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Horizon 2020 - Coordination and Support Action

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MAMCA	Multi-actor multi-criteria analysis

Executive Summary

Mobility4EU is a Coordination and Support Action of the European Commission started in January 2016 and lasting for 3 years, until 31 December 2018.

The project will deliver a vision for the European transport system in 2030 and an action plan including a roadmap to implement that vision. The work towards that vision and action plan is based on the identification and assessment of societal challenges that will influence future transport demand and supply and the compilation of a portfolio of promising cross-modal technical and organisational transport solutions. The entire process from studying trends and options for solutions, developing a vision and finally the action plan are organized within a structured participatory approach that focuses on user-centeredness and that aims to engage a broad stakeholder community into the consultation processes. A further goal is to build a European Transport Forum that continues the work beyond the project duration and works on complementing the action plan.

The aim of this deliverable is to outline the process of the development of the scenarios for the future of mobility in Europe and present the narrative scenarios that were co-created with the consortium members, associated partners and external stakeholders of the Mobility4EU project.

Scenario building is the first step of the multi-actor multi-criteria analysis (MAMCA), the methodology used to conduct a broad stakeholder consultation to develop a vision and action plan for mobility in Europe in 2030. Scenarios represent a range of possible developments in the future. In the Mobility4EU project the scenarios have *communicative, goal-setting and decision-support* functions. We applied the intuitive logics method combined with scenario co-creation workshops.

Each narrative scenario is a description of future trends and technological, organisational or policy-related solutions. Based on a survey of 33 stakeholders, we selected *policy & legislative framework* and *lifestyle & user behaviour* as pivotal uncertainties (i.e. trends that have the *highest uncertainty and the highest impact)* to steer the scenario building.

Four preliminary scenarios were defined and discussed with the stakeholders at the scenario building workshop (Brussels, 22 October 2016). Based on the stakeholders' feedback we developed the following four scenarios:

1. ***DATA WORLD***
   Harmonisation of regulations and technology standards at the European level is limited. The activities of companies in the transport and mobility sector are less strictly regulated. Government support for innovation is limited, innovation mainly comes from private companies, which collect, own and manage transport data. People are becoming increasingly flexible with an accelerated pace of life. Individualisation leads to smaller household size and flexible employment.

   This scenario mainly includes solutions that increase efficiency and profitability of private actors in transport and enable large private corporations to provide integrated mobility services.

2. *Digital nomads*
   There is a high level of standardisation of regulations and technology standards at the European level. The activities of companies in the transport and mobility sector are more strictly regulated. The boundaries between private life and work disappear as people become always online and available.

   The solutions in this scenario enforce cooperation between private and public actors to reduce carbon emissions and increase efficiency. Full digitalisation and automatization of the transport system is supported by government regulation and funding. Integrated mobility services are strictly regulated to provide a balanced set of transport options to users.

3. *Slow is beautiful*
   European policy focuses on enabling local initiatives rather than supranational standardisation. Innovation is less supported due to scarce financial resources. People more and more turn to eco-friendly local cooperative production of food and energy, urban gardens and peer-to-peer services. Bottom-up initiatives of local communities thrive with few legal limitations on local sharing and production initiatives.

   The solutions in this scenario aim to restrict local road traffic and enable local initiatives to share mobility resources. The approach to digitalisation and automatization is more cautious.

4. *Minimum carbon*
   Due to the severe pressure of climate change governments want to fundamentally change the behaviour of their citizens and companies to steer them to reduce carbon emissions and move them away from fossil fuels. Burn-out from fast-paced work have turned people towards healthier and active life.

   The solutions support strict regulation of carbon emissions both for freight and passenger transport. The focus is on reducing travel demand and provide accessibility to work and services within local self-sustaining neighbourhoods.

1 Introduction to the Mobility4EU project and first results

Mobility4EU is a Coordination and Support Action of the European Commission started in January 2016 and lasting for 3 years, until 31 December 2018. The project is working on delivering a vision for the European transport system in 2030 and an action plan including a roadmap to implement that vision. Recommendations for tangible measures in research, innovation and implementation targeted towards various stakeholder groups are being derived. The work towards that vision and action plan will be based on the identification and assessment of societal challenges that will influence future transport demand and supply, and the compilation of a portfolio of promising cross-modal technical and organizational transport solutions. The entire process from studying trends and options for solutions, developing a vision and finally the action plan is organized within a structured participatory approach that aims to engage a broad stakeholder community into the consultation processes. This is achieved by employing a structured tool, the Multi-Actor Multi-Criteria Analysis (MAMCA), and an accompanying story mapping process that supports the process in a more creative and interactive way (Figure 1).

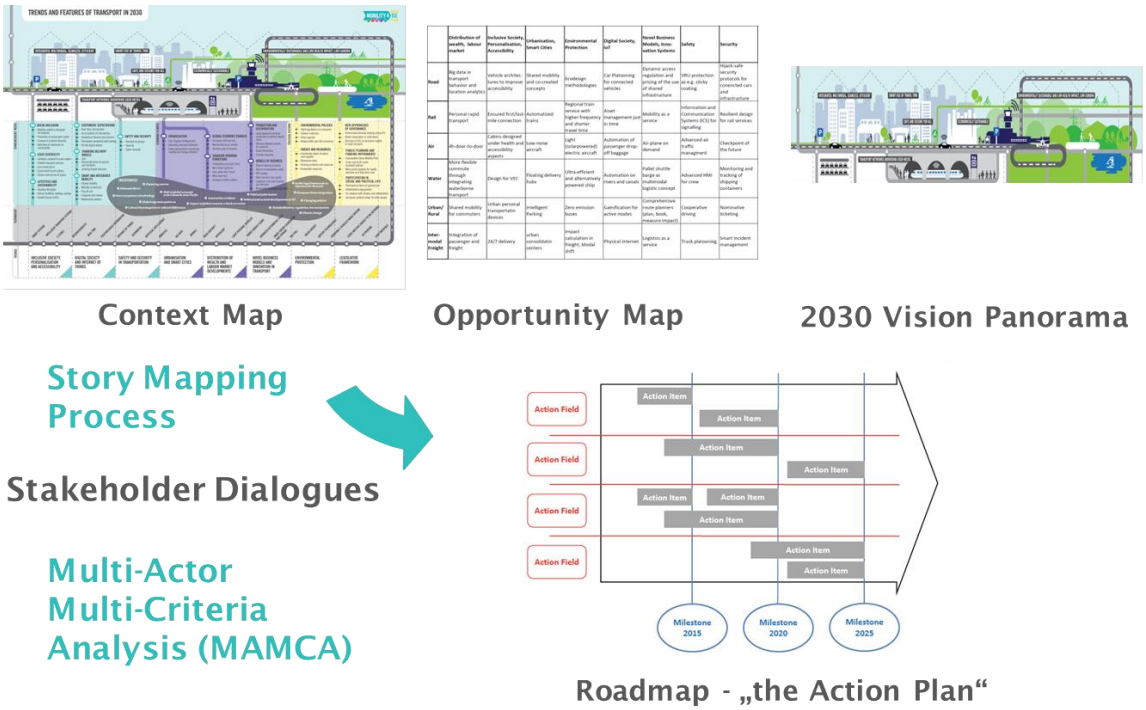

Figure 1 Complementary stakeholder dialogues in Mobility4EU that lead to the action plan.

Within the first phase of the project, societal challenges, requirements and needs that will influence the future transport demand and supply have been researched and assessed and discussed within an interactive workshop. The results have been formulated within 9 trends that impact transport and mobility demand (Mobility4EU, 2016a). These trends represent long-term issues that are projected to have relevance for at least 20 years, shaping the future European transport system in 2030. They were used as a starting point to represent the Mobility4EU context map, a map

created based on the results of the first M4EU workshop on "Societal requirements and challenges for transport" (Mobility4EU, 2016b).

From the study of trends and drivers for the future of mobility, user needs that call for solutions can be derived. Hence, the next step was to compile a portfolio of promising novel and innovative transport and mobility solutions responding to the mobility demands and trends as well as challenges and barriers in the current European transport system (Mobility4EU, 2016c). The links from the solutions to the user demands are made within an opportunity map that will be published on the Mobility4EU website.

A context map and the opportunity map build the first part of the story mapping process that will be completed through the generation of a vision for the transport system and eventually an action plan. This interactive and creative story mapping process is being complemented through the structured approach of the multi-actor multi-criteria analysis that has been started in the second phase of the project. Further explanations as well as details on the first phase will be provided in the following chapters.

2 Introduction to the MAMCA methodology

In order to obtain a widely supported and consensus-based action plan, the Multi-Actor Multi-Criteria Analysis (MAMCA) methodology (Macharis et al., 2009) is used to consult a broad stakeholder community representing the main mobility actors in Europe. This stepwise and scientifically sound approach allows the consortium of the project to involve a large group of stakeholders in the process of evaluating and prioritising future user needs and new transport concepts.

MAMCA has seven steps, which are facilitated in the following manner in the Mobility4EU project (Figure 2):

Step 1 Scenario building
The process started with the consolidation of dominant trends and potential future solutions into 4 scenarios that depict the future of the European transport system. These narrative scenarios were built using the intuitive logics method (see section 3.2) and further refined and validated at a stakeholder co-creation workshop that is described in section 3.2.2 in more detail.

Step 2 Identification of stakeholders and their objectives
In the stakeholder analysis, all stakeholder groups that are relevant for the evaluation were mapped and their objectives were identified through an online survey (e.g. reduction of air pollution, reduction of noise, reduction of the number of accidents etc.). The objectives were translated into simple criteria (e.g. reduction of traffic accidents = traffic safety).

Step 3 Criteria and weights
Each stakeholder group attaches weights to their criteria to express the importance of them. This has been done and is still continued through an online survey. It has also been exemplified together with stakeholders in a workshop (MAMCA Weighting Workshop, Brussels, 22 November 2016).

Step 4 Indicators
Then, indicators and measurement methods for each criterion will be identified with international experts. Indicators are used to measure the performance of a scenario

i.e. how a certain future scenario would impact a criterion (e.g. air quality) compared to the business as usual (current trends continue).

Step 5 Evaluation by experts

The scenarios will be evaluated by international experts based on qualitative assessment (e.g. slight improvement, significant improvement, etc.). Therefore the impact of each scenario on each criteria will be assessed to see e.g. how the scenarios affect traffic safety, greenhouse gas emissions etc.

Step 6-7 Scenario ranking and consensus building

The results of the evaluation will be produced by the MAMCA software in the form of the ranking of scenarios for each stakeholder group (step 6). The results of the MAMCA will be discussed with the stakeholders at a dedicated workshop where the outcome of the evaluation process will be presented to and discussed with them (step 7). Since MAMCA does not produce an ultimate ranking of the scenarios this workshop will serve as a consensus-building platform where all stakeholders will come to a consensus on the scenario that best represents their objectives for the future of transport in the EU. This together with the results of the story mapping process will provide the basis for the development of the action plan (Macharis et al., 2012).

The above methodology will be facilitated through an online decision making platform, i.e. the innovative MAMCA software providing an interactive method to weight stakeholder objectives, evaluate options and provide easy-to-understand visualisations of the evaluation outcomes.

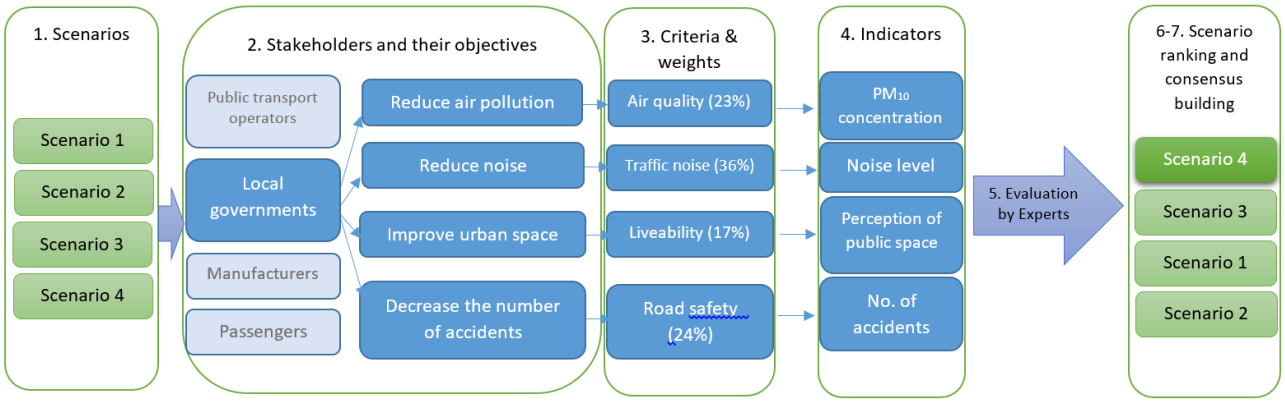

Figure 2 An example of the MAMCA process

With the conclusion of the scenario building process the first step of the MAMCA evaluation has been completed. The four scenarios will be carried forward and evaluated based on the criteria of the stakeholders in the next steps of MAMCA (Table 1). See Section 2 for more details.

Online questionnaire to identify significant but uncertain trends	October 2016
Scenario building workshop, Brussels (WS3)	21 October 2016
Online questionnaire to identify stakeholders' objectives	October-November, 2016
Weighting workshop, Brussels	22 November, 2016
Online questionnaire to weight stakeholders' objectives	November 2016 – January 2017
Evaluation of scenarios with international experts	April 2017
Consensus building workshop	September/October 2017

Table 1 The schedule of the MAMCA evaluation in Mobility4EU

3 Building scenarios for the future of transport in Europe

3.1 What are scenarios?

Scenarios represent a range of possible developments in the future. An important assumption of the scenario method is that several different futures are possible. Scenarios are hypothetical, they are based on assumptions about the future and they include possible, probable and desirable future changes. Nevertheless, scenarios are not capable of providing precise predictions of future development paths. They do not deliver a comprehensive description of the future but 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 will be selected and transformed into a vision and action plan after evaluating several alternative scenarios with the MAMCA methodology (Bröchler et al., 1999; Greeuw, 2000).

3.2 The scenario building approach in Mobility4EU

In the Mobility4EU project, we apply the *intuitive logics method,* which is a form of *creative-narrative scenario techniques.* Narrative scenarios are short texts describing future developments drafted by a small team of authors. There is a strong focus on the communicative value of the scenarios and the participatory approach.

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 taken into account. 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). This technique is often criticised for being non-participative since scenarios are worked out in small groups. Therefore, in the Mobility4EU project, preliminary scenarios were built by the consortium. These were further refined within a scenario building workshop[1] where the scenarios have been co-created in a participative manner based on the preliminary versions. Further details on this process can be found in the following chapters.

The scenario building process outlined in this section ensures that the scenarios were constructed in a participative manner, which is a core feature of the Mobility4EU project. While being integral part of the MAMCA method, this scenario technique with creative contributions from the stakeholders through the workshops complements the story mapping process well.

3.2.1 Construction of preliminary scenarios

Each scenario that was developed in Mobility4EU is based on different assumptions representing diverse possible future development paths of a number of key factors or driving forces resulting from the investigation of trends and solutions as detailed in section 1. Hence, the scenarios represent a selection of the major trends that influence mobility and a subset of the technological, organisational and policy-related solutions that respond to these trends.

In October 2016, a survey was carried out among the consortium members and external stakeholders of Mobility4EU to identify which trends may have the highest degree of uncertainty and impact. The survey was filled in by 33 respondents representing a wide variety of organisations. The aggregated results are shown in Figure 3. The blue dots represent the trends which are plotted on a graph in which the horizontal axis represents the impact of the trend while the vertical axis shows uncertainty.

[1] The workshops on *societal requirements and current challenges in transport* (Berlin, 03/05/2016), and on *novel and innovative mobility concepts and solutions* (Brussels, 05/07/2016) are considered to be part of the scenario building process since the dominant societal trends and the technological and organisational solutions that are part of the scenarios were developed there.

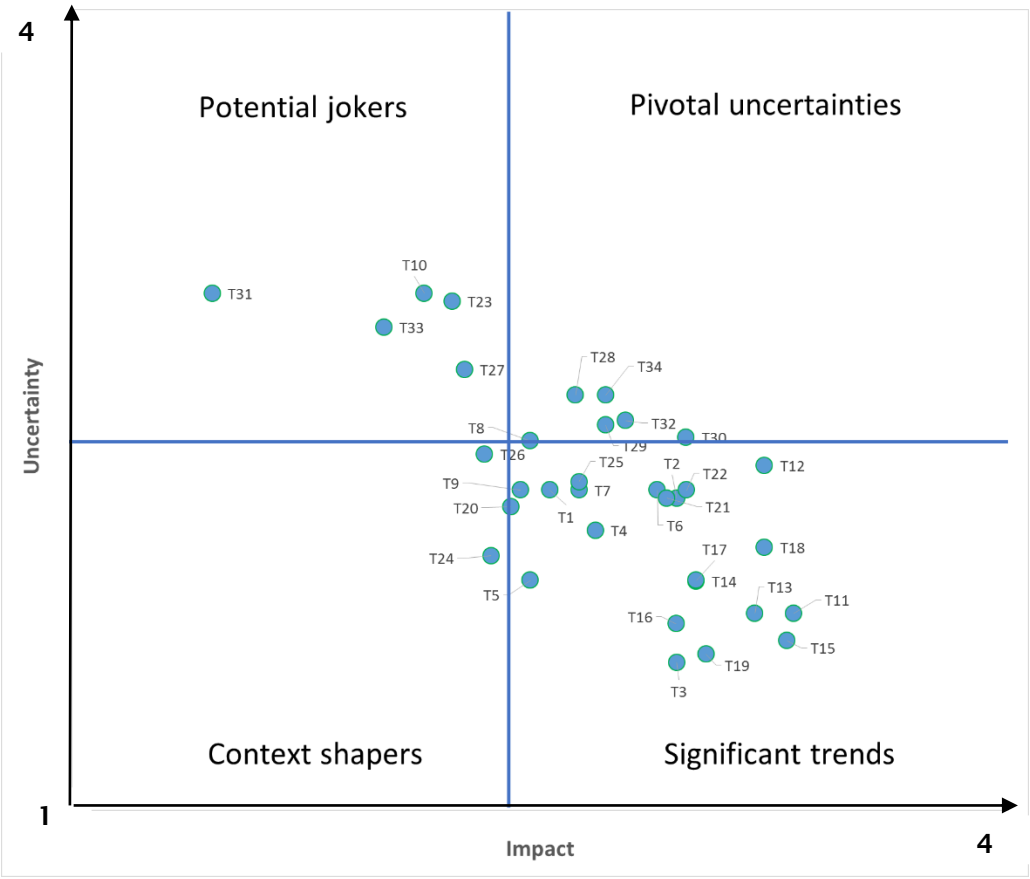

Figure 3 Distribution of trends according to their degree of uncertainty and impact based on a survey of 33 stakeholders

Based on their score of uncertainty and impact, the trends can be classified according to the categories in

Uncertainty	Impact	Category of key factors
High	High	pivotal uncertainties
High	Low	potential jokers
Low	High	significant trends
Low	Low	context shapers

Table 2 Categories of trends based on their degree of uncertainty and impact (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 Figure 3 and they are called *pivotal uncertainties*. Table 3 lists the pivotal uncertainties that we identified and their broader thematic categories.

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

Table 3 List of trends with the highest score of uncertainty and impact

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 highest impact in terms of mobility demand in 2030 in Europe.

Pivotal uncertainties define the differences between scenarios and hence provide the basis for the development of alternative scenarios. Table 4 shows the two key factors (1 & 2) and their two extremes (a/b) that were used to define the four scenarios that reflect four possible combinations of these key factors as depicted on the axis of the two key factors in Figure 4.

1/a. Harmonisation of regulations and technology standards at the European level is limited. The activities of companies in the transport and mobility sector are less strictly regulated. Government support for innovation is limited, innovation mainly comes from private companies.
1/b. There is a high level of standardisation of regulations and technology standards at the European level. The activities of companies in the transport and mobility sector are more strictly regulated. Government support for innovation is strong, innovation is driven by the policy goals of the government rather than private initiatives.
2/a. Traditional and local values are regaining importance and define people's lifestyles. Burn-out from fast-paced work and social life turns people towards family values, national and local identity and cooperation within their local communities. Acceptance and adoption of new technology is slower.
2/b. There is a fast-paced transformation of lifestyles. People are becoming increasingly flexible with an accelerated pace of life. Individualisation leads to smaller household size and flexible employment. Adoption of new technology is fast.

Table 4
Possible combination of key factors that define the Mobility4EU scenarios

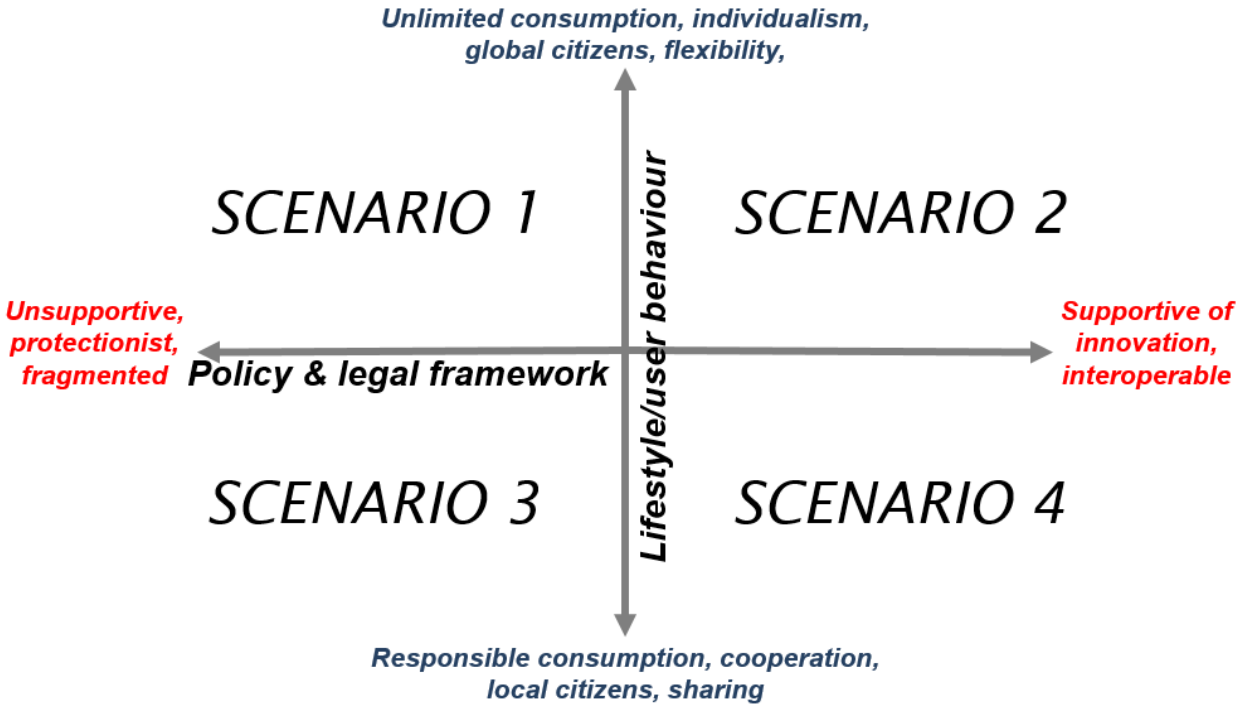

Figure 4 Four scenarios combining the possible outcomes of the pivotal uncertainties

The other driving forces besides pivotal uncertainties are used to describe the scenarios: *significant trends* are used in each scenario but with different consequences; *context shapers* are integrated into each scenario; and the *potential jokers* are used to provide some variation. In the next steps, the trends are combined into four preliminary scenarios. These preliminary scenarios are not prescriptive; rather they provide a starting ground for discussion.

3.2.2 Scenario building workshop

The objective of the first MAMCA workshop was to co-create four scenarios describing the alternatives for the European transport system until 2030 by drawing upon the expertise of various stakeholders. The event brought together experts for passenger and freight transport across all modes. They discussed the preliminary scenarios that depict different futures.

The workshop included two interactive sessions:
The first interactive session aimed at validating the trends included in a certain scenario. Therefore, the participants worked in small groups to evaluate each scenario in terms of its credibility and probability (Figure 5).

The second interactive session aimed at matching technological and organisational solutions to the scenarios and their trends. The solutions were printed on cards. The participants continued working in small groups and they selected the most effective solutions from their point of view for each scenario matching them to broader categories of trends (policy, environment, society, technology or economy) (Figures 5 & 6).

Further details about the methodology and the outcomes of the workshop are available in the report on the workshop (Mobility4EU, 2016d).

Figure 5 Comments of the stakeholders on the trends and their impact on mobility for scenario 1

Figure 6 Matching solutions to trends at the workshop

After the workshop, the input received from the stakeholders to make the scenarios more realistic and consistent was analysed and taken into account when drafting the next version of the scenarios. The titles of two scenarios were changed to avoid negative connotations. The scenario descriptions were extended with a list of solutions for each scenario based on the proposals of the stakeholders.

The scenarios that were drawn up are all plausible depicting four different pathways to future. Therefore, a vision and action plan developed as a follow-up of the scenario building and evaluation should address all potential trends from these scenarios to remain 'future-proof'. Consequently, the solutions that are included in the vision and action plan should be able to respond to this broad set of trends.

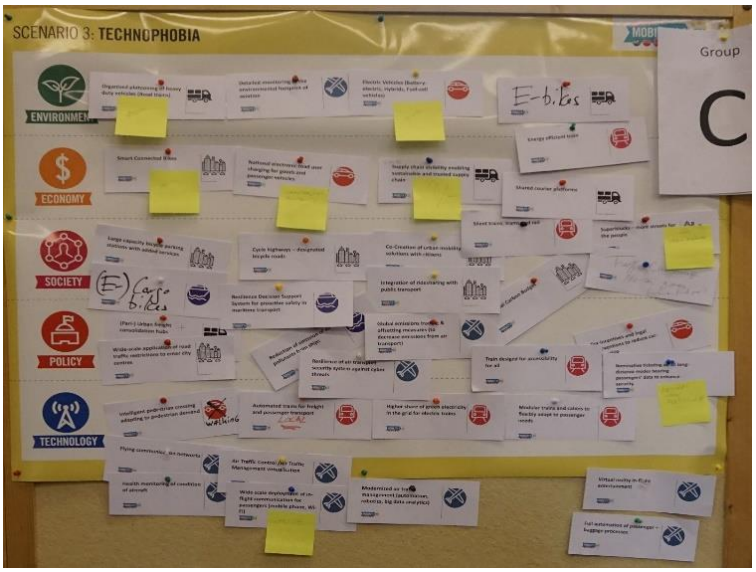

Figure 7 Solutions proposed for scenario 3

Solutions that are part of three or all four scenarios – based on the suggestions of the stakeholders – are considered as 'generic solutions' that can address all trends. Therefore, these 33 solutions will automatically be considered for the vision and action plan without evaluating them in the MAMCA further. Furthermore, the rest of the 66 solutions were matched to each of the scenarios based on the recommendations of the workshop participants. These solutions will undergo further evaluation by the MAMCA to find the scenario that would be the preferred future development path for most of the stakeholders. Once this scenario is identified, the specific solutions linked to it can be transferred to the vision and action plan. This way, the action plan will be equipped to respond to any of the future pathways; and by including solutions form the most preferred scenario, it will also endorse the most preferred future pathway of the stakeholders.

While writing the scenario texts they were checked against the following criteria:

- Plausibility: the scenarios depict possible developments.
- Consistency: paths to the future within a scenario do not contradict each other.
- Comprehensibility and traceability.
- Distinctness: alternative scenarios differ from each other.
- Transparency: Assumptions and decision processes should be open.
- Degree of integration: Are the causal relationships between social, economic, ecological and institutional development taken into account?
- Quality of reception: the scenario should be readable (Kosow and Gaßner, 2008).

3.3 Scenarios for the future of mobility in Europe

Based on the above methodology we identified four scenarios (Figure 8):

1. DATA WORLD
2. Digital nomads
3. Slow is beautiful
4. Minimum carbon

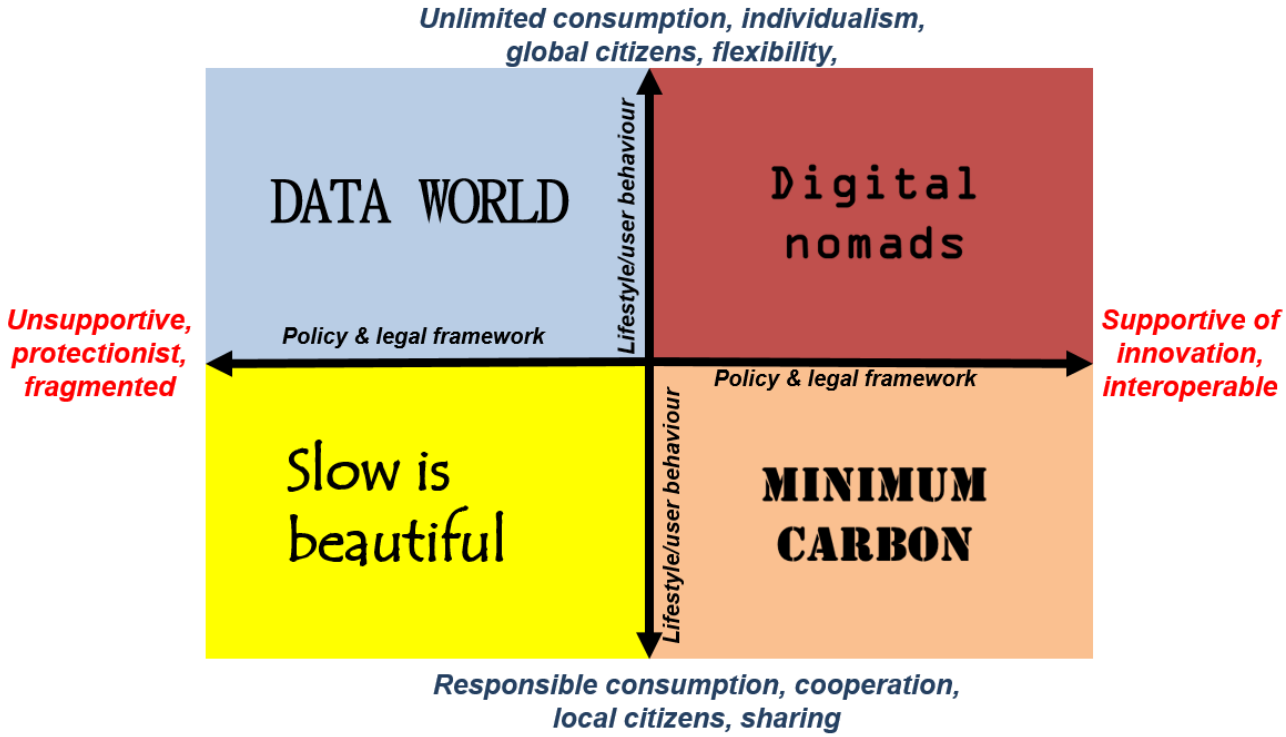

Figure 8 The four Mobility4EU scenarios

Each of the scenarios is described below with its underlying trends. Trends are indicated by a grey background. The packages of technological and organisational solutions to be evaluated follow the specific trends to which they respond. Each scenario is divided into two parts: trends and solutions for freight transport and passenger mobility. Each part begins with a summary of the solutions for that particular topic.

3.4 Scenario 1 DATA WORLD

Underlying trends

Legal and policy framework:
Harmonisation of regulations and technology standards at the European level is limited. The activities of companies in the transport and mobility sector are less strictly regulated. Government support for innovation is limited, innovation mainly comes from private companies.
User behaviour and lifestyle
There is a fast-paced transformation of lifestyles. People are becoming increasingly flexible with an accelerated pace of life. Individualisation leads to smaller household size and flexible employment. Adoption of innovative technology is fast.

Freight transport
Main solutions

- Automation of freight terminal facilities to increase capacity and efficiency
- Floating delivery hubs
- Personalised delivery systems to cater for individual needs (from drones, small autonomous trucks, to unmanned scramjet for high value express goods deliveries)
- Organised platooning of freight vehicles

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 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 automate container terminals, port operations and trans-shipments.

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 optimise deliveries.

As a response to increased demand from costumers 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/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. Automation and technology exploitation are expected to have profound impact on employment conditions in the logistics sector.

Passenger mobility
Main solutions

- Government regulation for transport organisation is less strict
- Data collection from smart sensors and users' devices for real-time traffic management
- A few large companies provide traffic management and integrated mobility services catering for individual needs
- Large, multinational mobility providers
- Mobility companies' interest is to serve personal needs of their target groups
- Mobility as a service is organised by private companies
- Flexible timetables and modular trains in public transport
- Internet connectivity everywhere provided by commercial companies
- Virtual reality entertainment and internet connection in airplanes
- Car/bike/ride sharing services directly provided by private mobility companies in cooperation with vehicle manufacturers
- Personalisation of mobility: intelligent chatbots provide travel and marketing information, personal rapid transit systems, personalised and individualised transportation to/from and within airports, small on-demand aviation, differentiation between flight cabin classes and zones
- Smart electric shared bicycles carrying advertisements
- Diverse proprietary solutions are developed by technology companies for connected and autonomous vehicles, charging stations, data platforms and safety solutions
- Autonomous transport systems have a low level of compatibility
- Government regulations on vehicle emissions and infrastructure operations are less severe; voluntary sustainability initiatives
- Fragmentation of security rules, regulations and procedures

Transport users want to enjoy the benefits of the digital and technological revolution. Demand for information and online services to book and pay for mobility services is high, especially from the younger generations. Internet connectivity and direct data collection from users (e.g. through smartphones and internet of things devices) is key for the management of the transport system.

Technology companies provide continuous and reliable internet connection at stations and on vehicles (connected airplanes, trains & cars). 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, multinational mobility providers emerge and compete with each other. They own, manage and process the immense amount of mobility data.
They collect data from smart sensors (e.g. internet of things devices) in the infrastructure and vehicles (e.g. smart connected bicycles) and by engaging transport users through gamification (collecting rewards for preferred behaviour, e.g. for providing access to personal data) using data from their connected devices (smartphones, wearables). They provide real-time traffic optimisation and safety information to transport authorities (cooperative intelligent transport systems - C-ITS). C-ITS is implemented on motorways and the main road network. 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 companies that levy a charge for the use of infrastructure. Due to the lack of government regulations the prices vary considerably across operators and no common payment system is introduced across major operators and across Europe.

Public and private transport services converge in Mobility as a Service (MaaS) initiated by these large mobility companies providing real-time trip planning, booking and payment services for all transport modes. Within MaaS, mobility companies promote their own transport solutions such as car-sharing (in cooperation with car manufacturers) and widely deployed ride-sharing. Traditional public transport and taxi companies become subcontractors of the mobility companies to retain business. Mobility companies develop intelligent chatbots, which can react to human voice and messages to provide travel and marketing information to passengers. To serve individual needs the first commercial personal rapid transit systems are promoted in urban areas by private investors. Personalised and individualised transportation to/from and within airports are developed by mobility companies and airports. Public transport operators adopt flexible timetables and modular trains to provide flexibility to adapt to passenger needs and demand. Airlines differentiate flight cabin classes and zones according to individual needs and provide high-speed internet connection and virtual reality entertainment

services. Airlines and aircraft manufacturers develop the first small on-demand aviation services (Air Uber) to provide flexibility to customers with tight schedules. The mobility companies focus on satisfying travel demand by high capacity and individualised transport solutions (self-driving solutions, public transport with improved comfort and commercial speed). Cycling and walking are only niche markets for them. Nevertheless, shared smart electric bicycles carrying advertisements are introduced in urban areas for which the rental fee depends on the visibility of the ads (how long the trip is).

Due to fragmented local regulations and differing priorities in transport policy in the member states, diverse proprietary solutions are developed for connected and autonomous vehicles, charging stations, data platforms and safety solutions. Due to fierce competition and the lack of supranational regulations autonomous transport systems have a low level of compatibility across regions or countries. Government regulations on vehicle emissions and infrastructure operations are less severe, the emphasis is on the voluntary sustainability initiatives of vehicle manufacturers and infrastructure managers.

Security is a major concern in all walks of life, but there are no strict regulations in place to increase security in a way that would contribute to delays and a deterioration of comfort for passengers. Pan-European cooperation for transport security is at a low level. This leads to a fragmentation of rules, regulations and procedures in cross-border traffic.

The lack of harmonisation and the limited support for innovation threatens the competitivity of the European automotive industry. The former does not only render sales in the European market more cumbersome, but also weakens Europe's position concerning global standardisation and regulations, making it more complex for European players (especially SMEs) to access and/or consolidate positions in global markets. Innovation mainly occurs in premium cars, and Europe remains a niche market player, resulting in a reduced market share. Profitability in lower car segments will decrease and risk for hostile takeovers and fierce competition from emerging economies is high, resulting in a decline of the automotive industry in Europe and relocation of production outside Europe. This reduces the employment in the sector, an effect increased by a high-level automatization of the production process in the industry 4.0 context. In order to mitigate the loss of market share, OEMs strongly get involved in alternative business models such as Mobility as a Service, resulting in a shift from the manufacturing industry to a more service based sector, and hence offering job opportunity to other profiles (sales, financial, operational).

Evolution in the commercial vehicle segment is similar, in a sense that the European industry will continue to dominate the high-end market driven by a high degree of automatization, safety, efficiency and connectivity urged by a strong need to reduce costs and offer flexible deliveries. However, the lack of increasingly stringent environmental regulations will allow easier access for truck builders of emerging markets into the European market. It will urge the European OEMs to develop low budget trucks in order to maintain market share in Europe and increase market share in certain new markets (such as Africa, Southeast Asia, and Central America), which will entail additional development and investment costs, and hence putting a burden on profitability. Due to the lack of innovation to reduce the environmental impact of cars and trucks internal combustion engine based vehicles will remain a main component of the fleet.

3.5 Scenario 2 Digital Nomads

Underlying trends

Legal and policy framework:
There is a high level of standardisation of regulations and technology standards at the European level. The activities of companies in the transport and mobility sector are more strictly regulated. Government support for innovation is high, innovation is driven by the policy goals of the government rather than private initiatives.
User behaviour and lifestyle
There is a fast-paced transformation of lifestyles. People are becoming increasingly flexible with an accelerated pace of life. Individualisation leads to smaller household size and flexible employment. Adoption of innovative technology is fast.

Growing concerns about climate change, stricter EU-wide regulations to reduce CO_2 emissions and an increased focus on renewable energies and materials have brought innovative technologies and business models into the limelight.

Freight
Main solutions

- **Regulations push freight transport towards sustainable modes**
- **Dimensions of trailers, containers and pallets are internationally standardized**
- **Government regulations require logistics players to share their data with each other**
- **A global logistics system emerges based on the physical internet**
- **Co-modality with public transport and intermodality is supported**
- **Automatization of all logistics operations at terminals**
- **Innovative technologies like underground cargo transporters are introduced firstly in pioneering cities and, after they proved a success, implemented widely**
- **ICT solutions are exploited to increase the infrastructure/network capacity**

A reindustrialisation takes place in Europe based on the latest technologies and innovation driven by increasing transportation costs. This mainly affects non-labour intensive industry, which can be easily automated. Labour-intensive industries remain outside Europe. Trade barriers have been lifted.

European and national policies support and enforce cooperation between players and transport modes in the freight sector. Shippers, freight forwarders and receivers of goods are obliged to share their data on logistics operations with each other. Data sharing supports the development of the physical internet, an open global logistics system that allows for a more sustainable logistics chain where modular containers of different standardized sizes are equipped with a protocol and an interface to allow better handling and transshipment. Digital security becomes a great concern. Freight and public transport is integrated through co-modality by using available space on public transport vehicles during non-peak-hours (e.g. at night) or on duty vehicles (e.g. cleaning or maintenance vehicles). For last and first mile deliveries small electric vans, electric bikes or tricycles are used because in most cities low emission zones are introduced.

Full digitalization of the transport system promotes the automatization of all logistics operations at terminals and vehicles (ships, trains, organized platooning of trucks).

Passenger mobility
Main solutions

- **Supranational regulations at the EU level and new monitoring technologies to increase security across all transport modes.**
- **Governments require full connectivity and digitalisation of the transport system: all stations, network infrastructure and vehicles (public and private) vehicles are connected to the internet**
- **Interoperability of C-ITS and digital interfaces**
- **Road capacity is primarily increased through Cooperative ITS and dynamic road user charging as well as new infrastructure where demand justifies**
- **Strict regulation of shared and public transport services with a requirement to integrate them in Mobility as a Service systems.**
- **Regulations push transport operators towards sustainable modes Intermodal mega-hubs to support intermodality for passengers**
- **Faster and more energy efficient high-speed trains with inductive charging**
- **Seamless integration of other modes with air transport**
- **Internet connection in airplanes**
- **Proliferation of personal mobility devices in cities**
- **Training programme for the elderly for digital services**
- **Advanced lightweight materials in vehicle design**
- **Automated maintenance of road and rail infrastructure**

Despite increasing migration and security concerns, borders within the EU remain open and the remaining non-Schengen countries join the area of free movement.

Airports introduce the 'No borders' approach i.e. the integration of passenger information and security checks. Seamless security checks and intelligent CCTV technology at airports and high speed rail stations utilize preselection based on big-data and advanced screening equipment. Advanced digital security devices are also used to increase security in public areas through advanced face recognition and risk analysis. Since aviation relies fully on digital communication and management, protection against cyber threats is strengthened.

People are becoming increasingly flexible in their work and private lives. The boundaries between private life and work disappear as people become always online and available. Travel time is used for multitasking (working) to add useful minutes to an otherwise very crowded daily schedule.

Governments embrace the 'internet everywhere and for everyone' concept which requires transport operators and vehicle manufacturers to provide internet connection at all stations and on board all vehicles including private cars.
Governments focus on improving the efficiency and capacity of existing road and parking infrastructure and construct new high-capacity infrastructure where needed to cater for increasing demand for travel. New roads are built only where ITS and demand management cannot provide a solution to congestion problems. New infrastructure is mainly built in public-private partnership where public authorities retain control over user charges.

Governments support full digitalisation of the transport system. Strict pan-European regulations ensure interoperability of transport infrastructure and digital interfaces

as well as data privacy. Cooperative Intelligent Transport Systems (C-ITS) are developed in public-private partnership to increase road safety and road capacity. C-ITS is comprehensively implemented on motorways, the main and secondary road network and provides comprehensive real-time information about incidents and roadworks, speed limits and diversion routes. The vulnerable road user protection system will increase safety of pedestrians and cyclists by alerting drivers of the presence of vulnerable road users. Preventive and predictive maintenance of road and rail infrastructure is increasingly automated (remote asset inspection, autonomous operations, and integrated scheduling and system control). Local governments introduce dynamic road user and parking pricing using smart sensors. Existing public transport and new mobility services focusing on individual needs (personal rapid transit, personalised transit to airports, ride-sharing, parking-sharing etc.) are strictly regulated and they are required to be integrated in mobility as a service systems with services that are accessible to the disabled and the elderly. These systems mainly promote motorized modes (road and rail rather than cycling and walking) to cater for the increasing travel demand and travel distances. Intermodal mega-hubs are built in public-private partnership to connect transport modes and host commercial activities.

Long distance travel is supported by faster and more energy efficient high-speed trains with inductive charging and a seamless integration of other modes with air transport in order to reduce the maximum travel time between any two points in Europe to 4 hours. Flight cabins provide internet connection.

Vehicles will be produced mainly from advanced lightweight materials to increase fuel efficiency and emissions. There is a high degree of standardisation of charging, connectivity and safety systems for cars and other motorised vehicles.

There is high demand in urban areas for battery-operated personal mobility devices (e.g. Segway), local authorities adapt the walking and cycling infrastructure to accommodate these devices. The purchase of smart electric bicycles is subsidised by the government to enable longer trips even on hilly terrain.

The elderly population embraces digital communication technologies and benefits from easier and more accessible local and long-distance travel.

An EU-wide training programme for the use of digital services is launched to train the elderly enabling them to benefit from connected mobility services. Autonomous vehicles provide new opportunities for door-to-door transport. Special financial aid is provided to the elderly and the disabled who would otherwise not be able to afford such vehicles or services.

The high level of standardisation, the stringent environmental regulations in combination with strong support for innovation, and the fast acceptance of new technologies allow the European automotive industry to successfully launch sustainable technologies, reaching economy of scale, resulting in a strong increase in employment and profitability, keeping the European automotive industry among the frontrunners. However, this reindustrialisation process requires the increased availability of specialised skills, such as electric engineers, mechatronic and ICT specialists. The shortage of these skilled working forces, will result in better working conditions. In addition, the industry aims to attract more female employees and therefore offer working contracts that make it easier to combine private and professional life. The strict regulations with respect to emissions delay the entrance of players from emerging markets allowing the European OEMs to focus on the

development of advanced, automated, connected, safe and efficient vehicles and keep market share in Europe, and maintain profitability. Due to the fast acceptance of new sustainable technologies environmental impact of the vehicles is considerably reduced, but this is counterbalanced with the increase of travel and transport demand.

3.6 Scenario 3 Slow is beautiful

Underlying trends

Legal and policy framework:
Harmonisation of regulations and technology standards at the European level is limited. The activities of companies in the transport and mobility sector are less strictly regulated. Government support for innovation is limited, innovation mainly comes from private companies
User behaviour and lifestyle
Traditional and local values are regaining importance and define people's lifestyles. Burn-out from fast-paced work and social life turns people towards family values, national and local identity and cooperation within their local communities. Acceptance and adoption of new technology is slower.

Governments turn inwards to guarantee national security and supply of resources to their citizens. European policy focuses on enabling local initiatives rather than supranational standardisation. Innovation is less supported due to scarce financial resources.

Freight
Main solutions

- Electric cargo-bikes
- Urban freight consolidation hubs
- Sharing courier platforms
- Public transport used for deliveries
- Slow steaming practices in maritime transport
- Synchromodality

People more and more turn to eco-friendly local cooperative production of food and energy, urban gardens and peer-to-peer services. Citizens aim to produce what they consume within their neighbourhood. Bottom-up initiatives of local communities thrive with few legal limitations on local sharing and production initiatives. Willingness to pay for eco-friendly solutions increases.

In order to support self-sustaining urban communities, there is a growing market for electric cargo-bikes that are used to distribute goods within the local communities where no motorised vehicles are allowed. Logistics companies set up urban freight consolidation hubs from where goods are distributed by e-bikes and minivans. Goods deliveries also increasingly rely on sharing courier platforms connecting people who need items that are delivered with drivers and couriers 'going there anyway'. Public transport services (rail, trams, inland waterways and underground) are also used for deliveries and collection of waste.
Also, supply chain de-stressing gains momentum through different practices (i.e. syncromodality, slow steaming etc.), to reduce supply chain complexity by using the right mix of transportation modes to operate sustainably at lower cost with higher quality.

Passengers
Main solutions

- **Online co-creation platforms for citizens**
- **Traffic restrictions and local road user charging with no EU-wide coordination**
- **Peer-to-peer applications developed by local start-ups**
- **Lax legal and government control over sharing initiatives: many car/ride/parking sharing platforms**
- **Cycling in shared spaces**
- **Cautious government and public approach to the introduction of autonomous vehicles**
- **Focus on the optimal use of existing infrastructure (e.g. roads and railways) by retrofitting them**
- **Bus rapid transit systems to save cost of new tram/rail systems**

A service sector based on sharing resources such as time, space and vehicles emerges supported by local social networks. "Slow, healthy and sustainable" are the new buzzwords. People appreciate spending more time with their friends and family within their neighbourhood and rediscover their local environment. Mixed-use developments aim to decrease the distance between residential areas, jobs, education and services.

Local neighbourhood planning is initiated more and more by local citizens using social media and online co-creation platforms. More and more cities introduce car-free city neighbourhoods and various other restrictions on road traffic (e.g. limited parking). Road user charging is initiated in some urban centres using 'low-tech' solutions such as relatively low flat rates, number plate recognition or vignettes. There is, however, no EU-wide coordination of road charging schemes, payment systems and signage of restrictions. Peer-to-peer applications and online services developed by small local start-ups have replaced many of the car-sharing and ridesharing services of big corporations. Mobility applications and sharing initiatives can easily be launched with lax legal and government control concerning user rights and privacy. Many car/ride/parking sharing platforms are launched and often compete with existing public transport services.

The popularity of cycling and other electric two-wheelers is on the rise. Cyclists are encouraged to use existing roads as shared spaces.

There is a cautious approach to the introduction of autonomous vehicles especially in urban areas. Due to societal resistance (safety concerns, lack of trust in technology, concerns over jobs in the transport sector), autonomous private vehicles are only allowed on designated motorways.

Transport providers remain primarily national and local with little cross-border activities. Financial resources to build new transport infrastructure and maintain the existing ones are scarce. Therefore, there is more focus on the optimal use of existing roads and railways by retrofitting them.

In cities, Bus Rapid Transit corridors are built by private investors using existing road infrastructure instead of new rail/tram systems due to the lower cost.

The lack of support for innovation and standardisation, the reduced demand for mobility and transport lays a burden on the profitability of the automotive companies. Hence OEMs look for other business models in order to maintain profitability, such as MAAS and car sharing systems, or address (low budget) new

types of urban vehicles such as electric minivans for city-distribution or electric-L-type vehicles, a segment in which intense competition from emerging markets is seen. However, opportunities arise for SME's that address these means for transportation and produce them locally, adapted to the local needs, and possibly based on co-creation, and take into account a good work-private balance for the employees. Automotive companies that specialised in (electric) buses are competitive since investment costs are recovered to the wide spread of these systems in cities. In terms of environmental impact, the transition to alternative fuelled vehicles is limited.

3.7 Scenario 4 Minimum Carbon

Underlying trends

Legal and policy framework:
There is a high level of standardisation of regulations and technology standards at the European level. The activities of companies in the transport and mobility sector are more strictly regulated. Government support for innovation is high, innovation is driven by the policy goals of the government rather than private initiatives.
User behaviour and lifestyle
Traditional and local values are regaining importance and define people's lifestyles. Burn-out from fast-paced work and social life turns people towards family values, national and local identity and cooperation within their local communities. Acceptance and adoption of new technology is slower.

Due to the severe pressure of climate change, governments want to fundamentally change the behaviour of their citizens and companies to steer them to reduce carbon emissions and move them away from fossil fuels.

Freight
Main solutions

- Logistics companies are required to measure and report their carbon emissions. Eco-labels are introduced
- National and local electronic road charging schemes are widely introduced with variable rates based on demand
- Deliveries in city centres restricted to electric and non-motorised vehicles
- Urban cross-modal logistics using public transport capacity for deliveries
- Strict regulations on energy efficiency of freight transport
- Slow steaming practices are exploited in maritime transportation targeting at distressing the supply chain
- Electrification of ferries and vessels based on international agreements combined with the use of new lightweight materials
- The use of fossil fuel is almost entirely substituted. Low-carbon technologies such as carbon capture and usage (CCU) and a wide range of renewables make power generation almost CO_2 free
- Smartphones and intelligent CCTV recognition technology to monitor carbon use and security

Companies are required by government regulations to significantly reduce their environmental footprint therefore sustainable and bio-production are supported. Large international manufacturing and retail corporations adapt to the new requirements and regionalise their production. 3D printing becomes widespread

boosting customised local production. Customers prefer to buy products with the smallest carbon impact. Local programmes are launched by the government to recirculate materials inside the neighbourhood and the city to reduce waste and carbon emissions associated with mass production and long-distance distribution chains.

Logistics companies are required by law to measure and report their carbon footprint through smart sensors in vehicles and infrastructure. Products transported and logistics services receive Eco-labels based on this calculation therefore logistics companies are incentivised to improve their load factors and the environmental performance of their vehicle stock. Carbon taxation is widely introduced to reflect the amount of CO_2 generated by transport activities. National and local road charging schemes are also widely introduced with electronic tolling and variable rates based on demand to reflect external costs (especially noise, air pollution, congestion). Deliveries in/to city centres are restricted to small electric vehicles and electric bicycles. Urban cross-modal logistics uses all available modes of transport to provide the lowest possible carbon footprint.
Strict European regulation demand good energy efficiency of freight vehicles and the use of renewable fuels, in all modes (ships, aviation, road, rail). The electrification of waterborne transport by electrifying ferries and vessels is forced by international agreements.

Passengers
Main solutions

- Car-free neighbourhoods enforced in cities
- Superblocks concept applied widely
- Individual car ownership is discouraged by high taxes
- Fossil fuel is prohibited in most urban areas
- Personal 'carbon budget' for each individual
- Smartphones and intelligent CCTV recognition technology to monitor carbon use and security
- National and local road charging schemes
- Environmental footprint of transport is monitored and a carbon tax is introduced across Europe
- Citizens co-create their environment through smart apps
- Mobility as a service: high level of integration of mobility services steered by publicly managed transport partnerships
- Ridesharing is fully integrated with public transport
- Autonomous vehicles only for long distance travel
- Interconnected cycle highways
- Large capacity bicycle parking
- Walking and cycling environment adapted to the needs of the elderly population, children and the disabled
- Internet of Things devices to enhance safety and security

Burn-out from fast-paced work have turned people towards healthier and active life. Work is arranged to require less travel, in neighbourhood flexi-offices, by supporting work from home and by distributing smaller offices in city districts. Long-distance travel is expensive due to the carbon taxation introduced across Europe. People prefer to spend their free time and holidays in the proximity to their homes.

Cities embrace car-free neighbourhoods to improve liveability. Tax-incentives discourage private car ownership and support car- and ride-sharing instead. National and local road charging schemes are widely introduced with electronic tolling and variable rates with a standardised Pan-European payment and monitoring system.

Use of fossil fuels is prohibited in most urban areas and heavily taxed elsewhere. The environmental footprint of aviation is strictly monitored and a carbon tax is built into ticket prices across Europe.

Smartphone or wearables apps encourage users to travel in a sustainable way and oblige them to respect the personal 'carbon budget' (the maximum amount of CO2 they can generate per month), which is assigned to each individual by the government. Smartphones and intelligent CCTV recognition technology enables the monitoring of the carbon budget for each individual.

Smart online apps empower citizens through digital technologies to participate in planning and impact monitoring for urban and transport planning. There is a high level of integration of mobility services steered by publicly managed transport partnerships (associations integrating all shared and public transport services, travel information and payments). There is a significant increase in demand for public transport due to the introduction of the personal carbon budget, the extension of capacity, however, does not keep pace with demand due to the limited availability of space and the potential negative impact of infrastructure investments. Ridesharing is fully integrated with public transport to provide seamless first- and last-mile solutions.

The introduction of autonomous vehicles is limited to long distance travel. C-ITS systems are fully deployed only on motorways. Cities focus more on improving walking, cycling and public transport. Cycling is fostered by building interconnected cycle highways with added services (repairs, charging) and large capacity bicycle parking is built by local governments at public transport stations.

Travel demand is reduced through supporting densification i.e. living in densely built urban areas. Superblocks restrict road traffic to major roads around residential blocks where only local traffic is allowed with restricted speed (10 km/h). Everyone has the right to access to basic services guaranteed by the government. The walking and cycling environment is adapted to the needs of the elderly population, children and the disabled. Intelligent pedestrian crossings adapt to pedestrian demand. Internet of Things devices are used to enhance safety and security of pedestrians and cyclists integrated into everyday items such as wearable reflectors for children and smart monitors for the elderly to monitor their well-being and location. On the other hand, carbon rationing takes the activity level of citizens into account and allocates more opportunities for public transport capacity to the active population (e.g. commuters), also limiting the time periods when the non-active population can use such services (e.g. only outside peak hours).

The environmental policies urge the automotive industry to develop sustainable vehicle technologies, however the slow adaptation of new technologies, and the lower demand for travel slow down market penetration of sustainable vehicles, which has an impact on profitability of the automotive industry. This is, however, counterbalanced by tax- and incentivising measures of the government. The popularity of car sharing systems urges OEMs to engage in this sector. OEMs relocated their production to Europe, and local SMEs with innovative solutions for city distribution enter the market. The electrification of public transport supports OEMs making vehicles for sustainable transport, including buses, trains, trams and ships. Transition to sustainable vehicles is advancing at relatively high pace.

4 Next steps

The MAMCA method relies upon the evaluation of the scenarios using the unique criteria of the stakeholder groups. The ranking of the scenarios reflects the relative importance of these criteria to the stakeholders. The relative importance is expressed by weights. Therefore, it is essential that the stakeholders of Mobility4EU contribute to the criteria weighting which is carried out through an online survey. Stakeholders will be approached in December 2016 – January 2017 to fill in a short online survey about the weights.

By the end of the MAMCA evaluation a subset of the solutions identified will be selected that will be carried forward into the vision for transport in 2030 (Task 3.3) and the action plan (Work package 4).

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