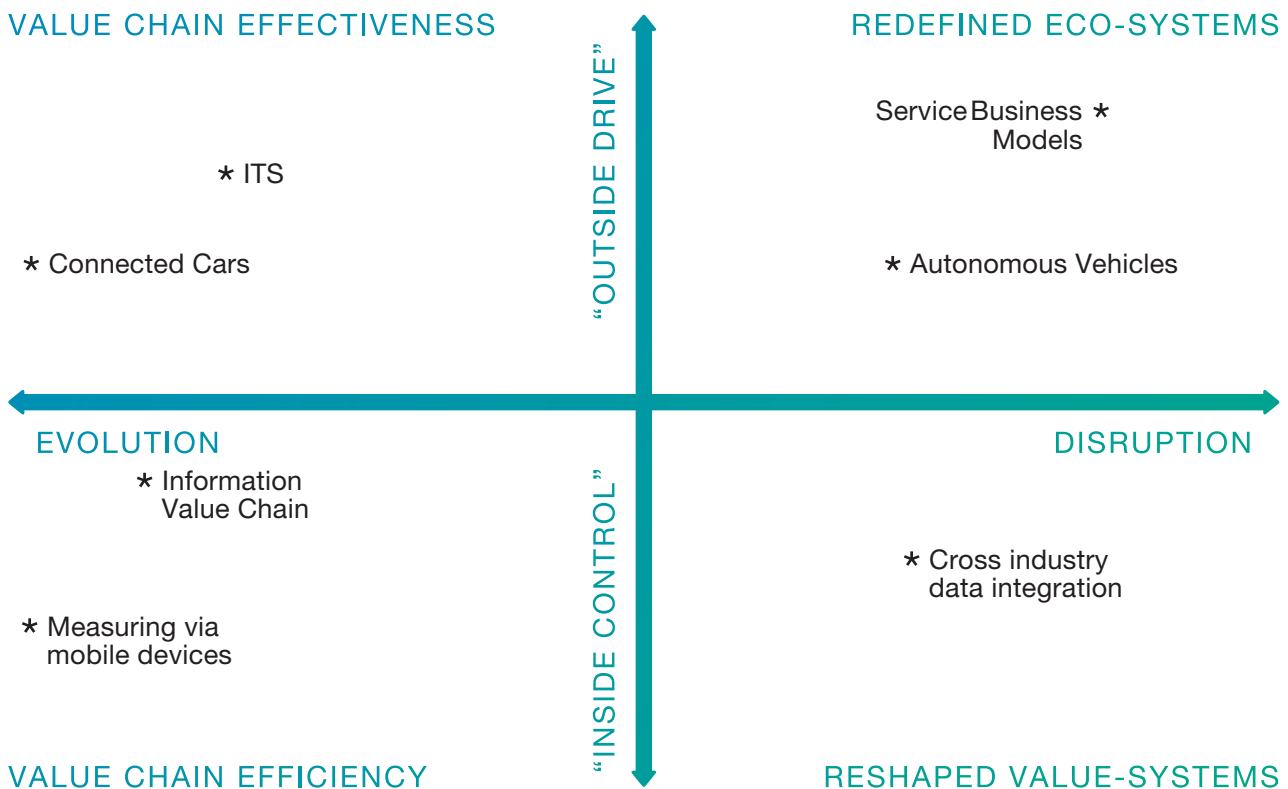
<sup>65</sup> <http://about.uship.com/post/media-coverage/opinion-transportation-techs-tipping-point/>

# 6. CONCLUSIONS

The transport industry is currently facing serious pressures from a variety of sources including growing populations, rising urbanization, changing work patterns and environmental pressures to reduce emissions. In order to face these challenges effectively, a broad array of technologies is required, including ICT.

In Figure 11, we illustrate this new landscape of ICT interventions in the transport industry, including those areas that lead to greater efficiencies and those that lead to industrial disruption.

Figure 11: Matrix of Transport Solutions and Impact on Value Chains and Eco-Systems



## 6. CONCLUSIONS

As a result of the deeper integration of ICT into the transport industry, new entry points are created into the industrial structure. The most obvious new entrants are the ICT manufacturers who are now critical parts of the supply chain for automotive manufacturers. For several reasons, end users are now also more deeply embedded in the transport value chain: firstly, through the capturing of an end user's private data, such as tweets about the performance of the transport infrastructure; and secondly, through the capture and analysis of an end user's driving performance. These driving statistics are then used to create improved vehicles or new insurance models, interventions that would otherwise be impossible without ICT.

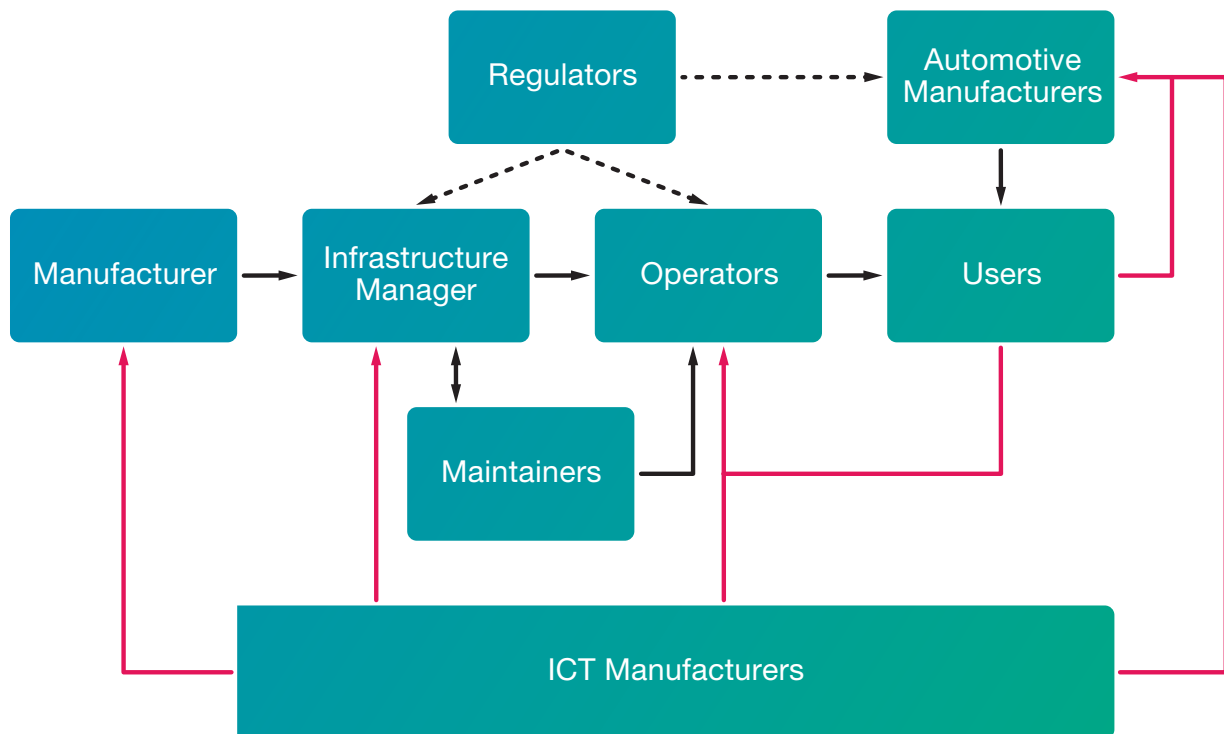
ICT is therefore set to become a vital component of all parts of the transport infrastructure. The manner in

which ICT is implemented will be critical to overcoming the pressures that are being exerted on the transport industry. ICT can play a role in reducing congestion without building entirely new transport infrastructure, and these solutions will need to be rapidly implemented in society in order to provide cost-effective transport solutions across the world.

At the same time, ICT is also helping provide end users more control over how they interact with transport systems, with the creation of disruptive applications that allow new organizational forms to emerge.

The next reports in this series investigate the other forms of industrial disruption that are occurring throughout our Networked Society and analyze the overall impact of these transformations on our economy.

Figure 12: ICT embedded into transport value chain



Ericsson is the driving force behind the Networked Society – a world leader in communications technology and services. Our long-term relationships with every major telecom operator in the world allow people, businesses and societies to fulfil their potential and create a more sustainable future.

Our services, software and infrastructure – especially in mobility, broadband and the cloud – are enabling the telecom industry and other sectors to do better business, increase efficiency, improve the user experience and capture new opportunities.

With more than 110,000 professionals and customers in 180 countries, we combine global scale with technology and services leadership. We support networks that connect more than 2.5 billion subscribers. Forty percent of the world's mobile traffic is carried over Ericsson networks. And our investments in research and development ensure that our solutions – and our customers – stay in front.