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Smart Mobility 2050

- Human centred Vision and long-term Horizon -

Paper incorporating the outcomes of the 12 June 2012 European Policy Workshop, Brussels

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Contents

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1 Introduction

Mobility and Transport are fundamental and vital for economies and societies at large. For Europe, efficient and sustainable transportation and mobility are essential for participating in the world economy and sustaining growth and prosperity. Transport and mobility have grown substantially over the past decades, facilitated by relatively low fuel prices, improving infrastructures and a lack of curtailing environmental constraints. Nevertheless, it is widely acknowledged that transport and mobility can no longer grow on the same path and with the same pace without serious environmental, social and economic consequences. As stated by the European Commission in the Transport 2050 Whitepaper (Roadmap to a Single European Transport Area), European mobility and transportation is facing a number of severe challenges[1]:

- To reduce CO_2 emissions while CO_2 from transport are still growing- despite more energy-efficient vehicles- with further increasing mobility and transport demand
- To reduce dependency on (exhaustive) fossil fuels. The transport sector is extremely dependent upon fossil fuels, while crude oil will become more scarce and expensive
- To curtail congestion levels while the demand for mobility and transport is still growing
- To withstand growing competition from other world regions where transport modernization and infrastructure investment programmes are being developed and transport technologies are innovated.

Some of these challenges have been are known for a long time now, while some are relatively new (such as the increasing competitive pressure in the global economy).

1.1 Policy context

The European Commission has developed a new vision, strategy and a long term agenda including policy measures for addressing these issues. In the whitepaper on transport, the policy response to the identified challenges is outlined which states a number of policy aims with regards to mobility:

- Reduce greenhouse gas emissions by at least 60%
- Increase the efficiency and capacity of the transport system
- Achieve close to zero accident rates and higher customer satisfaction
- Drive conventional cars out of the cities and optimize urban logistics

The strategy includes many different policy directions, from developing a single European transport area, to promoting the safety and security of the transport system, to investing in a connected trans-European transport network and coordinating infrastructure pricing and taxation at the national and regional level. Also part of this strategy is to stimulate innovation, both in terms of technologies and mobility and transport services.

In the Horizon 2020 programme for research and innovation, four main aims with regards to transport and mobility are outlined: sustainability, seamless transportation, competitiveness, and responsiveness. *Sustainability* involves making cleaner and quieter aircraft, vehicles and vessels, using smart equipment and infrastructures, and improving urban transport and mobility. Making mobility *seamless* requires that traffic congestions are substantially reduced, that the management of people and freight transportation is improved, that the number of accidents is reduced, and that intermodal mobility is achieved. To make the transportation sector competitive, a next generation of transport means must be developed based on interoperable standards and using advanced production processes. Finally, policy and regulations must become *responsive* to socio-economic

[1] The 'Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system', accessible on-line at:
http://ec.europa.eu/transport/strategies/2011_white_paper_en.htm

research on user behaviour and acceptance, mobility patterns, business models, transport and spatial planning, and accessibility issues.[2]
Many of the road maps, action plans and research priorities focus on realizing future technological solutions and service innovations to address the challenges that are presently recognized (like those described in the EC Transport Whitepaper). However, the addressed solutions often have a strictly technological focus. Visions on smart mobility and intelligent transportation would benefit from a thorough discussion on alternative opportunities which are at present not easily recognized. Such a discussion should incorporate a broad view on the impact of these opportunities on the lives of individuals and the European society at large.

1.2 Mobility in 2050

Several large socio-economic trends relate closely to the future of mobility and transportation. Predicted (and predictable) demographic changes involve an ageing of the world population. The balance of the global economy is also shifting, with strongly developing economies such as China and India taking a larger share of the world's consumption. The climate is changing as is observable in the melting of the Artic and Greenland icecaps. World population is rapidly urbanising, with a predicted 60% of the world's population living in cities by 2030.[3]

In the past years several foresight and forward looking activities were performed to look into the future of mobility and transport. Some of these activities at the national and the European level had a short and midterm horizon (2020 and 2030), but many others had as well a long-term 2050 horizon. In general two types of forward looking activities can be methodologically distinguished. On one hand, activities building on expert opinion and expert assessment finally drafting future scenarios: identifying main drivers and weak signals to find out new directions and even discussing some unexpected events (wild cards). On the other hand, many activities were performed trying to assess the opportunities of potential transition pathways by calculating the effects of a mix of feasible policy measures and future technology options referring e. g. to the European CO_2 reduction targets in 2050. Several of the participants taking part in the EFP European Policy Workshop on Smart Mobility were involved or coordinating one or the other of these activities.

What in our opinion has not been covered in past foresight exercises was a thorough discussion regarding potential fundamental changes in behaviour and the transformation of social arrangements related to mobility and transport that relate to an ageing society or the diversification of individual behaviour. It is for example expected that an "automobile lifestyle" will have in future not the same value as it had in past times of mass motorisation. Another feature that future life is expected to have, is that 'private life' and working environments will coincide more in local arrangements with less commuting and travelling. Far distance communication and exchange will mainly be organized in the virtual sphere. Production and provision may be organized at a local level at highly efficient micro-manufacturing sites in individual or community based working and living environments.

[2] The research & innovation agenda with regards to mobility was presented during the workshop by dr. András Siegler, Director Transport, DG Research and Innovation, European Commission.
Read more on Horizon 2020 on the initiative's website: http://ec.europa.eu/research/horizon2020
[3] Dr. Domenico Rossetti presented these trends and related European forward looking activities during the workshop. Read more on these initiatives at:
http://ec.europa.eu/research/social-sciences/forward-looking_en.html

1.3 Smart Mobility

For several years the term mobility has been frequently used in the debates in transport policy. This indicates in our opinion a systemic turn. Debates do not solely focus anymore on transport means and infrastructure, but also on reason and the frames for person mobility and transport. The focus is not only on physical activities of travelling and transporting, but also on the underlying decisions and behaviour. Alternatives such as tele-presence or electronic delivery can for example replace physical travelling or freight transporting. Personal life, mobility styles and related social arrangements, as well as the current organisation of production and provision, may change through societal transformation and further technological and economic developments. Main divers for these societal changes may be increasing fuel and energy prices, on-going demographic and social change and ambivalent globalisation trends between trans-nationalism and national and local protectionism.

Smart mobility implies making transport systems more intelligent, more flexible and adept by the use of ICT, in particular the opportunities that advanced ICT systems offer. Advanced ICT allows to managing complex transportation systems in a cooperative way. So called cooperative systems are defined as systems with dynamic feedback loops among operators and users to constantly optimize the system functions. These systems do not only allow to command and control, but also to monitor and intervene and even support self-regulation and systems learning. Advanced ICT in mobility and transportation supports decision making (smart choice) on how to travel or ship goods, offering options not to move or transport goods by organizing planned activities in another way. With advanced ICT the communication function has gained further importance. This communication is meanwhile widely organized as interaction in social networks and communities allowing a lot more than information and knowledge sharing. With involved persons not only sharing information and knowledge, but bringing in and deliberating personal views and opinions, community-based learning takes place. Participation in these networks is strongly motivated by individuals' urge to present themselves as members in a community. Networked and community applications like WAZE (*ww.waze.com*) are on the move in the transport sector. This trend - involving advanced ICT technologies- is often addressed in debates by using the term 'smart'. The smart city debate is for example referring to joint knowledge building in participatory arrangements. The European flagship initiative on smart growth and the smart regionalisation initiative are as well underlining the strong connection between digital society, education and learning, social networking and knowledge capacity building.

1.4 The Workshop

The European Foresight Platform (EFP) organized a workshop to discuss in more detail a selection of future visions on smart mobility and transportation in a long-term perspective. The focus of this discussion was on the consequences of these visions on the lives of individuals and the European society in 2050. The overall aim was to translate these far-horizon visions into more detailed implications and requirements for mobility and transport policy making. Specifically, the aims were:

- to sketch a range of future visions on smart mobility based on the latest insights that resulted from foresight and forward-looking activities in the mobility and transport domain and in society at large;
- to explore new views on potential developments in smart mobility and transport taking a human-centred perspective;
- to discuss credibility, feasibility of these visions and to identify the main drivers and barriers for developing towards these visions;
- and to suggest policy implications and requirements for dealing with the drivers and barriers.

The outcomes of the workshop have been incorporated in the background paper that was originally written to serve as a workshop guide, later resulting in this paper. The four visions should be

understood as complementing smart mobility and transport scenarios; our intent is not to choose one of the four future projections as 'most likely'. All visions take a human centred and societal viewpoint and complement previous foresight and forward looking activities.

2 Four Visions of Mobility Futures

The four projections of potential futures relating to smart mobility are introduced below. Each projection is an future outlook on smart mobility from a specific perspective. The different projections are not meant to exclude the other perspectives, but rather to be complementary and to stimulate framing the topic from different angles.

For each projection we also discuss drivers towards the projection, and barriers that may hamper the realisation of the projection. We also discuss the policy implications associated with realising the projection. Both the identified drivers and barriers, and the discussed implications are based on insights gained during the workshop discussions.

2.1 The Smart and Seamless Connected Traveller

We are moving towards a 'Connected World' in which everyone and everything is connected. People interact with each other and are highly involved in social media. Social media not only allows information sharing and online entertainment, but also the exchange of personal views and continuous learning. 'Smart Objects', like cars and traffic lights, are connected by sensor- and communication technology, and interact with each other without (direct) human interference. Data sources for traffic information and real time public transport schedules are open and interconnected to form a big cooperative data treasure chest. It is in this connected world that one can find the connected traveller, effortlessly making its way on the smart tracks of smart cities.

Source: http://www.tnooz.com/

The connected traveller is supported by the Future Internet for making smart choices. Stress factors like missing connections, reconfiguring travel plans for unforeseen events, and forgetting to buy a ticket, belong to the past. The connected traveller does not need to worry. He is accompanied by a virtual travel companion who provides real time advice, moulded by user preferences, and offers services like automatic ticket payment. The comfort and reliability that travelling with the virtual travel companion allows, encourages the connected traveller to use multiple transport modalities and is allowing seamless transportation. The connected traveller uses public transport, cars and bicycle sharing, taxis, personal bicycles and electric scooters or whatever means available (and certainly for many occasions also his own car). The services provided by the virtual travel companion runs in symbiosis with other mobility services like reservation services, mobile payment and entertainment devices and enable a traveller to choose the means of transportation that is most suitable and attractive taking into account all contextual variables.

When using car or a shared service, the connected traveller uses cooperative and intelligent transport systems. These systems allow for example the platooning of cars which reduces environmental impact, and increases convenience and efficient use of the road and reducing accidents. Cooperative systems include continuous route optimisation, parking place reservation, transport modality advice etc. The virtual travel companion uses a flexible human machine interface

in the vehicle, so that both the information amount and content are adapted to the current situation. Regarding freight transport cooperative systems allow an advanced organisation of freight transport demand, e.g. by optimizing routes, reschedule delivery times and reducing empty carriages by bundling supply chains. The connected traveller travels effortlessly and efficiently. Even in the occasion that traffic jams or other disruptive incidents do occur he will swiftly be directed to a smart commuter and working hub, close to his original route, to use another transport mode or to stay and work online till he can move on. Working spaces are no longer confining in the sense that one *has* to go there to work. Individual cars are no longer confining in the sense that one *has* to use one to get somewhere. New mobility routines and behavioural change from car ownership and car use to more flexible and service oriented ways of individual mobility patterns and lifestyles have become widely accepted.

2.1.1 Discussion

A number of drivers and barriers in the movement to this future were identified in the workshop:

Drivers	Barriers
Perceived benefits of traffic optimization (e.g. reduced travel times, fewer missed connections)	Competition with the private car is difficult: achieving a comparable level of flexibility, availability, robustness, etc.
New business models (e.g. free mobile internet)	Issues on data ownership, user privacy, security.
Unsustainability of current paradigm: increasing levels of congestion, energy costs, scarcity.	Behavioural change is difficult to achieve, potential users may be digitally illiterate.
Technological developments in creating and using 'big data', network capacity and reliability, mobile devices.	Technological challenges: many interoperability issues difficult to overcome, high dependency on networks.

The smart and seamless connected traveller scenario depends to a large extent on a public transportation (PT) infrastructure that has greatly improved compared to the current infrastructure. A major challenge here is to achieve PT that is seamless in use while being financially and environmentally sustainable at the same time. To achieve this Public Transport operators would have to cooperate much more, and integrate their services closely with others. Policy makers may support this process by actively stimulating or enforcing cooperation.

A strong dependency of mobility on network and 'big data' technologies brings along challenges regarding privacy and security, and technological challenges with regard to the availability, reliability and interoperability of digital networks and services. Privacy issues require a policy framework on a European level to protect privacy and manage data ownership issues (the current Data Protection Directive is under revision, which may be a step in this direction). The technological issues that must be overcome for this scenario require investments in (research and development of) high speed and very reliable internet infrastructure. In addition, use and private investments may be stimulated using subsidies. Open platforms and technological interoperability with regards to 'smart' transport optimization require further stimulation.

Another challenge with this future scenario is to get the travellers themselves on board, and out of their cars. To make the vision viable, use of seamless public transportation may be stimulated with positive and/or negative reinforcement, e.g. using subsidies or removing tax advantages that are stimulate private car use. From a sustainable forward looking exercise point of projection the far horizon perspective to tackle the European CO_2 emission targets in the mobility and transport sector

are rather convincing. Car use in particular in urban and wider urban environments has to be heavily reduced (up to 40% of present car use, see EU GHG-TransPoRD2050).
Alone a shift to electric vehicles will not solve the problems of increasing land use in urban areas.

2.2 Smart Mobility in Urban Environments

75% of the European people are living in a city or city like environments. This has led to an unprecedented spatial pressure in wider urban environments. This has particularly affected the paradigm of urban mobility, for whereas the pressure increases, movement comes to a halt. Urban environments have thus been plagued by traffic congestions, smog and rising particulate matter levels threatening public health. Gradually these problems have been solved however through an amalgam of developments.

Public transportation (PT) has flourished and even though in a lot of cities these developments also lead to an increase in 'spatial coverage' of PT, the more significant developments took place in the realm of travellers comfort, versatility and flexibility of use, and 'greening' of transportation systems. Virtually all public transport modalities now run on electrical systems although in some cities one can still see hybrids and natural gas busses (e.g. LNG is now considered to be a transition technology). The developments into all-electric urban transportation systems were of course not autonomous, but were paralleled by developments of a new generation of power grids (smart grids) and distributed power generation systems (renewable energy) of which greatly changed the odds in favour of electrical transportation.

Travellers comfort has most significantly been improved by the development of virtual travel companions. These companions are generally considered to be the summon of the human-computer interface. They have developed to such lengths that they can speak and be spoken to. During travel they take care of smart navigation, payments and personal safety and security. Travellers just tell their personal companion where they want to go and the companion basically takes care of everything else. The development of these companions- and of course their less sophisticated predecessors- have drastically lowered the boundaries of multi-modal transport and that is why public transport users often use shared bikes, electric scooters, and smart city cars in addition to the more classic PT modes such as light trains, subway and busses. All transport modes are intra- and intermodal seamlessly connected. Short transfer times and direct connexions are guaranteed.

Parallel to the improvements in public transportation, a decline in ownership of personal cars and other individual transportation devices has occurred. The practical use of cars steadily declined not only because of traffic congestions but also because of a lack of parking space and sky rocketing parking fees. When people need to travel outside the city, they use public transportation to travel to a smart hub located in the periphery of the city and rent an electric or hybrid electric car to take them to their final destination. In these smart hubs one can also encounter the long range high capacity freight vehicles with their impressive streamlined appearance. They drop off their loads here so that small electric delivery units can take them from into the inner-cities and the urban sprawl.

Combustion engines have not disappeared entirely out of the urban environment but out of the inner city centres. Today it is rare to spot cars in inner cities with combustion engines except some heavy duty vehicles for particular on-site traffic. Only a few enthusiasts still use combustion engines despite the practical and financial disadvantages that they bring: e.g. in some city areas they are no more allowed. Prior to the electrification of transport modalities combustion engine technology has become cleaner and more resource-efficient, but discouragement fees, the disappearing of fuelling stations, and a general public disregard for combustion engine driven vehicles has not made life easier for combustion engine enthusiasts. In general, the urban environment provides meanwhile an attractive and green living environment that is able to serve mobility demands to an extent that does not reflect the spatial pressure in the cities and urban regions of 2050. To acquire such high levels of mobility technology developments had to be accompanied by social innovation and a strict interdisciplinary approach to motivate changes in behaviour and social practice. Mobility and transport developments have been strongly tied to developments in the energy, ICT, and urban and regional planning domain.

2.2.1 Discussion

A number of drivers and barriers in the movement to this future were identified in the workshop:

Drivers	Barriers
Policy in general is focused on sustainable development and thus drives towards sustainable, efficient and clean city transport.	Commuter behaviour and practice are an obstacle; people like driving cars and the comfort related to.
Unsustainability of the current paradigm: increasing levels of congestion, energy costs, resource scarcity, etc.	Lack of space to build new public transport infrastructure or other city planning barriers; road space may be used for other purposes.
Benchmarking of cities may drive cities to improvements: there is a public demand for greener, cleaner and more liveable cities.	Conservative lobbies, political frailty and lack of priority and coherence in policy making; lack of public investment budget for improvments.
Improvement in the primary function of public transport, e.g. higher spatial coverage. Secondary improvements, e.g. higher comfort levels, may act as positive reinforcement.	The costs involved in improving the primary function of public transportation are not or only to finance under a very long term horizon.

Overcoming the mobility challenges posed by rapid urbanisation is no trivial task. It involves finding the right mix in available and affordable transport modalities. This mix should be diverse to cater different needs and wishes, but should at the same time not exclude specific user groups. This requires that policy makers achieve a level of political stability that facilitates investments and reduces risks associated with sunk costs. In addition a practice of long term urban planning favouring sustainable public transport should be strived for. To avoid excluding specific user groups, incorporating the public opinion should be an integral part of policy making and this practice should represent all different user-groups (e.g. the elderly).

Similar to the 'The Smart and Seamless Connected Traveller' vision, improving connectivity between public transport operators and reducing fragmentation of diversified public transport systems is an important factor. However, this includes as well connectivity to road side individual transport with integrated traffic network management and other instruments. Developing viable operation models may initially require subsidies and where benefits for transport and infrastructure providers are not be found, public intervention may give direction. Finally, incentives and regulatory push for people to leave their cars may help in making this vision more appropriate, e.g. subsidize environmental friendly transport modes and penalize the use of others.

2.3 Virtual Mobility

Hardly anyone leaves the neighbourhood anymore. And why would you?
For work? For a long time already, job vacancies and curriculum vitae were exchanged online. Now job interviews are just as virtual as practically many of the jobs that people do in a European knowledge based economy.
For meeting people and workshops it has hardly any added value to meet in the physical selves compared to their virtual selves. Virtual presence technology has evolved to such an that for the human senses there is little difference anymore between the "real" and the "virtual". You'd swear there is an actual person sitting in front of you, discussing or dancing with you, instead of a holographic projection augmented. Unless you touch the hologram of course, but how many meetings really need physical contact? And for that, in many cases, the virtual extensions do just fine. Surgeons, mechanics and craft shop manufacturers work in the neighbourhood. Thus for health services or for buying things there is no reason to leave the neighbourhood. Online shopping is hardly something new, but now that common household items, clothing, furniture, and practically everything else can be examined virtually in great detail and manufactured and printed through personal 3D micro machinery or 3D printers at micro-production sites at home or in in the neighbourhood. Production and reproduction patterns have become in all areas of provision like food, housing etc. much more integrated again. Visiting a physical school sounds like something ancient, and going out for a night boils down to dancing and having party with virtual friends worldwide in your own living room or together with the whole community in the neighbourhood.

In many ways private worlds are much larger now. They transcend space and time: working with people from all over the world, having friends that share the same interests and are not from the neighbourhood, and having experienced things that nobody could have even dreamt of fifty years ago. At the same time, worlds have somehow become closer. We know the people directly around us much better, having a live in the neighbourhood and a live in the virtual sphere. There are still large groups of people that are "virtual illiterates", and lack the capacities to achieve virtual mobility like children and high age elderly and persons particularly refusing this way or literacy, but they are embedded and secured in the neighbourhood

Ever increasing congestion on infrastructure and pollution with growing mobility and transport demand and steeply increasing energy prices have driven us from cars, and even from public transport, to a situation in which energy-efficient virtual technologies form our main – and for many only – way of being mobile and interacting with far distance locations.
A novel generation of virtual agent technologies substituting existing mobility and transport going along with technological advances in robotics, holographics, human-machine interfaces and enhancement technologies and the internet infrastructure have made a virtual kind of mobility for communication so much easier than dragging our physical bodies around the planet. The implications for this change are not entirely clear yet, but maybe you have some ideas on this.

2.3.1 Discussion

A number of drivers and barriers in the movement to this future were identified in the workshop:

Drivers	Barriers
Financial and environmental costs of traveling are increasing, awareness of environmental issues grow, traveling becomes a burden.	Access to advanced virtual presence technologies is expensive and only for the privileged. A risk of new social inequalities is uprising.
Work and social relations become increasingly flexible, allowing to expanding horizons for working or recreating together remotely.	Privacy and cyber security issues in a future which depends on ICTs on a much larger scale and lack of public sector investments are main obstacles.
New production technologies such as 3D printing allow local production as alternative to centralized mass-production supported by an increasing popularity of local communities.	Regionalized individual production may ultimately not be competitive with mass-production or be cost-effective in many manufacturing areas.
New ICTs increase the "bandwidth" of experience, making virtual mobility increasingly a viable alternative.	Humans have "needs and wants" to be mobile, e.g. to "see the world". Social connections go beyond virtual contacts and communication, no matter how good the "bandwidth" of experience is.

There is little doubt that the future that is sketched here is unlikely to become reality in exactly this way. Much depends on how new distributed production technologies and services, human-machine interfaces and ICTs will further develop. More fundamental however, is the question of whether being mobile, physically traveling, and meeting new people in different contexts, is a fundamental human need and cannot be replaced by virtual mobility. In a less extreme manifestation, technological and social developments are already replacing physical movements for virtual "mobility". And some of this virtual mobility patterns replace physical mobility; think of shopping online instead of in a physical shop, or sending e-mails instead of paper letters.

Participants of the workshop indicated that this development should be viewed in concert with other possible socio-economic developments, such as a transition from a rather unsustainable "consumerism" to more sustainable consumption patterns and individual lifestyles, which are based on, amongst other things, more regionalized and community based production and consumption patterns. The virtual mobility vision sketched is such intertwined with *local and regional innovation and production capacity building*; creating economic opportunities in neighbourhood environments. This may even involve a certain level of protectionism of local or regional production. However, production sites need to be multiplied with this, and this makes production less cost-effective.

There appears to be little need to promote ICT research in this area, as the market is currently actively developing many technologies driving virtual communication and presence technologies However, two areas of interest where additional research would be valuable were identified. First of all, researching means of making advanced production technologies (such as 3D printing and higher "experience bandwidth" ICTs) accessible to the masses and not just the (relatively) rich and educated is important to avoid social and economic exclusion of the less privileged. Find ways to let these new technologies help to develop countries in the global south. Second, the effects that virtual mobility technologies may have on society need to be better understood, including the opportunities, risks and not intended side effects involved.

2.4 Mobility & Healthy Living

Source: Honda.com; http://www.inewidea.com/

The ageing population of Europe has posed considerable challenges till 2050. The model of the 'welfare state' has nearly crumbled under the weight of a population that was in past years more top-heavy than ever before. The welfare state has managed to survive though, if only in a reduced form. Population has grown mainly due to migration within the European Union and migration from the outside to European member states.

The elderly in 2050 are more vital in general and they need to take care much more on their own than before, while being able to rely on the infrastructure facilities that society offers. This has led to a situation in which the elderly not only remain more mobile but also remain more active with a diversified mobility demand in the mobility system. The active elderly autonomously commute to diverse decentralized personal health care and cure centres but also seek recreation and new experiences using the system of mobility. Higher-aged elderly are however not so active. Many of them are highly dependent of care and support. This has led to the development of a manifold of mobility devices and services for the elderly but also to modifications in public transport to facilitate the elderly such as 'seating' for their carebots and accessibility in transport hubs.

The greying of the population also had its impact on younger generations. Society at large has nourished the idea that prevention and a conscious way of living provides the key to a healthy long life. Against that background, the young have taken a more conscious approach to their mobility demands. While the elderly are usually happy to pick public or automated individual transit systems , the young and as well some active elderly find pride in choosing their own muscle power to move around. You can often see groups of teenagers 'speed walking' to school or the cinema and a wide range of hybrid vehicles that combine muscle power and electric power have been developed. This has enriched public spaces in the city that now show a plethora of colourful clean vehicles.

Whilst the elderly become older and remain healthy up to higher ages, medicine and medical treatment have not progressed as far as to keep them healthy until their lives end. To illustrate: although vision impairments largely belong to the past, older people remain slower in the processing of perceptual stimuli and reacting to them. In the fast moving and multi-modal mobility system of today's future this would form a significant threat if it weren't for all the intelligent assistive systems that have developed. Technology has slowly but surely taken over control from the human operator: what once started with technologies like electronic brake assist and assistive lane guidance systems, developed into more intrusive and autonomous technologies when the awareness grew that the human driver is in fact the weakest link. The names of these new systems still incorporate the adjective 'assistive' but surely they do not assist a human driver that is in control. Furthermore restrictions in moving and walking with higher ages were demanding for advanced accessibility options for the elderly to public transport and individual transport means.

The general demand for mobility has considerably grown in particular due to the active elderly and the 'activated' young and younger elderly. However, due to developments in smart mobility, the demand has not outgrown supply. Furthermore, the increased mobility demand by the manifold of different age groups with an increasing diversity of socio-cultural backgrounds (migration) has also

not led to more traffic victims or unsafe situations. If anything else it has enriched public spaces and coloured the streets. This situation would not have risen if it wasn't for developments in artificial intelligence, sensing technology and changes in the public perception of what is a good quality of life.

2.4.1 Discussion

A number of drivers and barriers in the movement to this future were identified in the workshop:

Drivers	Barriers
"Healthy" mobility may be necessary to help decrease rising personal health costs.	Human behavioural patterns are hard to change. People may prefer to avoid physical exercise or find it difficult to switch to unfamiliar transport means.
Demographic changes means relatively more aged people with special mobility needs at least till a certain point in time in the future.	Accessibility for the elderly, an environment is needed that suits their demands: sidewalks, user friendliness, short distance access, etc.
People increasingly want to stay mobile & active until high age (driven by an increasing quality of life at higher age).	High diversity in special needs for elderly requires very versatile and flexible means of transport and ephemeral and removable infrastructure.
Mobility expectations increase, almost to the level of a basic human right in the EU.	Providing specialized means of transport for different generations may increase segregation between generations.
Social pressure on being healthy may make it more acceptable to combine exercise with mobility and transport.	

To achieve the goal of making people become mobile in a healthy manner, getting humans to change their behavioural patterns and social practices is a major issue. The assumption behind this is that people naturally tend to be slow and lazy and need incentives to make them undertake physical activities, exercise, sports, etc. Many options are possible when attempting to achieve behavioural changes: education, offering incentives, increasing awareness of mobility and personal health. Incentive schemes may be designed to promote healthy mobility patterns (e.g. earn 'health credits' to reduce health insurance costs).

A special category of people in relation to mobility are the elderly. The demographic age shift that is unwinding makes this category a large and ever more important one. There will be a growing market for mobility services for the elderly, but an important point of attention is that there will also be people that cannot afford such services. Attention should be given, therefore, to reduce effects of income inequality, and to provide mobility access to all the elderly despite differences in income. Social innovations like people-bus projects may particularly serve mobility for the elderly.

Making mobility work for the elderly is not only about providing devices, but also about the accessibility of public transport and infrastructure. Transport services, and street environments, should be made fully accessible ('universal design'). This also has implications for urban environmental planning in a wider sense: infrastructure may be designed to stimulate healthy mobility within an appropriate cycling and walking distance (e.g. build walkways, cycle paths etc.). Safety is a factor to take into account, since in general the reaction times humans get slightly slower with age, while the pace of mobility is still increasing.

In general, making mobility healthy also implies coordinating two very different fields of policy: personal health and precaution policy and mobility and transport policy. Bringing these two policy areas together is a major policy cohesion challenge. Both policy areas are not connected today. Research that is important for this vision includes getting a better understanding of the mobility

needs of different types of elderly people in different periods of their life. It is important to better understand how personal mobility opportunities, in particular in the near neighbourhood, supports healthy ageing and social wellbeing of the elderly.

Finally, one visionary idea is to combine healthy mobility with mass transit/ collective mobility. Today many human powered vehicles are built for 1 person, but there are opportunities for healthy mobility conceivable in which multiple persons power a 'public' kind of transportation.

3 Conclusions

Looking at the discussions of the four different future visions of smart mobility and transport, some overall conclusions can be drawn. Several drivers forcing transitions into the future were identified, amongst which the unsustainability of the current mobility 'paradigm' is a centre source: increasing levels of congestion, climate and environmental problems and challenges of equality and social inclusion. Rising energy costs and resource scarcity, as well as demographic change with much more aged people with special mobility needs (at least till 2050) are seen as most relevant drivers to push transition in a far horizon perspective. A major challenge to address is, how to change human behavioural and lifestyle patterns and social practices in mobility and transport to achieve CO_2 reduction and environmental targets. Another major future challenge is how to guarantee accessibility and affordability of mobility and transport to a wide range of societal and age groups despite of rising costs and increases in special mobility needs. Technological developments, many of them enabled by ICTs, are expected to offer a wide range of solutions today and in the future.

Acceleration of modernisation and growth (increase of individual choice, productivity) is going along with rising individualism and "individual responsibility". For example in the 'mobility and healthy living' projection, the elderly are expected to be very self-active and mobile. In the virtual mobility vision, the innovative self-entrepreneur is a driver for growth and prosperity. These elites will use artificial agent technologies like telepresence and other digital communication and interaction devices, and even human enhancement technologies (trans-humanist perspective) to connect to the world. This type of vision is very much related to future threats scenarios in security foresight: global elites living in gated communities, due to security concerns not much travelling, but communicating and interacting for business and private life in the virtual sphere. If travelling is still needed, public and mass transit systems are avoided, but individualized transport systems like personal rapid transit (PRT) or personal aerial transportation (PATS) are preferred. On the other hand, there is a counter trend in this vision pointing at community building along with these technologies including the virtually non-literate (humanist approach), in community based manufacturing and communitarian neighbourhoods. With the broader implementation of advanced ICTs, questions of equality and social inclusion may come up in the debate.

The projections of 'smart and connected traveller' and 'smart mobility in urban environments' are in comparison rather viable visions. One participant in the discussion pointed at the imperative of better involving citizens, in particular young people, in drafting these visions. In a foresight process on urban mobility launched by the European Parliament, young generation involved pointed at personal mobility used as individual services rather than own car ownership. With rising costs for the car, particular social- and age groups cannot or do not want to afford a car, and can use the remaining household budget for other activities. With increasing multimodal choice a lifestyle without individual car ownership or a less frequent car use can be very attractive. A paradigm shift from monomodal and automotive to multimodal and public transport oriented mobility patterns can be witnessed since the 1990s in Europe. However, for some kind of trips, e.g. for leisure travel, individual car use may still stay the most attractive option. In many cases even car rental service and car sharing is not sufficiently attractive in comparison with owning a car: e.g. travelling out for the weekend. The focus of policy makers should be on stimulating cooperation among public and individual transport offering novel solutions to better connect public/ mass and individual/ personal mobility and transport. Communication devices and infrastructure plays a major role regarding these solutions, particularly for the actual smart-phone literate generation. Mobile devices are meanwhile more important as all-day commodities for younger generations, than personally owning a car.

Appendix A - Workshop Agenda

11:00	Welcome and introduction to EFP and to the workshop
11:05	Introduction to Forward Looking Activities Domenico Rossetti, DG Research and Innovation
11:15	Introduction to EU policy context to smart mobility Dr. András Siegler, European Commission, DG Research and Innovation, Director Transport
11:45	Smart Mobility towards 2050 – beyond intelligent transport systems –what may it look like? *Future developments and research associated with smart mobility, emerging technologies and other non-technical solutions* Claus Seibt, Austriatech
12:30	Presenting four future visions for smart mobility: - The Smart and Seamless Connected Traveller - Smart Mobility in Urban Environments - Virtual Mobility - Mobility & Healthy Living

13:00 Lunch break

14:00	Group brainstorm sessions – futures The future visions for smart mobility will be discussed in smaller groups, in moderated brainstorm sessions. The focus will be on the following topics: - Credibility, relevance, feasibility, desirability - Main drivers, barriers and challenges for this future.

15:00 – 15:15 break

15:15	Group brainstorm sessions – implications Implications of the future visions discussed in the first brainstorm session will be discussed in the groups. Topics for discussion: - What would be would be necessary to organise to develop smart mobility and transportation in the direction of the future visions sketched? - What technological innovation is absolutely necessary to make this sketch possible? What research would be required to make such an innovation a reality? - How would social structure evolve in this sketch? Would this require government intervention? - What would be needed from the industry?
16:15	Plenary session: moderators of the groups will give 5 – 10 minute feedback presentations on the results of the discussions, focusing on the implications for policy and open questions. Reflection on results from the discussion by Marcel Rommerts, European Commission, Directorate-General for Mobility and Transport Summary and closing by Claus Seibt and Annelieke van der Giessen
17:00	End of the workshop. Time for informal discussion.

Appendix B - List of participants

Alessandro Coda	*EUCAR (European Council for Automotive R&D)*
Alessandro Damiani	*EC - DG Research and Innovation*
Andras Siegler	*EC - DG Research & Innovation*
Annelieke van der Giessen	*TNO*
Bertram Ludwig	*UITP*
Claus Seibt	*Austriatech*
Domencio Rossetti	*EC - DG Research and Innovation*
Gino Franco	*MIZAR AUTOMAZIONE S.p.A.*
Hans van Vliet	*TNO*
Helen Köpman	*EC - Information Society and Media DG*
Ian Hodgson	*EC - DG Climate Action*
Irmgard Heiber	*EC - DG Information Society and Media*
Jens Schippl	*Karlsruhe Institute of Technology (KIT)*
Jill Weekley	*TRL Limited*
Marcel Rommerts	*EC - DG Mobility and Transport*
Marie-Pauline van Voorst	*Stichting Toekomstbeeld der Techniek*
Mihaela Williams	*EC - DG Research & Innovation*
Oliver Lah	*Wupperinstitute*
Paul Moraal	*Ford*
Riné Pelders	*TNO*
Sander van Oort	*TNO*
Steve Philips	*FEHRL*
Susanne Giesecke	*AIT*
Suzanne Hoadley	*Polis*
Umberto Pernice	*MRCMH*
Willy Diddens	*ECTRI*
Wolfgang Schade	*Fraunhofer Institute for Systems and Innovation Research (ISI)*