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**POLICY DEPARTMENT**  
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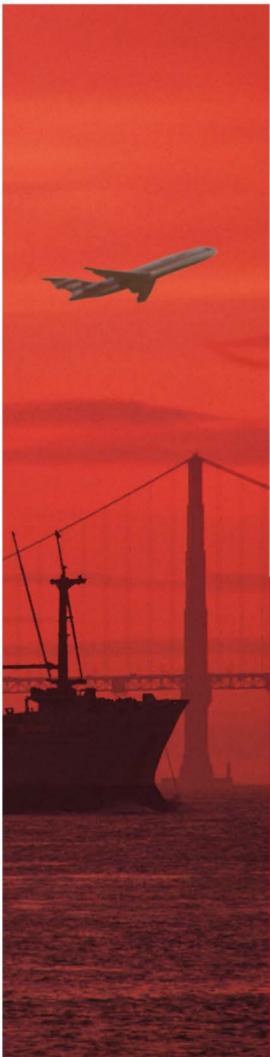
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**RESEARCH FOR TRAN  
COMMITTEE - THE  
WORLD IS CHANGING.  
TRANSPORT, TOO.**

**STUDY**





**DIRECTORATE-GENERAL FOR INTERNAL POLICIES**  
**POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES**

**TRANSPORT AND TOURISM**

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This document was requested by the European Parliament's Committee on Transport and Tourism.

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**DIRECTORATE-GENERAL FOR INTERNAL POLICIES**  
**POLICY DEPARTMENT B: STRUCTURAL AND COHESION POLICIES**

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**Abstract**

The (more and more urban) European population is growing and ageing. Mobile information and communication technologies are developing rapidly. Global competition and the fight against climate change are pressing. These developments all have an impact on transport as a whole. As this paper shows, mobility needs and patterns evolve; new transport services/systems emerge; transportation technologies aim to become more 'environmentally-efficient'. This transformation challenges the existing transport sector's structure and governance and calls for major changes in the regulatory framework.

**2016**

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## FOREWORD

The world and the transport sector are changing.

The (more and more urban) European population is growing and ageing which affect mobility needs and patterns. The rapidly developing mobile information and communication technologies give rise to new transport services/systems. Transport technologies are also evolving because the sector is pressed to run in a more 'environmental-efficient' way and is increasingly subject to global competition.

All these societal (e.g. sharing economy), technological (e.g. unmanned vehicles) and economic changes (e.g. E-commerce) have an impact on transport as a whole, whether it is long distance (e.g. multi-modal travel planning and integrated ticketing), urban (e.g. 'Transportation Network Companies') or freight transport (e.g. upheaval in logistics and delivery services).

This overview addresses this evolving context and the related challenges.

Part I, which is principally related to the major urban areas of the west of the continent, is about the ***new trends in transport demand and related impact on transport systems and patterns*** generated by changes in demography, mobile technologies and the internet.

Part II relates to ***changes in technologies to meet emerging urban mobility patterns***. It shows that transport is undergoing massive digitisation. Furthermore it advocates alternative drive technologies and electric vehicles as the key technologies for a decarbonisation of the sector.

Part III provides an in-depth analysis of ***the role of regulation in preparing transport for the future***. It notably underlines the regulatory implications of the current challenges affecting different transport modes and the mobility system as a whole.



## LIST OF ABBREVIATIONS

<b>ANSP</b>	Air Navigation Service Provider
<b>ATM</b>	Air Traffic Management
<b>AV</b>	Automated Vehicles
<b>BEV</b>	Battery-electric vehicle
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>EASA</b>	European Aviation Safety Agency
<b>EETS</b>	European Electronic Toll Service
<b>ENRRB</b>	European Network of Rail Regulatory Bodies
<b>ERA</b>	European Railway Agency
<b>ERRU</b>	European Registers of Road Transport Undertakings
<b>EU</b>	European Union
<b>FAB</b>	Functional Airspace Block
<b>FCV</b>	Fuel-cell vehicle
<b>FP7</b>	7 <sup>th</sup> EU Research Framework Programme
<b>GDP</b>	Gross domestic product
<b>GHG</b>	Greenhousegas
<b>GPS</b>	Global Positioning System
<b>IATA</b>	International Air Transport Association
<b>ICAO</b>	International Civil Aviation Organisation
<b>ICT</b>	Information and Communication Technology
<b>ITS</b>	Intelligent Transport System
<b>Km</b>	Kilometre
<b>kWh</b>	Kilowatt per hour

<b>LCV</b>	Light commercial vehicle
<b>NAA</b>	National Aviation Authority
<b>NPE</b>	Nationale Plattform Elektromobilität
<b>OEM</b>	Original Equipment Manufacturer
<b>ORR</b>	Office of the Rail Regulator (UK)
<b>PKM</b>	Passenger-kilometre
<b>PT</b>	Public transport
<b>PV</b>	Photovoltaic
<b>R&amp;D</b>	Research and development
<b>RPAS</b>	Remotely Piloted Aircraft System
<b>RTTI</b>	Real Time Traffic Information
<b>SERA</b>	Single European Railway Area
<b>SES</b>	Single European Sky
<b>SESAR</b>	Single European Sky ATM Research
<b>SESAR JU</b>	Single European Sky ATM Research Joint Undertaking
<b>SETA</b>	Single European Transport Area
<b>SHIFT<sup>2</sup>RAIL</b>	Shift to Rail - European rail joint technology initiative
<b>SSS</b>	Short Sea Shipping
<b>TEN-T</b>	Trans-European Transport Network
<b>UAS</b>	Unmanned Aircraft Systems
<b>UK</b>	United Kingdom
<b>US</b>	United States
<b>V2G</b>	Vehicle to grid

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## **PART I**

# **NEW TRENDS IN TRANSPORT DEMAND AND RELATED IMPACT ON TRANSPORT SYSTEMS AND PATTERNS**

**by University of Leeds, Institute for Transport  
Studies**

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## EXECUTIVE SUMMARY

There are five factors which will have significant influence on the demand for travel over the coming decade whatever actions are taken within the transport sector:

1. *Population growth and immigration:*  
The growth in the population of the European Union and the ageing of this population will increase the demand for travel within the EU.
2. *Migration and urbanisation:*  
In the preceding 15 years some countries have seen population growth of over 25% whilst others have lost almost 20% with a tendency to move towards Western Europe. There is also significant growth pressure on major cities and particularly capital regions.
3. *The changing nature of both work and employment market participation:*  
There will be a continuation of the participation of women in the labour market and increases in flexible working including part-time and role sharing. Overall there will be a net increase in travel demand but there will be a more diverse workforce with different demands.
4. *Income growth:*  
The rise in income that should accompany increased employment and gross domestic product (GDP) growth will act as a continuing upward pressure on mobility in most areas. There will be increased disparities in income growth across the population which will influence how travel demand grows. It is anticipated that there will be growth of light commercial vehicle traffic in particular and road freight will remain the dominant freight mode.
5. *Mobile technologies and the internet:*  
Much focus has been on the potential of such technologies to substitute physical travel for virtual travel but there is no evidence to suggest that this reduces the amount of travel done. The rise of e-commerce seems to be creating a significant upward pressure for light commercial vehicle traffic in countries which have been strong early adopters. This pressure for growth will continue.

A critical observation across all of these factors is the need to understand the distribution of change spatially, across income groups, with disability and capacity to use and afford technology.

The most important changes that will have a clear relationship with demand resulting from transportation technologies is the price which citizens will face to travel in the coming decade. In particular this relates to changing engine efficiency, technology and fuel types. The commitment to a 95 g/km of CO<sub>2</sub> for new car emissions by 2021 constitutes a 26% improvement on the 2015 standard and will, significantly reduce the costs of motoring and stimulate demand in many areas.

Whilst there will be a continued roll out of intelligent transport systems, integrated ticketing and shared mobility options it seems likely that this will happen at a slower pace than many of the changes set out above with impacts being more local than European scale. In general, the demand impacts are small with the emphasis being on improving operational efficiency.

It is anticipated that there will be a continued and significant development in the application of increasingly intelligent real-time traffic management tools which will free up some additional network capacity through smoother flows. In addition, the continued transition of the vehicle fleet towards full automation will see improved in-vehicle driving experience. However, these technologies require investment (for fixed infrastructure schemes) and consumer acceptance and willingness to pay (for in-vehicle). Their roll out will therefore happen over several years and perhaps decades. Efficiency gains are soon likely to be swallowed up by the latent demand for travel in the congested areas where they are most typically deployed.

A transition to a fully automated driving system could be transformational as it fundamentally changes the role of the vehicle in the transport system. However, in the context of this report looking 15 years ahead, full automation will likely remain confined to niches and it will be a period of learning rather than transformation.

Mobility as a service will undoubtedly mature in the coming decade. However, it will need to be more attractive to users than the existing system so is most likely to emerge in large cities where the push and pull factors make the offering attractive as a replacement to owning a car.

Eight principal knowledge gaps have been identified in the course of developing the report which have been uncovered by considering gaps in the evidence base (Section 9.3). Eight recommendations for action at EU level have been derived from the report (Section 9.4):

1. Address the knowledge gaps in the changing influences on travel demand.
2. Develop a policy pathway for the pricing of transport.
3. Research the transition and deployment options for fully autonomous transport.
4. Continue to invest in programmes to address challenges in growing cities.
5. Establish new planning approaches for areas of no-growth or population loss.
6. Investment in solutions for more inclusive mobility systems.
7. Develop consumer-led regulatory approaches to unlock greater shared mobility.
8. Close the skills gap in the urban freight planning sector.

## 1. INTRODUCTION

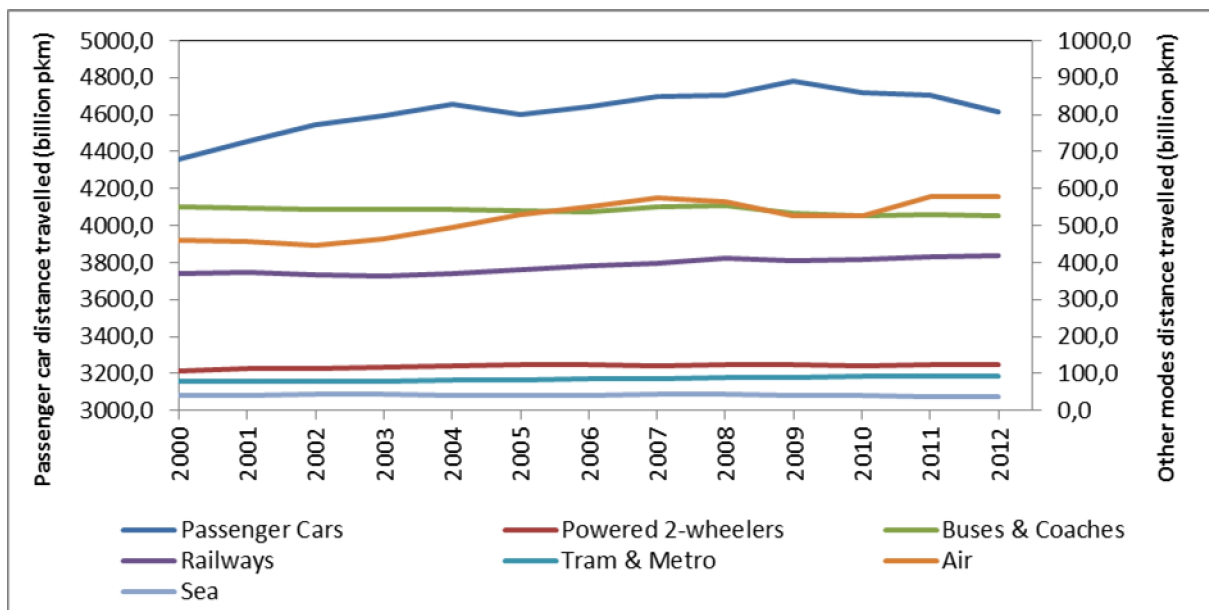
This paper explores new trends in transport demand across the European Union. In thinking about the impacts of different trends on future traffic growth there are some factors where there has been a well-established evidence base “such as where people live, levels of congestion, costs and income” (DfT, 2015, p14). The paper therefore begins with an exploration of these trends looking across influences around demographic change, migration, changing household size, urbanisation and employment. It is possible to think through the extent to which particular trends in these variables might impact on total demand or the relative balance of demand between modes.

However, there are “other factors that could continue to have an effect on traffic growth, but on which we currently have insufficient evidence. For example, lifestyle changes or impacts of changes in technology, that could affect the nature of the trips that we make and reduce the potential for car dependency. These factors are more difficult to incorporate as the evidence on their causal effect is not readily available or conclusive” (DfT, 2015, p15). Uncertainty exists surrounding the implications of changing labour market participation, the role of mobile technology and the internet and the shared economy. This paper seeks to plug those deficiencies or identify priority areas for further work.

Finally, there are changes to the transport system itself which result in part from rapid technological advances in engine technologies, data handling and integration and automation of the control and management tasks which are reviewed. All of these will have an influence on the price, convenience and quality of different forms of transport in the coming decades and these are reviewed.

This paper highlights some critically important dynamics which will influence the development of future European Transport Policy but it is also important to think about the pace of change. Figure 1 shows the change in passenger kilometres for each mode of transport between 2000 and 2012.

**Figure 1: Passenger kilometres for all modes of transport in the EU-28, 2000-2012 (European Commission, 2014)**



Trends such as ageing occur over decades and can be seen with some certainty. New vehicle technologies take years to come to the market and then to penetrate in large numbers. There are occasional external shocks such as oil price spikes or the banking crisis of 2008 which can lead to rapid change observable at a whole EU level. There are also aspects of the market which are changing rapidly such as new app development for urban transport. However, the impacts on demand of these more rapid changes will depend also on the extent to which other constraints such as where we live and how we work also evolve over longer time scales. Understanding the dynamics of demand is not a one off review task but will require a continual monitoring of what aspects of society are on the move and which are not.

Further, it is important to understand that travel demand evolves from the reconfiguration of ways of doing things which are not always immediate or even immediately obvious. For example, whilst there has been optimism about the internet reducing travel by more people working from home, this dynamic can also increase home-work distances. The ability to work remotely also extends across international boundaries with even more profound effects on how work is organised, with greater international collaboration made possible. Changes across the different areas (e.g. technology, employment, socio-demographics) are inevitably inter-related.

## 2. DEMOGRAPHIC CHANGE

### 2.1. Population growth

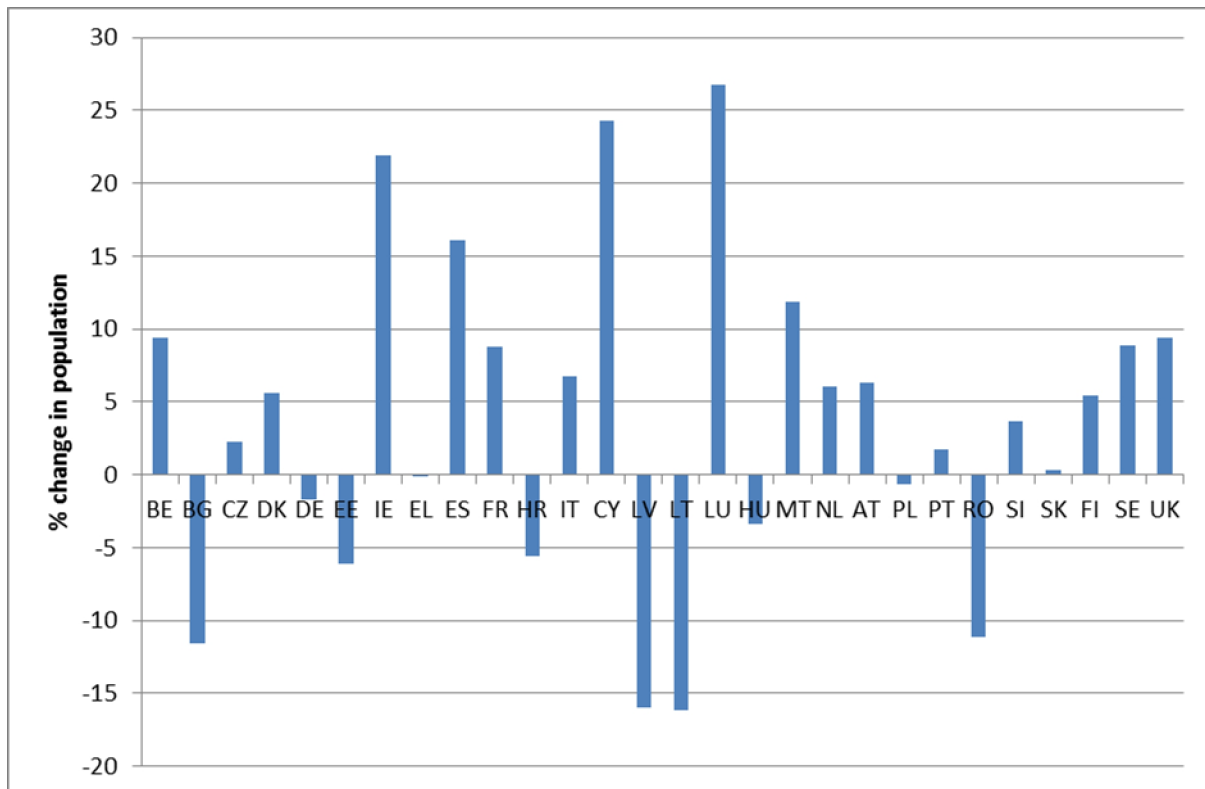
In 2014, the total population of the EU-28 was 506.8 million inhabitants, an increase of almost 20 million (4%) from 2000. This represents the continuation of a historical trend towards increasing population since at least the 1960s. Whilst historically natural population change has accounted for most of the increase there are three key drivers contributing to the change since 2000 (Eurostat, 2010):

- Life expectancy (up 3% from 2000 to 79.6 years).
- Fertility Rates (up 6% points to 1.58 in 2012 after a long decline).
- Migration.

Since 1992 net migration has contributed most of the change (Eurostat, 2014a) with the crude rate of net migration up from 2.1 (2000) to 3.2 per thousand inhabitants.

Different combinations of the factors are behind population increases in most Member States, although total population actually decreased in several Eastern European countries (Bulgaria, Croatia, Estonia, Latvia, Lithuania, Hungary, Poland and Romania) as well as in Germany, while it remained essentially stable in Greece over the period 2000-2014 (Figure 2). As a result, the EU-15<sup>1</sup> accounted for a larger share of the EU-28 population in 2014 (79.3%) than it did in 2000 (77.4%), corresponding to a net increase of 24.7 million inhabitants.

**Figure 2: Population change rate (2000-2014) for EU-28 Member States**



Source: Eurostat.

<sup>1</sup> The 15 Member States before the 2004 enlargement.

Urban (and notably capital city) regions are overrepresented among NUTS-3 areas<sup>2</sup> with the greatest population growth rate between 2008 and 2012, as a result of both high net migration inflows and high crude birth rates (Eurostat, 2014c). Overall, population statistics at the regional level generally show population growth for the majority of urban regions over the period, with a notable 'pull effect' of capital regions, and decline for rural areas (Eurostat, 2014c). This is considered further in Section 3.

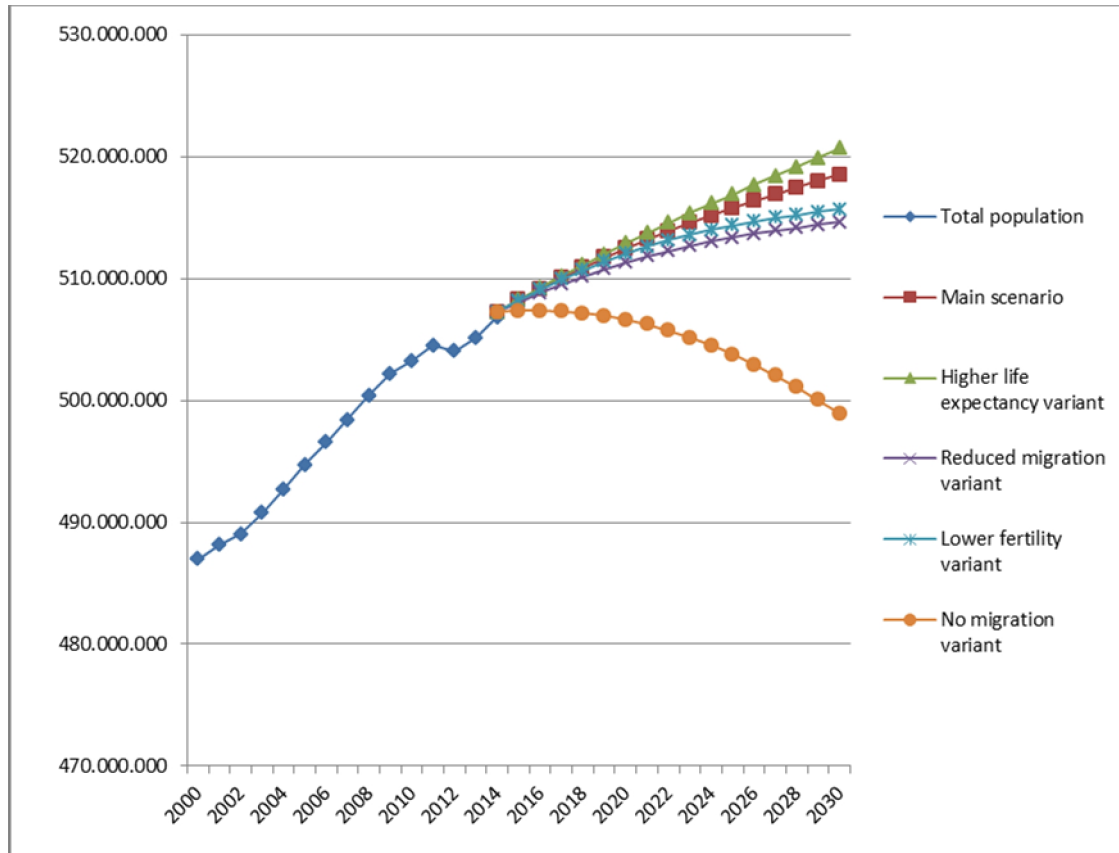
Figure 3 shows a range of scenarios for future population growth with different assumptions around the three main drivers. These suggest increases of around 10 million to the EU population over the next 15 years. Projected increases in population levels will, all other factors equal, result in growing travel demand. In addition, the increasing concentration of the EU-28 population in the EU-15 countries might result in an overall increase in car use, as standards of living are generally higher than in the EU-13<sup>3</sup> and this is associated with levels of motorisation and car use (Eurostat, 2014d). However, congested networks may act as a brake on growth in these areas relative to the EU-13 where motorisation is catching up.

Migration will remain the key driver of growth. The effects of increased migration on travel demand are difficult to assess. Research literature on the travel behaviour of people with a non-domestic background in Europe is sparse and underdeveloped, partly as a result of a lack of data (Haustein, et al., 2013). Existing studies on daily mobility suggest that, other factors equal, they tend to drive car and cycle less than the rest of the population, with notably low levels of travel among women, although this varies considerably across ethnic groups and generations (Harms, 2007; Welsch et al., 2014). Accordingly, the International Transport Forum assumes that increases in the foreign-born population will lead to a reduction in car travel demand (OECD/ITF, 2013). It has been suggested, however, that people with migration background are more likely to undertake international long-distance travel to stay in contact with more dispersed social networks (European Environment Agency, 2014).

---

<sup>2</sup> The NUTS classification (Nomenclature des Unités Territoriales Statistiques) is used by Eurostat for dividing up the economic territory of the EU. It ranges from larger (NUTS 1) to smaller (NUTS 3) territorial units.

<sup>3</sup> The 13 Member States which joined the EU from 2004.

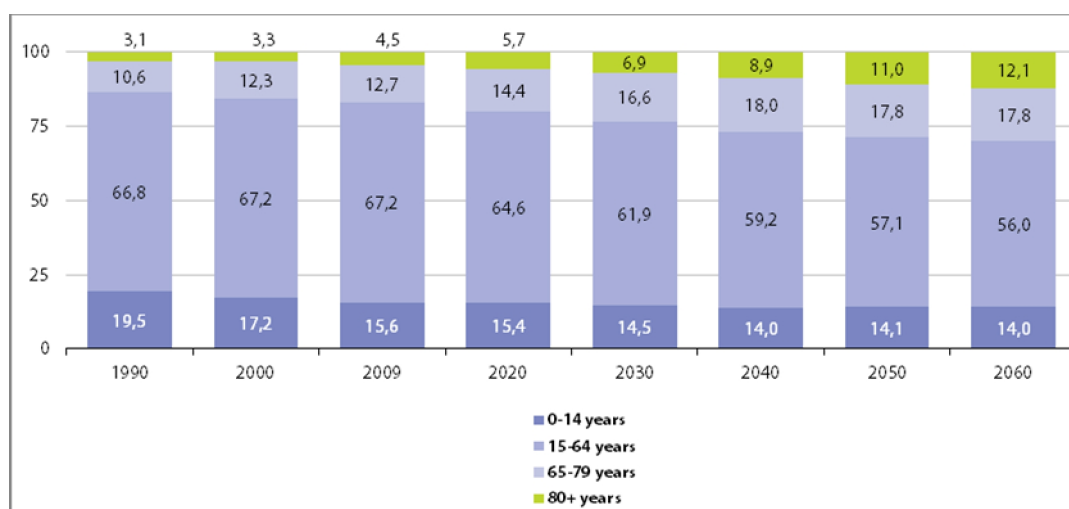
**Figure 3: Total population in the EU-28 (2000-2014) and EUROPOP2013 population projections (2014-2030)**

Source: Eurostat.

## 2.2. Older Travellers

The EU population has become older between 2000 and 2014, with median age increasing from 38.0 to 42.2 years, and significant increases in the percentage of people with more than 65 (from 15.6 to 18.5%) and 80 years (from 3.3 to 5.1%<sup>4</sup>). In parallel, the proportions of young people and young adults have been declining with both of these trends set to continue well into the future (Figure 4). This is the result of persistently low fertility rates combined with (still) increasing life expectancy. Increasing inflows of comparatively younger migrants are insufficient to reverse the trend. While there are still large differences between countries in the percentage of population over 65 in 2014, ranging from Ireland (12.7%) to Italy (21.4%), in all countries (except Luxembourg) this is higher than in 2000. The implications of these changes on travel demand are considered below.

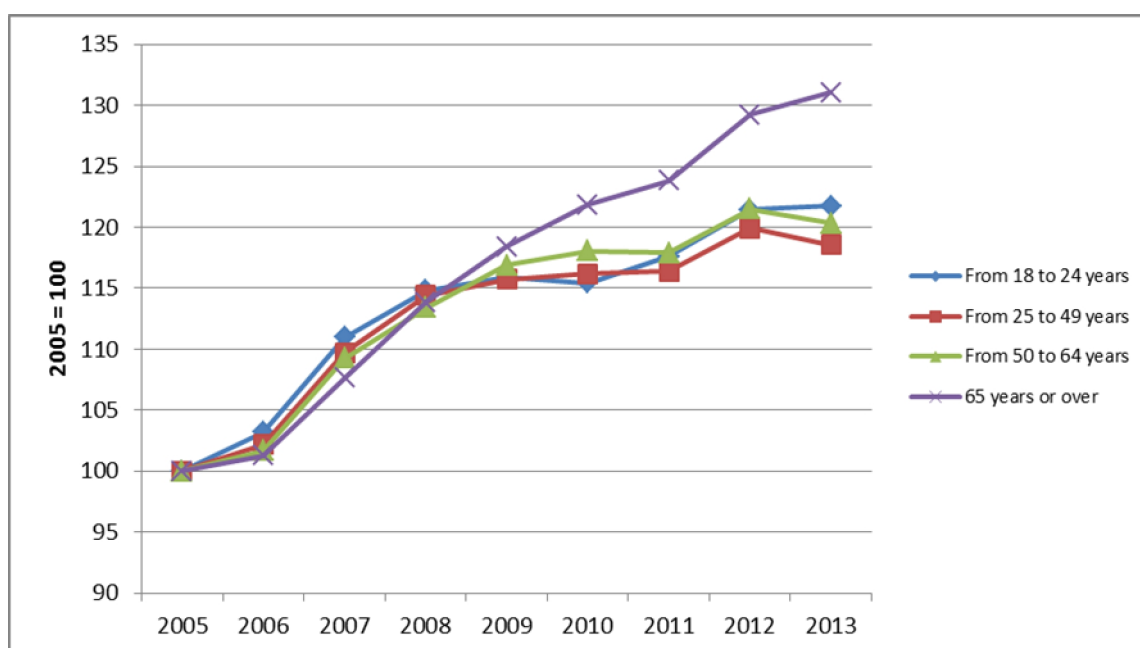
<sup>4</sup> All figures for 2000 refer to the EU-27.

**Figure 4: Population structure by major age groups, EU-27 (% of total population)**

Source: Eurostat.

There is a distribution of travel behaviour within age groups and this is particularly true of older people where there is greater divergence in physical and mental characteristics, life styles, travel patterns and transport needs (GOAL, 2011). For instance, some older people will be more active whilst others will become increasingly isolated (TRACY, 2013).

In general, the over 65 age group has fared well in terms of median equivalised income levels compared with other age groups (Figure 5) although, in the long term, pension reforms are happening which will reduce the gap between age bands. Nonetheless, for the coming decades this creates a dynamic where older people, on average, are better off and where more of them will be retiring as car drivers.

**Figure 5: Median equivalised net income by age group in the EU-27, 2005-2013 (2005=100)**

Source: Eurostat.

The ageing population will be a driver of increased demand for transport and, over time, increasing demand for car based transport. This will be a differentiated trend, with rural dependency on the car likely to be far higher than urban dependency. Even in urban areas the development of assistive driving technologies may further support this growth as a means to overcome the growth in visual, physical and auditory disability associated with ageing (Fielder, 2007). Whilst initiatives are underway to promote active ageing and to stimulate public transport use through measures such as more accessible services and discounted tickets, the overarching trend has been to car use and this seems set to continue.

The impact of ageing on car travel demand will result from the composition of two counteracting effects (OECD/ITF, 2013). Older people drive on average less than individuals in working age, so their increasing demographic weight tends to result in car mileage reductions (age effect). However, new cohorts of older people are characterised by higher levels of car ownership and use than in the past, and this increases car travel demand all other factors equal (cohort effect). International studies suggest that the latter effect has so far prevented a drop in car use in a number of large EU countries (Zumkeller et al., 2013). While eventually the cohort effect will phase out and the age effect will prevail (OECD/ITF, 2013), it is unclear whether this will happen at the aggregate EU-28 level before 2030.

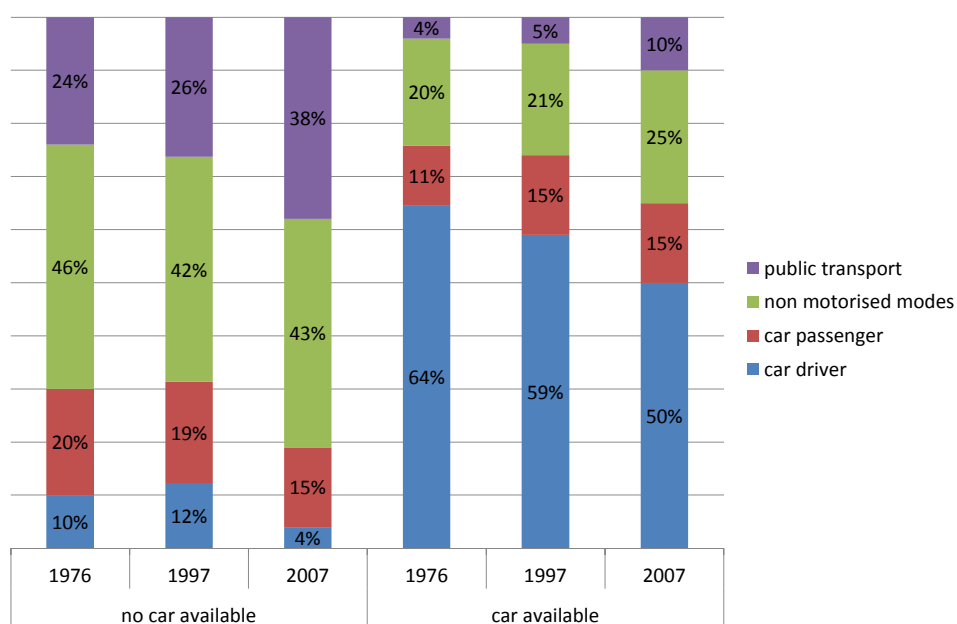
It is also possible that decreasing working age population and the associated decline in total labour supply at the EU level will result in a shift of travel demand from the journey to work to other travel purposes, including leisure and long-distance travel. These are currently less well understood, despite accounting for a large proportion of transport's environmental impacts (European Environment Agency, 2014).

Trends for the last decade, and especially since the 2008 economic crisis, show a redistribution of disposable income towards the older age groups and away from the rest of the population, with notable increases in poverty and social exclusion among the youngest households. If these trends were to continue, they might reinforce current trends towards increasing car travel among older cohorts and decreasing car ownership and use among young adults (OECD/ITF, 2013).

### **2.3. Younger Travellers**

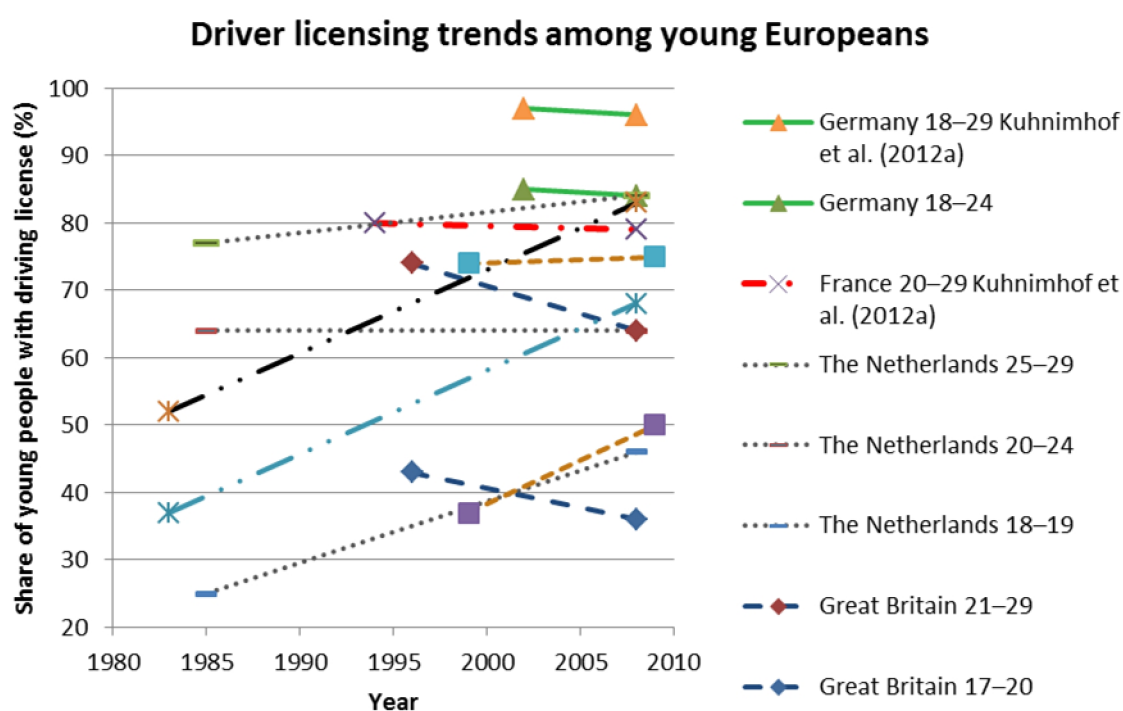
Over the past decade, in some countries at least, there has been a significant reduction in driving license uptake and a reduction in distances travelled by young people. In the UK, for example, national statistics show that 17-20 year olds are travelling 1400 miles per year less now than in 2003 (DfT, 2014). Kuhnimhof et al. (2012) shows a similar shift away from car to other forms of transport over time for travellers between 18 and 29 years of age in Germany.

**Figure 6: Mode share of travellers aged 18-29 by car availability in Germany (adapted from Kuhnimhof et al., 2012)**



Delbosc and Currie (2014) examined global car license holding trends across several countries. In the sample of EU Member States (plus Norway and Switzerland) France, Great Britain, Germany and Sweden all registered a reduction in the licensing of young drivers, while Switzerland and the remaining EU nations studied (Finland, Spain and the Netherlands), reported an increase in younger licensed drivers.

**Figure 7: Younger people driving license trend from international data (adapted from Delbosc and Currie, 2014)**



Delbosc and Currie (2014) suggest a number of potential causal factors from amongst the literature:

- Life stage
- Affordability
- Location and transport (availability)
- Driver licensing regulations
- Attitudes
- E-communication

However, the vast majority of research on youth mobility has focussed on independent mobility, safety and the journey to school. Only recently (Le Vine and Jones, 2012; Kuhnimhof et al., 2012; Metz, 2012; Delbosc and Currie, 2014) have these broader trends begun to be taken seriously. Currently there remains considerable uncertainty over the causes of the drop (in places where it is happening) and the extent to which it will persist across the life course. Whilst cost matters it is not apparent that reductions in costs lead to strong rebounds in driving and it may be that the advances in Information and Communications Technologies (ICTs) discussed elsewhere in this report mean that some younger people are living life differently and in a less mobility dependent manner. It is difficult to assess how this trend will continue to play out given the lack of uniformity and the weak understanding of the causal factors. The more substantive questions for future demand are whether these trends of reducing car use will emerge more universally and how this will play out across the cohorts of middle age and older people as these younger groups age.



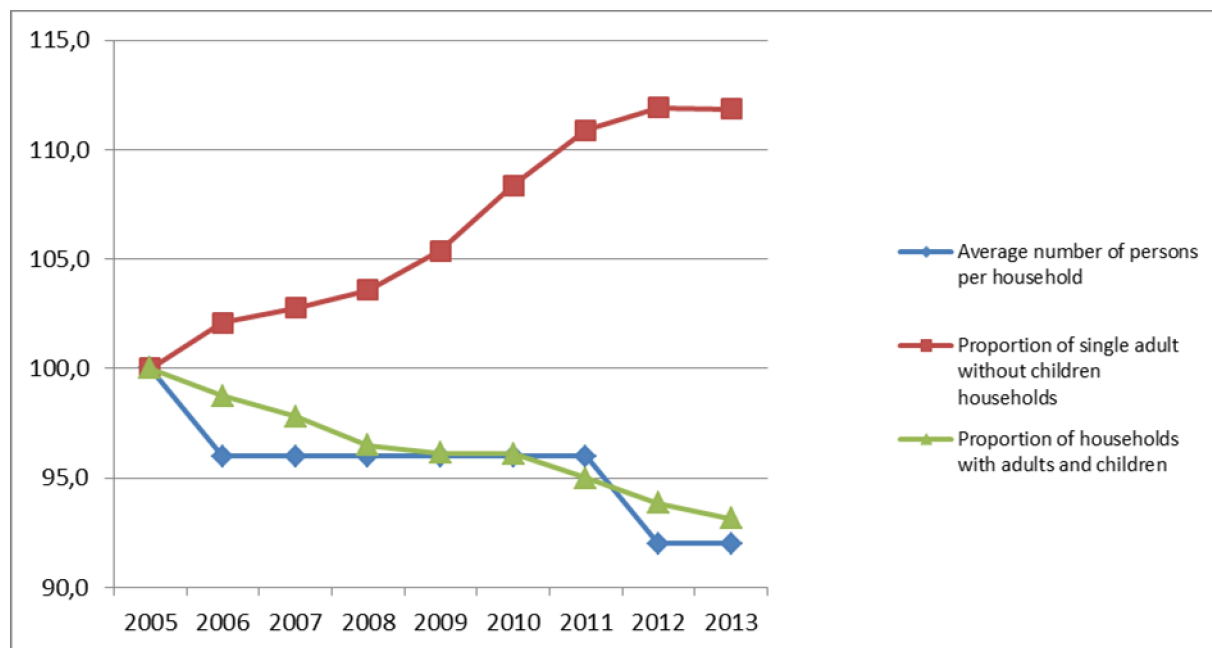
### 3. HOUSEHOLD SIZE, URBANISATION AND EMPLOYMENT

There is an increasing trend for urbanisation, particularly towards major cities and most notably capital cities. In addition to this, there are changing patterns of living with reductions in the average household size and an increase in single adult households without children (Figure 8).

#### 3.1. Household size

The impact of the increasing proportion of single-person households on travel demand is not clear. Single-person households are significantly less likely to own and use cars, but their average *per capita* motorisation rate can still be higher than for larger households. Lifestyle differences associated with solo-living might also correspond to different travel behaviour (e.g. more leisure), including on long distances. Recent studies commissioned by the European Commission (EC) assume that decreasing household size will result in more transport, car ownership and use (Petersen, et al., 2009; Schrotten et al., 2012).

**Figure 8: Household composition indicators for the EU-28, 2005-2013 (2005=100)**



Source: Eurostat.

#### 3.2. Urbanisation

With regard to urbanisation trends, the increasing proportion of the population living in urban areas to 2030 should reduce car use, especially since differences in daily travel behaviour between large cities and car dependent rural areas have increased over time (OECD/ITF, 2013). In general, larger cities have good public transport networks and lower car use. However, much will depend on the detail of where population growth takes place, as mobility patterns can vary significantly *within* metropolitan areas and the growth may out strip the pace at which new transport systems can be developed or existing ones expanded.

On the other hand, recent studies suggest that residents of large urban areas travel on average shorter distances in daily mobility, but significantly longer distances for long-distance (notably air) travel, with this resulting in higher transport-related climate impact for city dwellers (Holz-Rau et al., 2014; Reichert & Holz-Rau, 2014). With this in mind, it is unclear whether increasing urbanisation in the EU will result in a reduction in total travel demand and its environmental impacts.

### **3.3. Employment**

Throughout the EU since 1995 there has been, and will continue to be, a shift in the structure of the economy. In particular there have been significant declines in employment within agriculture and manufacturing and increases within real estate and business services activities (Stehrer and Ward, 2012). The changing nature of the economy is changing not just what work is done but where and how it is done which in turn will have potentially important impacts on travel demand. Eurofound (2015) identify employment trends for increased flexibility by employers and employees and enhanced use of ICTs for doing work. New forms of employment include employee sharing; job sharing; interim management; casual work; ICT-based mobile work; voucher-based work; portfolio work; crowd employment and collaborative employment (European Foundation for the Improvement of Living and Working Conditions, 2015, p. 4). Whilst not all of these are 'new' they are becoming more prevalent.

As well as the type of work changing, the size and composition of the workforce is changing. The EU has introduced targets to 2020, which sets the goal for employment rate to reach 75%, with aspirations to increase the rate for both women and older workers (European Commission, 2010). The employment rate of women within the EU-28 has increased 5.4 percentage points since 2002 to 63.5%, with the employment rate of older workers (those aged 50-65) increasing by 13.4 percentage points in the same time period to 51.8%, still over 20% below male labour market participation rates (Eurostat, 2015a, Eurostat, 2015b).

In 2009, the part-time employment rate was 18.8% for the EU-27, representing an increase of almost three percentage points in ten years. Part-time work has grown markedly since 1999 for both genders. However part-time work remains unequally distributed between genders (32% women versus 8% men) and also across the EU (with nearly 50% of workers being part-time in the Netherlands compared with only 3% in Bulgaria).

Since the 1990s Europe has experienced job polarization, that is, a disproportionate increase in high-paid and low-paid employment. Goos et al. (2010) explains that employment is rising fastest for the highest-paying jobs and declines for those earning the mean wage, thus: *'the high-paying managerial, professional and associate professional occupations experience the fastest increases in their employment shares... whilst the employment shares of some clerks, craft and related trades workers and plant and machine operators and assemblers, which pay around mean occupational wage, have declined'*. Furthermore, *'there has been an increase in employment for some low-paid service workers and low-paid elementary occupations'* (Goos et al., 2010, p.8). These findings are echoed by a recent report on the 'Drivers of recent job polarisation and upgrading in Europe' (Eurofound, 2014).

The implications of changes in the employment sector are complex but this is clearly a critical dynamic to understand as the size of the peak demand for transport, principally

associated with journeys to and from work, is often central to the investments made in physical infrastructure.

Increased labour market participation will, all things being equal, drive up demand for both work and non-work based trips as workers have greater disposable income. The closing of the gender gap will be part of this pressure for growth but it will also promote the choice of home-work locations which make managing the time constraints of parenting in dual income households possible or generate pressures for increased car use to enable longer distances to be travelled within those time constraints (Schwanen and Kwan, 2008). The relationships between job type, income and mode choice will also be strongly influenced by the housing market (Hartell, 2014 and Mattingly and Morrissey, 2014) in a given city. The rise in part-time employment will drive up the number of work based trips which will offset some leisure trips. Part-time jobs tend, on average, to be based closer to home so will have a comparatively low impact on trips by car relative to full-time employment.

The impacts of changing employment and urbanisation need to be considered together as how they will impact on more localised travel demand will be strongly related to how growth in housing is accommodated in cities relative to the transport networks available. Whilst growing employment in larger urban areas tends to have lower per person car demand associated with it, the growth in some cities makes achieving other sustainability goals such as air quality, climate change reduction, health and livability much more challenging.

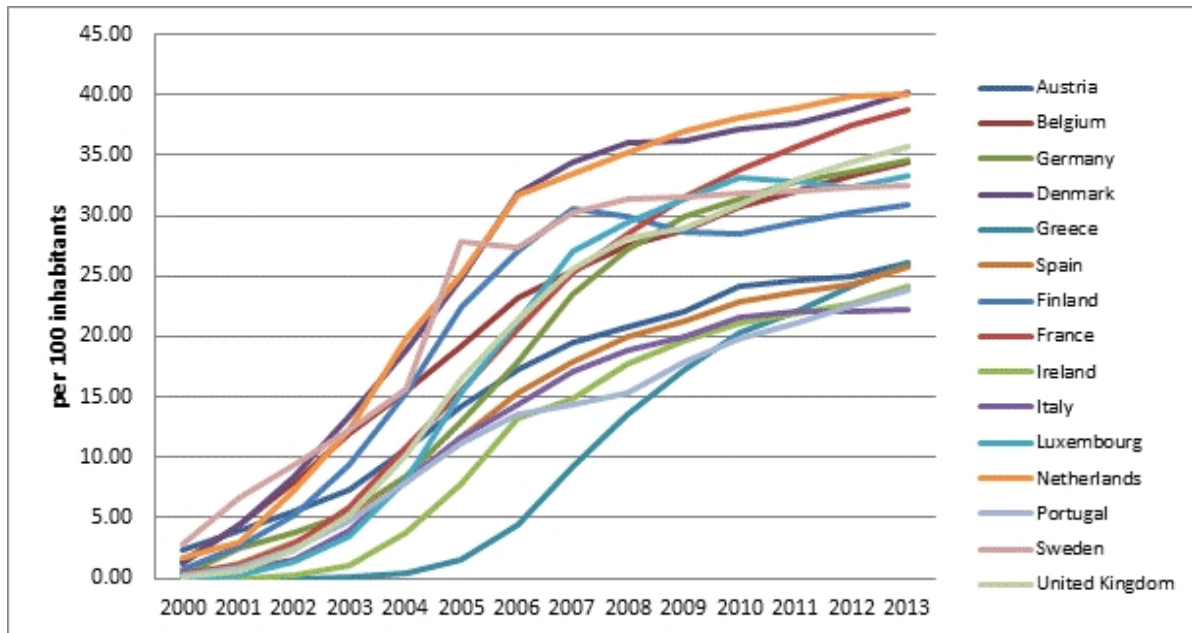


## 4. INTERNET AND MOBILE TECHNOLOGIES

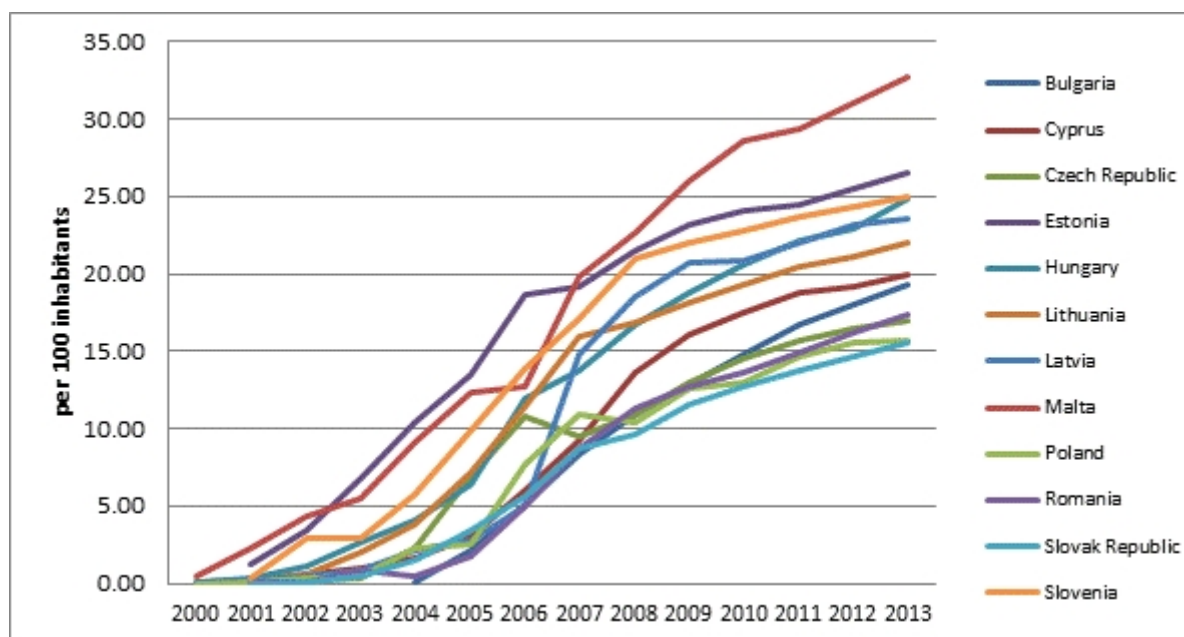
In the last 10 years, the proliferation of mobile devices and related technology and infrastructure in Europe has been significantly profound. Mobile technologies range from smartphones and tablets, to handheld or wearable devices for communication and information (Manci, 2015). Combined, there are now more than 7.4 billion mobile devices worldwide (Cisco, 2015). Growth in mobile devices such as tablets and smartphones is beginning to outpace the traditional mobile personal (PC) computer. In 2008, 139 million smartphones were sold compared with 1.2 billion in 2014 (<http://www.statista.com>).

Similar to internet on mobile devices, fixed-line home internet subscriptions have grown steadily over the past decade. Recent European statistics suggest that 78% (28% broadband) of households now have internet service, almost doubling in a decade (ITU, 2014) and the distribution of internet between EU Member States is converging as shown in Figure 9.

**Figure 9: Growth in fixed (wired) broadband subscriptions for EU-15**



Source: ITU, 2014, publicly available.

**Figure 10: Growth in fixed (wired) broadband subscriptions for EU-12**

Source: ITU, 2014, publicly available.

Mobile phones have now become normalised and adopted as the primary communication device in everyday life for both developed and developing countries (Ling, 2012). Across the EU-27 the lowest mobile phone ownership numbers per 100 population are around 100 in Cyprus and France. In Western Europe over half of the population now uses a smartphone (Emarketer.com, 2014b). The rate of mobile data traffic growth over the past decade has been unprecedented. Average broadband mobile users in 2013 consumed 39 times more data than they did in 2009 (Lee et al, 2013). Such download capabilities have been made possible with the success of both mobile service providers as well as technological developments around Wi-Fi. The 'centralised' storage and on-line only access to documents and software (in the 'Cloud') is also new within this time. In sum, within the last 10 years the 'mobile internet' has essentially 'happened'.

Looking ahead is particularly challenging given the rapid rate of change in not just ownership but also capability and data processing of new devices. The trend towards higher-speed internet access at home, in offices and on the move continues. Wi-Fi technology is being developed to reliably deliver these faster speeds to user devices. The next generation of mobile internet (4G/LTE) is also being deployed across Europe (Morris, 2013). The past impacts of growth in mobile devices and technology may well not be a good guide to the future as what they enable is also changing with the advances in communication speeds and data storage.

The relationship between mobile technology and mobility, and the potential of devices such as smartphones have on travel demand can be broadly understood as four different kinds of relationships (Mokhtarian, 1990). One, is substitution, where devices decreases travel; two is enhancement, where technology changes the 'utility' of particular modes of travel, thus affecting choice between modes rather than a strict binary decision to travel or not; three is efficiency, where telecommunications make travel operation more efficient; and four is indirect, where telecommunications affect land use, which in turn affect travel. Research being undertaken by the Dynamics of Energy, Mobility and Demand (DEMAND) centre suggests a fifth relationship between mobile technology and mobility which accounts for reconfiguration of systems of provision and ways of doing

things (<http://www.demand.ac.uk/>). Consequently, as impacts potentially result in reduced travel as well as generate new and/or more demand for travel, it is difficult to be certain what the overall demand for travel will be over the next decade.

It has long been recognised that telecommunications more broadly, and mobile devices more recently, have the potential to, or have been specifically designed for, substitution for travel and therefore a reduction in travel (Mokhtarian, 2002). The initial belief was that faxes, computers, Internet and more recently smartphones, video conferencing and 'telepresence', would reduce the need for work travel. Yet, for example, the number of UK residents travelling for business has undergone a 40% increase, with Europe (EU-15) accounting for an average of 72 percent of overseas business visits by UK citizens between 1993 and 2005 (Faulconbridge et al, 2009). A recent study of European cities reviewed existing scholarly literature concerning substantial change and mobility (van Cranenburgh, Chorus and van Wee, 2012). The authors defined a 'substantial change' as "an unconventional change that directly or indirectly causes an "enduring" change in at least one principal indicator of mobility of at least 5% on a supranational scale" (van Cranenburgh, Chorus and van Wee, 2012, p. 571). The authors found that impacts from ICTs such as teleworking and teleconferencing are so diverse and complex, that it remains largely unclear how such changes "unfold on aggregate level mobility patterns" (p. 593).

By contrast, there are several areas where mobile technology might create more or new demand for travel. A recent European study of households, although small, suggests internet-based relationships promote travel (Røpke & Christensen, 2012). Similarly in the business sector more and better communications have increased the opportunities for interaction and with that come some associated travels even if some aspects of work can be done without travel (Faulconbridge et al., 2009). E-commerce is expected to reach an annual growth rate of more than 10% across the EU by 2016. As the internet reduces search costs and improves consumer comparison, one outcome from continued expansion of a more mobile world is lower prices, which in turn will likely result in stimulating demand, whether for services or things. Such technology help grow e-commerce as well as the rise of home deliveries, a trend which is likely to continue and expand over the next decade (see Section 8).

There are several areas where mobile technology can make travel operations more efficient. The rise of the company Uber provides a clear demonstration of how mobile technology can quickly reconfigure existing aspects of travel in new ways. Uber provides customers the ability to hire a taxi and/or hire a car via a smartphone app. Customers book their ride and pay for it via credit card at the end of the trip without the need for cash or an in-advance booking (Connellan, 2014). Whilst controversial in places, Uber is offering a taxi service with rapid response times which is easy and intuitive to use. Similarly, there is a wealth of lift sharing apps available and apps which allow people to share access to their own private vehicles. Lower perceived costs will stimulate some additional journeys but more efficient sharing for some trips that would otherwise be made alone will reduce demand.

Mobile technology can directly and indirectly impact land use, which in turn can impact demand for travel. Businesses are, for example, reconfiguring office locations and sizes to facilitate greater flexible working, reduce land and building costs and to locate low value activities in lower cost venues (including overseas with, for example, call centres and computing support). Less direct but equally important has been the impact of e-services and infotainment. As of 2014, 25% of Europe's online retail consists of

electronics, followed closely with clothes (19%), books/music/videos (15.5%) and other (40%) which includes the growing market of online grocery shopping. The growth of online shopping coupled with recent economic difficulties has resulted in physical stores struggling (Grece et al, 2015). Notable examples include major retail chains HMV Group (UK), Virgin Stores (France) and Blockbuster (various countries) dramatically reducing their physical stores. The nature of the high street is changing and this means that city centres need to rethink their role and the purposes that bring people there.

In summary, there remains considerable uncertainty as to the impacts of mobile technology and improved internet connectivity on travel demand. There is little evidence in support of technologically optimistic assumptions that physical activities would be substituted by virtual travel. Instead, new ways of doing things emerge which bring different travel needs with them. This is important as it may represent a change in the strength of correlations between income, price and personal transport. However, the potential for the internet to lower transaction and purchase costs would potentially support a growth in demand. Given that mobile and internet technology is one of the most rapidly changing dynamics studied in this note it is paramount importance that more is done to understand how this is impacting travel demand.

## 5. THE SHARED ECONOMY

Here we use 'the shared economy' as a term to reflect a broad range of organisations and their associated business models that provide access to, rather than ownership of, tangible and intangible assets to customers. The most common models of exchange in transport are 'business to consumer' where there is interaction between consumers wanting access to a good or service and companies who own or directly manage an inventory of these assets. The other model is peer-to-peer where two or more private individuals interact to trade or exchange a good or service. This is typically facilitated by a company, usually through a smartphone 'app' or internet platform, but the company is not directly involved in the transaction (Stokes et al. 2014, p12). This note covers the three key areas of transport involved in the shared economy;

- Car-sharing: short-term access to a car, typically business to consumer
- Bike-sharing: short-term access to a bike, typically constrained to city-based schemes, based on a business to consumer model
- Ride-sharing: connecting passengers with drivers, either to share a mutually intended journey, or for a passenger to be driven to their chosen destination

### 5.1. Car-sharing

The carshare sector has been in a state of constant flux over the last decade, making it hard to find up to date and comparable data on its development. The 2009 figures quoted in Table 1 below are from the European Union funded 'momo' Car Sharing Study' (Loose 2010) where all known carshare operating companies for the countries studied were sent questionnaires including questions regarding customer membership and amount of car-share vehicles in their fleet. The most recent figures are the best available to the research team using desk-based research only. The figures are therefore not comparable, and only indicative of the type of change seen in some EU Member States.

There has been a large and rapid level of increase in carsharing shown in Table 1, most notably in Belgium, Germany and The Netherlands. The Netherlands figure represents a 113% growth on 2013 (Kpvdashboard 2014). Bundesverband CarSharing (2014) estimates that growth is continuing in Germany and there will be one million carshare users in the country by the end of 2015. In 2012, there were over 8000 carsharing members in Brussels alone, over 1000 more than there had been for the whole country only three years previously (Martens 2012). Membership in Brussels has continued to grow, with 9000 members sharing 270 cars in 2014. Growth across Europe (and worldwide) is concentrated in urban areas, where it is logistically easier to provide a service (Leveque 2011).

**Table 1: Number of carshare customers and vehicles by country: 2009 to most recent year available.**

Country	Carsharing customers (2009)	Carsharing customers (most recent year available)	Carsharing vehicles (2009)	Carsharing vehicles (most recent year available)	Notes on most recent data
<b>Austria</b>	11,000	10,000	169	Approx. 200	<b>2012</b> figures. Source Zipcar (2012) when acquired fleet. Only provider in market.
<b>Belgium</b>	6,932	27, 787	248	709	<b>2015</b> figures reflecting Cambio membership only (Cambio 2015) (market leader)
<b>Germany</b>	137,000	757,000	3,900	13,950	<b>2014</b> figures for whole market. Source: Bundesverband Carsharing (2014).
<b>Ireland</b>	63	2000	9	62	<b>2014</b> figures. Source: O Bryne 2013
<b>Italy</b>	15,850	22,500	498	666	<b>2015</b> figures. Source: ICS (2015)
<b>The Netherlands</b>	27,000 (estimate)	110,000	1,832	11,210	<b>2014</b> figures source: (kpvvdashboard 2015)
<b>Switzerland</b>	84, 500	120,300	2,200	2,700	<b>2014</b> Figures for 'Mobility Cooperative' company only (only provider). (Mobility 2014)

Carshare users have a distinctive socio-economic profile. Users tend to be young adults, predominately male, between the ages of 25-45, well-educated, and living in upper or middle/upper income households as a single person or in childless-couple (Burkhardt and Millard-Ball 2006; Leveque 2011; Le Vine, Zolfaghari and Polak 2014, p10; Loose 2010). Users also tend to be relatively higher users of non-car forms of transport (e.g. public transport, walking or cycling) before and after joining a scheme. Evidence, for example, from England and Wales suggests that carshare members had an estimated annual vehicle mileage of 4,510 miles before joining a scheme - 40% less than the national average of 7,500 miles and their car usage fell even lower once joining a carshare (Zolfaghari et al 2014; Carplus 2015a, p17).

Evidence on the impact of carshare on travel dynamics is disparate and lacking robustness given the limited quality and quantity of peer reviewed literature on the topic. A variety of operator-led studies suggest that somewhere between 4 and 20 privately owned vehicles are removed for each car club vehicle (Trivector 2015; Mobility 2014 and Carplus 2015a).

Looking ahead there appears to be diversification in the market. Most of the growth in carshare to date has been through a 'fixed' or 'round' trip offer, where a car needs to be picked up from a fixed point and returned to that same spot. Large carshare operators such as Car2Go and DriveNow have begun to introduce more flexible 'free-floating' models, which allow people to drive one way, and allow the customer to decide the pick-up and drop-off points for vehicles they hire. This, the companies argue, is a more

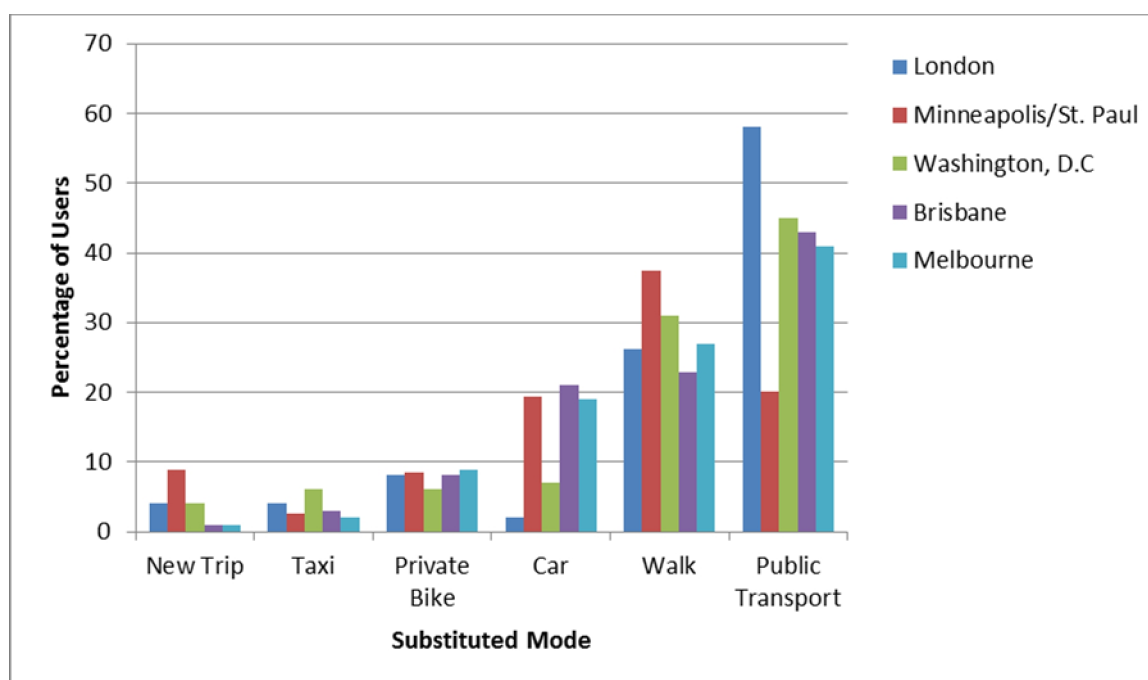
appealing offer for more customers (Car2Go and DriveNow 2015). Peer-to-Peer markets, in which cars are privately owned, are also an emerging market (e.g. JustShareIt).

## **5.2. Bike-sharing**

In the past decade Europe has led the way in the development and subsequent popularity of bikeshare schemes across the world. As of 2014, there were 414 bikeshare programs in Europe, compared to 50 in North America. The Velib' scheme in Paris, introduced in 2007 has grown to be the largest single bikeshare scheme in Europe (the second largest in the world), with approximately 20,400 bicycles. While there has been a boom in bikeshare popularity and scheme growth, there is evidence to suggest that the size of the bicycle fleet within schemes is only moderately increasing. Of 19 European schemes examined by Parkes, Marsden, Shaheen and Cohen (2013) seven had a growth of ten percent or less.

As with carshare, bikeshare users have a distinctive socio-economic profile (not dissimilar from that of a carshare user). Users tend to be younger, have a higher than average income, be engaged in full or part time work, have higher educational attainment, and also are more likely to be Caucasian and living within the inner urban area (Fishman et al. 2014; Fishman 2015, p8; Fishman et al. 2015; Lewis 2011; LDA Consulting 2013; Shaheen et al. 2013; Woodcock et al. 2014). Research from London suggests that it may be where bicycles are placed rather than the type of people attracted to bikeshare that is the motivating factor for use (Fishman et al 2013, p158; Ogilvie and Goodman 2012).

Bikeshare usage can vary significantly between city schemes, but generally exhibit a similar daily usage profile. Weekday usage 'peaks between 7am-9am and 4pm-6pm, while weekend usage is strongest in the middle of the day' (Fishman 2015, p4). Evidence also shows that members of bikeshare do not use the service particularly frequently (Fishman et al., 2014; Fishman, 2015 and Buck et al., 2013). Bike hire schemes are often used as an integrated part of a trip chain (Fishman 2015, Murphy 2010) and as an occasional supplement to general travel modes. One of the consistent themes from research has been that bikeshare journeys tend to replace trips formerly made by public transport and walking (Fishman et al., 2015 and Zhu et al., 2013). However, with the exception of London, where car substitution is very small, all of the schemes shown in Figure 11 reduce car mileage. Advances to booking and location technologies and the potential introduction of e-bikes are the principal advances anticipated for the coming decade (Fishman 2015).

**Figure 11: Mode substitution rate due to use of bikeshare**

Source: Fishman 2015, 13.

The evidence base on car share and bike share schemes both suggest that they will contribute to modest reductions in car mileage by offering an alternative to car ownership either entirely or for second cars, or by making multi-modal trips more attractive and feasible. There are limits to the scale at which they can be deployed in a cost effective fashion but their use will grow in the coming decade as more providers and different systems come on stream, particularly in larger cities where it seems much of the growth pressure will be (See Section 3).

### 5.3. Ride-sharing

While sharing a ride with a family member, friend, or work colleague is not a new phenomenon technological innovation has spurred the recent development of ridesharing between strangers, and in particular encouraged business 'start-ups' such as Uber, GetTaxi, GrabTaxi, and Hailo to set up ridesharing platforms that offer an alternative business model of traditional ride-hire (taxi) services. Other apps which are coming to the market are based around social network: based car sharing amongst students (JumpIn) or clubs (Faxi). This is such a new area that peer reviewed data on impacts is not robust. There are aspects of ride sharing which will act to reduce demand (through wasted single occupancy trips) but also aspects that will increase demand (through cheaper journeys) and make shared cars more cost efficient than public transport. Given that it is such a fast moving area and has the potential to become a more significant part of the mainstream transport provision this is a major gap in knowledge. This may be of particular relevance to those of the EU-13 Member States where current car ownership levels, although growing, are still lower, and where there is a range of ride-share services advertised<sup>5</sup>.

<sup>5</sup> In March 2015 the French global leader in online (long-distance) ridesharing 'BlaBlaCar' absorbed the Hungarian 'AutoHop' to expand into Hungary, Croatia, Romania and Serbia.

## **6. TRANSPORTATION SYSTEMS TECHNOLOGY**

The last decade has seen several innovations in road transport technology which in various ways act to make better use of system capacity and provide better information to users. There are many innovations which could be discussed such as smarter intersection control in urban areas, ramp metering on access to motorways, contactless toll payment systems, parking guidance systems and variable message signs (VMS) that display information associated with congestion, alternative routes and other important road user guidance.

The impact of these systems on overall travel demand is difficult to assess. With the exception of pricing (discussed below) - which is explicitly focussed on managing demand or speeds within a specific geographical area (typically the core of a major city) and where managing total demand is part of the scheme objective - the other measures improve the efficiency of flow or reduce the uncertainty of the traveller. This reduces the perceived or actual cost of a journey and therefore makes it comparatively more attractive, releasing latent demand. In general, improvements in the efficiency of control systems will be swallowed up by the latent demand caused by increased urbanisation, population and income growth given the current situation where demand exceeds supply in the peaks. That is not to suggest that these interventions are not worth doing, simply that they release space for demand growth.

The systems which are implemented today are far more advanced than those of even a decade ago, with greater availability of Global Positioning System (GPS) technology impacting on where and how real time information and navigation can be delivered to travellers (and the costs of doing so) and advances in control algorithms. Motorway control technologies have evolved from VMS communication to 'Smart Motorways' which are designed to maximise available road capacity by the use of variable speed limits, temporary use of hard-shoulder and varying lane running (Highways Agency, 2015). By 2010 over 800 km of Variable Speed Limit-equipped motorway stretches were installed and in operation in Germany (Carlson et al., 2010). However, the roll out of fixed infrastructure based systems is a relatively slow process as existing investments have a useful lifetime so take time to change. In addition, cost considerations mean they will only ever cover parts of the transport networks in their current form - generally central urban areas and the busiest stretches of inter-urban routes. Compared with the pace of change and ubiquity of mobile communications this is an area of slow change which can be well mapped out by public authorities. A recent study commissioned by the EC concluded that the speed and reach of Intelligent Transport Systems (ITS) over the next decade will continue and has the potential to "cause a paradigm shift in the way road and traffic data is collected, processed and distributed to end-users" (van de Ven and Wedlock, 2014, p. 3).

Looking ahead, there is considerable on-going investment in the automation of driving but also considerable uncertainty as what this will mean for travel. Carsten and Kulmala (2015) suggest that in the near to medium term "most of the changes are likely to be evolutionary, with a gradual introduction of higher levels of automation, particularly for privately driven vehicles". Additionally, urban "pods" (see <http://www.citymobil2.eu/en/>) may operate in limited and perhaps segregated environments.

There are still some major technology and design issues to be solved, including:

- Whether automated vehicles will have manoeuvring capability, e.g. to carry out lane changes. Some Original Equipment Manufacturers (OEMs) envisage such capability within a few years, but it is as yet unclear under what circumstances vehicles will have lane-change authority.
- Maintaining driver situational awareness at medium levels of automated driving in moving towards full automation, given that humans tend not to maintain attention over long periods of supervisory control.
- Ensuring safety in mixed traffic including with vehicles at different levels of automation.
- Ensuring safety of vulnerable road users in interaction with automated vehicles (on motorways, interaction with motorcycles is the main issue).

Looking further into the future, Carsten and Kulmala (2015) suggest that fully automated driving systems “would constitute a totally new mode of transport, whose impacts are quite hard to predict (in the same way that the impacts of mass car ownership and large-scale road freight on almost every aspect of social, economic and cultural life could hardly be predicted at the onset of the twentieth century” (p10). Whilst the impacts of full automation on travel demand are unclear various speculative analyses are emerging (Mokhtarian, 2014; Schoettle and Sivak, 2015).

For the purposes of this review which looks ahead 15 years, the changes in automation seem likely to be incremental, particularly given the time it takes for the fleet to renew. The pathway and pace of change towards higher levels of automation will though become clearer. In the near term it would seem that the continued automation of parts of the driving task have the potential to improve the driver experience and, therefore, to improve the comparative advantage of inter-urban motoring. Any environmental and cost savings from smoother driving (Hibberd et al., 2015) may be offset by greater use which comes through the additional quality the driver perceives over other modes and a fuel savings rebound effect. Although unclear, the impacts are likely to be modest with a tendency to stimulate demand for car use. The demand implications of automation is an important area for future research given the amounts of money being invested in autonomous systems and the extent to which such systems would undoubtedly impact on the wider activity system, the volumes of travel and split between motorised modes.

A small number of cities have introduced road pricing to ease congestion including Gothenburg, London, Milan and Stockholm. Road pricing schemes have shown evidence for long-term decreased demand without leading to generated traffic. Other schemes have shown evidence of this result, in Stockholm an average decrease in traffic volume of 22% was observed (Eliasson, 2008), in London a 32% reduction in congestion was measured (Quddus, Bell, Schmöcker, & Fonzone, 2007), motorists in Milan saw similar results with a drop of 25.1% during the morning peak (Percoco, 2014). However, whilst the number of such schemes slowly grows there appears little political will in most places to expect this to accelerate.

There have been substantial improvements in real-time information available to passengers in the past decade. This began with countdown information at specific bus stops and PC based real-time information; this has recently evolved into real-time information for many systems delivered to a phone or even GPS tracking of services. As waiting time is valued around twice as highly as in-vehicle time due to the uncertainty

associated with it (Abrantes and Wardman, 2011), then this is a significant enhancement to public transport.

Integrated payment systems are being developed by some cities which will allow for not only rail-bus-metro integration (e.g. Prague, Budapest and Stockholm) but the full set of mobility solutions which are now emerging including bike and car share and taxi systems (e.g. Bremen, London, Lyon). Integrated payment reduces the hassle of multi-modal journeys and will enhance the competitive position of non-car based trips. Currie and Rose (2008) identify faster boarding times and simpler fares as key advantages to integrated bus ticketing and show that this increased bus patronage by 3 to 5% in two case study cities. Such shifts will have limited impact on total car demand but are also more limited in scope than the fully integrated systems involving use across modes including some of the newer shared options for which evidence is yet to emerge (Preston, 2012).

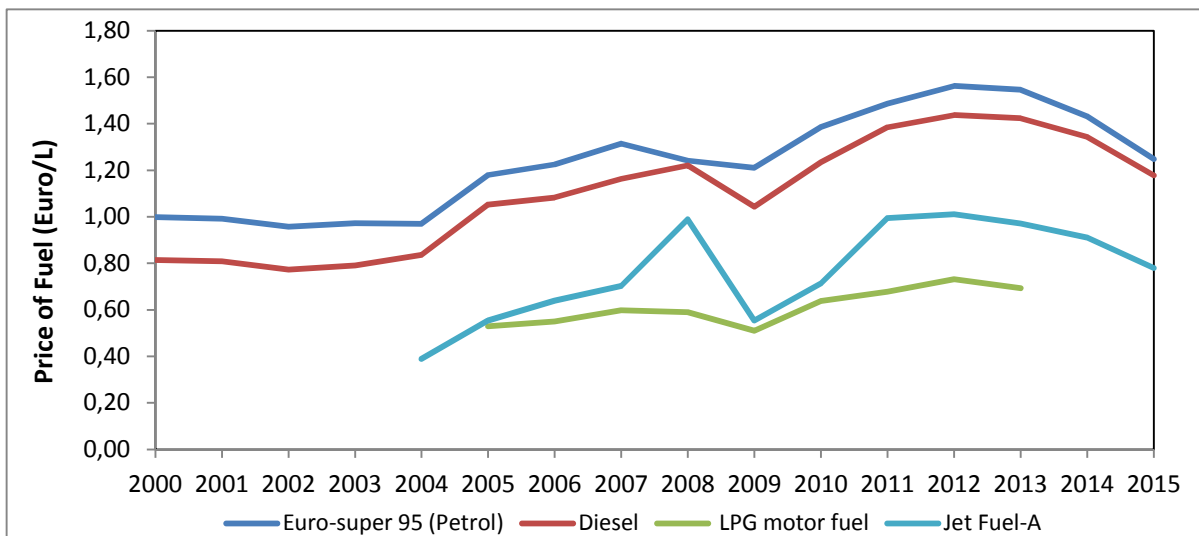


## 7. VEHICLE AND FUEL TECHNOLOGY

The sources of energy used to fuel transport modes and their associated prices have an important role in determining the level of transport demand. The dominant energy source in transport is oil, with Europe depending on it for 94% of its transport fuel in 2010, 84% of which was imported. But, with concerns over greenhouse gas emissions and energy security issues, the European Union is looking to diversify its use of fuels, with electricity, liquefied petroleum gas (LPG), natural gas, biofuels and hydrogen all being considered as alternative energy sources (European Commission, 2013).

Figure 12 shows the steady rise in prices across all oil-derived transport fuels over the EU-28 since 2000. Jet fuel prices have seen the biggest growth of an average of 11% per year, with petrol and LPG experiencing the slowest growth rates of 3.6% and 3.9% respectively<sup>6</sup>. However, prices started to plateau in 2013 and as of January 2015 have seen a significant drop. Although prices have overall increased between 2000 and 2015, year-on-year there has been varying amounts of volatility for each fuel type with a particular spike in 2008. Across the EU, the impact of such spikes varies significantly due to taxation regimes.

**Figure 12: Prices of oil-derived transport fuels in the EU-28 from 2000 to 2015 (European Commission, 2015a; International Air Transport Association, 2014)**

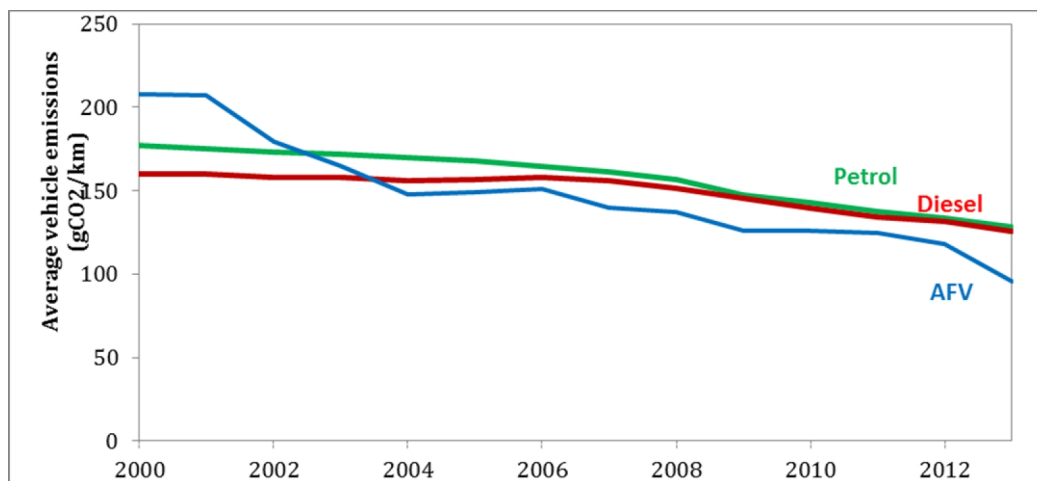


Since 2000 there has been increasing uptake in alternatively fuelled vehicles. The primary reason for this has been an increased drive for efficiency, particularly after mandatory targets for CO<sub>2</sub> emissions were set for new cars sold in the EU (Regulation (EU) No 333/2014). Figure 13 shows how the CO<sub>2</sub> emissions for petrol, diesel and alternative fuelled vehicles have decreased, particularly for alternatively fuelled vehicles since 2000 and since 2007 for petrol and diesel. The fleet average to be achieved by all new cars is 130 g CO<sub>2</sub>/km by 2015 and 95g CO<sub>2</sub>/km by 2021, representing reductions of 18% and 40% respectively compared with the 2007 fleet average of 158.7g CO<sub>2</sub>/km (European Commission, 2015b). Evidence suggests that the 2015 target will be easily met as the average emissions level of new cars sold in 2014 was already below target, at 123.4 gCO<sub>2</sub>/km (European Commission, 2015b).

<sup>6</sup> Comparing years 2005-2013 when data was available for all fuel types.

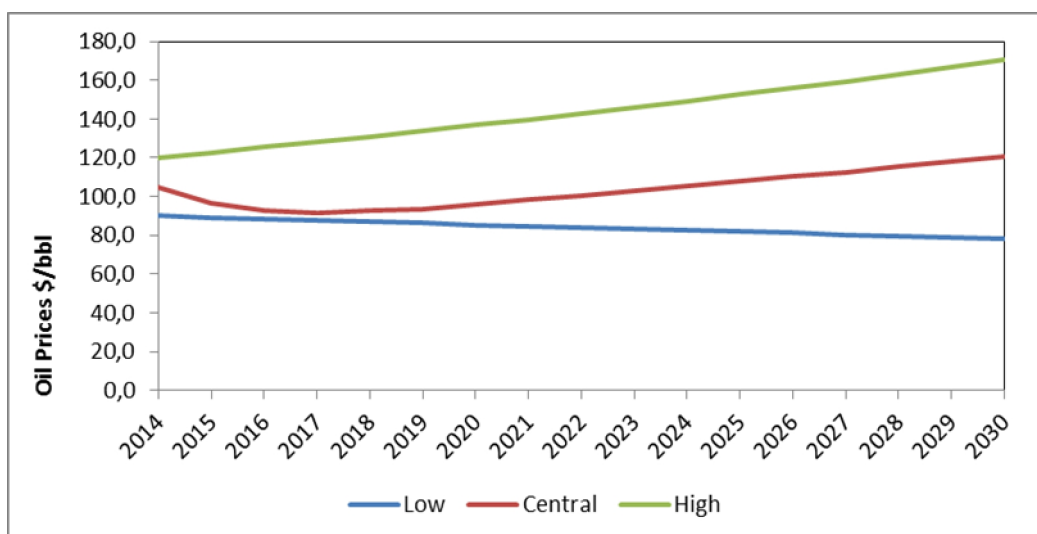
Ten years ago the alternatively fuelled vehicle fleet mainly comprised of LPG and Compressed Natural Gas (CNG) technology as opposed to electric vehicle technology. Only in the last few years has electric vehicle technology successfully moved to the mass market (International Council on Clean Transport, 2013). Although they are currently seen in small numbers across the EU, monthly sales in May 2015 were estimated at 13000, up 50% on the same month in 2014 (ev-blogspot.com). This represents 1.1% of new car sales across Europe.

**Figure 13: Average Petrol, Diesel and Alternately Fuelled Vehicles (AFVs) CO<sub>2</sub> figures for passenger cars: EU-28 data. (Data compiled from EC monitoring (2000-2009) and EEA monitoring (2010-2013))**



Going forward, transport is likely to remain heavily reliant on oil. However, prediction of oil prices is challenging. In the wake of the fall in oil prices at the beginning of 2015 many predictions have not been updated to include these trends. The Department for Energy and Climate Change in the UK provides the most up to date figures representing the future predictions for crude oil prices (Figure 14). The projections give a range of between \$75/barrel and \$190/barrel with a central estimate of \$135/barrel.

**Figure 14: Crude oil price predictions to 2030 (UK Department of Energy and Climate Change, 2014)**



Looking ahead, the car fleet is likely to continue a shift towards electric mobility. Advances in battery technology are expected, leading to battery electric vehicles with an increased range and more efficient hybrid vehicles (Zubaryeva, Thiel, Barbone, & Mercier, 2012). Many European countries have significant electric vehicle targets for 2020 or 2025 (for example see Foley, Tyther, Calnan and O Gallachoir, 2013). It is highly unlikely that other technology will breakthrough within this timeframe with the other main shift being an increase in the proportion of drop-in biofuels with the EU having a target to reach 10% use of biofuels in transport fuels by 2020<sup>7</sup>. In 2015 the Parliament and Council amended Directive 2009/28/EC. The main change resulting from this is a 7% cap on biofuels produced from food crops. The remaining 3% of the target can be reached using biofuels from cooking oil and animal fats, renewable electricity in rail, renewable electricity in electric vehicles and advanced biofuels.

A key change to the future dynamics on pricing will be the link between domestic electricity prices and travel costs. Overall in the New Policies Scenario<sup>8</sup> of the International Energy Agency, per capita spending on household electricity in the EU will increase by 31% between 2011 and 2035 (International Energy Agency, 2012). Charging an electric vehicle to travel the same distance as the average car at present can be about 50% cheaper than using the petrol or diesel<sup>9</sup>. Therefore even with an increase of 30% in electricity prices, electric charging will still be cheaper than using oil-derived energy sources. There is evidence to suggest that a rebound effect from driving electric cars is likely, with greater overall travel distances. Research has demonstrated that this effect could increase travel distance by between 1.5% and 12.2% depending on the home/work location (Whitehead et al., 2015). However, there is also evidence that the rebound effect has been overplayed (Gillingham et al., 2013). Assessment of the distance travelled by electric car drivers is more complex as both urban and long range driving has to be considered. Electric cars are initially being marketed for urban use, especially in Europe where there is a high share of short trips. As urban driving tends to be for repeated trips such as commuting or shopping, it is reasonable to assume that this distance will not increase significantly with the use of electric cars.

Improvements in efficiency of new cars will lower per kilometre cost of running. All other things being equal this will lead to an increase in demand for travel. This will likely be quite differentiated across the EU and within countries with particular differences between rural areas where higher increases will likely be seen and urban areas where the lack of growth and even reductions in travel demand over the past decade suggests that other factors are more important in explaining demand change.

<sup>7</sup> See: *The impact of biofuels on transport and the environment and their connection with agricultural development in Europe*, European Parliament, 2015.

<sup>8</sup> The New Policies Scenario is based on changes in the system from policy interventions that are planned.

<sup>9</sup> Based on a 24kWh battery for an electric vehicle with a range of 100km and a fuel consumption of 5.6 litres per 100km of petrol and 4.9 litres per 100km for diesel.



## 8. FREIGHT

Historically a close correlation between freight transport and economic activity has been promulgated (OECD/ITF, 2015). Yet, this relationship is not clear cut (McKinnon, 2007). Whereas under current trends and adopted policies, the European Commission (EC, 2013b) assumes a strong relationship between freight travel and GDP and thus significant growth in freight transport, in particular from 2010 to 2030, scenarios developed by OECD/ITF (2015) question the relationship between GDP and freight transport. Much of the change seems to relate to changing stockholding and supply chains. "Three-quarters of total freight transport (tonne-kilometres) in the EU-28 is associated with distances greater than 300 km... with sea freight the dominant mode for long distance freight movement (53%), followed by road (37%) and rail (10%)" (EEA, 2014, p. 8). For developed regions like the EU, growth in freight movement is more due to more units of freight "being transported over greater distances than to the physical mass of goods in the economy expanding" (McKinnon, 2010, p. 2).

Globalisation will remain a driving force underpinning growth in freight transport volume. Roll out of several technological innovations likely to impact urban freight is underway (Oehry et al, 2013). Yet, how new technology will impact and shape growth in freight will differ across Europe in different ways. Pricing has the potential to reduce travel demand for freight. Heavy goods vehicle (HGV) kilometres are quite sensitive to charges. As such, evidence suggests reduction in vehicle-km stems largely from efficiencies made in road transport operation and optimised chains of distribution, with roughly one-third being attributed to modal shift (Transport and the Environment, 2010). Though hybrids and electrical vehicles are likely to contribute to a more efficient freight transport, such efficiencies can be offset by fuel and labour costs (Arvidsson, Woxenius, and Lammgård, 2013), and thus their impact on demand is not likely to be strong. As road freight will continue to be the dominant mode of freight transport over the next decade, future demand will remain largely contained to the road. This in turn suggests that future demand will require either new road construction, re-allocation of road space or much more effective management of road space to assist in efficient movement. Though promoting efficient modes is an important policy goal, similar to hybrids and electrical vehicles, making freight modes more efficient does not directly address the need to reduce demand for freight transport. As intermodality will likely increase demand for freight transport, improvements in this area will impact freight and logistics in a variety of ways. For example, recent evidence suggests that intermodal freight systems do not always emit less CO<sub>2</sub> than truck-only systems (Kim and Van Wee, 2014). Development in intelligent transport systems such as geolocation has helped companies contain travel costs (Pilla et al., 2013). Thus, greater uptake of ICTs and ITS technology help make freight travel more efficient. Yet, depending on business models, such efficiencies can both reduce freight travel, as well as generate more demand for freight as businesses potentially pass cost savings to their clients via reduced freight prices. There are a variety of reasons as to why urban freight collection and delivery will rise up the policy agenda and become more acute over the next decade with two factors being prominent. First, the city is now regarded as the primary settlement form, accommodating half the world's population, a trend expected to continue (Vallance and Perkins, 2010). Second, continued uptake of e-commerce, including home and office delivery of clothes, books, electronics and groceries, will generate additional delivery trips (EC, 2012). In contrast, continued improvements in the reverse logistics area have the potential to reduce the overall need for freight vehicle movement. Though a market for more localised production and consumption continues to grow, implementing stand-alone policies such

as time and load restrictions can, paradoxically, negatively impact vehicle numbers and distance travelled (Arvidsson, 2013). Further, scholars cite a 'green logistics paradox', where environmental costs become externalised. For example, shifting towards smaller trucks to offset dominant use of lorries (least environmentally friendly mode), results in further contributing to congestion and space consumption (Rodrigue, Slack and Comtois, 2001).

Amongst these, e-commerce has particularly notable potential to generate additional as well as changed demand for freight transport (see Section 4). The Green Paper on the parcel market and e-commerce (EC, 2012) argues e-commerce must be accessible to all citizens and businesses, irrespective of size and location, and emphasises cross-border delivery of parcels and need of SMEs and less-advanced and accessible regions. E-commerce has the potential to significantly increase use of light van and other smaller delivery vehicles over the next decade. From 1994 to 2012, the number of light commercial vehicles (LCV) registered in the UK, for example, increased by 29% (3.28 million), compared with heavy goods vehicles which decreased by 5% (460,600) (Clark et al, 2014). In the UK, use of such smaller freight delivery vehicles is predicted to almost double between 2010 and 2040, and is now the fastest growing mode of all vehicle groups. There are some difficulties in identifying comparable trends across Europe as some countries include buses and coaches within the LCV/HGV classification (Nicodème et al., 2013, p. 39). Casullo and Kohli (2012) found that registration of LCV/LGV grew faster than HGV registration in France and the Netherlands between 2005 and 2010. LCV activity is predicted to almost double between 2010 and 2040, and is now the fastest growing mode of all vehicle groups within the EU-28 (EC, 2015, p. 90). Currently, over 32.2 million LCVs are registered in the EU, representing 12% of the total vehicle stock (Clark et al, 2014). Yet, in addition to the rise of e-commerce, growth in ownership and use of LCVs can be attributed to a multitude of factors such as 'just-in-time' deliveries and restrictions on HGVs in urban areas (Clark et al, 2014; EC, 2009b).

## 9. CONCLUSIONS

This section summarises the key changing dynamics of travel demand. Some impacts can be foreseen with reasonable confidence, others much less so due to the novelty and emergent nature of the changes and trends. Priority areas for further research and assessment are therefore identified. Inevitably, any review of trends at an EU level masks significant variations and sometimes divergent trends. There is a need to consider national, regional or local contexts in greater detail and this is specifically identified for some issues. The section finishes by identifying some actions that might be undertaken at EU level to meet the existing and future challenges and to adapt the transport systems to these changes.

### 9.1. Major dynamics of change

There are several factors which will have significant influence on the demand for travel whatever actions are taken within the transport sector over the coming decade:

#### 1. Population growth and immigration

The population of the EU is forecast to grow by 10 million over the coming fifteen years. This is driven largely by immigration and people living longer, with the proportion of the population over 65 set to increase to 23.5%, almost 8% higher than in 2000. A larger population will increase travel demand although the key driver will be amongst younger migrants rather than older people where total demand increases will be less significant. There will be increased pressure to adapt the transport system however to support greater mobility for an ageing society.

#### 2. Migration and urbanisation

The total population increase masks very significant differences across Europe. In the preceding 15 years some countries have seen population growth of over 25% whilst others have lost almost 20% with a tendency for migration towards Western Europe. There is also significant growth pressure on major cities and particularly capital regions. The total volumes of demand growth on already congested networks and overcrowded public transport systems will therefore be very significant at a more local scale.

#### 3. The changing nature of work and employment market participation

There will be a continuation of the growth of participation of women in the labour market and increases in flexible working including part-time and role sharing. The structure of the economy will continue to evolve to a more knowledge led economy although this appears to also be accompanied by a polarisation in income between high skilled and low skilled employment. All of these changes will impact on the volume, timing and location of journeys to and from work but in ways which are not well understood. Overall there will be a net increase in demand.

#### 4. Income growth

The rise in income that should accompany increased employment and GDP growth will act as a continuing upward pressure on mobility in most areas. It is important to note that in some central city areas that dynamic is not in evidence, at least in daily travel, and the relationship between GDP and freight growth has also changed. Nonetheless, the European Commission anticipates that there will be growth of light commercial vehicle traffic in particular and road freight will remain the dominant freight mode in the EU. Whilst this paper has not reviewed longer-distance travel in-depth, it is anticipated that greater income will continue to stimulate growth in the long distance travel market.

## **5. Mobile technologies and the internet**

The mobile internet has arrived in the past decade and is set for further significant innovation in speeds, connectivity and storage. Much focus has been on the potential of such technologies to substitute physical travel for virtual travel. Indeed, many tasks once conducted face to face are now done on-line. However, there is no evidence to suggest that this reduces the amount of travel done. Instead, greater peer to peer communication opportunities exist which is changing the distances over which work is conducted and therefore how much travel is associated with that. The rise of e-commerce seems to be creating a significant upward pressure for light commercial vehicle traffic in countries which have been strong early adopters. This pressure for growth will continue.

A critical observation across all of these factors is the need to understand the distribution of change. This can be:

- spatially across the EU where there will be places with population loss as well as those with significant growth pressure;
- within countries where there will be divergences between rural and urban areas and between larger cities and smaller towns;
- in income across the population with significant differentials in income changes between high and low skilled workers and between older and younger people where the impacts of the recession have been quite distinct;
- in physical and mental capabilities within and across age groups, most notably driven by ageing;
- through access to technology with quite distinct differences in capabilities to access and interact with the state-of-art in technology.

## **9.2. Changing Transportation Technologies**

The most important changes that will have a clear relationship with demand resulting from transportation technologies relate to the price which citizens will face to travel in the coming decade. In particular this relates to changing engine efficiency, technology and fuel types.

The commitment to a 95 g/km of CO<sub>2</sub> for new car emissions by 2021 constitutes a 26% improvement on the 2015 standard and will, despite anticipated rises in oil price, significantly reduce the costs of motoring and stimulate demand. In congested urban areas the rebound effect of these reductions may be lower than for rural areas. However, in urban areas the potential advances in electrification of the vehicle fleet will lower per mile costs still further which may support demand growth.

Whilst there will be a continued role out of intelligent transport systems, integrated ticketing and shared mobility options it seems likely that this will happen at a slower pace than many of the changes set out above, with impacts being more local than European scale. In general, the demand impacts are small with the emphasis being on improving operational efficiency.

It is anticipated that there will be a continued and significant development in the application of increasingly intelligent real-time traffic management tools which will free up some additional network capacity through smoother flows. In addition, the continued transition of the vehicle fleet towards full automation will see improved driving

experience, driver assistance aids for impaired drivers and generally will act to incrementally improve the driver experience. However, these technologies require investment (for fixed infrastructure schemes) and consumer acceptance and willingness to pay (for in-vehicle). Their role out will therefore happen over several years and perhaps decades and the impacts on demand will therefore be difficult to determine. New systems tend to be targeted at the most congested locations and therefore any efficiency gains are soon likely to be swallowed up by the latent demand for travel in these areas.

A transition to a fully automated driving system could be transformational as it fundamentally changes the role of the vehicle in the transport system. However, in the context of this report looking 15 years ahead, full automation will likely remain confined to niches and it will be a period of learning rather than transformation.

The most dynamic changing transportation technology relates to advances in mobile technologies. There will be a step change in the ability of companies to track or crowd source movement data and use this to generate increasingly tailored information to users. This may be tied in to incentive schemes to encourage mode shift and could form part of integrated payment platforms. Mobile devices may then become the glue for the notion of mobility as a service, where people are provided with options which meet their journey needs without the need to own a car. Mobility as a service will undoubtedly mature in the coming decade. However, it will need to be more attractive to users than the existing system. In the more central areas of large cities where there will be increasing population pressures and where there is a mixed system of provision of public transport, car clubs, bike hire and taxis as well as pressures on parking which make car ownership difficult this could begin to take root. However, outside of such places where alternatives to the car are limited there seems less prospect of a revolution in the coming decade, particularly if motoring costs are falling and public transport costs are not.

### **9.3. Knowledge gaps**

Eight principal knowledge gaps have been identified in the course of developing the report:

1. Research literature on the travel behaviour of people with a non-domestic background in Europe is sparse and underdeveloped, partly as a result of a lack of data. The dynamics between local travel and longer distance travel are also not well understood.
2. There is evidence from several countries that younger people are taking up driving licenses later and travelling fewer kilometres. This is not consistent however across the EU and the factors that explain it are still poorly understood. However, should this tendency to travel less play out across the lifecourse as these people age then this could be an important change to the assumptions that underpin demand growth.
3. The changing nature of work, participation in the work force and income disparities across job types are all significant given the importance of traffic peaks to the way that networks are designed and sized. This remains poorly understood.
4. There is currently a very narrow approach to understanding the impact of mobile technologies on travel demand with efforts focussed on the interesting questions surrounding the provision of better information and incentives to individual

travellers. However, far less is known about how people and organisations are reorganising activities to take advantage of the new opportunities. Greater thought needs to be given to reconfiguration and understanding the longer term ramifications relative to the focus on delivering better choices.

5. The potential around increased sharing of transport and notions of mobility as a service will require on-going research in the coming decade. This is partly because of the dynamic nature of the technologies and partly the need to share lessons about what types of approaches work and the limits to different business models.
6. The potential of full automation to change the role of the private car, the dominant mode of transport in Europe, means that work into what different visions of implementing automation might mean to cities and to managing flows on inter-urban networks will be an on-going research need.
7. Urban freight is poorly understood and very little knowledge and capacity is held in local government to tackle this. This is particularly noteworthy given the significant rise in light commercial vehicles that have been observed in many cities.
8. Finally, given the significant distributional considerations highlighted earlier, there is a significant gap in explaining whether the relationships between the trends highlighted and the demand outcomes are universal in any way and how they might be distributed across the population in different contexts.

#### **9.4. Recommendations at EU level**

As this paper has indicated, the influences on future travel demand are numerous and diverse. Any set of recommendations could therefore be similarly numerous and diverse. Those listed below are derived from reflections on the findings and represent the views of the authors for possible actions at EU level to meet existing and future challenges and adapt transport system to changes in individual mobility.

1. Given the complexity and many dynamics which underpin the future changes in demand, future research funding streams should incorporate calls for topics which address the key demand uncertainties from Section 9.1. If the new contributing factors to demand change remain poorly understood then strategies and investments could be mis-intentioned and not deliver full value for money.
2. A policy pathway for the pricing of transport must be developed which will be fair and efficient under an increasingly diverse future for vehicle technology, energy sources and levels of automation.
3. Research into the transition and potential deployment of fully autonomous transport systems should continue as this is potentially a critical long-term issue for travel demand. Existing ITS innovation will continue but the market in some areas is already mature and therefore lower priority in demand terms.
4. The challenges of growing cities should continue to be supported by innovation funding and networking activities such as CIVITAS<sup>10</sup>
5. In parallel programmes of work should establish new planning approaches for areas of no-growth or population loss.
6. Investment in solutions for more inclusive mobility systems which work for a greater diversity of mobility needs and cognitive capabilities will remain necessary and will have benefits well beyond Europe.

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<sup>10</sup> The EU CIVITAS Initiative helps cities to make urban transport more eco-friendly.

7. To fully unlock the benefits of peer to peer and shared ownership transport a clear regulatory framework should be developed which places the consumer and not the incumbent industries at the centre.
8. There is a substantial skills gap in freight planning which should be addressed given the significant rise in demands on urban and inter-urban networks for moving the goods which service everyday life.



## **PART II**

# **CHANGES IN TECHNOLOGIES TO MEET EMERGING URBAN MOBILITY PATTERNS**

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## EXECUTIVE SUMMARY

### KEY FINDINGS

- Decarbonisation of transport requires technical and societal innovations aimed at greater efficiency and comprehensive electrification of the transport system.
- Demographic changes and urbanisation are the primary drivers of innovation, in addition to the need to move away from carbon-based fuels.
- Alternative drive technologies and new transport services are joining the market. Incumbents are therefore facing increased competition from new players.
- Electric mobility is a “double basic innovation,” sweeping both the transport and electric power sectors while being driven by digitisation.
- People’s behavioural patterns regarding travel are also changing. Digital platforms make it easier for them to use various means of transportation and share both cars and rides for individual trips.
- The political levers to promote mobility without fossil fuels are ambitious CO<sub>2</sub> limits, internalisation of external costs of transport, and implementation of the costs-by-cause-principle.

### Problems and solutions

Transport leads to urban congestion and pollution and contributes to climate change. In addition, improvements in greenhouse gas emissions are stagnating since gains in engine efficiencies are being eroded by more and heavier vehicles.

Ideally, passenger and freight transport should require no fossil fuels at all which can be possible with a more efficient and largely electric transport sector. This requires many things: new drives and fuel types, innovations from both society and the transport industry, and a new regulatory framework. Currently, the EU is seeing a growth of renewable energy sources and a decentralisation of electricity network management. The steep rise of renewables in electricity production is revealing promising options and making a post-fossil fuel energy supply viable. New vehicle technologies like fuel cells and battery-powered drives are sufficiently developed in principle, but most of all, digital networks technologies are widespread and affordable. Information and communication technologies (ICT) provide services and information in real time. Digital technologies allow for networking and new approaches in transport, providing means to optimise and/or reduce mobility needs thereby saving energy.

### Technological trends and drivers of transport transition

In addition to both these technological developments and to demographic and urbanisation trends, digitisation is also a driving factor in transport innovations. With immense efforts in research and development, car makers have successfully arrived at the connected car which can partially drive itself. At the same time, new drive and vehicle technology concepts are being developed. Three different electrical drive options are key: the battery-electric drive, the hydrogen fuel cell technology, and various hybrid

types. Furthermore, new transport services are constantly emerging due to the widespread use of smartphones and intelligent application developments. Therefore, all the elements needed for the transition beyond fossil fuels are available today. Besides, the digitisation and the expansion of renewable energies offer unprecedented opportunities for cross-sector base innovation: the renewable sector will benefit from a new intelligent organisation of transport that will aid network stability and will smooth out unpredictable residual loads. Electric cars can be linked in smart grids, especially if operated by professional fleet managers. Electric vehicles could then help to better match the production and consumption of fluctuating renewable energies, becoming an additional storage and buffer option in smart grids.

## **Intermodal services and changing political parameters**

The transformation of transport goes beyond new car drive systems and fuel types. In practice, transport will become increasingly multimodal, resulting in one useful service instead of a collection of distinct modal options. Increasingly, this modal coordination is spreading in Europe's capitals and major cities. Citizens are making ever more pragmatic transport choices, such as riding bicycles and using public transport instead of using cars. Meanwhile, sharing services offer several means of traveling at low cost, such as car or ride sharing. Thus, ICT firms are the newest players in the transportation sector.

The best strategies for the success of post-fossil fuel mobility include (1) ambitious limits on CO<sub>2</sub> emissions, (2) mandatory pricing for traffic and parking areas with exceptions for shared zero-emission vehicles, and (3) experiments with decentralised networks in field tests under realistic conditions.

## 1. BACKGROUND: MOTORISED TRANSPORT IS THE PROBLEM

### KEY FINDINGS

- The need to move beyond carbon-based transport is increasing due to European climate policy targets.
- Previous efficiency gains have been offset by the growth both in traffic and in heavier and more powerful vehicles.
- Technical and societal innovations in transport, including the promotion of non-motorised options, are crucial.

The threat of climate change should lead to a transition from a fossil-fuel to a post-fossil fuel economy. The transportation sector will be particularly affected by this, as approximately 95% of its energy use is petroleum based products. The challenge is clearly described in the 2011 EU White Paper on transport: by 2050 at the latest, greenhouse gas emissions from the sector must be reduced by at least 60 percent as compared to 1990 levels (EU Commission 2011).

From both a climate and an economic perspective, there is pressure to decarbonise transport, making it more efficient and electrified. However, this cannot merely involve substituting an electric engine for the internal combustion engine. Instead, this will require not only new drives and fuels, but also societal and systemic innovations to reduce traffic levels.

Motorised transportation as a climate policy challenge relates to both passenger and freight transport. In most Member States, motorised personal vehicles account for more than 75 percent of all passenger transport; the remaining 25 percent is split between more environmentally sound modes, such as buses, trains, bicycles, and walking. (Eurostat 2014: 140; Statistisches Bundesamt 2013: 7). As part of local climate protection policies, local authorities are heavily encouraging walking and cycling as integral parts of strategies for modern, sustainable city development. Whether in Copenhagen, Milan, Munich, London, or Vienna, major cities are leading the way. They are prompting a renaissance in cycling, making it once again an important mode of urban transport. To facilitate this, cities are investing in bike paths, bike parking areas, and bike rental systems (see Gehl 2010). But even the most bicycle-friendly city also needs motorised public and private transport and, for the most part, these modes come with internal combustion engines.

Motorised transport based on fossil fuels is the core of the problem. Inertia both in car industry and among costumers is considerable. Even though conventional drive technology can be considered a dead-end technology, much of the automotive industry's research and development (R&D) expenses are dedicated to optimising conventional combustion engines. This research aims to reduce consumption and minimise pollutant emissions. To some extent, conflicts between these two objectives arise, and some believe these conflicts will be solved by the use of improved fuels. (This conflict stands behind the so-called "Dieselgate-scandal" of Volkswagen in autumn 2015.) The industry believes that it can achieve CO<sub>2</sub> emission savings of 25 to 30 per cent using internal combustion engines. Additionally, research also focuses on the development of new lighter-weight chassis materials for additional energy savings.

Because the automotive industry sees the internal combustion engine as the proven drive unit, its further development lies at the heart of the industry's efforts to lower consumption and thus reduce emissions per kilometre (see Schade et al. 2012: 97 ff.).

However, the successes to date in achieving emissions savings with new drive units and more lightweight design are being largely offset by more powerful motors even in small cars, the development of feature-rich new models which are heavier with each new feature, and a market shift toward Sport Utility Vehicles (SUVs). Moreover, the actual day-to-day consumption levels and those certified through fuel consumption tests often diverge, sometimes by a wide margin (see ICCT 2014).

It will require considerable effort to achieve additional efficiency gains with internal combustion engine technology. Although this technology has matured over more than one hundred years, it has a fundamental disadvantage in overall efficiency compared to electric mobility. The internal combustion engine has an overall efficiency of only 20 percent. On the other hand, a direct conversion of electrical energy uses 70 percent of its (potentially renewable) primary energy. Even fuel cells have an overall efficiency of 29 percent (see Canzler, Knie 2015: 21).

Motorised transport is responsible for around a quarter of the EU's man-made CO<sub>2</sub> emissions. Unlike in the energy sector, transport is still far away from a transition to renewable energy as required by climate policy. In addition, motorised traffic is largely responsible for the hazardous particulate and noise pollution in many European cities.

Against this background, it is unknown which trends and driving forces will shape the transport sector in coming years. The questions are: which technical and societal trends will emerge, and what influence will they have on mobility solutions?

## 2. NEW SOCIETAL AND TECHNOLOGICAL TRENDS IN THE TRANSPORT SECTOR

### KEY FINDINGS

- The main driver of innovation in transport is digitisation.
- New mobility services accessible via smartphones are booming.
- Several alternative drive options exist side by side: battery-electric vehicles, fuel-cell vehicles and hybrids.

Without an accelerated *decarbonisation* of transport, European and global climate change goals cannot be achieved. The still-growing pressure to resolve the climate change problem will dominate both the technological developments and the organisation of transportation in the coming years. In addition to the sector's important contribution in reducing greenhouse gases, demographic change and urbanisation will also have a major impact on the future organisation of transport.

However, urban population growth means increasing competition for space, resulting in congestion. Non-motorised transport and public transport offer a partial solution for sustainable mobility as they require less physical space than private cars. For reasons of demographic change and strong competition for space, some say that "peak car" has already occurred (i.e. car use is on the wane, see Millard-Ball, Schipper 2011). Reductions in personal vehicle travel are often offset by an increase in commercial traffic, especially distribution traffic due to increasing e-commerce. Another significant constraint on future transport is the required investment in infrastructure - which is often at or near the end of its design life. This applies to roads, bridges, and tunnels as well as most of metro and commuter rail systems in large European cities. Considerable investments are needed in the coming years if severe usage restrictions of urban transport are to be avoided.

Moreover, over the last 10 years a trend among young people suggests a "demystification" of the car (see ifmo 2013; Frontier Group/US PIRG Education Fund 2012). Young people acquire driver's licences much later in life, fewer buy or lease vehicles, and, for many people, cars have lost their rank as a status symbol. At the same time, significantly more people are using public transport, especially in the 20 to 30 age group. Finally, bike traffic has increased in many places as well. In Berlin, for example, the number of bicycles in the city centre has more than doubled in the last 10 years. As a visible sign of this trend in changing travel behaviour, car sharing has moved beyond being a niche service and has become a visible transport practice. At the end of 2014, carsharing services in Germany had an estimated 1 million customers (see BCS 2014).

Nonetheless, all of these background trends are being surpassed by the all-dominating megatrend: digitisation. Car manufacturers are currently investing considerable R&D efforts into projects such as the 'connected car' and different models for (partially) automated driving. Many in the industry expect quite a bit from autonomous driving (see Bertoncello, Wee 2015). At the same time, new opportunities for intermodal transport services are emerging as a result of platform strategies. Some platforms, such as moovel and quixxit, enable integration of diverse services for users which benefit from information about public transport and car and bike rental systems. Others, like blablacar, Uber or Lyft are currently individual services for users, but they offer an as yet

untapped potential. However, there is an unknown factor in the foreseeable scenario for the progressive digitisation of traffic: data and thus operational safety may not be able to be fully guaranteed. Therefore it may not be possible to adequately cover the liability risks.

Against this backdrop, different fuel and drive options are currently on the table. The fuel types based on biomass seem to have hit their limits as a result of intensified competition for land, because they are captured in extensive land use<sup>11</sup>. However, there are a variety of power-to-gas processes that are only at their early stages. There are also various drive options to consider. In addition to the battery-electric option, there is the fuel cell technology based on hydrogen, as well as various hybrid variants.

The following sections further discuss these emerging transport technologies (section 3) and services (section 4).

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<sup>11</sup> This applies at least to the so-called first generation biofuels. Hope rests on the 'second' generation which should make possible to process energy crops as a whole.

### **3. NEW TRANSPORT TECHNOLOGIES**

#### **3.1. New types of fuel and propulsion**

Existing biofuels include bioethanol or biomethane and forms of autogas like liquified petroleum gas (LPG) and compressed natural gas (CNG). Electricity-generated fuels such as hydrogen and synthesised gases are also increasingly coming into focus (for an overview, see Nieuwenhuis 2012: 25ff.). There are multiple reasons for this. On the one hand, conflicts in land use exist between the growing of energy crops and food production. On the other hand, there is an accelerated expansion of facilities for renewable electricity production. Biofuels produced from biomass are facing increasing criticism. Surplus wind and solar energy converted into "green hydrogen" (and sometimes further metabolised into methane) represent another option for power generation from renewable sources (see e-mobil BW 2014: 18ff). Green hydrogen and wind gas are options to store electricity which is not needed at the time of generation. These options are summarised under the heading of "power-to-gas". Power-to-gas procedures are conversion processes of wind and solar power into chemical storages. They are not yet cost-effective, as significant economies of scale are still to be achieved.

Since the late 1990s, efforts to develop new drives have centred on two paths to the electric drive. These paths are based on different strategies for supplying current: the fuel cell based on hydrogen (fuel-cell vehicle - FCV) and the accumulator battery (battery-electric vehicle - BEV). While considerable R&D efforts focused on hydrogen fuel cell options for a number of years, the battery-based electric drive has also been a priority of research policy since 2008. Both technologies and their performance characteristics vary considerably.

The chemical reaction of hydrogen and oxygen in the fuel cell produces directly usable electrical energy and pure water as a waste product. At up to 30 percent overall efficiency, the FCV is theoretically (about 20%) more efficient than the internal combustion engine (see IEA 2015: 21). Nevertheless, hydrogen and fuel cell technologies have been stagnating for years, even though their basic technical feasibility has been demonstrated. However, they failed to make a plausible case for their "environmental value and user value" (Canzler, March 2011: 237). With regard to performance, a FCV-engine approximates a conventional combustion engine; the time and process of refuelling is also similar. The user does not need to learn a new system. Although the battery-powered electric drive is more efficient than fuel cell technology, the energy density of the battery cells is much lower and the charging times are considerably longer, even if someone uses a quick charging system.

Both variants of the electric drive cost significantly more than the combustion engine. To date, fuel cells have only been produced on a small scale and the few available FCVs are accordingly expensive. For example, the upper-mid-size-class Toyota Mirai, available in Europe since autumn 2015, costs about €80.000. In contrast, the cost of batteries has been declining for years due to new production capacities. A further reduction in the cost of battery packs is to be expected in the coming years (see Nykwist, Nilsson 2015). In addition, the establishment of a gigawatt factory in Nevada, which will be jointly operated by Tesla and Panasonic, should lead to an additional drop in prices of BEV. By 2017, Tesla expects battery costs to be less than €200 per kilowatt-hour, which would be 50 percent lower than today (ibid).

### **3.2. New vehicles**

Development of alternative drives and use of new fuels has been closely linked to the demand for city cars and small vehicles from the oil crisis of the 1970s to the present day. For a short time in the mid-1970s, small and fuel-efficient vehicles were an important goal in automobile development. Lower oil consumption was required, and there was demand to replace oil as the main fuel. Automobile companies launched ambitious development programmes for new vehicle and drive concepts. But the momentum did not last long. The programmes were shut down because, within a few years, the turmoil on the world oil market was forgotten and the demand for large, fast and heavy cars again rose sharply. None of the alternative development ideas came even close to the production stage (see Canzler, Knie 2011: 104ff.).

In the latest electromobility-wave, at the end of the 2000s, car manufacturers launched a number of electric vehicles. However, in most cases, these were a conversion design of existing models. Only a few electric cars – for example, Mitsubishi i-Miev; Citroen C-Zero and BMW i 3 – were specifically designed as electric vehicles. With the exception of the Tesla Model S, which is a luxury sedan with a battery capacity of 72-85 kWh, all electric cars developed to date have had a limited range of, at best, 200 km per charge. For the BEVs, the ranges that customers actually achieve depend more on driving style and the outside temperatures than they do for other types of drives. On cold winter days the decrease in range is particularly dramatic, sometimes up to 50 per cent.

In addition to the FCVs and BEVs, most manufacturers are also offering plug-in hybrid vehicles. These are generally conventional vehicles equipped with an additional electric drive and an externally loadable battery. The Toyota Prius and the GM Volt are exceptions, as they were designed as plug-in hybrids. Plug-in hybrids can be driven solely with electrical power with a range usually limited to 20 to 40 kilometres. This means they can partially be operated with zero emissions (except emissions from electricity generation) and achieve emission levels of less than 50 grams of CO<sub>2</sub> per kilometre according to the current rules for consumption measurement. However, this is only a theoretical value if hybrid vehicles are driven primarily in combustion mode.

In addition to a number of electric cars that are now available in nearly all segments of the market, various types of two-wheeled vehicles have been electrified in recent years. Bikes equipped with a hub motor, the so-called "pedelecs" (i.e. electric bikes), have enjoyed a real boom in some European countries. The supply of electric scooters has grown strongly, while the electrification of motorbikes has only just begun. In addition, the (not really successful) Renault Twizy represents the emergence of a new segment of small four-wheeled vehicles for city use. Several other innovative vehicles in this segment have been developed as prototypes, but have not (yet) reached the production stage.

### **3.3. Vehicle-to-vehicle and vehicle-to-infrastructure communication**

In addition to the various drive innovations, vehicles are becoming digitally networked both among themselves and with the infrastructure. Work on the technical requirements for the connected car is well advanced (Bertoncello, Wee 2015). The vehicles are connected with other vehicles and with the road infrastructure via Information and Communications Technology (ICT) and sensors. Today, interconnected automobiles are capable of driving without driver behind the wheel. Extensive sensor technologies and

communication protocols are available, comprehensive tests are underway or in preparation, and pilot tests, both in urban environments and on motorways, are intended to prove the technical feasibility and reliability of these systems. Other applications already exist, such as autonomous parking or the virtual coupling of individual vehicles in convoys. In tests, cars look for parking lots autonomously after the driver exits the car. Autonomous driving means that tomorrow's mobility will look very different than today's.

In the scientific discussion, the autonomous driving of cars is unanimously defined as fully automated driving (see Maurer et al. 2015). When a vehicle is driving fully autonomously, it is managed by a robot driver. This robot "performs the functions of perception, cognition, behaviour decision and behaviour management. For this, the robot driver needs information about the state of the vehicle such as position and velocity, as well as information on the environment and the passengers. This information is obtained either by sensors, by reading a memory storage device or via communication" (ibid. 27). The precursors to fully automated driving are driver assistance systems such as adaptive cruise control and the lane tracking assistant, which support drivers with individual tasks. However, there will be a long and likely tortuous road before steering assistance systems are replaced by autonomous driving systems that do not require a person behind the wheel with ultimate responsibility. Not only from a technical viewpoint, but also because the legal framework is not yet in place. This does not merely require individual countries to adapt their registration laws. The "Vienna Convention on Road Traffic", one of the key conventions on international traffic law, will also have to be amended as its Article 8 states that "every moving vehicle or combination of vehicles shall have a driver."

Nevertheless, all car makers are undertaking projects related to autonomous driving. In addition, Google and Tesla have a wealth of experience with autonomous driving – and with electric cars. This combination has significant disruptive potential. When combined with the replacement of the internal combustion engine by an electric engine, the connected car may boost post-fossil fuel mobility. The share of renewable energies in electricity generation is likely to increase dramatically. An electric "car on demand" which automatically drives to where consumers need it, may prove to be an attractive element of a new integrated mobility service that will make the classic private car obsolete (see OECD/International Transport Forum 2015). Such a car would also become part of the smart grid when it is not needed for driving, making it also a "battery on wheels" for fluctuating renewable energies (see Mitchell et al, 2010: 115 ff.; Canzler, Knie 2013)<sup>12</sup>. This convergence of ICT-based connected-car-concepts and e-mobility in smart grids is further explained in section 5.

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<sup>12</sup> A smart grid is defined as a local grid that includes both various energy generation sources as well as consumers. These two elements have different load curves. EVs can be an additional option for energy management and can play an important part in balancing the energy generation and consumption on the grid at the distribution level (vehicle-to-grid).



## 4. NEW TRANSPORT SERVICES

### KEY FINDINGS

- New intermodal services in passenger transport, such as bike- and carsharing, have emerged as part of public transport services.
- Digital platforms facilitate new transport services, especially combining different modes.
- Climate-friendly urban delivery services are being developed and tested.

### 4.1. Intermodality and integration of transport modes

On the supply side, a number of innovations can be summarised under the heading "intermodal services". The intermodal principle initially prevailed in freight transport with the introduction of the standardised container, which can be transported by various modes. The possibilities for rationalising transport chains increases greatly with the IT-based handling of containers and the integration of all transport modes via communications technology. The productivity effects achieved in freight logistics have been an important driver of the growing global trade of goods.

Analogously to these ICT-driven logistical services in goods transportation, new intermodal services in passenger transport have also emerged. The service offered by mobility service providers is either to organise the transport chain for the user or to provide the platform for users to organise their own journeys.

### 4.2. New transport services

Many new transport services are supported by digital platforms which make information (that was previously only available in analog form) easily and instantaneously available. These platforms link previously separate transport options and also combine booking, ticketing and payment functions. Intermodal apps are particularly interesting from a transport policy point of view, as they have the potential to change transport choice patterns. For the user, these apps – which make everything up to paying simple and fast – mean the effort drops significantly. The transport providers, for their part, are forced to set up their own apps and/or participate in integrated platforms so as not to be left behind. The rapidly progressing digitisation of transport markets leaves them no choice.

However, the supply situation is often confusing for the user. After all, there are a variety of options, ranging from real-time information on public transport arrivals and departures to ticketing functions and various sharing options. A "super app" that would integrate everything does not exist.

### 4.3. Ride sharing through mobile devices and online apps

A growing segment of mobility services are ride-sharing services, which are essentially carsharing and carpooling services. They constitute an important element of the booming sharing economy. They exist both as deals between individuals (so-called peer-to-peer-ride sharing) and between commercial providers and individuals (business-to-customer-ride sharing). Over the years, car sharing has been station-based. Unlike conventional car renters, car sharing customers can access more decentralised stations and rent cars for very short periods (minute or hours). Based on high smartphone use rates, a start-up scene of sharing services emerged. With the entry of car manufacturers into the car sharing market, the number of users has increased dramatically. The quality of service ("keep it simple and easy") and the professional sales operations have led to a boom in

free-floating (one-way) car sharing. These services provides their users with much more flexibility as users can drive wherever they need to go and then terminate the rental of the vehicle by simply parking it within a defined area. Daimler, with car2go, and BMW with DriveNow have been especially successful at reaching new user groups from various segments of the transport market. A large proportion of free-floating carsharers previously used a private car. A similarly large portion was previously users of public transport, and a third relevant user group has switched from the bike or is using the new service to travel more (see Firnkorn, Müller 2012). Further growth in both free-floating carsharing and in stationary carsharing can be expected.

#### **4.4. Urban deliveries and urban logistics**

In view of the rapidly growing urban delivery transport, urban and climate-friendly logistics strategies are needed. These strategies include alternative drive systems as well as a bundling of trips. Electric vehicles have several advantages: they do not emit pollutants and they cause little noise. In addition, the distances travelled daily by urban delivery vehicle can be driven by battery-driven vehicles, usually with only one charge. This is especially true because high energy recuperation levels can be achieved in stop-and-go mode. The global players in the delivery services, such as DHL, are preparing to electrify their fleets and are setting up separate business units offering "carbon-free delivery."

At the moment, there is strong growth in the use of delivery bikes in inner-city traffic. Bicycles have a small footprint and can also take advantage of bike path networks that are emerging in more and more cities. The next step is electrification of the bike. E-delivery bikes allow the user to expand their range, overcome topographic differences, or increase the load weight.

#### **4.5. Facilitation of cycling and walking**

Walking and cycling have a crucial role in shaping urban life. Compared to motorised transport, they are space-saving, emission-free, and quiet. In addition, the health benefits of walking and cycling are increasingly clear. However, in order for these forms of transport to have a higher modal share, travellers need a suitable infrastructure, especially when walking short distances between places where everyday activities take place. Only when safe and broad footpaths are highly accessible does walking become more attractive.

Bike traffic also requires its own paths and its own road sections in order to achieve greater safety and to increase the user's sense of safety. Here, it is crucial to achieve a critical mass of bike riders and thus increase the visibility of bikes on public roads. In addition, cycle highways have been constructed not only in Copenhagen and in several Dutch cities but also in London and Paris; these have proved to enhance the attractiveness of cycling. On these broad and non-crossing lanes for bicycles, commuters can travel longer distances within acceptable travel times.

What is the role of new technologies in facilitating cycling and walking? Firstly the renaissance of the bicycle as an urban transportation mode is associated with the widespread introduction of public bicycle rental systems. Easy access to these rental systems with smartphones and integration of the systems into public transport services make the bike systems attractive. Secondly, e-bikes expand the range for user dramatically. For intermodal connections, secure parking spaces near train stations are necessary. Cycle highways furthermore help encourage travellers.

## 5. E-MOBILITY AND ELECTRICITY PRODUCTION

### KEY FINDINGS

- Decarbonisation is required. Biofuels are limited resources, electrification of transport is inevitable.
- Electric mobility is more than electric cars – it includes public transport and bicycles as well.
- Electric mobility is furthermore a double fundamental innovation with great potential for the transport as well as the electricity sector.

### 5.1. E-mobility as a solution?

Previously, the automotive industry had high hopes for biogenic liquid fuels. The so-called biofuels have an energy density approximating that of the oil-derived fuels. In addition, biofuels can be stored and dispensed via existing facilities. For these reasons, biofuels seemed to be the way out of the fossil impasse for many years. Adding new fuels was thought to successively decrease the proportion of conventional fuels. However, these hopes have so far gone unfulfilled (see European Parliament, 2015a). Consequently, in 2015, EU law on the promotion of energy from renewable sources<sup>13</sup> was amended to limit the use of biofuels made from food crops. Under the new rules, the share of first generation biofuel must not exceed 7% of the final consumption of energy in transport from 2020 (see European Parliament, 2015b).

Decarbonisation is not only an issue in Europe and in the US, but also in China. For many years, the Chinese have considered electric mobility to be an innovation and industrial policy response to the anticipated electrification of the vehicle fleet. China intends to leave the era of fossil-fuel-based automobility behind quickly (see Wang, Kimble 2013). The rapid and almost complete electrification of the scooter market is considered to be the first step of an ambitious Chinese leap-frog strategy.

However, e-mobility is not as new as it is sometimes thought, and it is also not limited to cars. Trams and underground lines were electrified early on, and trains have been largely electric for more than 100 years. Road vehicles were mostly electrically powered at the beginning of the 20<sup>th</sup> century. Even though the internal combustion engine dominates automobile drive technology, there are long-standing R&D projects and e-vehicle prototypes with both batteries and fuel cells. The electrically assisted bicycle has gained a significant market share with the recent e-mobility hype. The e-bike is the real success story of the recent e-mobility wave.

Electric mobility is usually reduced to a substitution of the current engine with an electric engine. This reveals a path dependence that hinders innovation and obscures development opportunities. Transport electrification's ability to facilitate a shift to a post-fossil fuel era depends on how the energy used to fuel transportation is generated. With respect to CO<sub>2</sub> emission and hence climate protection, it matters greatly whether the energy comes from wind turbines or from coal-fired power plants (Canzler, Knie 2015: 20).

<sup>13</sup> Namely Directive 98/70/EC and Directive 2009/28/EC.

In a broad sense, electric mobility is a fundamental innovation. In fact, it is a double fundamental innovation affecting both mobility and energy infrastructure; it is also strongly driven forward by disruptive digitisation. In order to understand the potential of this innovation we must overcome the widespread perception of focusing on private cars.

## **5.2. A "mobility-oriented fundamental innovation"**

Modern thinking about e-mobility, broadly speaking, aims to create integrated mobility services based on electric drives that are available for users from "one source". This can be realised with non-electric transport options, but it will be sustainable only on a base of renewable energy. The "comfortable e-seat kilometre" (to borrow a phrase from Daimler from the 1990s) includes electrically operated mainline train services as well as trams, underground train or city train services, and e-bikes and e-cars. This is where public transport (PT) comes into play. Whether and to what extent PT can reach its transport and environmental potential and really achieve noticeable modal shifts strongly depends on increasing its attractiveness. It is unlikely that people will again – as in the 1920s and 1930s – make local and long-distance journeys exclusively with rail-based transport, given how important cars are today. Times have changed. In the meantime, daily life often depends on car availability and it is impossible to travel by train or tram to all places due to lack of infrastructure. Therefore, users require services that will turn all existing modern public transport modes into the backbone of a wide-ranging intermodal service. In addition to changing financial structures, new competition and new business models will be necessary to stimulate public transport's innovative potential. It is also important to open up further opportunities for transport companies to become more entrepreneurial and to develop their own products (see Projektgruppe Mobilität 2004).

This intermodal e-mobility is currently largely a fantasy and has only been observed in a few pilot studies. However, social and technological trends support its implementation. In some major cities, it has been possible for some years to observe how modern mobility could work. City dwellers, particularly younger people, use all available means of transport more than ever, and they combine these modes according to pragmatic considerations. In this context, the availability of a means of transport based on ownership ("possession") no longer plays a decisive role. Instead, it is much more important that those transport options offer flexibility and convenience.

The most important precondition for multimodal practices to thrive is a very high quality range of transport options, including of public trains, buses, cars, and bicycles offered via sharing models. The "use-rather-than-own" scheme can only be a successful formula where one can find many offers (see Rode et al. 2014). The service's attractiveness depends not only on availability but also on the individual's ability to use it easily and immediately. This requires uniform information design and access mediums as well as appropriate access and payment systems. Connections between various urban and agglomerated areas over longer distances must also be guaranteed (see Ruhrort et al. 2014). The mass distribution of smartphones facilitates the easy use of information, access, and billing services. Because users and devices are in constant bidirectional communication, availability, prices, and access can be checked and compared from practically any location. The widespread usage of smartphones means most people can directly access a large vehicle fleet. British transport researcher Glenn Lyons rightly speaks of "transport's digital age transition" (Lyons 2015)

### 5.3. A "cross-sectoral fundamental innovation"

Electric mobility is also a "cross-sectoral fundamental innovation". Renewable energies are expanding in parallel to digitisation. Most projections regarding the further expansion of renewables assume a significant increase in generation capacity (for a summary for Germany, see Fraunhofer ISE 2015; for Europe, see Eurostat 2014). Because of the expansion of facilities using fluctuating wind and solar energy, the need for flexible options is growing immensely.

"Flexibility is the ability of a power system to maintain continuous service in the face of rapid and large swings in supply or demand. Traditionally, flexibility was provided in power systems almost entirely by controlling the supply side. In systems with increasing shares of renewable energies, additional flexibility is needed to maintain system reliability as the variations in supply and demand grow to levels far beyond what is seen today" (ecofys 2014: 2).

A key challenge is balancing variable renewable energy feeds with conventional power plants (or combined heat and power plants) to at least partially compensate for asynchronicities and to reduce gaps between supply and demand (see Krzikalla et al. 2013). At the same time, new options for the use of excess power are emerging and counteracting the so-called negative residual load. The impact that stationary batteries as home storage units and battery-powered electric vehicles can have on the attenuation of negative residual loads depends not only on their usable capacity and network capability, but also on the existence of viable business models. This business models, in turn, can only be realised if enough time intervals are compensated as storage periods or at least as compensable storage options.

In current cost comparisons between the various flexibility options, the new construction of transmission lines usually appears to be the least expensive type. The two storage options that are relevant for transport are battery storage and power-to-gas; these are seen to be more expensive in comparison to the load management, the flexible use of biogas and CHP plants, and the use of electricity for heat. The introduction of battery storage and power-to-gas in use is expected to come by the end of 2020s (see DEFINE 2014). Meanwhile, there have been dramatic reductions in the cost of batteries. A further cost reduction is expected from 2017 due to the large-scale production of batteries announced by Tesla and Panasonic. This will lead to a battery cost of below €200 per kilowatt of performance, as compared to about €300 currently. After 2030, battery costs are expected to drop again by half to under €100/kWh (see Canzler, Knie 2015: 30). This means lower vehicle prices and decreased costs for integrating battery storage into smart grids as a buffer for fluctuating renewable energy levels. Local surpluses and occasional network congestion may lead to asking whether to "switch off or save" much earlier than expected in an increasing number of individual cases. Considering the average national share of renewable energies may provide little help to individual regions with high levels of wind and solar energy generation and/or limited network access. In those areas the incentives will become greater to integrate new flexible loads into cross-sectoral smart grid solutions (see Canzler, Knie 2013).

In addition, today's small batteries can already compensate for short-term fluctuations at the local distribution grid level (see DLR et al. 2012: 97ff.). Electric cars are attached to the network and act as potential buffers when they are set to controlled charging mode. It is precisely at low voltage levels that quicker compensation is necessary if several fluctuating feeders are connected.

But how realistic is this idea of network stabilisation via e-vehicles in the “vehicle-to-grid” (V2G) concept? Time-delayed charging within a defined period has been tested successfully in e-mobility projects. This means there is interesting room for electricity feeders to manoeuvre. For example, the electric car’s battery may be set to be fully charged by 7 a.m. but the vehicle itself is connected to the electrical outlet by 9 p.m. the evening before. For ten hours, the energy supply company can perform a controlled charge if it wishes to eliminate unneeded energy in order to stabilise its own network elsewhere. E-cars can be coupled with solar photovoltaic (PV) systems and therefore gain a portion of their electricity needs directly from the solar modules. The cars can then be operated with lower operating costs while relieving the network during the lunchtime peak. In the next step, flexibility may increase further through bidirectional loading, which allows energy recovery from the battery when needed. So far, bidirectional charging has been available only for a few models.

What about the users? It is still unclear whether and to what extent private users will be willing to allow their vehicles to be used as community power storage. One example is going beyond the overnight charge in order to extend the potential charge time in return for discounted electricity rates. A potential target group for controlled charging could be commuters who would connect their vehicles to the company car park network in order to contribute to solar PV midday peak absorption. Further opportunities are available to professional fleet operators. For them, both time-delayed buffering and above all bidirectional V2G are realistic prospects because they can allow for predictive load management more easily and fulfil obligations to do so to a much greater degree than individual private users can. Fleet managers are already trained to optimally use their available vehicles. The controlled charging of e-vehicles is an additional parameter for fleet usage that works into their logistic core business.

Under the terms “vehicle2grid” or “mobility2grid”, future business sectors are already considering various research projects based on this type of sector coupling. Nearly all projects are aimed at fleet management models. Whether these concepts will be successful depends on the economic and regulatory frameworks and on the transaction costs of complex network stabilisation. Electric-vehicles will be initially primarily battery-electric, while in the medium and long term there will be a rising share of fuel-cell vehicles. All of these vehicles will, for the most part, be part of vehicle fleets, and can be integrated completely or partially into smart grids. Their role will thus shift from being a battery to being an integral part of the complex load management system.

Power-to-gas is another option to use surplus renewable electricity, but this option is still in its infancy. In addition to biomethane, hydrogen is also a chemical storage option. Both can be fed into the existing gas network in substantial quantities. The electrolysis process for the production of hydrogen and renewable methane is sufficiently mature. It is, however, not yet cost effective, as economies of scale have not yet been realised (see DLR 2014). Hydrogen has been used mainly in stationary applications. There has been growing experience over the years with e-vehicle prototypes that derive their energy from the chemical transformation of hydrogen into fuel. Daimler AG has developed several generations of fuel-cell models based on their B-class vehicles. However, the first vehicles with fuel cells in series production are Toyota’s Mirai and Hyundai’s ix 35 FC.

While the Asian companies, especially Toyota, are playing a pioneering role in the mobile hydrogen and fuel cell technologies, Tesla is the pioneer in the battery-powered cars. Clearly, Tesla understands itself as a company that can also supply the power and the storage for future electric vehicles. The California company has single-handedly built a

fast-charging network in the US, China, and some parts of Europe. For 2017, Tesla has also announced the introduction of batteries for mobile and for stationary use that they will produce in-house. These will cost less than half of today's batteries.

The technology strategies from Toyota, Tesla, Hyundai and other manufacturers are generally not associated with an integration of the car into intermodal mobility services. However, there is an increasing connection with renewable energy – i.e. the second aspect of mobility as a basic innovation. Especially in Japan, various large-scale smart city projects connect electric cars to the power supply of residential houses and commercial buildings and test them under real conditions with bi-directional charging (see D'Arcier, Lecler 2014). Both in China and Japan as well as in the US, an accelerated expansion of renewable energies is occurring. For the coming years, these countries are expected to install three-quarters of all new wind and PV systems in the world.



## 6. POLITICAL CONDITIONS FOR THE TRANSITION TO A RENEWED TRANSPORT SYSTEM

### KEY FINDINGS

- The conditions for a decarbonisation of transport are already present.
- Ambitious CO<sub>2</sub> limits are the most effective leverage of decarbonisation of transport.
- The promotion of non-motorised transport and comprehensive real-world experiments are also necessary.

CO<sub>2</sub> emissions differ from one means of transport to another. However, the means are not the only determinant of the climate effect of transport. A person's individual CO<sub>2</sub> footprint depends on the mix of transport modes used, but the average values substantially depend on the degree of occupancy. A poorly occupied bus or metro is a set-back in terms of climate protection (Canzler, Knie 2015: 19). Technological innovations, such as electrification based on renewable energy sources and the substitution of fossil fuels with biogenic ones, make it possible to push emissions in motorised transport close to zero. There has long been research into technological alternatives, but the future of post-fossil fuel mobility is in no way merely a technological issue. Some of the essential requirements for sustainable transport services already exist. Pragmatic and coordinated transport practices are becoming increasingly common, especially in the big cities, but also in rural areas. Quiet and clean technologies are available, and the smartphone is widely used as a universal information and access tool for integrated transport services on digital platforms. The missing item is a helpful framework. A transport transition can only succeed if political conditions change and new business models become possible. To date, the private car, with its internal combustion engine, has been the central frame of reference for EU legislation, applying to both private and commercial use.

The prerequisites for transportation transition are present but cannot be taken for granted. The general framework and political and legal conditions will determine whether the objectives of the 2011 White Paper on transport are met. The transition will not happen without restrictions on conventional car traffic. However, these limitations should always be coupled with offers of something new and be associated with long-term goals of sustainable transport as formulated in the White Paper. Ambitious emission limits should open space for new opportunities. In this way, not only will combustion vehicles be displaced, but electric vehicles and hybrid vehicles will be privileged. If vehicles with higher emissions incur high emission-related fees, innovative vehicle engines will become worthwhile. This will also open up a space for mobility providers who have low-emission and emission-free vehicles in their rental fleets. Another way to achieve this is to limit the total number of privately registered cars in densely populated residential areas and to make an exception for shared cars. This is already a reality in Chinese cities like Beijing and Shanghai due to a lack of space. The range of shared-mobility services which are based on public transport would explode immediately.

Electric mobility and its prospective implementation imply both a connection of various transport methods and also the connection of discussions about the energy and transport transition. Through electric-mobility projects, energy suppliers are suddenly forced to cooperate with the automotive industry and to search for common projects. Individuals,

assembly initiatives, housing associations, and actors from civil society bring together the previously separate energy and transport markets to work on electromobility projects. Through their decentralised activities, they confront the corporate utility industry with completely new challenges (see Canzler, Knie 2013).

So what needs to happen to give e-mobility a chance as a basic innovation? It first needs **ambitious emissions limits**. The limits on CO<sub>2</sub> emissions to 95 grams per kilometre for new cars registered from 2020 onwards should quickly and consistently be tightened. The European Parliament Committee on the Environment calls for a target range of between 68 and 78 grams/kilometre for the year 2025, while environmental groups call for 65-68 grams/kilometre. Current car models show that a value of 50 grams per kilometre can be feasible. Beyond 2025, this limit of 50 grams should be subject to further binding reductions. This scheme would allow sufficient planning security for both car makers and mobility suppliers as well as for the users. The latter want a clear perspective as to which drive technologies will have a future and which not before they put significant investments into a personal vehicle.

The instrument of CO<sub>2</sub> standards for new vehicles in a fleet has proven its worth. Common consensus is that these standards must be ambitious in order to meet the climate policy objectives. In addition emission limits must be defined in 2025 and 2030 and shall not be put up for renegotiation in the meantime. It is obvious that technical standards are adopted at the EU level, not at the local level, and are compulsory. Local authorities can impose limitations on use of vehicles as long as the limitations are not discriminatory and do not violate other EU standards in force. In this context, **local authorities should restrict circulation for new cars beyond the minimum EU requirements and provide incentives for compliance as a kind of “seal of approval”**. Why shouldn't metropolitan areas like Paris or Helsinki or the Stuttgart region, for example, decide to apply low emission zones for ultra-low emission vehicles at about 35g CO<sub>2</sub>/km from 2025 onwards – without any discrimination and open to any particular technology? This could halve emissions in urban centres by 2050 and zero-emission urban logistics could be attained by 2030 and achieve the Transport White Paper's objective of banning combustion engine cars from urban areas by 2050.

The consistent management of public transport and parking spaces will continue to be key. **Comprehensive pricing policy for public space** is an important lever to overcome the decades of privilege the private car has enjoyed. To date, public space has generally been used for free or for a symbolic price. In addition to a mandatory parking permit for new registrations and re-registered cars – as has been common in Tokyo for a long time – parking charges are an effective way of achieving these goals. Shared electric cars should be exempted and allowed to park in public spaces without restrictions, as is already practised in Stuttgart and elsewhere.

Private users, with few exceptions, have also been able to use the streets free of charge. Circulation taxes are paid, but they are non-targeted and disappear into budgets. Several EU Member States finance the construction and maintenance of motorways via taxation. This not only contradicts the economic “polluter-pays principle”, but it is also an invitation to over-use the common good that public space represents. Scholarly discussion of transport and environmental issues has long agreed that users should bear the cost of road use directly and that the burden should not just be placed on public budgets. Usage fees should therefore not take the form of a flat rate. They should instead **charge for use**, weighted according to mileage, vehicle weight, level of occupancy, and pollution and noise emissions, time of day etc. This is already possible

with electronic recording systems in principle, but there has been a lack of courage and political will to tackle this systemic change in the financing of transport infrastructure. Such a change would also have promise for the dual transport and energy policy transition because shared vehicles using renewable energy (e.g. e-car sharing) would be exempted from use charges, resulting in their being well-utilised and operated efficiently.

Finally, **experimental spaces, under real conditions, are needed** to answer the unresolved technical, economic and organisational questions of how to connect transport and achieve an energy transition. There are many uncertainties and unintentional effects that may arise. Therefore, it will be useful to initiate pilot tests under real conditions and with a sufficiently complex constellation of actors, and also to clearly define the objectives of these tests. The latter should address not only corporations, but also organised citizens. By accepting a defined minimum area size and a pre-determined degree of autonomous supply, decentralised networks operated by citizens may create interesting business models with a high production and service range. This would make it possible to test very different forms and constellations of energy and transport transformations. At the centre of such efforts lies the "prosumer", who produces and uses energy at the same time. Decentralised supply networks will require considerable management expertise and a distributed intelligence. Storage and smart grids must be designed with redundancies in order to stabilise distribution networks. This transformation will open many opportunities for innovative techniques – in particular steering tools – and require new forms of governance for cross-sector integration on transport and electricity and business models.

With electric mobility as a guiding principle, the transition to post-fossil fuel mobility has prospects for social acceptance. This is because there is a strong foundation of fundamental confidence in the capacity of this technology to be implemented. Success will ultimately depend on both reliability and costs. So far, however, the spread and visibility of electric cars is disappointing. This is true not only in Germany, where the Federal Government has set a clear goal of 1 million electric vehicles in 2020 (see NPE 2014). In Europe, sales of electric cars are highly dependent on national stimulus measures, and overall this market is moving slowly (see Transport & Environment 2014). However, like the historic triumph of mass car transport, it is necessary to initiate dialogue on this "new green and sustainable traffic world" and not reduce it to drive technology. Likewise, political will, including tax incentives for the purchasers and lessees, is necessary to create the conditions for a transport transition.

This transport transition cannot be achieved without conflicts of interest. There will be losers, primarily producers of combustion engines and parts for them. Additionally, valued travel routines (including time spent alone in a privately owned vehicle during the daily commute) will become obsolete, as this transportation transition shakes the foundations of modern lifestyles. The "social practices of high carbon living," as described by John Urry, will be shaken (Urry 2011: 16). People will protest when the benefits and perks associated with the private car, such as the company car privilege and the often still free use of public space for parking, are disrupted. In both cases there are hidden subsidies in place, but no one likes to dispense with cherished subsidies. Many will likely perceive even a gradual implementation of user financing as an attack on automotive freedom. In addition, any increase in the price of conventional cars will provoke social inequalities. Not everyone can afford a Tesla. In fact, social selection effects cannot be avoided. They require at least partial compensation and the need for

subsidies. Alternatively, the transition to new post-fossil fuel transport strategies needs to be made easier.

At the same time, in a multi-level political system, some proposals also threaten to fall into the joint decision-making trap. Road tolling on highways, for example, is a matter for the national level, with the EU looking at potential discrimination. In disputes about parking space pricing, municipalities must withstand the competition for retail shop locations. By contrast, the intermodal services relate to the amorphous regional units and sometimes even cross national borders.

Last but not least, the powerful car industry will face great pressure for structural change. Their unions also have good reason to be sceptical. If fewer cars are built, well-paying jobs will be lost. The electrification of the engine may lead to a devaluation of existing expertise in combustion engine technology and to a rupture in the engine and engine components production sector. It is clear that e-cars need maybe more sensors and software but fewer drive-components and successful intermodal services need far fewer individual cars.

In summary the transformation of the transport system is a mammoth task. Nevertheless, the first steps towards this transition are possible if the political will is present and the parties involved do not shy away from conflict. A zero emission policy for urban freight distribution may be forced by regulatory means and could be praised by the audience in the media and the political sphere. However, the situation for passenger transport is more complicated because many people feel personally affected – and sometimes offended. Regulations alone will not help. Here a transformation needs to be carried out in at least three ways at the same time:

- *The internalisation of external costs of transport and ambitious limits for greenhouse gases:* the environmental economic principle of internalising external costs in transport means consistent and comprehensive user financing of transport and infrastructure. User financing instruments range from road and city tolls to consistent parking management. Another important factor is a long-term CO<sub>2</sub> limit involving the reduction of greenhouse gases down to zero emissions as promoted by climate policies. This will accelerate the electrification of drive systems.
- *The promotion of non-motorised transport:* the success stories of bicycle and pedestrian-friendly infrastructure show that local measures are most successful. Building strategies such as wide footpaths, cycle lanes on the streets, and convenient bicycle parking facilities at transport hubs are a key part of this. Other keys include the curbing of motorised individual traffic and the actions of real-life role models such as local mayors and opinion leaders.
- *The integration of various modes of transport into intermodal services:* another starting point for a post-fossil fuel transport era may be provided by a consistent integration of all transport modes based on electric drives powered by renewable sources. This kind of intermodally-oriented transport operates on the basis of an efficient public transport system. It also can satisfy the mobility needs of citizens and businesses, provided the services in question are easy to use, reliable, and affordable. Digitisation promises to make many things possible. Smartphones can do more than just provide necessary real-time information. They can also serve as a ticket, access key, and personal assistant in all transport situations.

## **PART III**

# **THE ROLE OF REGULATION IN PREPARING TRANSPORT FOR THE FUTURE**

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## EXECUTIVE SUMMARY

New social trends and technological developments fundamentally modify the transportation system. Furthermore, the emergence of new business models and new types of service challenge the existing transport sector's structure and governance.

EU regulation covers all modes of transport, which have been so far mainly regulated through a sector-specific approach. Yet, the new challenges relate to the various modes. Hence, while the rigorous implementation of the existing sector-specific rules remains necessary (to, notably, make the use of the infrastructure more efficient), regulation has to evolve from a sectoral to a more encompassing approach of mobility.

A renewed regulatory framework for transport should focus on the following five key elements:

### **- Regulating customer protection**

As the role of data in transport operations is becoming ever more important, privacy and data security will become a major issue for the entire transport sector. European standards are therefore needed on both the technical level and the level of general cross sectoral principles and rules for data protection.

### **- Regulating mobility solution providers**

Travellers will increasingly become customers of intermediaries, i.e. mobility solution providers rather than transport operators. Mobility platforms that offer information and booking options across modes will become widespread, and so will companies that facilitate the exchange of services on line. The development of these actors can lead to a more efficient transportation system if regulation guarantees fair competition and clearly defines liabilities.

### **- Regulating the newly emerging data layer**

Integrated mobility solutions and corresponding services can only exist on the basis of open and accessible transport data. For this data layer to become openly accessible and usable, strong regulation on data standardisation and data accessibility has to be developed. This is probably the biggest challenge for EU regulators.

### **- Regulating intermodality and intermodal competition**

As mobility services are by definition intermodal, special attention needs to be paid to the regulation of intermodality and intermodal competition. On the one hand, intermodal transport hubs (ports, airports, railway stations) must be regulated as such. On the other hand, special attention needs to be paid to removing distortions among the different transport modes.

### **- Regulating the infrastructure layer and guaranteeing a stable legal framework to favour investments**

As new mobility services become a new reality, both transport service providers and transport infrastructure operators will come under further financial pressure and this in addition to increasingly scarce public finances. Consequently, regulation will have to ensure a stable and EU-wide regulatory framework fostering investments, as well as appropriate infrastructure pricing and financing.



## **1. INTRODUCTION**

Transport worldwide is facing major changes, and regulation has to address old and new challenges. Regulation of transport at the European level has been concerned, first of all, with moving from a state-centric system of national monopolies to a Single European Transport Area and a single market for transport services. Initially, European transport policy focused on two major aspects: allowing competition and ensuring public service provision. As this process evolved, the logic of de- and re-regulation progressively extended the scope of policies to cover several other areas such as social and environmental concerns, as well as consumer protection.

This broader scope means that there is now a wide range of goals to be achieved, and regulation has to cover an ever-growing number of aspects that go beyond preventing market distortion, ensuring fair competition and guaranteeing public service provision. Yet, in spite of a mounting number of goals, the initial concepts and policy goals have still not yet been fully implemented: this why the primary focus needs to be on the rigorous implementation of the existing regulations.

In addition, there are now significant technological developments, especially in the area of the Information and Communication Technologies, which are affecting the transport sector and require new perspectives in transport regulation.



## **2. REGULATING TRANSPORT**

This section aims at providing an overview of the European transport policy, with special attention paid to the evolving role of regulation. As is the case in all the network industries, the main driver of European transport policy is the underlying trend towards liberalisation. Consequently, for many years regulatory interventions in the area of transport have favoured competition as well as guaranteed public services. Recently, new factors have challenged the traditional transportation sector and new actors are gaining a prominent role in reshaping the sector as a “mobility system offering transportation services”. Therefore, regulation needs to develop and refocus its priorities in order to play an effective and enabling role for the newly emerging mobility system to unfold.

### **2.1. European transport policy and the role of regulation**

Transport was included among the Community’s common policies since their inception in 1957, to contribute to the removal of the barriers between Member States and to favour the achievement of the freedom of movement of goods, services, capital and peoples. The process of market opening and liberalisation has displayed some success in moving towards a single European market for transport but is still far from being completed. This process has also led to the Europeanisation of policy-making. The logic of de- and re-regulation meant that several issues, namely social, environmental and consumer rights gradually became part of the European transport policy agenda. The common market renders purely national approaches less effective, leading to the need to agree on common standards at a European level. In the context of European integration, this new form of harmonised rules that apply to the entire single market is referred to as “positive integration”, as opposed to “negative integration” that focuses simply on the removal of market barriers (Scharpf, 1997).

The EU, however, appears to be more effective in removing barriers than in establishing common rules to counterbalance the undesired effects of a deregulated market. The process of harmonising the diverse social systems in Europe has proven to be immensely difficult. Therefore, rules on social issues are often criticised as being rather of a symbolic nature. Besides, the lack of effectiveness of European Union regulation for achieving public policy objectives is visible in other areas as well: for instance, the lack of an EU competence in the field of taxes will continue to prevent progress on such long-standing policy objectives as the internalisation of externalities in transport.

A comprehensive European transport policy started to take shape in 1992 with the first White Paper on Transport (COM (92) 494). Over the following 20 years, the liberalisation of the market progressed significantly and, in this process, the scope of the European transport policy widened significantly. In 1992 the main goals of this policy were to create the Single European Market and to establish the Trans-European Transport Network. As of 1995, greater emphasis was put on social cohesion, sustainability, intermodality, safety, quality, as well as on the accession countries. This new Common Transport Policy crystallised in the 2001 White Paper, where particular attention was paid to modal shift, i.e. to the establishment of a “balance” between the modes of transport by way of creating competition, eliminating bottlenecks and placing the user at the heart of the European transport system.

The current (2011) White Paper continues this approach of focusing on multimodality. Indeed, since 2011 the overarching goal of the European Union is the creation of a

Single European Transport Area (SETA) and the completion of the Internal Market for the transportation of goods and passengers by removing barriers to transport operations and by promoting safe, efficient and environmentally sound as well as user-friendly transportation services without curbing mobility<sup>14</sup>.

Conceptually, the 2011 White Paper moved one step forward by introducing terms that relate to all transport modes and by structuring the strategy in such a way that transport is no longer approached sector-by-sector but rather as a **mobility system**. This reflects the new attention given to the user, in particular to the needs of customers, service providers, industry, and public authorities. Such a mobility system requires, first of all, the integration of the different modes. Important prerequisites for that are research and innovation as well as technological interoperability based on standardised European systems and data platforms. The White Paper stresses the importance of developing these in accordance with EU competition rules.

## 2.2. New trends and developments

Transport worldwide is facing major challenges: next to those mentioned above (section 2.1), congestion is becoming the most compelling problem in many cities with serious environmental, economic and social consequences. In the 1950s, 30% of the world's population lived in urban areas. In 2014 this figure was 54%. By 2050 it could reach 66% (United Nations, Department of Economic and Social Affairs, 2014, p. 1).

In 2010, 64% of all kilometres travelled were made within urban environments (25.8 trillion pkm p.a); the demand for urban journeys is expected to rise by 68% in the period 2010-2030 and by another 55% by 2050, which means tripling today's number of journeys (Van Audenhove, Korniiichuk, Dauby, & Pourbaix, 2014: 9). Furthermore, traffic on congested European highways (mainly freight) is becoming an ever-growing problem, decreasing the overall efficiency of the transport system.

The traditional way of dealing with mobility problems (i.e. building capacity by way of new, costly and slow-to-be-built infrastructure) should no longer be the preferred choice of decision makers. Yet, thanks to new transport technologies – especially the information and communication technologies – city planners as well as policy makers discover new ways of making more efficient use of existing infrastructure, mainly by optimising its operation.

Some elements that characterise this new approach are different from the past and need to be taken into consideration as they have an impact on the role of regulators. First and foremost, this process is not led by the public sector and is actually featuring newcomers on the transport scene: governments and national authorities need to acknowledge this shift of leadership and redefine themselves as service enablers rather than service providers. With regard to this, a new framework for the interaction between old and new players has to be developed, while regulation must be there to guarantee the principle of fair competition among all service providers. Secondly, **new business models** are emerging, thus offering new types of services to the citizens and users. In particular, the rise of a shared-economy has disrupted existing products, services and the way they are provided in the urban mobility space. In this respect, an entirely new service layer and related service industries for transport are increasingly impacting the sector. In this

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<sup>14</sup> This goal was outlined in these terms in the 2011 White Paper (European Commission, 2011c), accompanying Staff Working Document (European Commission, 2011b) and the Single Market Act II (European Commission, 2012b).

respect, not only has the level playing field to be guaranteed, but also safety and security standards have to be upheld. Last but not least, European regulators have to deal with the fact that the geographical scope and impact of these new technologies are global by nature.

As other world regions are tackling the issue of transport modernisation and rethinking the role of infrastructure and infrastructure investment, it is crucial that European transport continues to play a leading role and maintains its competitive position. This brings forward new regulatory challenges for EU policy makers.

The following parts detail the new elements of the mobility trend: the changing role of old actors and the emergence of new actors, the prominence that new business models are gaining, and the ever more important global dimension that makes Europe just one element of an ever more networked geography. The building blocks of the new mobility trends (namely, two sets of changes brought forward by automated transport technologies and the information and communication technologies) and the possible role that policy makers and regulators should play are also highlighted. These trends break down the boundaries between the different transport modes: indeed, at the data layer level there are no longer different transport modes, but there is basically only mobility. As a consequence, **mobility can now be seen as an information service with physical transportation products, rather than a transportation product with additional services.**

### 2.2.1. Transport technologies

A system characterised by more automated vehicles (AV) is currently emerging. From a technological point of view, this is an incremental rather than a disruptive innovation as the system builds on existing and evolving technologies. While technology in itself is not usually an issue, the rollout of these technologies is more problematic. Autonomous, self-driving and driverless vehicles are indeed gradually entering the rail, road and air transport sectors all over the world. AVs have the potential to bring many benefits, such as saving time and reducing the number of collisions; yet, as they unfold, they will be disruptive for the entire transportation system (Gill, Barrie, Godsmark, & Flemming, 2015).

In the US, Google began its self-driving car project in 2009, leading the States of California and Nevada to adapt new legislation to allow such new technologies (Jaffe, 2014). In Singapore the SMART Project (Singapore-MIT Alliance for Research and Technology started in 2007) is about to implement the testing phase under real traffic conditions on public roads. In this context, it is particularly worth mentioning CityMobil2, a European project financed by the 7<sup>th</sup> EU research framework programme which aims to contribute to the harmonisation of the EU legal framework for the development of validation and certification processes for automated vehicles<sup>15</sup>. In the field of aviation the ALIAS project deals with liability aspects of the use of automated systems (Addressing the Liability Impact of Automated Systems).

Measuring the benefits and the economic and the social impact that AVs could bring might still be premature. However, the abovementioned pilot projects illustrate the role that AVs could and will play in the future. These projects could furthermore help define

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<sup>15</sup> Among the outcomes of the projects, two publications are particularly relevant in this respect: Csepinszky, A. «Legal concerns related to the deployment of fully automated urban vehicles» and Parent, M. «Legal issues and certification of the fully automated vehicles: best practices and lessons learned», both available at [www.citymobil2.eu](http://www.citymobil2.eu).

the regulatory framework needed for the deployment of automated transport vehicles and systems. In particular, this deployment entails two types of rules: those related to the vehicle itself and its certification (including common standards mutually accepted by the certifying authorities); and those related to the system and the connectivity between vehicles (including peer-to-peer communication, interaction with infrastructure, interaction with users).

The potential of this technological evolution, which is driven by the trends of computerisation (automation) and miniaturisation, is not always fully understood by both the users and the regulators. It is difficult for the users to change their habits and take full advantage of the new technologies. Regulators have to adapt and understand how to intervene (if at all) in order to allow technological innovations to deploy their full potential while preventing undesired effects. First and foremost, regulators should make sure that the principles of fair competition and full market access are guaranteed to all players. Furthermore, no discrimination because of standards should be allowed. Moreover, regulators have to deal with new issues deriving from the loss of jobs that might be caused by automation. There is also a challenge to keep the regulations up-to-date and relevant in this rapidly evolving environment, characterised by new threats such as cybercrime and abuse of personal data, as well as a new understanding of liability and responsibilities. Therefore, regulatory authorities need to anticipate action in these fields, instead of only reacting to the innovations promoted by industry players.

### 2.2.2. Information and Communication Technologies (ICTs)

The nature of the transportation system is changing. Traditionally, the focus has been on the physical movement of individuals and goods and on the infrastructure networks. Nowadays, thanks to technological development, a transportation system is much more than this: “mobility is a means of access – to goods, services, people and information. This includes physical movement, but also other solutions such as ICT-based platforms, more effective public service delivery provision, and urban design that improves accessibility” (Townsend, 2014:6).

The introduction of the ICTs into the transportation system basically leads to the creation of **an additional information/data layer** on top of the physical transportation layer. This creates new kinds of opportunities: it enables the optimisation of the existing physical layer thanks to the analysis of the data; it also enables the creation of new services stemming from the commercialisation of data thanks to new business models, some of which being based on peer-to-peer activities (see section 2.2.3).

#### **Box 1: The disruptive effect of the sharing economy and peer-to-peer in the transportation sector**

The speed and scale of change in technology-related and sharing-economy based businesses brought by service providers such as Lyft, Uber, BlaBlaCar, Getaround, make the application of traditional regulation difficult. Yet, these developments raise issues of safety, data security, adequate insurances, accessibility, and labour rights that need to be addressed. Existing regulatory models no longer seem to provide adequate measures to deal with these new types of businesses. Furthermore, a competition issue arises when operators such as taxi and car rental companies, which are traditionally highly regulated, are forced to compete with these new entrants.

As stated by Prof Sundararajan in 2014 in front of the US House of Representatives, “the current regulatory infrastructure can impede the growth of these businesses, in part because of misalignment between newer peer-to-peer business models/roles and older guidelines developed to mitigate safety concerns and economic externalities for the existing ways of providing the same or similar services.” (Sundararajan, 2014) In order to foster marketplaces that promote both innovation and competition, governments should focus on reducing the ‘regulation gap’ between new and existing operators and “to restructure the regulatory framework to address new issues raised by the expansion of peer-to-peer businesses, delegating more regulatory responsibility to the marketplaces and platforms, while simultaneously preserving some government oversight.”

A fully self-regulated market is not the solution, because without the appropriate regulatory framework these digital technologies, which are the enablers of the sharing economy system, may not yield their promised overall economic gains. Incumbent regulated industries are indeed challenged by newcomers and, for the time being, courts, public utility commissions and city councils have started to take action - mostly in favour of incumbents - with regard to the issue of competition. However, decisions are rarely definite and there are examples of national regulators that have called for a more consistent rethinking of the rationale behind tightly-regulating paid-ride services.

Future regulation has to modify the current legislative framework and take into consideration both traditional operators and new peer-to-peer service providers. This inclusion would also be a concrete step in the shift of mind from transport sector regulation to mobility regulation. Despite the possibility of leaving market-based self-regulation to deal with certain aspects, regulators must retain some functions such as the establishment of a framework that guarantees fair conditions for competition, citizens’ rights, and legal stability.

**Source:** Sundararajan, 2014.

Hence, because of the increasing deployment of ICTs in transportation the need for regulating mobility, rather than regulating the different transport modes separately, will rapidly emerge. Therefore, regulators will have to acknowledge that they are called to act as enablers for better mobility, and they have to design a new comprehensive regulatory framework for “mobility as a means of access to transportation services”. To do so, regulators will be in charge of designing a new regulatory framework that first thinks of mobility from the perspective of the customer; second regulates the newly emerging data layer; third addresses the question of interoperability across the transport modes; and fourth makes sure that the transport infrastructure layer is in line with the above (see section 3).

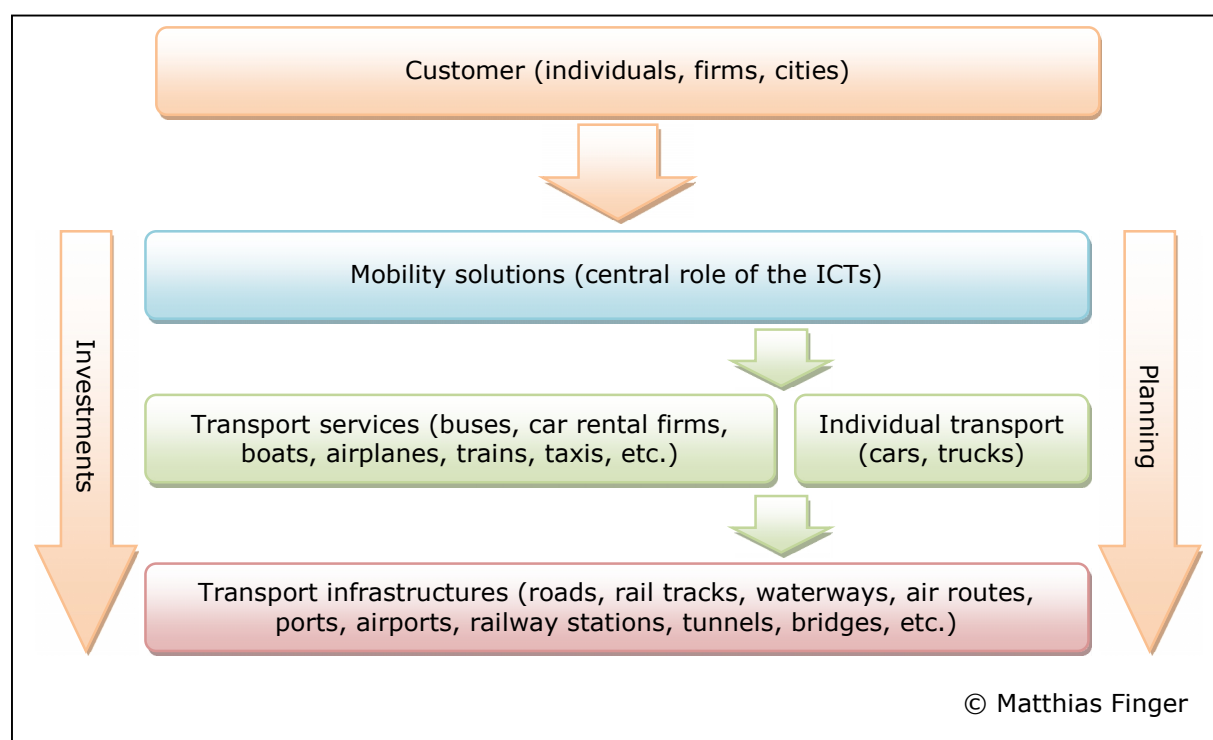
**Figure 15: Conceptualising mobility in the age of the ICTs**

Figure 15 summarises this new approach which puts customers (individuals, firms, cities) at the top of an integrated mobility system, whose main purpose is to offer them customised mobility solutions. Such an approach is basically made possible thanks to the ICTs which would command the appropriate usage and combination of the different transport operators' services, including individual transport (e.g., cars and trucks). Of course, investments in and planning of these transport operations and especially investments in and planning of the different transport infrastructure will have to be aligned with the integrated mobility solutions. It is assumed that such a system will not only be more customer-friendly, but also more efficient overall and probably more resilient.

### 2.2.3. New actors and business models in the mobility arena

The core function of the transportation system, which is to ensure safe and smooth connections for its users in an economically and environmentally sustainable way, has not changed and will not change in the future either. However, the traditional way of dealing with mobility problems has to evolve. As a consequence of the introduction of new transport technologies (2.2.1) as well as the ICTs (2.2.2), actors that have already engaged for many years in transport planning and service provision have to adapt to the new situation as much as customers will adapt their new way to move and haul their goods. Therefore, great attention should be paid to the changing role of actors that are already present in the different transport sectors as well as to the newcomers.

The role of the private sector will become more important in the sector because of its better understanding of customers' needs. As a consequence, governments and public authorities will shift their focus from providing infrastructure and capacity to services and connectivity. They will have to play a key enabling role as facilitators for innovation. Indeed, national and local public transport authorities have to optimise capacity (also adding new services) and maximise the usage of the existing infrastructure. As it can

already be seen in some cases (such as the introduction of the Mobility-as-a-Service paradigm in the city of Helsinki<sup>16</sup>), public authorities have started to redefine themselves as service enablers rather than as service providers, while maintaining their role as guarantor of the principle of fair competition among all service providers.

Providers are also changing. The most striking characteristic of this change is the fact that operators go beyond their local borders and provide transportation outside their traditional regions and countries of operations. Furthermore, a recent study by Accenture (2012) has shown that the traditional indicators related to performance such as safety, distance to public transport, price, punctuality, and decrease in travel time are still high on the agenda of both authorities and operators that want to achieve an increase in usage, better quality of service and accessibility for all. However, this is not sufficient and new goals such as better value for money, a more customer-centric approach and more sustainable city development have to be included in the priorities of authorities and operators in the transport sector. Therefore, the traditional indicators also have to be complemented by new elements that build on investment in technology and mobility solutions, such as establishing real-time mobile and direct communication with customers. In-app ticket purchasing is becoming a common habit for customers as well as instant messaging, and news spread through social media is penetrating the traditional means of information by service providers. This entails a series of regulatory challenges.

Furthermore, new actors are entering the mobility arena, most of them filling a gap in the service provision by taking advantage of new technological possibilities and new customer needs.

We can identify three new types of business models:

- first: the traditional type of businesses that incorporate the sharing economy principle;
- second: new businesses based on peer-to-peer exchange; and
- third: integrated mobility platforms.

Firstly, the popularity of companies that offer services based on the principle of the sharing economy has to be acknowledged. They offer services which are already provided within the traditional transport scheme, yet they introduce new elements and new regulatory challenges. Established examples of car-sharing schemes include: 'Mobility Cooperative Carsharing' in Switzerland, 'Cambio CarSharing' in Germany and Belgium, 'Greenwheels' mainly operating in the Netherlands, 'Car2Go' in Germany, Austria, Italy and more. Also, in many cities, bike sharing schemes are available, often offering partnerships with the public transport sector, parking schemes or car-sharing companies.

Secondly, there are new initiatives based on peer-to-peer exchange that are even more disruptive for the traditional transportation system services. They have significant effects on both users' demand as well as on the availability of non-scheduled transport services. National regulators are starting to address the issue: for example, the Italian Transport Authority recently called on the Government and the Parliament to act in this sense and

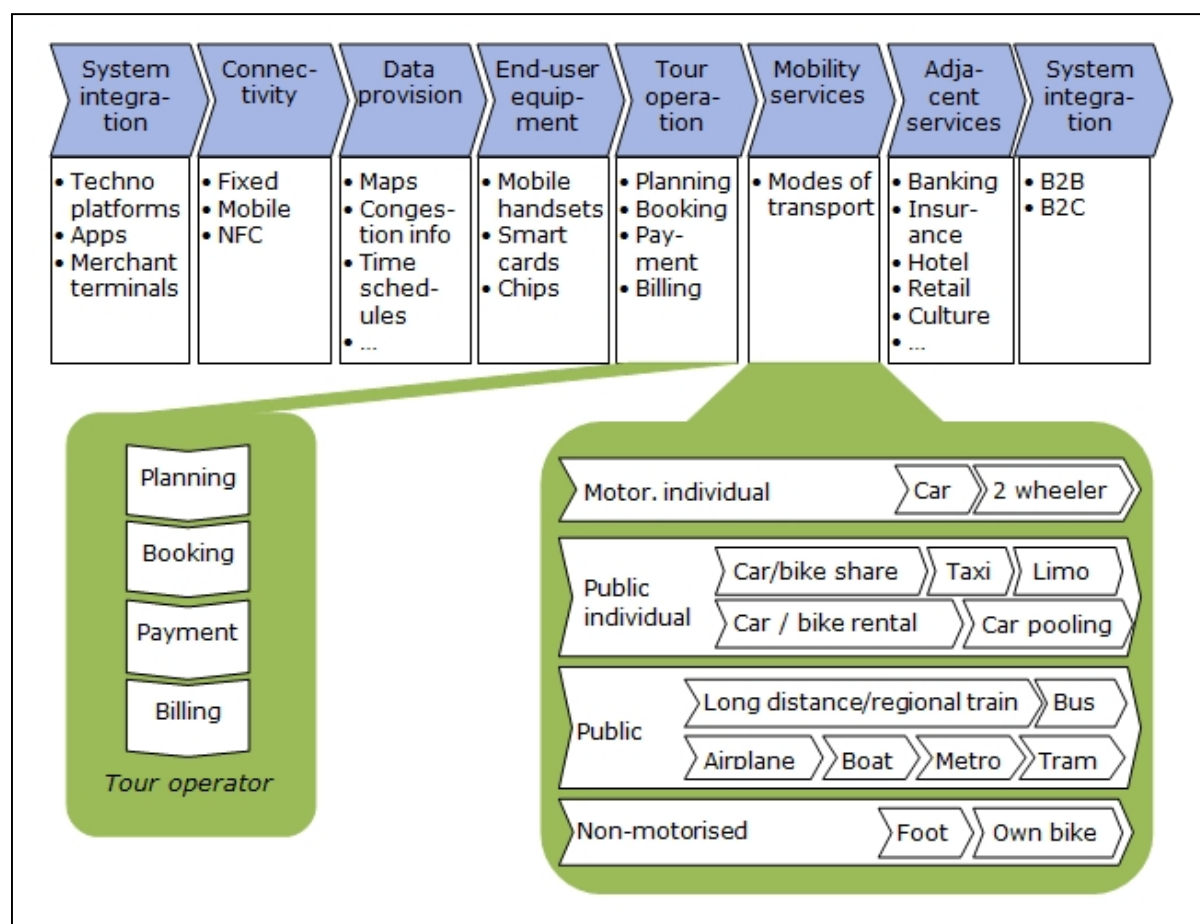
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<sup>16</sup> See the summaries of the discussions and the presentations given at the 3<sup>rd</sup> Florence Intermodal Forum "Mobility-as-a-Service: from the Helsinki experiment to a European model?" (Florence, 9<sup>th</sup> March 2015).

to update the existing normative framework (Autorità di Regolazione dei Trasporti, 2015<sup>17</sup>) (see box 1).

Thirdly, integrated mobility platforms are being developed. To date, there is no fully functional example of an integrated mobility platform. There are, however, pilots and trials experimenting with this business model. For example, 'moovel' started in 2012 in Germany and has since been extended to other European countries and North America; 'Qixxit' was launched by Deutsche Bahn in 2013, and 'Smile' is a pilot project currently active in Vienna. As a result, an urban transportation system characterised by a massively networked multimodal system, dynamic pricing, a user-centred approach, integrated information and coordination between new and already existing services (Fishman, 2012) is emerging. It appears that there is clearly a need for system-level collaboration between all stakeholders of the mobility eco-system to come up with innovative and integrated business models that better cover the mobility chain as a whole.

**Figure 16: Integrated mobility platforms**



**Source:** adapted from Arthur D. Little, in Van Audenhove, 2013.

<sup>17</sup> The first bill in Italy is dated 21/05/2015 and was discussed at the Chamber of Deputies on 01/07/2015 [www.camera.it/leg17/995?sezione=documenti&tipoDoc=lavori\\_testo\\_pdl&idLegislatura=17&codice=17PDL\\_0031940](http://www.camera.it/leg17/995?sezione=documenti&tipoDoc=lavori_testo_pdl&idLegislatura=17&codice=17PDL_0031940)

#### **2.2.4. Globalisation of transport**

The development of new transport technologies as well as the ICTs has also given a new impetus to the trends of internationalisation and globalisation that were active in the latter part of the 20<sup>th</sup> century.

Air and maritime transport are typical examples in this sense. The modern air transport industry increasingly operates within a liberal and global market context, and the implications of globalisation have been profound for the international air transport industry. Changes both on the demand side and on the supply side led to unprecedented growth of the market, as well as to a process of consolidation and a strengthening of global alliances. Pursuing Open Skies policies that allow free exchanges and provision of services on the global scale has become the priority for governments, international organisations and stakeholders. The trade-off between implementing liberal trade agreements and supporting the domestic airline industry is a major concern for both Europe and the US, especially in light of the emergence of new competitors coming from the Middle East and Asia.

Maritime transport remains the backbone of the goods trade. The European shipping sector is facing global competition, especially on the long distance routes from the Far East to Europe. Therefore, there is a need for the European Union to work with international partners and to act in the international fora (bilateral agreements with the main partners; World Trade Organisation; International Maritime Organisation) to both guarantee quality shipping and to promote the competitiveness of Europe's shipping sector at the global level (Finger et. al., 2015: 51). Furthermore, the evolution of long-distance shipping has a relevant implication for the EU internal dimension of freight transport. The regulator also should pay attention to the analysis of the potential to develop integrated multimodal transport chains in the maritime sector (Monios, 2015). In fact, ports and intermodal terminals will play an increasingly important role because of the key role they play in the achievement of modal shift.



### **3. FUTURE CHALLENGES IN REGULATING THE DIFFERENT TRANSPORT SECTORS IN EUROPE**

Despite several common trends, transport policies have developed along different modes. Much sectoral specificity remains and rules cannot always address all the modes at the same time. Some of the regulatory challenges are therefore specific to individual modes.

#### **3.1. Rail: Infrastructure regulation, intermodality and independent regulators**

Establishing a Single European Railway Area (SERA) and enabling efficient transport services throughout the EU and its neighbouring countries is the declared goal of the European rail transport policy. This goal is to be achieved by way of an open market for operators and service providers, an integrated infrastructure network and interoperable equipment.

The first initiative to extend the Single Market to the railway sector dates back to 1991 (Council Directive 91/440/EEC). Today, after almost 25 years of regulatory fine-tuning and new legislative initiatives, the general institutional framework and the broad market structure are taking shape. But the market will look different in the future, and regulation needs to take account of the evolving situation of the railway sector in Europe that, in spite of European regulation, remains fragmented along national lines.

There are a number of highly relevant issues which should be focused on in the future: some pertain to the provisions of the currently discussed 4<sup>th</sup> Railway Package (European Commission, 2013a), others to the consistent transposition and implementation of previous legislation. This section focuses on four main issues:

- The organisation of the railway market and of railway undertakings.
- Strengthening the role of the European Railway Agency and the independent national Regulators.
- Intermodal competition: Increasing the railway modal share.
- Appropriate financing for rail infrastructure.

##### **3.1.1. The organisation of the railway market and of railway undertakings**

In principle, the European Commission advocates a model of full vertical separation between transport services and infrastructure management as a tool to guarantee fair market conditions for new entrants. This approach has not been implemented uniformly, mainly because several actors from the industry and some national governments oppose this model. So far, two models of railway organisation have emerged as the current regulation allows both the integrated (holding) and the fully separated model: some Member States have fully separated the railway infrastructure from transport operations (e.g. Denmark, Portugal, Spain, Sweden and the UK), while other Member States have implemented a holding model as is the case in Austria, Germany, Greece, Italy, Poland and France. However, there is no general consensus about the optimal model for the organisation of railway undertakings. Both in academia and in the world of practice there have been advocates for different models (van de Velde, et al., 2012). Under the integrated railway model, infrastructure management and maintenance and the provision of rail transport services operate under one roof either as different units of the

same company or separate companies of the same holding. The argument from the supporters of a more integrated railway system is that vertical separation prevents overall system optimisation, causes duplication of fixed costs and may reduce the potential for technical innovation covering all stakeholders in the rail system (McNulty, 2011). In fact, evidence from Great Britain seems to support this view. In the UK, a model of full vertical separation has been followed: several franchises exist and tendering for lines is running relatively smoothly. Yet, this seems to be to the detriment of the original goal: overall system costs are extremely high and ways are now being explored to reduce them. It seems that efficient coordination in an unbundled system is not possible without extensive (and costly) coordination at the state level (in the case of the UK by ORR, the Office of Rail Regulation). This is particularly true in larger countries and densely used networks. As a result, unbundling in the railways sector may come at a price that is higher than the efficiency that can be gained by it.

At the present moment, it does not seem useful to further insist on the full separation of infrastructure and operations. A lot of energy has been invested and it remains unclear to which extent full vertical separation is ultimately beneficial for the rail sector. Furthermore, some examples indicate that under the right framework conditions, especially in the presence of a strong regulator, competition can thrive even when there is an integrated railway company.

### **3.1.2. Strengthening the European Railway Agency and the independent national regulators**

The market structure that is unfolding in Europe depends on a system of independent regulators. Given that larger holding companies will continue to be the dominant players, it will become even more important to ensure that regulatory bodies oversee the independence of the infrastructure managers.

Overall, there has been significant progress in the establishment of national regulatory bodies in all the Member States. Yet, even though the Recast Directive (2012/34/EU) provided for truly independent regulators constituting a “stand-alone authority which is, in organisational, functional, hierarchical and decision-making terms, legally distinct and independent from any other public or private entity” (Art. 55, 2012/34/EU), full independence and sufficient resources are, by far, not the case everywhere<sup>18</sup>. Full implementation of the Recast Directive is also necessary to further improve the relevance of the “European Network of Rail Regulatory Bodies” (ENRRB). Enhancing the cooperation between the different national bodies is a promising strategy in many ways. There is, amongst other things, the need to find common European framework rules for the imposition of Public Service Obligations as well as rules for the definition of track access charges. Such rules can only be agreed upon if there is a continued process of exchanging the experience and practices of regulators and transport authorities. Looking further into the future, it is possible that the ENRRB constitutes the nucleus of a future pan-European railway regulator. A similar process had taken place in the field of air transport, where initially the Joint Aviation Authorities exchanged best practices in order to increase the efficiency of rulemaking processes. This institutional arrangement later developed into the powerful European Aviation Safety Agency (EASA).

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<sup>18</sup> See the summaries of the discussions and the presentations given at the 7<sup>th</sup> Florence Rail Forum, “Current Challenges of Rail Regulation in Europe: the Regulators’ View” (Florence, 29 November 2013).

### **3.1.3 Intermodal competition: increasing the railway modal share**

There has been little progress when it comes to creating a level playing field for intermodal competition. The 2011 White Paper set the goal to reach a 30% shift from road freight to rail freight for journeys of over 300 km by 2030, and over 50% by 2050. However, this goal is now almost impossible to achieve. The main reason for this is the absence of a clear cross-modal strategy to implement it. If the ambitious goal of an intermodal level playing field is to be taken seriously, it will be necessary to also include modal shift as a goal in the other transport modes. One of the major, if not the most important, challenges is the alignment of costs for using road and rail infrastructure, as well as the internalisation of externalities of the different transport modes. The challenge of intermodal competition can only be addressed with an overarching financing or pricing policy (e.g. mobility pricing) across the transport modes.

### **3.1.4. Appropriate financing for rail infrastructure**

Regulation has to ensure that the political barriers to more sustainable financing are overcome, as too often new infrastructure is planned without a coherent business plan which includes future investments for maintenance (Finger, 2014). For this reason, compulsory development plans (as foreseen by the Recast Directive) can help to make these investments more sustainable.

In particular, the development of the freight sector relies on financing: there is an urgent need to focus investments in international corridors and specifically in the missing links. Better connections, in particular to the big ports, are essential and have often been neglected in the past in comparison to other national priorities. There is, in fact, a misalignment of incentives: because of the distributional effects of railway investments, the logic followed when deciding where to focus these investments still respects national considerations. It is therefore essential for European regulation to define stricter rules for investment in cross-border links.

## **3.2. Aviation: Regulating infrastructure and new technologies**

Aviation is one of the areas where liberalisation policy has been most successful. Barriers to a single European aviation market have successfully been removed in air transport services. In 1993 the so-called 9<sup>th</sup> Freedom was passed, allowing all EU airlines to operate on any route within the EU. The process of liberalisation saw the emergence of low cost carriers, caused the bankruptcy of several traditional airlines and eventually led to a still ongoing process of consolidation of established national flag carriers. The process simultaneously led to the Europeanisation of aviation policy. Less progress has been made in air traffic management and airports. In order to deal with the increasing traffic volumes, there has to be a more efficient use of the infrastructure. Therefore, existing rules need to be enforced. This includes making progress in the Single European Sky to make air traffic management more efficient, as well as enforcing a more efficient system of airport slot allocation. On the other hand, the emergence of new technologies in aviation, such as civil drones, requires new regulatory approaches.

This section focuses on two key areas that regulation should tackle:

- Regulating the Air Traffic Management (ATM) infrastructure: making progress towards the Single European Sky.
- Regulating new technologies: Remotely Piloted Aircraft Systems (RPAS).

### **3.2.1. Regulating the Air Traffic Management Infrastructure: making progress towards the Single European Sky (SES)**

One of the most important challenges in the future will be to make further progress towards the Single European Sky. The SES initiative was launched in 2004 with the central objective of defragmenting the European airspace and improving its overall efficiency, yet it remains far from completion. There is general agreement about the considerable savings in travel times, and consequently in costs and emissions, that could be achieved by organising the European Airspace along frequently used flight paths rather than along national borders. This is the central objective of the SES. Given the projected growing traffic volumes, the SES will become a necessity as more capacity cannot be accommodated without a more efficient system.

Regulation has to take account of what is currently blocking the advancement of the Single European Sky.

As a matter of fact Member States currently lack the incentive to reform national Air Navigation Services Providers (ANSPs) as such reforms would generate political and financial costs: the high number of control centres in Europe is due to the fact that they are structured along national borders. This creates a high degree of technical fragmentation. Comparisons with the US system regularly show the inefficiencies resulting from the fragmented system in Europe. However, a consolidation of control centres as recommended by IATA<sup>19</sup> will not be feasible in the near future, and national control centres will continue to exist. The creation of Functional Airspace Blocks (FABs) was meant to organise airspace in a more efficient way and gradually move towards a single European system of air traffic control yet the implementation of the FABs shows severe weaknesses.

With the SES II package, the Commission has moved towards a strategy of focusing strictly on performance. Such a strategy can deliver results and overcome political resistance, as achieving greater performance is a goal that all Member States can agree upon in principle. It is however hard to agree on the specific performance objectives. Reforming the ANSPs creates political costs for Member States governments which are therefore reluctant to agree on very far reaching performance targets.

Another problem is that there are not yet any functioning sanctioning mechanisms available at EU level. Thus, even when there is agreement, Member States cannot be forced to implement it.

When there is no pressure to increase performance because of acute capacity shortages, national ANSPs are not really incentivised to increase their efficiency and to make the necessary investments. Member States, on the other hand, are reluctant to compromise on airspace sovereignty for the sake of a better performing ATM system. Also, ANSPs generate revenues for their owners, who are the national governments in most Member States. This misalignment of incentives regularly results in poor implementation or gridlock in the governing bodies. This is exemplified by the frequent blockage in the Single European Sky Committee, which is composed of the Member States and is in charge of ratifying the performance targets for ANSPs.

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<sup>19</sup> The US handles 67% more flights with 38% less staff; there are 20 control centres in the USA as compared to 68 in the EU (IATA, 2012).

Today, technical solutions are available that can bridge these differences, but they need to be implemented, something that requires political leadership. Such technical solutions include the development of a shared data infrastructure. A shared data infrastructure would provide for a “virtual consolidation” reducing costs for individual control centres. EU Regulation can provide incentives for those ANSPs that “opt in” to such systems by financially supporting the necessary investments. Further regulation, such as the current SES II+ proposal (European Commission, 2013e) offers a political solution that builds on these technological possibilities. It aims at creating a common European infrastructure which is politically managed by the European Commission and run by the ATM industry, including ANSPs.

The technological pillar enabling the Single European Sky is currently entering its crucial phase with the deployment of the first solutions developed by the Single European Sky ATM Research Programme (SESAR). After the successful development of a variety of ATC technology and pilot projects, the focus now lies on organising their deployment. This phase of the process is, however, a complicated endeavour, as many different interests will need to be overcome to deploy ATM technology in a standardised and harmonised way across Europe.

### **3.2.2. Regulating new technologies: Remotely Piloted Aircraft Systems (RPAS)**

A test case for this new performance-based approach to regulation will be the development of a regulatory framework for Remotely-Piloted Aircraft Systems (RPASs or drones<sup>20</sup>). The challenge here is to rapidly develop the necessary legislation in order to keep up with the pace of industry development. The proliferation of civil (and military) drones certainly poses a new challenge for the regulation of aviation. Drones can offer new services and develop into a new field of aviation that bears prospects for growth both in manufacturing and service provision (European Commission, 2014a). On the other hand, there are a number of risks that regulation needs to address. At the European level, it has to be assured that regulation on drones is integrated into the existing system of aviation safety in a way that is proportionate to the risks entailed by the different ways in which drones are operated. There is an extremely varied use of drones: they are used for private as well as commercial purposes, ranging from sport events to infrastructure inspection in the energy sector and possibly for the delivery of small cargo in the future. Apart from immediate safety risks (mid-air collision with aircrafts, harm to people and damage to property and critical infrastructure), there are other public interests concerned, such as privacy and security (EASA, 2015).

From the experience with regulation on aviation safety it is clear that, in order to allow the drone industry to prosper while guaranteeing an adequate level of safety, a differentiated approach is needed. The European Aviation Safety Agency has proposed to define three categories to balance safety with type of operation (EASA, 2015: 4):

- A so-called “open category” that includes small drones which are operated at visual line of sight. These would not require authorisation by aviation authorities, nor airworthiness approval or licences for operators.
- A “specific category” would involve operations that pose more significant risks. Here authorities are in charge of risk mitigation and would define the appropriate requirements for every individual operation.

<sup>20</sup> The word drones commonly refers to both Unmanned Aircraft Systems (UAS) and Remotely Piloted Aircraft Systems (RPAS) as defined by ICAO.

- A certified category which would include those drones that have to be treated in the “classical aviation manner”, requiring certificates as well as licences for pilots.

Regulation of drones is at an early stage; yet, the “open category” for small drones and the “certified category” big drones flying at high altitudes seems to be relatively uncontroversial. The challenge will be to regulate those drone operations within the specific category. Here regulators need to gain knowledge of the emerging sector, as they will need to define specific requirements for the different types of operations on a case-by-case basis.

### **3.3. Road Transport: Regulating innovation and enforcing existing regulation**

EU policy on road transport covers a wide range of issues. In order to achieve progress, it will be necessary to combine the push for the consistent application of existing rules with an adequate reaction to new developments. In fact, the technological challenges outlined in 2.2.1 will particularly affect road transport, and regulation needs to ensure that the potential of new technologies is fully used.

It is especially important that the sectoral policy for road is consistent with the general objectives of transport policy and other sectoral policies. In other terms, the efficiency of the road transport sector must be compatible with the overarching goal of shifting traffic to more sustainable modes. When compared with other modes, the road freight sector has become “too successful” with a modal share of about 45% in volume (European Union, 2014). However, prices do not accurately reflect the negative externalities the sector produces, most importantly congestion, air pollution and CO<sub>2</sub> emissions.

Against this background it is important to address enforcement of existing legislation, innovation and technology, and infrastructure financing and intermodality.

#### **3.3.1. Enforcement of existing rules**

Even though frequently addressed in the past, there has not been substantial progress in a harmonised enforcement of EU legislation in road transport. EU regulation is in place for all matters concerning the access to and operations in the haulage market ((EC) No 1072/2009). This includes, among others, rules for working time, vehicle specifications, training for drivers and other issues related to quality and safety. The biggest challenge is the lack of uniform enforcement across Member States. Practices still differ in terms of the frequency of controls, as well as penalties for non-compliant freight companies (European Commission, 2014b). In order to address these issues, several options are available. A standardised approach for enforcement rules needs to be pushed forward and agreed upon among all Member States. As proposed by the European Commission, standardisation of the training of enforcement officials would also make a big contribution. In order to give competent authorities better opportunities to monitor the compliance of road transport undertakings when they are operating on international routes, an Electronic Database containing information on the compliance records of operators has been established (ERRU, 2015). Member States should be encouraged to make wider use of it.

In order to guarantee the correct enforcement of social rules, it is necessary to further develop joint responsibilities and liabilities. There has been a significant change in the freight sector in recent years, which resulted in the emergence of bigger and globally

operating logistics companies that use a large network of subcontractors for their deliveries. This has created a practice of dispersed responsibilities that complicates the correct enforcement of penalties in case of infringement. Regulation should further aim at establishing joint responsibilities, tying the responsibility for compliance not only to the individual driver but also to the principal operator, subcontractor, driver employment agencies etc. This has already been achieved in the field of driving times (European Parliament and the Council of the European Union, 2006) and should be extended, as a principle, to other relevant areas for the working conditions in the sector.

### **3.3.2. Innovation and technology**

Unlike other sectors, there is a certain lack of awareness about the usefulness of innovation in road freight, and often the relevant industry actors refrain from investing in it. This is why there should be a focus on supporting pilot projects in order to demonstrate the usefulness of technology.

The need for innovation in the road freight sector was recognised in the 2013 Trans-European Transport Network (TEN-T) Guidelines (European Parliament and the Council of the European Union, 2013). In fact, technologies that are already available can improve the sector and further the overall EU goals. Innovations can relate to technical improvements of vehicles (improved aerodynamics) as well as to fleet and personnel and inventory management. It is most urgent to standardise technologies and develop common platforms. This can enable the use of advanced traffic management systems and significantly increase efficiency and reduce the environmental impact of the sector (see 2.2.2). Another example of using new technologies is the establishment of a system of “relay points” which would allow drivers to coordinate where they want to start and end their shift by using a common platform (Bayliss, 2012). This could also significantly improve working conditions and the attractiveness of the job. New technologies such as Real Time Traffic Information and other ITS solutions can furthermore improve road safety (see 3.5).

### **3.3.3. Infrastructure financing and intermodality**

The biggest challenge in road transport is that a truly intermodal policy needs a harmonised approach to infrastructure pricing. Member States need to work more in this direction and incorporate the European dimension in their national strategies.

New technologies can set the incentives for this, but regulation has to set the right conditions for their deployment. For example, the deployment of the new European Electronic Toll Service (EETS) has faced several difficulties. The goal of the directive (European Parliament and the Council of the European Union, 2004b) was to allow hauliers to pay tolls by concluding one subscription contract with one service provider using the same on-board device in different regions. However, this could not be realised, in part because of the complexity of the toll domains: the companies responsible for setting up the system, the toll payment system service providers, would face disproportionate costs concluding contracts and adhering to the different requirements of over 200 toll domains in Europe. Stakeholders point out that the current regulatory framework fails to provide business cases for these service providers (Krosnar, 2014).

### **3.4. Regulating waterborne transport: key for intermodality<sup>21</sup>**

Waterborne transport could be a competitive and more environmentally friendly alternative to road transport. As in the other modes, the EU started to liberalise waterborne transport during the 1980s and the markets for inland waterways transportation, short sea shipping and maritime services are now liberalised throughout Europe. Competition in the shipping sector increased significantly over the past years and shipping companies are now regrouping so as to gain economies of scale.

However, full market opening has not yet been achieved, and the European Commission has listed the removal of existing administrative barriers among its strategic goals (European Commission, 2009a). In particular, both inland waterways transport and short sea shipping face higher administrative burdens compared to land transport, which prevents their development and distorts multi-modal competition.

In the future, in order to improve ports' performance and increase the modal share of waterborne transport, EU rules should focus on the role that this mode could play in reducing congestion, especially as regards freight transport. In particular, the coordinated development of ports as an integral part of the Trans-European Transport Network could prevent congestion in urban nodes. A regulatory framework that takes advantage of new technologies and favours multimodal connection is also necessary.

The development of multi-modal logistic chains that include maritime operations is the main challenge for the waterborne transport sector in both long-distance and short sea shipping. The inclusion of the Motorways of the Sea in the TEN-T planning as well as the inclusion of several ports in the TEN-T core network is a good starting point, both from a policy and from a financial perspective. Ports should become multimodal hubs along the corridors that act as interface between maritime and land (both road and railway) transport. The development of a port that is consistent with urban planning would also favour employment and make the port become a real market place and not just a transit area.

One key enabling element for the implementation of a strategy that has the ports at its core is the digitalisation of the different phases of the shipment. Short-sea shipping is currently fragmented along national or existing navigable corridors' lines. In this sector as well, the implementation of best practices developed thanks to pilot projects could play an important role. The Third Maritime Safety Package (European Commission, 2005) has called for the use of advanced information and communication technologies, as well as for the overall promotion of innovation and technological research in shipping (EU e-Maritime initiative). This would not only facilitate internal coordination with other modes of transport but also increase the global competitiveness of the European maritime industry while at the same time meeting environmental, energy, safety and human challenges.

Particular attention should be paid to the possibility of using unmanned vessels, which remains one of the main open issues for the sector. Technology is already available ([www.worldmaritimeneews.com](http://www.worldmaritimeneews.com)), yet the current regulatory framework does not allow its

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<sup>21</sup> The main input for this section comes from Christa Sys, Edwin van Hassel and Thierry Vanelislander (2014) "Regulation of maritime transport and inland waterways: the European balance sheet". *Forthcoming publication*.

use. Regulating the vessels' certification and validation so as to guarantee safety standards is also essential when deploying unmanned maritime vehicles.

### **3.5. Regulating the data layer in transport: Intelligent Transport Systems (ITS)**

Intelligent Transport Systems are already of major importance and will become increasingly relevant in making transport more efficient, safe and sustainable in the future. As such, ITS can contribute to more general policy objectives, such as cutting emissions. Furthermore, ITS are a growing new market with significant economic relevance.

Regulation here pertains to the enabling data layer, on the one hand, and to data protection and privacy on the other.

#### **3.5.1. The Role of Data for deploying a Real Time Traffic Information System**

One of the most significant elements of ITS in Europe in the near future is Real Time Traffic Information (RTTI). RTTI services provide road users with information related to their journeys: traffic regulation (speed limits etc.), recommended driving routes, estimated travel time, information about congestion, road works etc. While such data are already available and commercially used, they are not sufficiently interoperable across Europe, their geographical scope is limited and their quality cannot be ensured because of the lack of monitoring systems.

There is a clear need for an EU policy initiative to address these problems: new businesses that drive innovation in the sector need common technical standards and a legal framework that allows cross border operations and the exchange of data.

The ITS action plan (European Commission, 2008) and the ITS Directive (2010/40/EU) are the main pillars of the EU in ITS and the provision of RTTI was defined as one of six key priorities.

In order not to infringe on Member State's sovereignty in this area, the EU focuses on making "interoperable and seamless ITS services (available) while leaving Member States the freedom to decide which systems to invest in." The focus therefore lies on defining the specifications of ITS applications.

In 2014 the Commission put forward a regulation establishing specifications for the accessibility, exchange, re-use and update of road and traffic data for the provision of RTTI. Such specifications are of crucial importance for the emerging ITS industry, but they also show the difficulties of regulating the highly complex data layer in the transport system.

The challenges for regulation are due to the fact that RTTI change with technological innovation. As technology progresses, more traffic data can be collected and processed, while smartphones and personal navigation devices are offering more services to users. There have been major technological innovations over the past ten years and this is going to continue: technology, for example, allows for the connection between cars and with roadside equipment (e.g. connected cars). This shift towards connected vehicles will also affect how traffic data is collected and which kind of data is needed by road users. In general, due to the availability of better technology for both the collection and the

processing of data, more data will become available while the demand for more specific and more accurate data is also increasing.

Furthermore, the market for RTTI is fundamentally changing: private actors collect more and more relevant data and will continue to grow in their importance, as they have the necessary technology and the ability to develop the business models to attract investments. Nevertheless, public authorities remain the main source of many types of relevant data for RTTI (such as information about road blocks, road regulations, information on road works, accidents and diversions, and traffic management information on publicly operated roads) and they will continue to play an important role in the future, in all aspects of public interest.

Consequently, regulation has to focus on the most important following elements:

- **Standards:** as the standardisation for ITS is generally at a very early stage, advances in this field are of particular importance for this sector in which many SMEs develop products intended for the global market.
- **Availability of Data:** public authorities make road data, traffic information and traffic management information openly available. The challenge here is to make the data compatible with new technologies, which means making them available in formats that are machine-readable, as well as making them accessible to all service providers. Making data openly available can also have negative consequences: some private companies have built their business case on the collection and remunerated distribution of traffic data. Making data public can in some cases interfere with functioning business models and act as a disincentive to further investment in innovative data collection methods (Nabil, Abou-Rahme, 2012).
- **Governance:** just like technology, regulation also has to continuously evolve and adapt. The general trend will be for public authorities to focus more on the collection of data rather than on the provision of services, as this is done more efficiently and innovatively by private entities. Therefore, it is crucial to define which tasks fall under the responsibility of public actors and which ones should be left to private actors.

If regulation paves the way for the development of ITS, it can significantly contribute to the efficiency of the transport sector as well as to the growth of the ITS industry. Furthermore it is of particular importance for road safety: cooperative systems that allow communication between vehicles and between vehicles and road infrastructure are a pre-condition for the deployment of the so called advanced driver assistance systems that can significantly improve the safety of all road users.

### **3.5.2. Regulating personal data and privacy concerns in Intelligent Transport Systems**

Intelligent Transport Systems include a variety of technological solutions that can significantly contribute to a safer and more efficient transport system. Yet, these new technologies have a series of implications for personal data and the privacy of travellers. There has been a steep rise in the collection and processing of personal data related to transportation in recent years (International Transport Forum/OECD, 2015). The sensitive nature of these data that potentially reveal a person's habits and movement profiles makes the regulation of data protection one of the key future challenges in transport.

Currently the ITS Directive, which aims at accelerating the deployment of ITS, only requires that the processing of data is carried out in accordance with EU law, but does not formulate any specific requirements for the different applications. This is a very general statement, which creates the risk of an inconsistent and fragmented data protection system for ITS in Europe, which in turn could become a serious obstacle for the industry.

The right for data protection (laid down in article 16 of the Treaty on the functioning of the European Union) is further specified in the data protection Directive (Directive 95/46/EC) that is currently under revision.

The more operational principles of data protection are left to the Member States, but the fundamentals on which Directive 95/46/EC is built derive from the Organization for Economic Cooperation and Development (OECD) recommendations on data (OECD, 2013). The ongoing discussion about data protection regulation is mainly concerned with the extent to which this protection can be maintained in an ever more connected society which pose specific challenges for the different ITS technologies:

- **Notice:** subjects whose data is being collected should be given notice of such collection.
- **Purpose:** data collected should be used only for stated purpose(s) and for no other purposes.
- **Consent:** personal data should not be disclosed or shared with third parties without consent from its subject(s).
- **Security:** once collected, personal data should be kept safe and secure from potential abuse, theft, or loss.
- **Disclosure:** subjects whose personal data is being collected should be informed as to the party or parties collecting such data.
- **Access:** subjects should be granted access to their personal data and allowed to correct any inaccuracies.
- **Accountability:** subjects should be able to hold personal data collectors accountable for adhering to all seven of these principles.

There is a growing number of applications where regulation has to ensure that privacy concerns are integrated. Some of the main examples are as follows:

- **E-ticketing in public transport:** Electronic fare collection systems have developed significantly over the past few years. They offer a large amount of advantages for both users and service providers. While there are important differences between the schemes that are in place, a chip card is used to pay for the transport service.
- **Parking payment services:** ICT is used to replace traditional vending machines for parking tickets. A variety of options exist which allow users to pay their parking tickets more conveniently and city administration to collect fees more efficiently with less chances of fraud.
- **Road user charges:** Tolling based in vehicle equipment is becoming increasingly common and is replacing the payment of road tolls through a stationary toll booth to facilitate a free flowing system.

- **Pay-as-you-drive insurances:** Insurers offer to connect their car insurance premiums to the actual driving behaviour of an insurance holder, taking into account such categories as mileage and speeding. Different from the current system where premiums are based on fixed categories to determine a user's crash risk, this allows for a more precise calculation and individualisation of a user's premium.
- **Traffic Data Collection:** Whereas traditional methods of traffic data collection by means of stationary sensors pose no significant threat to traffic users' privacy, there are several new means that deserve attention. In particular, the "floating cars method" is an example where car owners on a voluntary basis act as a "probe" to monitor traffic flows by means of a global navigation satellite system (GNSS). In another method, individual cars are detected to compare the passage time between different points.

All of these systems pose different challenges. In practice, for instance, e-ticketing tends to not fully respect the "minimum disclosure" principle as users share vast amounts of personal data when registering for these systems. "Users tend to reveal a large number [sic] of personal information and leave traces of their location at various time points for the sake of 'convenience'. [...] The unique number that is stored on the card allows for the tracking of the location of the user and, when combined with the identification data of the user that may be revealed when the electronic ticket card has been purchased via a credit or debit card, it offers a rich amount of personal information that can be used for user tracking and user profiling" (European Network and Information Security Agency, 2012). In the case of pay-as-you-drive insurances, there is naturally a serious risk for the privacy of the insurance holders when the data that is necessary to calculate their premiums is stored in a central database.

The balance between privacy concerns and exploiting new technologies largely remains the responsibility of the Member States. Yet, there is a need to harmoniously develop European rules in order to allow a cross border development of the industry. A general principle for regulation on data protection in ITS should be to aim at a true "Privacy by Design" framework: to avoid the imposition of rules to existing applications that are already on the market, developers need to incorporate privacy concerns in the process of designing their product. EU regulation can provide the necessary standardised privacy risk assessment tools. The experience in the smart grid development in the energy sector could serve here as an example (Information and Privacy Commissioner Ontario, Canada, 2012): it is indeed possible to work with a variety of stakeholders to develop solutions that are both privacy-friendly and functional for the industry.

## **4. CONCLUSION: THE ENABLING ROLE OF REGULATION - RIGOROUS IMPLEMENTATION AND NEW PERSPECTIVES**

### **4.1. Rigorous implementation**

Effective regulation needs a coherent system of regulatory responsibilities and agreement among Member States on common objectives as well as on EU-wide sanctioning mechanisms. Currently, several systemic concepts remain inconsistently and incompletely implemented (Single European Sky, Single European Railway Area).

Thus, the market for Air Transport Services has been liberalised but there is still no Single European Sky to allow for an efficient system of Air Traffic Management. There is no Single European Railway Area and, in spite of some achievements, many of the core objectives such as creating more and better cross border rail links have not yet been accomplished. Ambitious goals for modal shift have been formulated but they should be rethought as their realisation has become increasingly unrealistic. This remark also pertains to road transport: very little has been achieved in shifting freight to rail and to waterways, or in developing a coherent system of infrastructure pricing that reflects true costs and could better modify behaviours. There has also been insufficient progress in the enforcement of regulation for working standards in the road freight sector.

The reinforcement of the independent regulators is therefore one of the crucial points to focus on. The challenge is to strengthen them in terms of resources and competences. One should also examine whether the existing European regulators (e.g., ERA, EASA) should be strengthened, as they can significantly contribute to speeding up the proper implementation of EU rules.

In other words, developing new regulation is not the most pressing issue. Rather, the focus should be on implementing the existing rules in a coherent way across the Member States.

### **4.2. New perspectives**

As shown above, technological developments, in particular, call for a new perspective in transport regulation. To recall, the ICTs allow for a more integrated approach to mobility, combining the different transport modes in the interest of the customer. Consequently, regulation has to adapt to this new situation by addressing the different elements of the mobility system as shown in Figure No.17.

**Figure 17: New challenges in transport regulation**

Element of the mobility system	Challenge in regulation
Customer	Regulating consumer protection (e.g. privacy)
Mobility solutions providers	Regulating competition
Data layer	Regulating the data layer (e.g. security, interoperability, access, transparency)
Transport services providers	Regulating intermodality and intermodal competition
Transport infrastructure operators	Regulating investments

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**Customers: Regulating customer protection**

Focusing on mobility requires a new approach to consumer protection: indeed, as the role of data in transport operations is becoming ever more important, **privacy and data security will become a major issue for the entire transport sector**. European standards are needed not only on the technical level but also on the level of general cross sectoral principles and rules for data protection. The difficulty of adopting a new general EU-data protection Directive (European Commission, 2012a) illustrates this challenge. More importantly, the right to privacy for citizens (which is among the fundamental principles of the European Union) is challenged in new ways if data protection is not fully integrated into the development of the new transport services and technologies. Not to mention the fact that a lack of data protection will ultimately hamper the potentially emerging new business models.

**Mobility solutions providers: Regulating competition and quality**

Travellers will increasingly become customers of intermediaries, i.e., **mobility solution providers**, rather than transport operators, such as rail companies or airlines. Mobility platforms that offer information and booking options across modes and according to the needs of the individual passenger or the shipper will become widespread. And so will companies that facilitate the exchange of services in line with the “sharing economy” (and, even more importantly, peer-to-peer solutions providers). Regulation should encourage the development of these actors because they are an important facilitator of a transition towards a more efficient transportation system. To do so, regulators must create a framework that guarantees fair conditions for competition and clearly defines liabilities.

### **Data layer: Regulating the newly emerging data layer**

Integrated mobility solutions and corresponding services can only exist on the basis of open and accessible transport data (e.g., data layer). Typically, such data exist among the transport service providers, the transport infrastructure operators, and also in individual vehicles (cars and trucks). Such data need to be standardised so as to be fully interoperable. For this data layer to become openly accessible and usable, **strong regulation on data standardisation and data accessibility has to be developed**. This is probably the biggest challenge for EU regulators.

### **Transport service providers: Regulating intermodality and intermodal competition**

As mobility services are by definition intermodal, special attention needs to be paid to the regulation of intermodality and intermodal competition. On the one hand, intermodality, in the form of intermodal transport hubs (ports, airports, railway stations) has to be recognised as a reality in itself and corresponding regulation geared at such intermodal hubs has to be developed. In other words, the new rules would not consider, for example, airports as being part of air transport regulation; rather, airports, ports and railway stations should be grouped together and regulated similarly as particularly important mobility nodes, so-called intermodal hubs. On the other hand, special attention needs to be paid to removing distortions among the different transport modes: the externalities in the different transport modes should be internalised, becoming ultimately part of a single integrated mobility pricing scheme covering all modes.

### **Transport infrastructure: Regulating the infrastructure layer and guaranteeing a stable legal framework so as to favour investments**

As new mobility services become a reality, both transport service providers and transport infrastructure operators will come under further financial pressure and this in addition to increasingly scarce public finances. Consequently, there will be an emerging need to focus regulation on investments, mainly in transport infrastructure, but perhaps also in rolling stock, at least in the case of railways. Here, regulation has to ensure mainly two things: a stable and EU-wide regulatory framework fostering investments, as well as appropriate infrastructure pricing and financing.



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## **Part II: Changes in technologies to meet emerging urban mobility patterns**

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