Lecture Notes in Mobility

Beate Müller · Gereon Meyer *Editors*

Towards User-Centric Transport in Europe

Challenges, Solutions and Collaborations

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Lecture Notes in Mobility

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Preface

User-centred design has been a leading paradigm in system and product design development for quite a while, now. The main idea is to optimize a product around how people use it, rather than forcing them to change behaviour and to accommodate to the product. Originating from the idea of ergonomics, user-centred design has been particularly prominent for the development of human–computer interfaces aiming at high usability. Nowadays, almost all new everyday services and objects are being created along user experience criteria, particularly those that leave design freedom due to. e.g. digitalization; this is the case for smartphones, washing machines and car cockpits.

Recently, the user experience trend has entered the domain of mobility as the transportation systems are under fundamental transformation towards multimodality and interoperability. While public transport in the past oftentimes, has been perceived as a rigid and inflexible monolithic system dictating the passenger when and where to use it, it may turn into a more user friendly option when combined with on-demand mobility offers like car, bike or ride sharing. In a more general sense, user-centred transportation holds out the promise to provide seamless and more integrated services that better adapt to individual user needs and wishes and thereby provides more and better mobility for all, including disabled or older people. In combination with smart systems technologies, user-centred design may also be applied to gently steer usage towards more sustainable and equitable mobility options.

The EU-funded Coordination and Support Action "Action Plan for the Future of Mobility in Europe" (Mobility4EU) has put the user into the focus of its activities when developing a vision of the transport system in 2030 and mapping out the path towards it. This has been achieved on the one hand by a number of systematic multi-stakeholder consultations, and on the other hand by co-creation processes unlocking creative potential and allowing the look into the future by visual tools. The book at hand summarizes the approaches and results of the Mobility4EU project and puts them into perspective of trends in socio-economic, political and technical development. Further, experts working on the main topics discussed in the project have been invited to contribute to the book thus broadening the views.

The book shall help to initiate a further research and discussion about user-centric future mobility in Europe, to be hosted not just by the Mobility4EU project but also by the European Forum on Transport and Mobility arising from it.

As editors of this contributed volume of the Lecture Notes in Mobility book series, we are deeply grateful to the dedicated scholars and practitioners who contributed to the book. Either as project partners or external experts, they are all connected to the fantastic Mobility4EU project, which we are coordinating. The readiness of the authors to mutually and critically review the chapters is greatly acknowledged as well. There are some further people that engaged in reviews and thus greatly contributed to the improvement of this book. These are Christine Zeller (SIEMENS), Cornel Klein (SIEMENS), David Storer (CRF), George Holley-Moore (International Longevity Center—UK), Armando Carrillo Zanuy (EURNEX), Sandra Wappelhorst (ICCT) and Annette Randhahn (VDI/VDE-IT). Not least, we would like to express our gratitude to the Directorate Research and Innovation of the European Commission for funding the Mobility4EU project, and thus, the work on this book, out of the Horizon 2020 framework programme.

Berlin, Germany
August 2018

Beate Müller
Gereon Meyer

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Part I
Setting the Scene—Towards a Vision for User-Centric Integrated and Sustainable Transport in 2030

Building an Action Plan for the Holistic Transformation of the European Transport System

Frauke Bierau-Delpont, Beate Müller, Linda Napoletano, Eleni Chalkia and Gereon Meyer

Abstract Global socio-economic and environmental megatrends are urging for a paradigm shift in mobility and transport. An action plan for the coherent implementation of innovative transport and mobility solutions in Europe is thus urgently needed and should be sustained by a wide range of societal stakeholders. The EU-funded Mobility4EU project developed such an action plan considering all modes of transport of passengers and freight. The action plan concentrates on user-centric issues and collaboration potential and synergies between modes. This contribution details the methodology of successful consultation with a very broad and diverse stakeholder community and summarizes major insights of the analysis and the resulting action plan towards an inclusive, seamless and sustainable transport system in Europe.

Keywords Multimodality · User-centric transport · Passenger transport
Freight transport · Societal drivers

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1 Introduction

Already today great challenges and demands are posed on mobility and transport due to emerging megatrends as urbanization, climate protection, digitalization etc. The future transport system will be strongly affected by those trends and linked to a multitude of novel developments that can only be partly anticipated today. Novel technologies and services for passenger and freight transport provide opportunities to answer these new demands. However, in order to become disruptive and change society, markets and behaviour, these solutions have to make most efficient use of all modes and they need to be tailored to the needs of users. Thus, user-centric design concepts and interfaces between modes have to be put in focus. Collaborations and exchange are needed across various sectors and perspectives to develop efficient solutions and tap the full potential of new opportunities. Most importantly, users will have to be directly involved in a bottom-up approach. Hence, it is required to bring together a very diverse stakeholder group with a variety of individual interests to discuss a rather complex topic. A process that enables such a group to develop a common language and vision and to discuss collaboration potentials has been refined and implemented by the project Mobility4EU.

Mobility4EU is a Coordination and Support Action of the European Commission that started in January 2016 and lasts for 3 years, until 31 December 2018. The project compiled a vision for a user-centered and cross-modal European transport system in 2030 and an action plan to implement that vision. This work has been carried out engaging a broad stakeholder community including actors from research, academia, industry, operators and decision makers from all transport modes and from passenger and freight transport as well as policy makers and representatives of public authorities from community to national levels. They have been brought together within a structured process that combines scientific consultation and assessment methodologies with a more creative and interactive story mapping method.

The resulting Action Plan for Transport in Europe in 2030 details measures that address technical topics but especially refer to societal aspects and issues for multi-stakeholder interaction, as e.g. policy, user acceptance, standardization, collaboration and the integration of the user perspective into the R&D&I process. It strives to provide recommendations from a strongly user-centered and cross-modal perspective as e.g. the mainstreaming of universal design and user-centric design processes, synergies and collaboration potential between modes and the combination of transport of passengers and freight.

In the following, the methodology towards the action plan is detailed and results of the analysis are summarized and referenced. Finally, the key points and insights of the action plan are summarized.

2 Engaging a Diverse Stakeholder Group to Discuss Visions and Strategies Towards a Complex Topic

As described in the introduction, a participatory approach that enables a broad stakeholder community to engage in a consultation processes has been employed to create a common vision and also the action plan to implement that vision. This has been achieved by employing structured scientific methods and tools, namely the Multi-Actor Multi-Criteria Analysis (MAMCA) and the extended Failure Modes and Effects Analysis (FMEA), as well as an accompanying story map method that supported the process in a more creative and interactive way. The focus of this chapter lies on the story map and its contribution to successfully engage diverse stakeholders, enable them to find a common language and jointly create the vision and action plan for user-centric and cross-modal transport. Later within this article, also the extended FMEA will be shortly introduced with focus on results, while details on the MAMCA are described elsewhere (Macharis 2007; Mobility4EU: D3.3 2018) as well as in another chapter of this publication (Keseru et al. 2019).

So-called story maps (Sibbet 2012) are a rather comprehensive approach of graphic visualisation in the context of strategy development. Large murals or a series of posters are created that represent e.g. the history of a problem, challenges and opportunities, individual values and expectations. Typically, it contains a context map, a commonly drawn picture of the future vision and a roadmap describing the action plan for achieving that vision. This approach supports the alignment of goals in a participatory manner, and helps to unlock creativity in forecasting the future.

Within the project Mobility4EU, a multitude of stakeholder groups covering all transport modes from supply and demand side and especially representatives of users have been engaged into the consultation process. Step by step, the action plan has been created by interactively working on the story map within dedicated workshops which can be referred to in detail in the respective reports (Mobility4EU: D5.6 2016; Mobility4EU: Deliverable D5.7 2016; Mobility4EU: D5.11 2018; Mobility4EU: D5.13 2018; Mobility4EU: D5.14 2018).

The path along the different stages of the story map towards the action plan of the project Mobility4EU, namely the context map, the opportunity map, the vision and action plan, is shown in Fig. 1 and explained in more detail in the following. First, the status and issues of the current transportation system have been assessed from multiple standpoints. Within an interactive workshop with stakeholders from all fields of transport and mobility, expectations, economic and political factors and technologies as well as uncertainties and finally overall trends have been identified that together influence the developments towards transport in 2030. Thus, during the discussions the trends shaping the future European transport system have been put into context which was visually recorded within the context map (Mobility4EU: Deliverable D2.2 2016). Then an inventory of future transport solutions has been compiled. The solutions have been collected through the input of experts and additional desk research. Many solutions were gathered within the second interactive

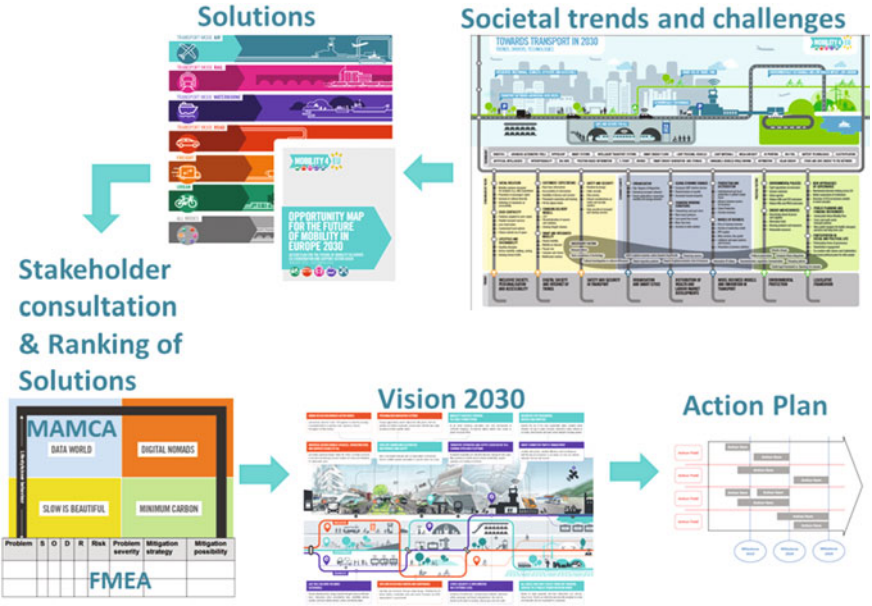

Fig. 1 Mobility4EU process towards Vision and Action Plan for transport in 2030. The story mapping methodology has been combined and complemented with structured scientific approaches, the Multi-Actor-Multi-Criteria-Analysis (MAMCA) and the Extended Failure Mode and Effects Analysis (FMEA). The parts of the story mapping are indicated from the context map (societal trends and challenges) to the opportunity map (Solutions) to the Vision and Action Plan

workshop of the project. The solutions concern all modes of transport of passenger and freight. Also walking and biking are included as active modes.

The links from the solutions to the user demands they satisfy are visualized within an opportunity map (Mobility4EU: Deliverable D2.4 2017). This opportunity map composes the second step of the story map process after the context map. The process to mediate different opinions and preferences and to prioritize between the various solutions has been supported through the more structured and scientific approach of the MAMCA. Within the MAMCA, scenarios have been built out of the solutions and preferences of various stakeholders have been gathered. For creating the vision for 2030, which again builds one part of the story map, more creative activities have been allowed to invite visionary thinking and combine possibly contradictory elements of the previous analysis. The process of action plan building was again done in various steps within interactive workshops employing visual techniques. Nevertheless, it has also been supported by a scientifically structured process for a risk analysis (extended FMEA) which is explained in more detail in a later paragraph. In a final step that action plan has been consulted and validated with a broad stakeholder community.

The approach described above greatly enabled discussions between industry and users, stakeholders of different transport modes etc. The interactive visual based methods enabled to make everybody heard and to directly record all ideas that could

then be evaluated and negotiated within the group. As can be seen in Fig. 1, the outcomes have in each case been transferred into a publishable image representing the main outcomes. Thus, participants could easily follow up the process, be reminded of previous results or integrate themselves into discussions also within a later stage of the project. The next section will focus on the results and insights that have been gained throughout the process and further provide details on the complementing scientific analysis.

3 Developing a Common Vision for Transport

The work towards the action plan was based on the identification and assessment of societal challenges, requirements and needs that will influence future transport demand and supply. The interactive part of the work described above was strongly supported and complemented by a dedicated research on trends and their impact on mobility assessing their complexity and interactions (Mobility4EU: Deliverable D2.1 2016). A summary of this work can also be found within another chapter of this publication (L'Hostis et al. 2019). This research as well as the interactive discussions concerning the context map allowed the definition of user needs setting the requirements in mobility and transport in Europe in 2030. These user needs have been further validated by the collection of stakeholder objectives which is one of the first steps within the MAMCA as well as through further desk research of existing studies. In this context, the term "user" includes end users as well as transport operators and service providers or public authorities, cities governments etc.

The analyzed user needs are rather complex, but have been formulated on a higher level with as little overlap between each other as possible without losing important aspects by reducing complexity (Mobility4EU: D2.3 2018):

- End users demand efficient and intelligently organized traffic and transport flows in all modes across borders and national networks.
- While traveling, vehicles systems and services should be easy-to-use, comfortable and offer a flexible modal choice.
- Opportunities for personalization of offers and to increase productivity and leisure time should be available.
- There is an increasing demand on being informed in real-time before and during travelling.
- Users demand individually adaptable intermodal transport with less transfers and good last mile services.
- Inter-operability and reliability as well as seamless end-to-end journeys are key, but also inclusiveness, accessibility and affordability of mobility offers.
- Data security and privacy and last not least safety in all traffic modes are of highest importance to users.
- Mobility should be low-emission and low noise.

The user needs as introduced have to be satisfied by specific user-centric implementations of solutions. Hence, in the next step, a portfolio of transport and mobility solutions that have the potential to respond to these user needs has been compiled. The focus hereby lies on solutions that are either in research or concept state or have just recently been implemented but did not yet reach wide deployment. The assessment of solutions versus user needs delivers specific insights into the requirements of the future transport system. The analysis strongly point to the potential of collaborations to enable or enhance solutions or speed up their implementation. This is especially the case for those solutions that would answer to the user needs mentioned above Main ideas are reported in the following.

Many technologies or concepts can be found across several transport modes but with specified applications within the individual modes. Hence, collaboration opportunities for stakeholders of different modes and beyond the transport sector to tap potential synergies are evident. This is the case for, e.g. game changers in materials, technologies for emission reduction, electrification and efficiency in propulsion systems, solutions and concepts for low noise (waves/vibrations) in transport vehicles and aspects of modular design. Furthermore, across all modes solutions employing IoT, smart systems, big data and automation are exploited to reach higher safety and security, enable predictive maintenance or smart traffic management and forecasting, support efficiency, comfort and personalization of transport offers as well as accessibility and inclusiveness. This calls for a broader cooperation strategy also beyond the traditional transport sector. Also, since data flows across and beyond transport sectors, data security, privacy and transparency can only be implemented in cooperation between transport industry sectors and even beyond. Sharing services as well as novel business models enabling on-demand services and multimodality are needed in all modes and especially enabling seamless interfaces between modes. Naturally, the transport of freight and urban transport of passengers calls for multimodal solutions as e.g. Mobility/Logistics-as-a-service concepts enabling modal shifts. Especially in the urban context additional novel solutions as e.g. co-creation, gamification and measures facilitating active modes will be needed to transform today's transport systems. In this context again collaboration across modes, beyond the transport sector but also to local and regional planners and policy makers is needed.

As mentioned in Sect. 2, the solutions were prioritized by a broad stakeholder community within the MAMCA. This participatory process delivered as common preferences of all stakeholders: a high level of standardisation and interoperability and a regulatory framework that supports personal and corporate carbon emission reduction as well as the full digitalization of the transport system. There also emerged conflicting concepts as on the one hand the preference for personalization and on the other hand a strict focus on shared use and active mobility. Linked with this issue is the question whether capacity should be increased to answer rising demand vs. the reduction of demand to fit existing capacity.

The vision for user-centric and cross-modal transport that was jointly developed by all stakeholders describes a future of transport of passengers and freight that is decarbonized, sustainable in economic, environmental and social terms and offers tailored mobility solutions for all. Main elements are:

- Universal Design is widespread, from smart urban planning to products and services to guarantee more control and freedom especially for people with reduced mobility.
- Transport equity is enabled through innovation for efficient and economic options and supported by policy and regulatory framework.
- Co-creation and participative planning and governance with citizens are common.
- High integration between modes and thus seamless multimodality and synchromodality are enabled by interoperable interfaces, interconnected infrastructures, vehicles and services.
- Full digitalization and automation enables optimized capacity.
- Standardization of interfaces, vehicles and infrastructure and modularization especially for freight transport enables the physical internet concept and open freight networks.
- Innovation enables diverse vehicle types and mobility service options including Mobility/Logistics-as-a-service concepts and other integrated booking and ticketing services.
- Data and cybersecurity are ensured as well as visibility in the supply chain. Incentives, urban design and updated infrastructure motivate the shift to low-carbon shipping options, public transport for passengers, shared modes and walking and cycling.
- Joint approaches of passenger and freight transport enable even better capacity use.
- All this, as well as efficient management of traffic flows, also leads to less cars and more attractive public spaces.
- Safety in transport is enhanced.
- Zero- and for some applications low-emission vehicles including adequate electricity/fuel infrastructures are deployed in all modes due to push-and-pull measures.
- Vehicles and infrastructure, electricity and alternative fuels are produced sustainably.
- Higher efficiencies of energy and resources in the transport of goods and passenger system further contribute to decarbonisation and sustainability.
- Improved modal split is incentivised and vehicle ownership is discouraged, e.g. through carbon footprint accounting, measuring and verification as well as decarbonisation regulations for logistics.
- Circular economy further supports sustainability in transport of passengers and freight.

4 Assessing Implementation Risks

One step in the action plan preparation was the identification and assessment of possible implementation risks and barriers of the solutions. For this purpose, the extended Failure Modes and Effects Analysis (FMEA) was used as described in Chalkia et al. (2018). This tool was developed in the ADVISORS project (Bekiaris and Stevens

2005). It is used for design improvement of products and processes by the identification and validation of technical and non-technical risks such as behavioural, legal and organizational risks and was adapted to the needs of the Mobility4EU project, in order to identify and assess the risks of future transport trends and innovative solutions. The process was supported by a large group of experts representing all key stakeholders from the Mobility4EU context. For each of the selected solutions technical, legal, organizational and behavioural risks were identified. The risks were then validated in terms of their severity, occurrence probability, detectability, and recoverability and classified through a risk number, which indicates the significance of the risk and the possibilities to mitigate it.

In the Mobility4EU project, a total of 171 risks for implementation of solutions was evaluated using the extended FMEA methodology. For each mode, the most severe risks were selected and mitigation strategies for these risks were developed (Mobility4EU: Deliverable D4.1 2017). Some issues were raised repeatedly in various contexts in the risk assessment. One of them is data privacy and protection which is an important issue in most innovative solutions to be implemented in passenger and freight transport in order to enhance safety and security as e.g. automated and connected driving and automated maintenance raise data privacy and security concerns. Mitigation strategies mostly consider strict legislative actions. Related to the issue of data privacy and security is legal liability. This challenge also plays a major role in most solutions related to automation and in all innovative solutions where there is still a lack of clear organization framework and the participation of different stakeholder groups is required who have not yet a clearly defined role in the process; one example for this is Mobility-as-a-Service. Also for this, clear harmonized legal and regulative framework which are transparent and determine liabilities of all stakeholders can mitigate this risk. Another horizontal issue is related to the deployment of renewable energies and alternative fuels in transport. High costs of the implementation of required infrastructure and low funding accompanied by low movement towards this goal is a concern for stakeholders from all modes. Also the lack of environmental regulations that further restrict the use of conventional fuels and hence, harmful emissions, concerns the transport system across all modes. This can be mitigated for example by a balanced allocation of free carbon allowances to entities across industries and regions and harmonized emissions standards. Other mitigation strategies are the introduction of financial actions which either incentivize investments in renewable fuels or increase the costs for conventional fuels for example the internalization of externalities. Another challenge which applies to all modes and novel mobility services is the lack of business models that need to be developed for the implementation of a solution to make it feasible. New business opportunities arise from strengthened cooperation between different transport modes for facilitating seamless transport; one example is luggage check-through between modes. In some cases, though, the cooperation of governments is needed for the framing of business cases, e.g. for the on-road charging for trucks solution.

5 The Action Plan for User-Centric and Cross-Modal Transport in Europe in 2030

In order to implement the vision as described in Sect. 3, an action plan has been developed within the Mobility4EU project that strives to provide recommendations for R&D, deployment, policy and regulatory frameworks and other implementation related issues from a user-centered and cross-modal perspective (Mobility4EU: D 4.4 2018). Thus, while some recommendations clearly support technological R&D&I initiatives, most proposed action items rather concentrate on improving the collaboration of stakeholders from different modes, sectors, or organizations, give priority to mainstreaming user-centric design processes, enhancing user acceptance and focus on policy development. Starting point for the development of measures and action items is the portfolio of solutions as well as results from the risk analysis. Furthermore, two stakeholder workshops have been held to interactively collect inputs. For compiling the action plan, action items have been clustered within 6 topics, namely:

- Low-/zero emission mobility (electrification and hybridization and other alternative fuels)
- Automation and Connected Driving
- Safety and (Cyber) Security in Transport
- Mobility Planning
- Cross-modal/cross-border transport and Integration of Novel Mobility Services in Public Transport
- Putting the User in the Centre

Within these topics, action items are provided with reference to a timeframe and to the actors addressed. They are further assigned to different action fields, depending on whether they focus on technical or societal challenges or foster the interaction and collaboration of different stakeholder groups in the transport community.

Focus is on the design of a sustainable energy-efficient transport system tailored to users' needs. In order to achieve a decarbonized transport system, actions concentrate on the promotion of stakeholder collaboration from all modes and beyond the traditional transport sector to enable technology and know-how transfer regarding electrification, hybridization and automation, e.g. in task forces across European Technology Platforms. Electrification in all modes is further promoted by common planning and synergetic use of infrastructure for powering novel vehicles across modes and sectors, in particular referring to the energy and transport sector as well as heat and sewerage. Higher energy efficiency in transport can be achieved by the integration of electrified vehicles in smart cities.

User acceptance towards automation which appears as a big trend in all modes can be considerably enhanced by the improvement of safety and data security. The latter is primarily promoted through legislative actions, e.g. new General Data Protection Regulation (GDPR), and adaptations of the legal and regulatory framework in terms of enhanced transparency and clear legal liabilities of stakeholders, harmonized throughout the EU. Safety in automated and connected cooperative driving

can be achieved by development of improved and secure vehicle software and electronics (e.g. sensors), technological progress in the field of artificial intelligence and cooperative ITS, and most notably, adequate testing of control software of automated vehicles under real conditions (e.g. in pilots). Automated transport services support people with reduced mobility and improve transport offers especially in rural areas.

Redesigning urban infrastructures on the one hand contributes to the improvement of safety in transport, on the other hand to emissions reduction and the improvement of air quality when new infrastructure prioritizes public transport and active modes such as walking and cycling instead of individual motorized traffic.

The implementation of push-and-pull-measures as well as the improvement of sharing services and well-working multimodal seamless transport contributes to a reduction of the total vehicle fleet. Seamless transport requires also improved stakeholder collaboration to facilitate the connection between modes and the integration of cross-modal mobility services. This is supported by the planning and deployment of cross-modal hubs in cities and around.

Much focus in the action plan is on policies and adaptations of the legal and regulatory framework. For example the wide introduction of standardized and interoperable interfaces, infrastructure and billing systems and the harmonization of laws and legal liabilities between member states are actions addressing policy makers to achieve cross-border seamless transport in Europe.

Mainstreaming accessibility and equity in transport is to be ensured by developing the appropriate legal framework, for example by making universal design a precondition for public R&D funding. The integration of the user perspective in the design process of the future transport system is facilitated by establishing co-creation processes and participatory forms of governance.

6 Conclusions

The Mobility4EU action plan seeks to answer new challenges and demands on mobility that arise from global socio-economic and environmental megatrends. Innovative solutions like novel technologies and services for passenger and freight transport can only become disruptive and change behavior, when they are sustainable and tailored to the needs of users from scratch. This is for example facilitated by the creation of a regulatory framework which enables the participation of citizens in the design process of the future transport system. It is further vital to involve the entire transport system including all modes in the transformation process and to improve the links between modes and also between sectors for tapping the full potential of new opportunities and achieving a collaborative decarbonization of the transport system. The emphasis on the user perspective and the comprehensive consideration of all traffic modes distinguishes the Mobility4EU action plan from the merely technology driven roadmaps, edited e.g. by the European Technology Platforms, and also makes is complementary to the policy driven Strategic Transport Research and Innovation Agenda (STRIA) issued by the European Commission (2017). It accordingly adds to

other initiatives by providing recommendations on the mainstreaming of universal design and user-centric design processes as well as pointing out opportunities for collaboration and knowledge transfer between stakeholders and the combining of transport of passengers and freight.

Equity, data and cybersecurity as well as strict regulation to foster innovation, interoperability and zero-emission mobility are called for. The proliferation of new and especially of digital services needs planning on policy level for maximum impact benefitting all Europeans. Issues of liability and ethical questions have to be addressed and frameworks for data privacy have to be enforced. Furthermore, business models and innovation systems that are able to turn opportunities into reality are needed. Moving towards sustainability drives efficiency in passenger and freight transport. Tools and business models are needed that enable the individual stakeholders to tap this potential. Risks and uncertainties lie in the implementation of renewable and alternative fuels infrastructure in all modes. Unclear situations regarding incentives/restrictions for low emission vehicles and fuels in all modes need to be countered.

Consequent inclusion of the user in the entire innovation and development process will be imperative to achieve the goals of a sustainable and integrated transport system. At the same time, user-centric approaches have the potentially to also act as a driver for the successful development and implementation of new technologies and services. For instance, universal design putting the user in the center delivers not only inclusive transport but improves mobility offers for all. To implement user-centric approaches, methodologies, tools as well as impact assessments have to be developed. This includes models for collaboration of users and the R&D&I community, the development of digital co-creation tools to enable broad collaborations etc.

As can be seen in the individual points raised above, cross-modal approaches can enhance the impact of transport solutions within a user-centred multimodal transport system. For the development and implementation of specific solutions, cross modal approaches are even a strong enabler or they open opportunities for high additional benefits. These are mainly solutions that are enabled or greatly benefit from interoperability, standardization or technology transfer across modes which applies especially to solutions in the urban or freight context or addressing horizontal issues as e.g. safety, (cyber-)security, advanced driver assistance and automation, testing, standardization, universal design etc. As regards the integration of users in the R&D&I process the collaboration across modes and multiple disciplines requires the development of methods, tools, suitable frameworks and platforms for collaboration. In general legal issues related to open innovation and co-creation as well as regarding IP have to be solved.

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Building Scenarios for the Future of Transport in Europe: The Mobility4EU Approach

Imre Keseru, Thierry Coosemans and Cathy Macharis

Abstract This paper outlines the scenario-building approach of the Mobility4EU project that aims to create a vision and action plan for mobility and transport in 2030. Scenario building is the first step of the Multi-Actor Multi-Criteria Analysis (MAMCA), the methodology used to conduct a broad stakeholder consultation. To emphasize the participative nature of the scenario building, the scenarios were created using the intuitive logics technique and participatory workshops. Each scenario describes future trends and technological, organisational or policy-related solutions. Based on a survey of stakeholders, "policy & legislative framework" and "lifestyle and user behaviour" emerged as pivotal uncertainties to steer the scenario building. They provided the basis for the development of four scenarios: Data World, Digital Nomads, Slow is Beautiful, and Minimum Carbon. The paper describes the trends and solutions that comprise these scenarios.

Keywords Scenario building · Mobility · Logistics · Participative · Multi-actor multi-criteria analysis

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1 Introduction

Looking into the future is always an exciting task. Contemplating how we will live, work and travel 10–15 years from now can help us to prepare for several possible futures or to try to achieve our own preferred future vision. The future is indeed uncertain since there are several development paths possible. The role of strategic planning is to devise actions that are appropriate for the most probable paths so that the society is prepared for possible positive or negative events and trends.

Such a foresight is also essential in the field of mobility and transport so that European, national and local policy makers can take the necessary steps to react to ongoing or upcoming trends within and beyond the transport sector with potentially great social and economic impact. The Mobility4EU project funded by the European Commission investigates these trends, potential solutions and future developments paths aiming to create a vision for mobility and transport in 2030 and an action plan to reach that vision. While there have been many similar efforts before (Bernardino et al. 2015; Leppänen et al. 2012; Krail et al. 2014), the approach applied in this project differs from previous studies in that it explicitly involves the representatives of the users of the transport system to explore future trends, solutions and development paths in an effort to balance technocentric views and user needs.

Our participatory approach has three pillars. On the one hand, based on a study of trends and transport solutions (Mobility4EU 2016; Mobility4EU 2018), future scenarios for transport and mobility in Europe including trends and solutions have been co-created with a wide range of stakeholders from and beyond the transport sector. Furthermore, a structured evaluation process, the multi-actor multi-criteria analysis (MAMCA) (Macharis et al. 2009) is used to evaluate the scenarios and find the synergies and conflicts between stakeholder groups. Finally, the story mapping technique is used to unleash stakeholders' creativity through workshops contributing to the scenario building and the creation of the vision (for details see the following chapter in this book and Muller and Meyer 2018).

This paper focuses on the first participatory element, i.e. the co-creation of scenarios. Nevertheless, this process is closely linked to the other two participatory methods: the co-created scenarios form the basis of the stakeholder-based evaluation within the MAMCA; in addition, the story mapping process contribute to exploring dominant trends and solutions that form integral parts of the scenarios.

The goal of this paper is to outline the process of the development of the scenarios for the future of mobility in Europe and present the scenarios that were co-created with the stakeholders i.e. the consortium members, associated partners and external stakeholders of the Mobility4EU project.[1]

The paper first outlines the scenario building approach, then the four scenarios are described that were co-created with the stakeholders. In the last section, the further steps of the participatory evaluation of the scenarios are briefly outlined.

[1]This paper is partly based on Deliverable D3.1 of the Mobility4EU project (Keseru et al. 2016).

2 The Scenario Building Approach in Mobility4EU

2.1 What Are Scenarios?

Scenarios represent a range of possible, probable and desirable developments in the future and paths that lead to that future. Since we can never be sure how the future finally develops, scenarios are hypothetical based on assumptions. Therefore, scenarios are not capable of providing precise predictions of future development paths i.e. they do not deliver a comprehensive description of the future but rather focus on its specific elements (Kosow and Gaßner 2008).

In the Mobility4EU project, the scenarios have a *communicative function* to enhance the cooperation of different actors in the transport and related domains; a *goal setting function* to define what the European Union intends to achieve in the transport sector until 2030 and contribute to *decision-making* since a 'best' scenario is selected and transformed into a vision and action plan after evaluating several alternative scenarios with the MAMCA methodology (Bröchler et al. 1999; Greeuw 2000). In addition, scenario building helps to explore and understand the relationship between political, environmental, economic, social and technological factors which is often very complex (Wright et al. 2013).

2.2 Participative Scenario Building Approach

A multitude of methods have emerged in the past to create scenarios (Wright et al. 2013). One of the most used techniques is the intuitive logics method. Intuitive logics is based on the estimates (intuition) of experts as a reference point (Wack 1985). The process focuses on decision-making. It is called intuitive because besides relying on objective data, intuitive estimates of future trends by experts are also considered. This technique has the advantage that it considers unpredictability and covers the so-called scenario transfer, i.e. the final stage of the scenario process when the scenarios are used for strategy making (Kosow and Gaßner 2008). The intuitive logics method has been found to enhance the understanding of the relationships between major factors that define the future and it can challenge conventional thinking (Wright et al. 2013).

This technique is often criticised for being expert-led allowing little involvement of stakeholders (Wright et al. 2013). To overcome this deficiency and involve a wide range of stakeholders in the process we combined the intuitive logics method with participatory workshops. This technique allows for the involvement of stakeholders, although the process is quite time-consuming (Kosow and Gaßner 2008).

The key steps of our combined approach are (Kosow and Gaßner 2008):

1. Scenario field identification: What is the purpose of the scenarios? What is the issue to be addressed?
2. Identification of key factors or driving forces

3. Clustering of key factors
4. Analysis of key factors for unpredictability and impact
5. Scenario generation: studying the scenario logic, i.e. to create a manageable number of scenarios focusing on 'pivotal uncertainties'
6. Drafting the scenario narrative
7. Scenario workshop to co-create scenarios and provide a better understanding of the scenarios as well as increase the legitimacy of scenarios
8. Scenario writing and optimisation
9. Participatory evaluation of the scenarios with the multi-actor multi-criteria analysis
10. Scenario transfer selecting concrete strategies.

2.3 Scenario Building for the Future Vision and Action Plan for Europe

Based on the above stepwise approach, first, we defined the scenario field. The scenarios should address transport and mobility in 2030 in Europe with focus on societal trends and user needs. Then, we identified key factors and driving forces i.e. trends that will influence transport and mobility by 2030. 34 trends were identified i.e. societal challenges, requirements and needs that will influence the future transport demand and supply. This work was based on desk research and an interactive workshop with stakeholders (Berlin, 03/05/2016) (Mobility4EU 2016). The trends were clustered into 9 broader categories: distribution of wealth and labour market developments; lifestyle and user behaviour; urbanisation and smart cities; environmental protection: climate change, pollution resource and energy efficiency; digital society and internet of things; novel business models and innovation in transport; safety in transport; security in transport; legislative framework [see also following chapter in this book and Mobility4EU 2016]. Then, in October 2016, a survey was carried out among stakeholders to identify which of these trends may have the highest degree of uncertainty and impact. The survey was filled in by 33 respondents representing a wide range of stakeholder organisations. Each trend was assigned a score between 1 and 4 for both uncertainty and impact. The aggregated results are shown in Fig. 1. The dots represent the 34 trends which are plotted on a graph in which the horizontal axis represents the impact of the trend while the vertical axis shows uncertainty.

Based on their score of uncertainty and impact, the trends can be classified according to the categories in Table 1 (Kosow and Gaßner 2008).

We selected trends that have the *highest uncertainty and the highest impact* (trends that received a minimum score of 2.4 for both attributes). These trends are situated in the upper right-hand side quadrant of the graph in Fig. 1 and they are called *pivotal uncertainties*. Table 2 lists the pivotal uncertainties that we identified and their broader thematic categories.

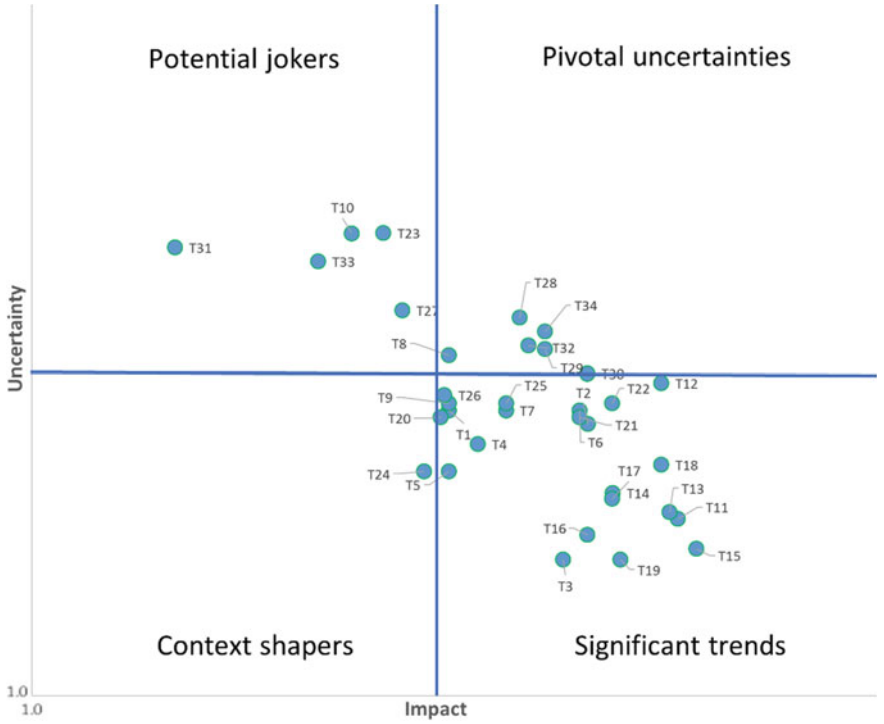

Fig. 1 Distribution of trends according to their degree of uncertainty and impact based on a survey of 33 stakeholders

Table 1 Categories of trends based on their degree of uncertainty and impact (Kosow and Gaßner 2008)

Uncertainty	Impact	Category of key factors
High	High	*Pivotal uncertainties*
High	Low	*Potential jokers*
Low	High	*Significant trends*
Low	Low	*Context shapers*

If we look at the larger thematic categories of the identified pivotal uncertainties, *policy & legislative framework* and *lifestyle & user behaviour* emerge as the key driving forces that have the highest uncertainty and greatest impact in terms of mobility demand in 2030 in Europe. These *pivotal uncertainties* define the differences between scenarios and hence provide the basis for the development of alternative scenarios. Figure 2 shows how the four possible combinations of the two extremes of the *pivotal uncertainties* define the four scenarios.

Besides major trends that influence mobility, the Mobility4EU scenarios comprise a selection of the technological, organisational and policy-related solutions that respond to these trends. 87 technological, organisational or policy-related

Table 2 List of trends with the highest score of uncertainty and impact

Trend code	Trend description	Trend category
T8	Acceleration of social life and more flexibility in spending one's time	Lifestyle and user behaviour
T28	Legislation adapts to new transport solutions and businesses	Policy and legislative framework
T29	Harmonisation of regulations at the European level to improve interoperability	Policy and legislative framework
T30	Rate of user acceptance of new technology	Lifestyle and user behaviour
T32	Increasing concern about financing transport investments	Policy and legislative framework
T34	New technologies and business models challenging legal frameworks	Policy and legislative framework

solutions were defined through a workshop with stakeholders and desk research (for details see Mobility4EU 2018).

Preliminary scenarios combining trends and solutions were created by the consortium. They were not prescriptive; rather they provided a starting ground for discussion. They were further refined at a scenario building workshop (Brussels, 05/07/2016) where the scenarios were co-created in a participative manner. The event brought together experts for passenger and freight transport across all modes. First, they validated the trends included in each scenario. Then they selected and

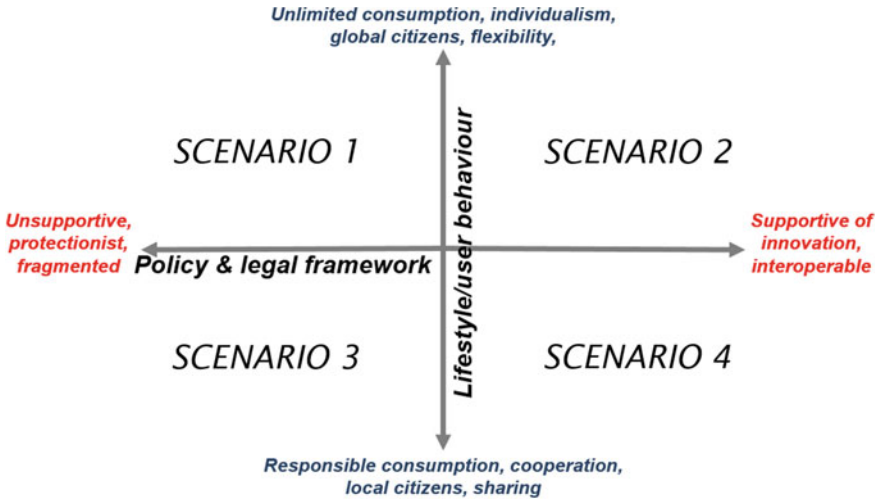

Fig. 2 Four scenarios combining the possible outcomes of the pivotal uncertainties

matched technological, organisational or policy-related solutions to the scenarios and their trends using cards depicting each solution and scenario boards representing the four preliminary scenarios (see Keseru et al. 2016 for more details). After the workshop, the input received from the stakeholders to make the scenarios more realistic and consistent was analysed and considered when drafting the next version of the scenarios.

3 Scenarios for the Future of Mobility in Europe

Based on the above methodology we identified four scenarios (Fig. 3):

1. Data world
2. Digital nomads
3. Slow is beautiful
4. Minimum carbon.

Each of the scenarios is described below with its underlying trends. Each scenario is divided into two parts: trends and solutions for freight transport and passenger mobility.

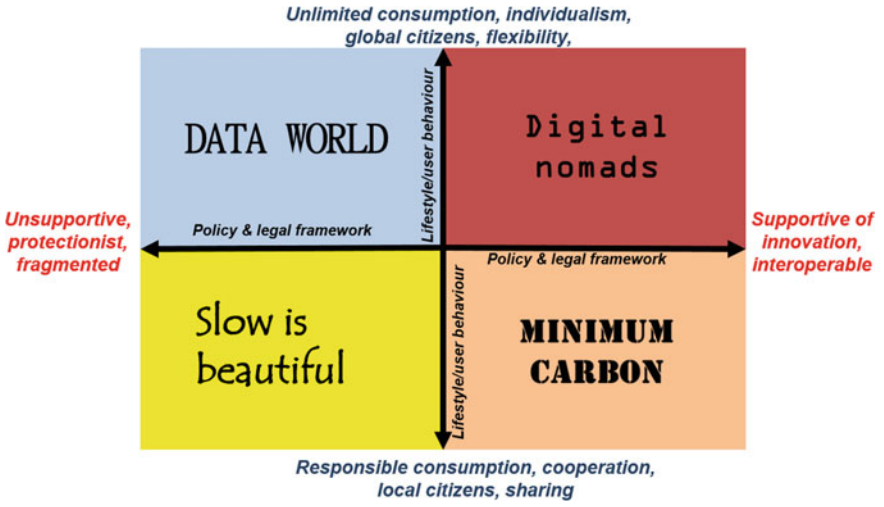

Fig. 3 The four Mobility4EU scenarios

3.1 Scenario 1: DATAWORLD

Industry and consumption increasingly rely on production outside Europe and hence demand for intercontinental freight flows is increasing. Increased trade flows from the E7 countries[2] are expected to change the scene in global supply chains and logistics. As a reaction to market demand, port operators extend seaport capacities by installing floating delivery hubs and automated container terminals, port operations and transshipments.

A growth in E-commerce stimulates intra-European freight flows as well. Supply chains become more complex, requiring tailored solutions that are industry- or even customer-specific. There is, however, little collaboration between delivery companies and shippers (e.g. retailers) to promote bundling flows and optimize deliveries.

As a response to increased demand from customers for instant deliveries and to save cost, delivery companies start to introduce personalised delivery systems using airborne drones and small autonomous freight trucks for first- and last-mile deliveries. Organised platooning of freight vehicles (road trains) will become widespread thanks to the deployment of cooperative ITS. This will increase capacity for long distance freight transport while also contributing to better safety and better fuel economy. Increased use of information and communication technologies and especially big data exploitation facilitate supply chain optimisation (i.e. cost/time reduction, load factor improvement etc.). Cybercrime becomes a great concern.

In passenger mobility, demand for information and online services to book and pay for mobility services is high. Internet connectivity and direct data collection from users is key for the management of the transport system. Technology companies provide continuous and reliable internet connection at stations and on vehicles. Their business model is to collect users' data extensively in return for free internet, travel information and entertainment.

National and local governments exercise little control over the provision of mobility services. A few large, private, multinational mobility providers emerge and compete. They own, manage and process the immense amount of mobility data collected from smart sensors in the infrastructure and vehicles and by engaging transport users through gamification using data from their connected devices. They provide real-time traffic optimisation and safety information to transport authorities. Due to the lack of expertise, governments mostly rely on these big data integrators for the management of their intelligent transport systems, road and rail infrastructure.

Travel demand continues to increase as people become increasingly mobile and flexible. The strategy of multinational mobility providers is to focus on individual needs, reduced travel time (faster travel) and specific consumer groups (e.g. young adults, families with children, medium-high income households), mainly in urban areas where demand is high. Therefore, they push governments to increase the capacity and improve maintenance of the transport network especially for roads and high-capacity public transport. Many major infrastructure investments (motorways, major roads and bridges in urban areas, high-speed railways) are implemented by private

[2]China, India, Brazil, Mexico, Russia, Indonesia and Turkey.