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# 1st TRIMIS Horizon Scanning Session

*Joint Research Centre,*
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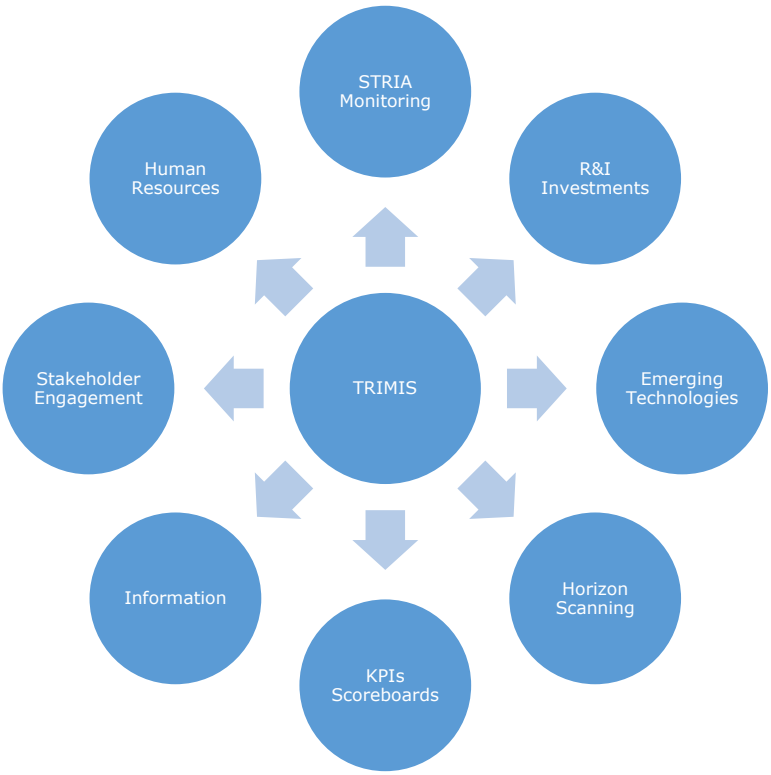
## Abstract

The Transport Research and Innovation Monitoring and Information System (TRIMIS) is an open-access transport policy-support tool developed and managed by the Joint Research Centre (JRC) to support the implementation of the Strategic Transport Research and Innovation Agenda (STRIA). One of the main objectives of TRIMIS is to provide a forward-oriented support to transport research and innovation (R&I) governance by using foresight in its technological and socioeconomic assessment process related to transport R&I. Within the TRIMIS framework, horizon scanning is applied through a structured and systematic collaborative exercise that contributes to the identification of new and emerging transport-related technologies and trends, with a potential future impact on the transport sector. Furthermore, it supports the assessment of current and future research needs and provides transport related insights to the broader European Commission foresight system contributing to a higher-level strategic framework also covering the transport domain. As part of this process, on 26 September 2019 the TRIMIS team, with support from the Unit for Knowledge Management and the EU Policy Lab of the JRC organised a sense making session entitled the 1st TRIMIS Horizon Scanning Session. It aimed at gathering insights from various transport experts with different backgrounds and make sense of previously collected, transport-related horizon scanning items through a process that could provide indications on relevant trends, new drivers of change, weak signals, discontinuities or shocks/'wild cards'/sudden unexpected events/'black swans'. This report collects and analyses the experiences that were shared and discussed during the session along with the supplementary material and initial results. Furthermore, it acts as a first input to the next step of the TRIMIS Horizon Scanning process that will involve policymakers with a focus on transport R&I.

# 1 Introduction

The European Commission's (EC) Transport Research and Innovation Monitoring and Information System (TRIMIS) is a policy support tool and an open-access transport information system monitoring the implementation and effectiveness of the roadmaps developed within the Strategic Transport Research and Innovation Agenda (STRIA). The TRIMIS database contains transport research and innovation (R&I) related projects and programmes funded either by the European Union (EU) or nationally, classified according to the seven STRIA roadmaps that were adopted by the EC in May 2017. The roadmaps cover seven thematic areas of transport, namely: cooperative, connected and automated transport (CAT); transport electrification (ELT); vehicle design and manufacturing (VDM); low-emission alternative energy for transport (ALT); network and traffic management systems (NTM); smart mobility and services (SMO); transport infrastructure (INF) (European Commission, 2017a, 2017b). The main features and functionalities of TRIMIS are presented in Figure 1.

**Figure 1.** TRIMIS main features and functionalities.




Source: Tsakalidis et al., 2018.

TRIMIS aims to support the establishment of an anticipatory and adaptive culture in the field of European transport R&I, providing insights to users and contributing to a higher-level strategic framework. One of the key objectives of TRIMIS is to support transport R&I horizon scanning. The Joint Research Centre (JRC) has already developed a capacity for foresight and horizon scanning. Within the TRIMIS framework, horizon scanning has the form of a structured and systematic collaborative exercise that aims at contributing to the identification of new and emerging technologies and trends. It supports the assessment of current and future research needs, and feeds into the broader JRC horizon scanning system with a focus on the transport sector and related elements. The TRIMIS horizon scanning process is an activity mainly based on manual research (i.e. desk-based analysis) that is supported by automated data mining and semantic analysis (Tsakalidis et al., 2020, 2019).

This report provides an overview of the activities carried out for the 1st TRIMIS Horizon Scanning Session that took place on 26 September 2019 at the JRC premises in Ispra, Italy.

# 2 Workshop activities

The TRIMIS horizon scanning activity and workshop process have been set up according to the following stages as defined by Krzysztofowicz et al. (2018), namely:

- Definition of purpose
- Methodology development
- Organisation setup
- Communication preparation
- Reach out to decision-makers

The complete analysis of the role of TRIMIS as a support tool for transport R&I horizon scanning towards an integrated European horizon scanning scheme can be found in Tsakalidis et al. (2019).

## 2.1 Purpose of the activity

On 26 September 2019, the TRIMIS team of the Sustainable Transport Unit, with support from the Unit for Knowledge Management and the EU Policy Lab of the JRC organised the 1st TRIMIS Horizon Scanning Session. Its purpose was to gather insights from various transport experts with different backgrounds and make sense of previously collected, transport-related horizon scanning items. Horizon scanning items refer to factual information coming from a variety of sources including already existing specialised scanning systems, scientific publications, trade and business publications, social media etc. that could provide indications on relevant trends, new drivers of change, weak signals, discontinuities or shocks/'wild cards'/sudden unexpected events/'black swans'. The ultimate goal is to provide useful technical insights regarding emerging trends and evaluate the potential of transport technologies. The results of this foresight process will inform policies related to transport R&I by highlighting trends in transport innovation. The experiences that were shared and discussed during the session along with the supplementary material and initial results are collected and analysed in this report, which acts as a first input for the next step of the TRIMIS Horizon Scanning process.

The objectives of the workshop were:

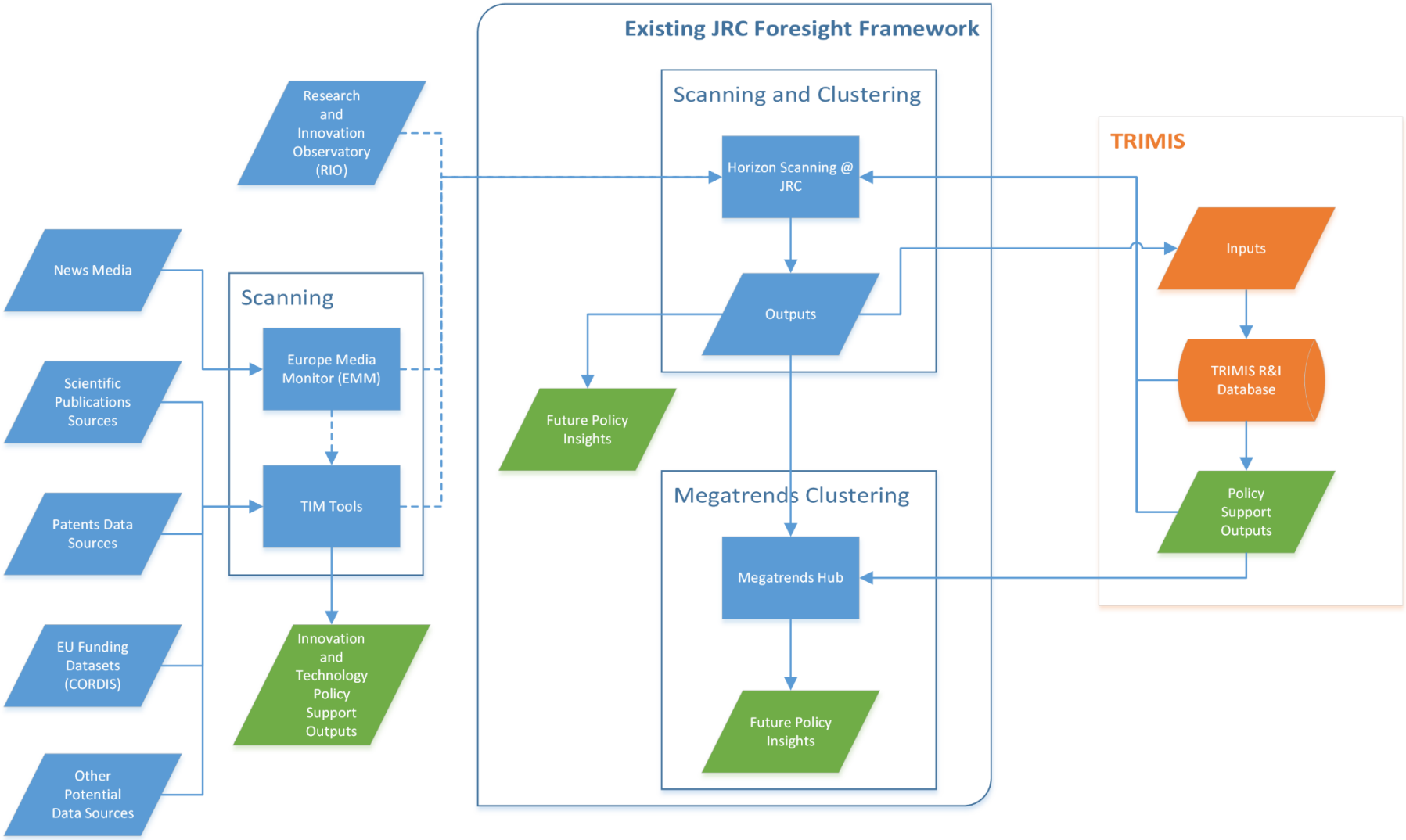
- To bring together diverse perspectives related to latest advances in the transport sector and linked domains
- To make sense and have a technical reading on potential emerging trends in the field of transport R&I and linked domains
- To present the potential of the use of foresight and to create a community of practice around transport related horizon scanning.

## 2.2 Methodology

The TRIMIS horizon scanning process combines the use of a JRC-wide horizon scanning scheme with support from dedicated external sources that use an already set-up network of scanners and scanning procedures. The inputs (i.e. potential horizon scanning items) provided by the external sources are reviewed by the TRIMIS team and are forwarded to the existing horizon scanning scheme. The use of the JRC-wide horizon scanning scheme instead of a fully outsourced scheme contributes towards the independency of the JRC policy advice, from an independent and multidisciplinary research service of the EC that is secure against biased scanning inputs and horizon scanning outputs. This allows for exploiting synergies within the JRC, advanced capacity building, and additional insight through a systematic study of the received outputs.

Once a critical mass of transport related horizon scanning items is gathered on an annual basis, a workshop is organised in order to initiate the sense making process and identify potential emerging future trends. Figure 2 presents TRIMIS horizon scanning in relation to JRC horizon scanning (Tsakalidis et al., 2019).

**Figure 2.** TRIMIS within the JRC horizon scanning context.




Source: Tsakalidis et al., 2019.

## 2.3 Organisation setup

In order for the workshop to be organised and completed, a series of steps were necessary both before and during the event. Before the workshop:

- The agenda of the workshop was developed and agreed by the organisers.
- A list of selected horizon scanning items was created from the organisers based on TRIMIS inputs to the JRC Horizon Scanning scheme and other relevant horizon scanning items. For a complete list of items see Annex I.
- A list of potential participants with a compatible background was created. Participants were required to have an expertise in the greater transport sector, preferable with diverse backgrounds and current tasks.
- Potential participants were invited and the agenda, instructions and list of horizon scanning items were shared.

During the workshop, the following stages took place:

- Introduction. Presentation of the concept of horizon scanning, the role of TRIMIS as a policy support tool and its position within the JRC Horizon Scanning scheme.
- Working on individual clusters. The participants were asked to cluster (group) the horizon scanning items that were shared before the workshop.
- Collecting clusters. Each participant shared their own clusters with the organisers and the rest of the participants for the creation of meta-clusters at a higher level of aggregation based on common technological areas or transport-related concepts.
- Eliminating least innovative clusters. The least interesting meta-clusters were eliminated through negative voting by the participants and were excluded from further consideration.
- Refining clusters. The remaining meta-clusters were further refined by adding more information on the context behind each of them regarding potential novelty, interest, expectations and potential unexpected events, and what kind of potential new trend/development they could spur. Moreover it was examined if there were counterintuitive elements or if they could have a disruptive effect and finally if they respond to some unmet/new demand. Through this process a revised premise was created.
- Mapping. The refined meta-clusters were used for a mapping exercise based on predefined thematic areas and cross-cutting themes (i.e. the seven STRIA roadmaps and potential implementation timeframes were used as a basis).
- Prioritisation. The participants prioritised the most important mapped meta-clusters through positive voting on those clusters which should be examined further.
- Reviewing prioritised clusters in groups. The prioritised meta-clusters were reviewed by groups of participants based on a template, adding information on restating the premise, providing a 10-year perspective (both a realistic and an extreme case), potential consequences (both expected and unexpected) and, in view of the above, the horizon scanning topic was reformulated.
- Final reporting from groups. The groups that reviewed the prioritised meta-clusters reported on the final outcomes of their outputs.
- Wrap-up. The organisers closed the session providing information on the future steps of the process, potential outputs and outcomes.

## 2.4 Communication preparation and reach out to decision-makers

After the closing of the workshop all material collected was assessed by the organisers and used for the preparation of the current report. In line with the communication strategy, the results of this assessment are published in a workshop report. This report will be used as input for the next step, which is the assessment of results by policy/decision-makers that are working in the area of transport R&I policies. The final goal is the production of a science for policy report and the publication of results through the TRIMIS online platform.

# 3 Workshop clustering results

This chapter presents the results of the workshop clustering activities. The list of horizon scanning items (I) was shared with the workshop participants, who assessed them and used them as the basis for the creation of clusters (CL). These clusters were used for a second level clustering that led to the creation of meta-clusters (MC). The current section provides an overview of the second level clustering exercise that includes meta-clusters, self-standing clusters and observations (OBS) that were made during the clustering process by the participants, introducing new elements to the discussion. The horizon scanning elements of the analysis are coded as follows:

- Items: Ixx*yy,
- Clusters: CL_zz_xx*yy
- Meta-clusters: MC_xx*yy
- Observations. OBS_zz_xx*yy

where xx is the item list number yy the title, zz the participant initials and * the title separator. Each cluster, meta-cluster and observation has potential links to other clusters, meta-clusters or observations that are visually presented through network mapping. A complete list of the aforementioned links and interconnections can be found in Annex II.

## 3.1 MC_1* Insurance as enabler for new technologies

DESCRIPTION*: This meta-cluster bundles together clusters indicating risks and threats linked to new technologies and how insurances, addressing these uncertainties, can help in speeding-up innovations.

This meta-cluster covers the following clusters:

CL_AM_1* Relying on and trusting innovation

CL_AM_2* New insurance regimes to bear the costs and risks associated with "dodgy" and less mature innovations

OBS_MCG_1* New technologies offer a world of opportunities, yet lead to new accidents and risks: Impact on insurances

### 3.1.1 CL_AM_1* Relying on and trusting innovation

DESCRIPTION* New technologies help but can be cheated. Should we trust them blindly? Should we test and improve them? Or should we accept the risks?

This cluster is based on the following news items[1]:

I4* Precision landing kit for drones

[1] For the abbreviations found in the lists of news items' titles under each cluster please refer to the list of abbreviations and definitions.

I15* Street level imagery

I51* System to legally test GPS spoofing vulnerabilities in automated vehicles

I66* Interconnected car dash-cameras used to improve urban GPS accuracy

### 3.1.2 CL_AM_2* New insurance regimes to bear the costs and risks associated with "dodgy" and less mature innovations

DESCRIPTION* The more expensive a car is, the higher the insurance premium becomes. However (expensive) safety features could potentially reduce the risks of accidents and/or their impact, thus the associated costs. Hence, there are clear links between innovation and risk/insurances.

Risks can be accepted, avoided, reduced or transferred. For established technologies, risks are well known and thus easier to manage. This is not the case for new technologies, thereby calling for a different approach to risk management.

Can insurance support innovation by cooperating with technology developers and offering a better defined coverage to end-customers? Should money be set-aside to cover the damages of immature innovation? Similar to aviation safety agencies, should technical boards review each accident to decide on the responsibility of new technologies and how to improve them?

This cluster is based on the following news items:

I3* Portable Rapid EV Charger

I51* System to legally test GPS spoofing vulnerabilities in automated vehicles

I59* New unmanned ship design

### 3.1.3 OBS_MCG_1* New technologies offer a world of opportunities, yet lead to new accidents and risks: Impact on insurances

DESCRIPTION* The real world environment changes continuously and even more so it will change in response of connected and automated vehicles (CAVs) market introduction. Not only the road infrastructure will be upgraded to support CAVs deployment, but also other road users will modify their behaviour to match the new changing environment. This might also bring new risks, like for example pedestrians or human drivers challenging CAVs, taking advantage of their more conservative driving style, or CAVs cabin occupants being involved in intentional or unintentional misuse of the vehicle's driving capabilities. New risks will result in new accidents scenarios and as a consequence this might also affect insurance cost and events coverage.

This observation has not been linked to specific news items but refers to important developments.

## 3.2 CL_BC_1* Weather extreme events to impact mobility


DESCRIPTION* Failing to stop or slow-down climate change will require our society to implement extreme adaptations strategy: Mobility may be strongly affected with continuous disruptions to the services. On the long run, most of the land transport services may be moved underground or replaced by urban aerial services if they will prove to be safe and effective under adverse conditions. Mobility patterns might change due to the

unreliability of transport services and transportation demand may be substantially reduced with related financial problems for economies counting on the revenues from transport activities.

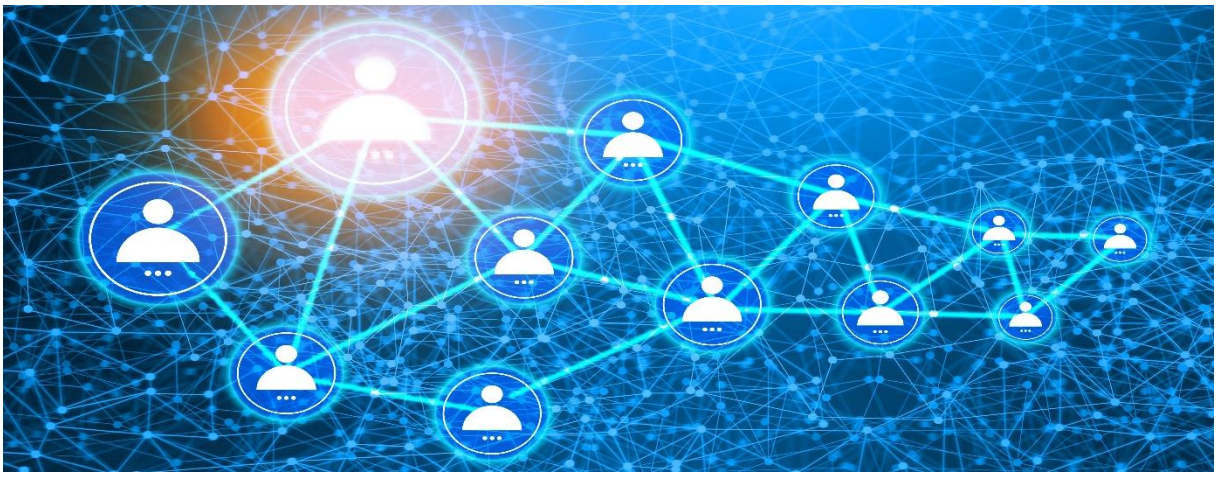
This cluster is based on the following news items:

I16* Tunnel based mobility

I22* Carbon-ion battery delivers ultra-fast charging & zero degradation

I74* Autonomous delivery robot

## 3.3 MC_3* Individualisation, diversification and interconnection of transport modes for minimising efforts and time



DESCRIPTION* This meta-cluster deals with the motivations behind ongoing trends in the transport sector.

This meta-cluster covers the following clusters:

CL_FP_2* Individual mobility, taken to the extreme, will have a negative impact on the environment despite electric vehicles/automated vehicles

OBS_BC_2* Personal robots to regain time for ourselves (logistic support)

CL_MCG_2* Use of transport automation to enhance service/support/life

CL_AO_1* Interconnection of transport modes (for people or goods)

OBS_BC_4* Reduced use of cars for mobility, enabled by autonomous vehicles

### 3.3.1 CL_FP_2* Individual mobility, taken to the extreme, will have a negative impact on the environment despite electric vehicles/automated vehicles

DESCRIPTION* Emerging technologies and mobility concepts, such as individual flying vehicles or underground pods have the potential to fundamentally change city landscapes. If shared, it is possible that these will drive demand away from public transport rather than from private vehicles, which will then deteriorate public transport services and thus limit the possibilities of moving the masses around in a sustainable way. Adding flying and underground individual vehicles and to the already existing stock of private cars is likely to aggravate congestion in and around cities and despite more energy efficient technologies, will need more resources and energy to build and propel and thus further increasing climate/resource impacts of transport.

Moreover, electric vehicles (EVs)/automated vehicles (AVs) alone do not solve congestion problems in cities where advanced public transport systems, ride sharing, and better infrastructures are needed so that people can safely walk or bicycle. The electricity for EVs needs to be produced by sustainable sources (solar; wind; water).

This cluster is based on the following news items:

I16* Tunnel based mobility

I20* Boeing's autonomous passenger air vehicle completes first flight

I42* Smart city concept based on autonomous vehicle fleets

I64* New suspended transport system nears commercial application

### 3.3.2 OBS_BC_2* Personal robots to regain time for ourselves (logistic support)

DESCRIPTION* Our packed lives will incentivise the fast deployment of cheap door-to-door automated vehicle delivery systems. Personal robots asked to replace all our logistics will boom in our cities. A combination of pods, drones, and automated services will reduce the time spent to deal with logistic activities. The time freed from these activities will be used to carry out additional activities making the overall mobility sky-rocketing. Urgent needs to find proper ways to manage the existing transport capacity will emerge also supported by the development of a cooperative, connected and automated mobility (CCAM) system. People's quality of life will not necessarily improve due to the ambition to carry out even more activities.

This observation has not been linked to specific news items but refers to important developments.

### 3.3.3 CL_MCG_2* Use of transport automation to enhance service/support/life

DESCRIPTION* The common element of this cluster of items is the general idea that automation will improve transport services in all transport modes, thus making our everyday life safer and more comfortable.

This cluster is based on the following news items:

I20* Boeing's autonomous passenger air vehicle completes first flight

I21* Drones shown to make traffic crash site assessments safer, faster and more accurate

I37* Driverless maglev train concept capable of 200km/h

I38* World's first fully autonomous freight ship

I52* AI cuts Dubai bus accidents by more than half

I58* New first and last mile transport service

I60* Urban flying vehicle study launched

I70* 'Drone train' completes first trial

I71* Autonomous following trucks

I74* Autonomous delivery robot

I78* End to end autonomous truck delivery

I84* roundAround: the world's first dynamic 'bridge' made of autonomous boats

### 3.3.4 CL_AO_1* Interconnection of transport modes (for people or goods)

DESCRIPTION* How to give information in real time to users so they can have accurate travel time and they will know what to expect for their trip. For instance, if an accident happens in any road, what are the best routes for my trip to arrive on time to my destination? If my train is delayed, what are the best alternatives for my trip?

This cluster is based on the following news items:

I10* Sensor fusion and tracking toolbox

I24* Block-VN: A distributed blockchain based vehicular network architecture in smart city

I39* Loop-based urban mobility solution

I54* System to fill the gaps of information from connected cars

I66* Interconnected car dash-cameras used to improve urban GPS accuracy

I89* Terminal tourism - plane spotting, restaurants, art also lure non-travellers

I92* Brain controlled film

### 3.3.5 OBS_BC_4* Reduced use of cars for mobility, enabled by autonomous vehicles

DESCRIPTION* Connected and Automated vehicles enabled a better management of the road infrastructure giving the possibility to define principles of access and usage of the road on the basis of the existing level of service. Access limitation will reduce the overreliance on road transport and will encourage the use of public transport and mass transit. The overall transport service will result more efficient both from an energy point of view and for the travel time reliability it can ensure.

This observation has not been linked to specific news items but refers to important developments.

## 3.4 CL_FM_3* Widening the scope of aviation - moving closer to urban mobility

DESCRIPTION* Future mobility solutions can include personal autonomous and electric aircraft, and bring air transport closer to urban mobility. This cluster also covers aircraft disruptive concept, architecture and propulsion.

This cluster is based on the following news items:

I9* New scheduling system could help reduce flight delays

I20* Boeing's autonomous passenger air vehicle completes first flight

I60* Urban flying vehicle study launched

I63* Funding boost for innovative flight concept known as the "Flying-V"

## 3.5 CL_EB_1* Hope or hype?


DESCRIPTION* Some innovations may be conceptually elegant and/or appealing when only their advantages are highlighted. Expert judgement may help to develop more informed views on future deployment potential and limitations of such innovations. Since many innovations develop at intersections of different domains and

may have far-fetching disruption potential, evaluating them may require a wide range of expertise. Below are a few examples of items that could benefit from reality-checks, for example on the extent of their environmental and/or clean-energy benefits.

This cluster is based on the following news items:

I33* Route to carbon-negative cars

I40* Interest grows in waste-to-energy for cruise liners, as new solutions emerge

I46* Will solar PV power the railways of the future?

I53* Solar-powered electric forecourts will charge EVs in 10 minutes

I54* System to fill the gaps of information from connected cars

I62* Wind propulsion for passenger ships

I65* Carbon-neutral fuel made from sunlight and air

I67* In-cabin monitoring with radar

I69* Wind propulsion cruise ship

I72* Highly-efficient compressed air systems for ships

I76* India makes advances on world's first passenger hyperloop system

I81* Cost-effective fuel cell technology

## 3.6 CL_MCG_3* Opening of markets to new passengers and users

DESCRIPTION* Transport automation will make available transport services also to new category of drivers/passengers, like for example the elderly, young people below driving age or persons with disabilities. Besides enhancing social inclusion, automation will also pave the way to alternative creative applications of the technology by the users, as the example brought by I88* *People are renting cars but not driving them*. The alternative use of CAVs could also bring negative externalities though. What if we imagine café, shops, hotels on wheels etc.: Will the environmental impact be positive or negative? Will that substitute/compete with active or public transport?

This cluster is based on the following news items:

I42* Smart city concept based on autonomous vehicle fleets

I56* GM patent to retro-fit vehicles with autonomous capability

I77* Autonomous pick up parking system

I88* People are renting cars but not driving them

I39* Loop-based urban mobility solution

## 3.7 MC_7* Artificial intelligence leading to optimisation at system level

DESCRIPTION* This meta-cluster bundles together clusters related to applications and enabling factors of artificial intelligence (AI) in the transport sector.

This meta-cluster covers the following clusters:

CL_MCG_4* Artificial intelligence to improve mobility and transport

CL_AT_1* Artificial intelligence to ensure driver safety

CL_AT_6* Sensor fusion for vehicle safety

### 3.7.1 CL_MCG_4* Artificial intelligence to improve mobility and transport

DESCRIPTION* Connectivity will also play a fundamental role in improving mobility through traffic prediction, weather adaptation or accident response.

This cluster is based on the following news items:

I11* Surtrac - Intelligent traffic signal control

I12* Blackberry traffic technology service

I21* Drones shown to make traffic crash site assessments safer, faster and more accurate

I25* Self-driving cars, robots: Identifying AI 'blind spots'

I36* Weather-responsive intersections could ease traffic congestion

I49* Artificial intelligence used for traffic prediction

I52* AI cuts Dubai bus accidents by more than half

### 3.7.2 CL_AT_1* Artificial intelligence to ensure driver safety

DESCRIPTION* The introduction of AI in the sector of vehicle design and manufacturing within a smart mobility context can have diverse benefits for the driver, including the rise of safety levels while driving. Applications can range from an upgrade of existing features to with the use of AI features to fully novel applications using the monitoring of drivers' functions.

This cluster is based on the following news items:

I50* Active safety features in passenger vehicles

I67* In-cabin monitoring with radar

I92* Brain controlled film

### 3.7.3 CL_AT_6* Sensor fusion for vehicle safety

DESCRIPTION* Contemporary vehicles are shifting from analogue platforms to fully digitalised platforms serving multiple roles apart from the basic transportation of people and goods from point a to point b. Transport infrastructure is also being upgraded with the inclusion of more digital elements, following the move towards the general digitalisation of transport. The generation, transfer, collection, use and analysis of data are constantly increasing and the use of sensors both on board vehicles but also from the infrastructure and external sources gains a more central role in how the transport systems function. This transformation can provide benefits to the transport system users, including the increase of safety levels at user and system level. The integration or fusion of various categories of sensors in the elements comprising the transport system can potentially provide a more complete and accurate set of data that can be used for enhancing the safety levels and user experience through smart systems and services.

This cluster is based on the following news items:

I10* Sensor fusion and tracking toolbox

I49* Artificial intelligence used for traffic prediction

I66* Interconnected car dash-cameras used to improve urban GPS accuracy

I73* Air quality sensors integrated into active traffic management system

## 3.8 MC_8* Safety, security and use of drones, small scale use/niches calling for regulations

DESCRIPTION* This meta-clusters looks into applications of drones in the transport sector.

This meta-cluster covers the following clusters:

CL_GH_1* Air delivery, drones in everyday life

CL_FP_3* More efficient deliveries that will not necessarily be positive for society

### 3.8.1 CL_GH_1* Air delivery, drones in everyday life

DESCRIPTION* A drone, also known as unmanned aerial vehicle (UAV), offers the advantage of speed, flexibility, and has the potential of not only delivering goods to customers but passengers too (e.g. drone taxi, flying taxi, or pilotless helicopter). Drones offer a wide range of possibilities for the benefit of the European society, ranging from environmental control and security to a fascinating variety of commercial services. They can perform air operations that manned aviation struggle with and their use results in economic savings and environmental benefits, whilst reducing the risk to human life.

This cluster is based on the following news items:

I4* Precision landing kit for drones

I58* New first and last mile transport service

I70* 'Drone train' completes first trial

I98* Commercial delivery drones create noise nuisance for residents

### 3.8.2 CL_FP_3* More efficient deliveries that will not necessarily be positive for society

DESCRIPTION* Drone technology has the potential to help society in many ways: e.g. delivering medicines to remote areas. They can also be used in urban environments for various tasks. For each of these solutions, the potential impacts have to be carefully evaluated and compared to other – often simpler but slower - alternatives. For example, in the case of parcel delivery, abated emissions of road vehicles need to be evaluated against faster delivery and the noise and visual impacts of fleets of drones flying around in future cities.

This cluster is based on the following news items:

I4* Precision landing kit for drones

I74* Autonomous delivery robot

I78* End to end autonomous truck delivery

I98* Commercial delivery drones create noise nuisance for residents

## 3.9 MC_9* Radical solutions to replace cars in urban environment

DESCRIPTION* Better urban infrastructure planning is necessary to improve quality of life in cities (better air quality and noise reduction). This includes the need of more space for pedestrians and cyclists, and increased use of advanced public transport systems. Solutions that can lead to decreased mobility needs can be very disruptive, as they can lead to drastic reductions in emissions due to transportation. One of the areas that can enable these is augmented/virtual reality, where presence in places can be guaranteed digitally.

This meta-cluster covers the following clusters:

CL_FM_2* No car/road vehicle urban mobility

CL_EB_2* Vehicles disruptively reinvented, if not obliterated

### 3.9.1 CL_FM_2* No car/road vehicle urban mobility

DESCRIPTION* Underground and tunnel based mobility are good candidates to replace some public transportation alternatives. As such, they do not contribute to traffic, can travel at higher speeds and can be better scheduled.

This cluster is based on the following news items:

I16* Tunnel based mobility

I39* Loop-based urban mobility solution

I60* Urban flying vehicle study launched

I64* New suspended transport system nears commercial application

I76* India makes advances on world's first passenger hyperloop system

### 3.9.2 CL_EB_2* Vehicles disruptively reinvented, if not obliterated

DESCRIPTION* off-the box thinking can lead to innovations addressing the need for transport/mobility rather than established transport modes.

This cluster is based on the following news items:

I16* Tunnel based mobility

I17* Hyundai unveil a 'walking' car design

I39* Loop-based urban mobility solution

I63* Funding boost for innovative flight concept known as the "Flying-V"

I64* New suspended transport system nears commercial application

I84* roundAround: the world's first dynamic 'bridge' made of autonomous boats

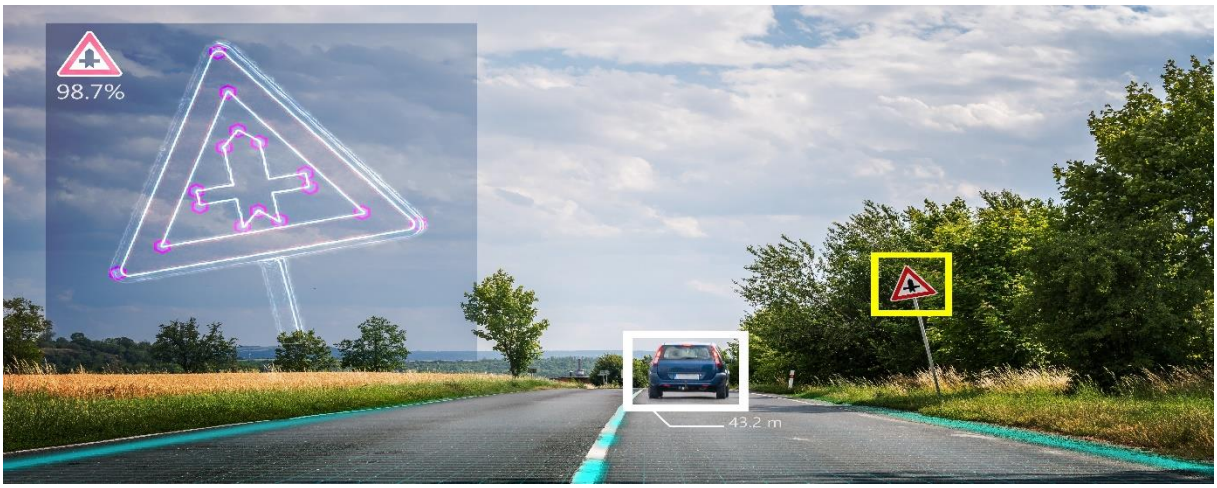
## 3.10 OBS_EB_3* User-based valuation of transport services

DESCRIPTION* User needs and preferences (e.g. in valuing flight punctuality) are becoming increasingly important in shaping transport systems, in addition to more established techno-economic criteria (e.g. maximal utilisation of airport runway capacity).

This observation is based on the following news item:

I9* New scheduling system could help reduce flight delays

## 3.11 CL_BC_5* Connectivity & automation to reduce individual freedom of mobility



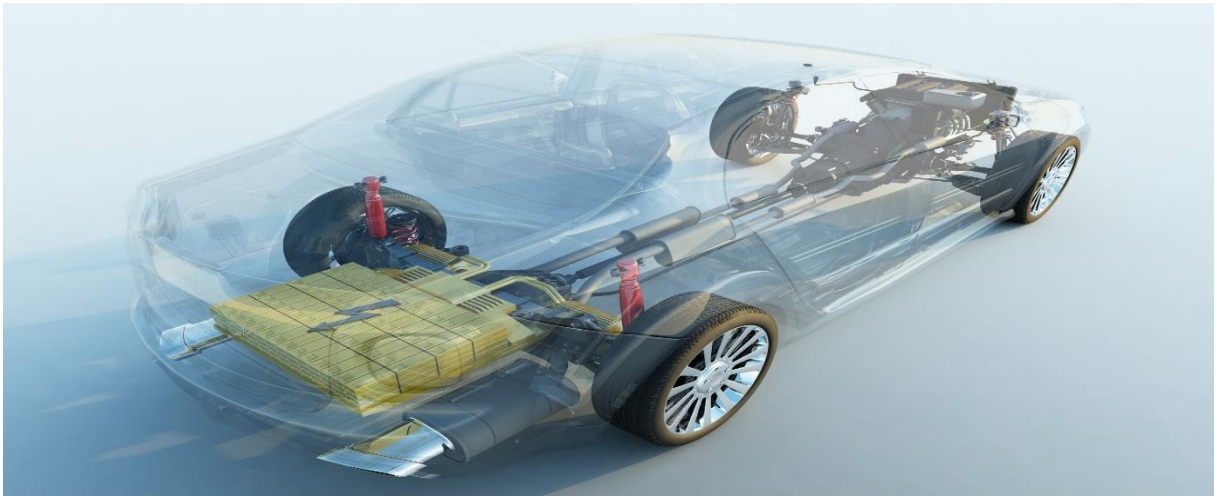

DESCRIPTION* Failure of many greenhouse gas (GHG) reduction policies will require new approaches in the transport sector. Eventually personal mobility could be limited. CAVs (whether electric of hydrogen based) may be a way to implement this. A new governance of road transport, enabled by connectivity and automation may hinder personal vehicle usage reducing the perceived freedom of the road transport system. Social acceptance of this type of solutions will be difficult to achieve but needed to achieve an improved road transport system.

This cluster is based on the following news items:

I11* Surtrac - Intelligent traffic signal control

I42* Smart city concept based on autonomous vehicle fleets

## 3.12 CL_FP_1* Vehicle design for new usage, ownership and business models



DESCRIPTION* Vehicles will have a radically new design for enhanced functions, passenger comfort and safety. Rethinking of vehicle designs will be enabled by EV and CAV developments as well as needs to limit material usage and enhance circularity.

This cluster is based on the following news items:

I14* Autonomous vehicle design begins to change direction

I17* Hyundai unveil a 'walking' car design

I30* Advanced external and internal air-bag design

## 3.13 MC_13* Integrated design innovations for vehicles and their ancillary systems

DESCRIPTION* This meta-cluster covers clusters dealing with alternative designs and alternative approaches to design autonomous vehicles,

This meta-cluster covers the following clusters:

CL_AM_3* Low tech/low cost autonomous vehicles for faster deployment

CL_GH_2* Human vehicle movements

CL_AO_3* Better design that reduces maintenance cost and is carbon free

### 3.13.1 CL_AM_3* Low tech/low cost autonomous vehicles for faster deployment

DESCRIPTION* Compromising on safety (or concerns) to reduce costs & speed-up roll-out.

Safety is presented as the main driver towards autonomous vehicles, preventing humans to interfere (Errare humanum est). However there is no limit to safety, as exemplified by the nuclear industry. Autonomous vehicles tend to increasingly rely on safety features embedded in the vehicle, based on different technologies tested against faults and malign intentions. This questions the ultimate cost of the technology, with potential negative impacts on widespread rollout. To balance this, one could think of a different approach, possibly relying more on system-level safety features such as positioning and imagery, thereby moving away from perfect vehicles towards simpler ones with increasing reliance on their surrounding/ancillary infrastructure.

This cluster is based on the following news items:

I4* Precision landing kit for drones

I15* Street level imagery

I51* System to legally test GPS spoofing vulnerabilities in automated vehicles

### 3.13.2 CL_GH_2* Human vehicle movements

DESCRIPTION* A range of technologies are being explored to allow human flying such as wearing a device like a jet pack, rocket belt, or rocket pack. Jet packs can be worn on the back and use jets of gas or liquid to propel the wearer through the air. Thrust boots include full leg clothing article constructed from a strong material capable of protecting the wearer from projectiles; at least has thrust, fuel, control, stability and at least one sensor associated with thrust boots and capable of detecting the body movement and automatically adjusting to keep them from overpowering the operator with thrust and preventing operator from spinning like a pinwheel instead of flying straight ahead. In addition, the flying or hover car is a type of personal air vehicle or roadable aircraft that provides door-to-door transport by both ground and air. The walking car is a vehicle with robotic legs that is capable of both mammalian and reptilian walking gaits. Such a vehicle can climb walls, step over large gaps and move in any direction – all while keeping its passengers level. Its legs are also retractable, providing a regular driving mode that reduces energy use and allows it to be operated as a normal car. While such human vehicle technologies, which were often a popular theme in fantasy or science fiction, are slowly becoming a reality, technology, operational, legal and social challenges still remain before they become a feasible transport mode.

This cluster is based on the following news items:

I17* Hyundai unveil a 'walking' car design

I60* Urban flying vehicle study launched

### 3.13.3 CL_AO_3* Better design that reduces maintenance cost and is carbon free

DESCRIPTION* This cluster focuses on how the transport system should be designed (e.g. vehicles, infrastructure) to achieve zero carbon emissions and reduce maintenance costs. For instance, how should the road surface be in order to minimise maintenance needs? How can engine design tackle emissions and save energy?

This cluster is based on the following news items:

I1* Piston engine returns as hybrid

I2* Solid-state airplane with no moving parts

I4* Precision landing kit for drones

I10* Sensor fusion and tracking toolbox

I13* Researchers use jiggly Jell-O to make powerful new hydrogen fuel catalyst

I14* Autonomous vehicle design begins to change direction

I17* Hyundai unveil a 'walking' car design

I30* Advanced external and internal air-bag design

I35* 3D printing in the railway sector with Deutsche Bahn

I44* Engineers develop concept for hybrid heavy-duty trucks

I56* GM patent to retro-fit vehicles with autonomous capability

I59* New unmanned ship design

I61* China unveils prototype for new high-speed bullet train

I64* New suspended transport system nears commercial application

I66* Interconnected car dash-cameras used to improve urban GPS accuracy

I72* Highly-efficient compressed air systems for ships

I73* Air quality sensors integrated into active traffic management system

I80* New electric motor could boost efficiency of EVs, scooters, and wind turbines

I82* Innovative valve train in internal combustion engine

I90* Floating cities to cope with rising sea levels

## 3.14 CL_JG_1* Competitiveness losses of leading EU rail manufacturers

DESCRIPTION* There is a potential risk for the EU industry; the EU rail supply industry is a major exporter of rail products, mainly of rolling stock. However, it faces growing competition, particularly from Asia. Developments in high-speed rail (e.g. bullet and Maglev trains in China) and hyperloop systems (e.g. in India) represent a potential market risk for the EU manufacturing industry.

This cluster is based on the following news items:

I61* China unveils prototype for new high-speed bullet train

I76* India makes advances on world's first passenger hyperloop system

I37* Driverless maglev train concept capable of 200km/h

## 3.15 MC_15* Fleet modernisation through retrofitting

DESCRIPTION* This meta-cluster refers to clusters considering retrofitting as an intermediate step towards autonomous vehicles.

This meta-cluster covers the following clusters:

CL_EB_4* Long live old rolling stock

CL_AT_2* Development of retrofitting solutions for transport modernisation

### 3.15.1 CL_EB_4* Long live old rolling stock

DESCRIPTION* Train wagons are resource-intensive infrastructure items, which often have longer operational life than associated systems (e.g. energy supply) or components. Ingenious ways to retrofit train wagons may range from user-oriented refurbishment (e.g. design interiors, ubiquitous WiFi and USB chargers, wheel chair toilets) to technical systems such as power supply/storage and to replacement of parts no longer available off-the shelf. Furthermore, retrofitting for autonomous capability could help pave the way for wider lower-cost deployment of autonomous vehicles.

This cluster is based on the following news items:

I35* 3D printing in the railway sector with Deutsche Bahn

I55* UK underground trains retro-fitted with fuel cells

I56* GM patent to retro-fit vehicles with autonomous capability

### 3.15.2 CL_AT_2* Development of retrofitting solutions for transport modernisation

DESCRIPTION* New retrofitting solutions are being developed that can have an application on existing fleets; new propulsion options or autonomous capabilities. Retrofitting solutions can be of relevance to various domains within the transport sector, ranging from low emission alternative energy and electrification to smart mobility and cooperative, connected and automated transport.

This cluster is based on the following news items:

I55* UK underground trains retro-fitted with fuel cells

I56* GM patent to retro-fit vehicles with autonomous capability

## 3.16 CL_FM_1* Alternative propulsion for aircraft

DESCRIPTION* To decrease emissions in air transportation, radical changes in propulsion should arise. This clusters also include new fuels for aviation.

This cluster is based on the following news items:

I2* Solid-state airplane with no moving parts

I8* Hybrid-electric aircraft performance tests

I23* BUSBOT - Solar powered information technology

I29* Hydrogen fuel cell regional passenger aircraft

I85* Plans to develop a state-of-the-art hybrid-electric aircraft

## 3.17 MC_17* Electrification and escalation of power demand

DESCRIPTION* Transport electrification entails significant challenges (e.g. emissions, security-of-supply) that need to be well understood, reliably assessed and honestly communicated.

This meta-cluster covers the following clusters:

CL_EB_5* Traction power demand escalating

CL_AO_2* Need for more sustainable energy (such as clean electricity)

### 3.17.1 CL_EB_5* Traction power demand escalating

DESCRIPTION* Demand for traction power is rapidly and globally escalating, with renewable electricity often proposed as a sustainable solution even though it is not always clear if or how renewable electricity can indeed provide (all) the required traction power.

This cluster is based on the following news items:

I46* Will solar PV power the railways of the future?

I48* Port-Liner's fully electric autonomous container barges to launch this August

### 3.17.2 CL_AO_2* Need for more sustainable energy (such as clean electricity)

DESCRIPTION* Decarbonisation of energy supply has to gain momentum by more use of solar, wind and water-based electricity production, combined with advanced electricity storage systems by batteries or hydrogen fuel cells to achieve carbon free transport and reduce pollutant emissions. The whole life carbon footprint must be considered as well as circular economy for all technologies. For all upcoming technologies/solutions a proper cradle to grave analysis is required, including recycling options for the materials. For instance, batteries for electric cars can lead to zero emissions when running a vehicle, but the energy used may not necessarily be green, while if the batteries cannot be recycled or reused they could become an environmental challenge.

This cluster is based on the following news items:

I1* Piston engine returns as hybrid

I2* Solid-state airplane with no moving parts

I4* Precision landing kit for drones

I10* Sensor fusion and tracking toolbox

I13* Researchers use jiggly Jell-O to make powerful new hydrogen fuel catalyst

I14* Autonomous vehicle design begins to change direction

I17* Hyundai unveil a 'walking' car design

I30* Advanced external and internal air-bag design

I35* 3D printing in the railway sector with Deutsche Bahn

I44* Engineers develop concept for hybrid heavy-duty trucks

I56* GM patent to retro-fit vehicles with autonomous capability

I59* New unmanned ship design

I61* China unveils prototype for new high-speed bullet train

I64* New suspended transport system nears commercial application

I66* Interconnected car dash-cameras used to improve urban GPS accuracy

I72* Highly-efficient compressed air systems for ships

I73* Air quality sensors integrated into active traffic management system

I80* New electric motor could boost efficiency of EVs, scooters, and wind turbines

I82* Innovative valve train in internal combustion engine

I90* Floating cities to cope with rising sea levels

## 3.18 MC_18* Reduction of maritime pollution

DESCRIPTION* Maritime transport has been steadily increasing worldwide in recent decades due to the globalisation-driven growing sea shipping of freight and cruise ship boom. Thus, the use of cleaner fuels (ban of heavy crude oil) and new technologies in maritime transport could be an important future trend.

This meta-cluster covers the following clusters:

OBS_RL_2* Maritime/shipping transport causes a fair share of pollution

OBS_FP_4* Autonomous ships to be rolled out

### 3.18.1 OBS_RL_2* Maritime/shipping transport causes a fair share of pollution

DESCRIPTION* Shipping is one of the main causes of air pollution in Europe. The emissions of seagoing vessels affect the environment, health and climate. In particular, sulphur oxides ($SO_x$), particulates (including soot) and nitrogen oxides ($NO_x$) pollute the ecosystems, contributing, for example, to the acidification and eutrophication of the oceans, and air pollution in seaport cities.

The exhaust gases of vessels can be cleaned in exhaust wet cleaning after-treatment systems, called scrubbers, on board the ship through finely sprayed water (technology is available).

In the near future, more liquefied natural gas (LNG)-powered cruise ships will be built because it is cheaper to use than gasoline or petroleum. LNG is easier and cleaner to use in engines, meaning less time is spent on engine maintenance. Moreover, it is far less harmful to the environment when burned in engines. LNG

releases absolutely zero sulphur, and less particulate, $NO_x$, and GHG emissions. Engines that are designed for and use LNG won't need to also install scrubber systems or pay high prices for low sulphur fuel[2].

Furthermore, hydrogen fuel cells technology is likely becoming viable in the maritime sector within five years[3].

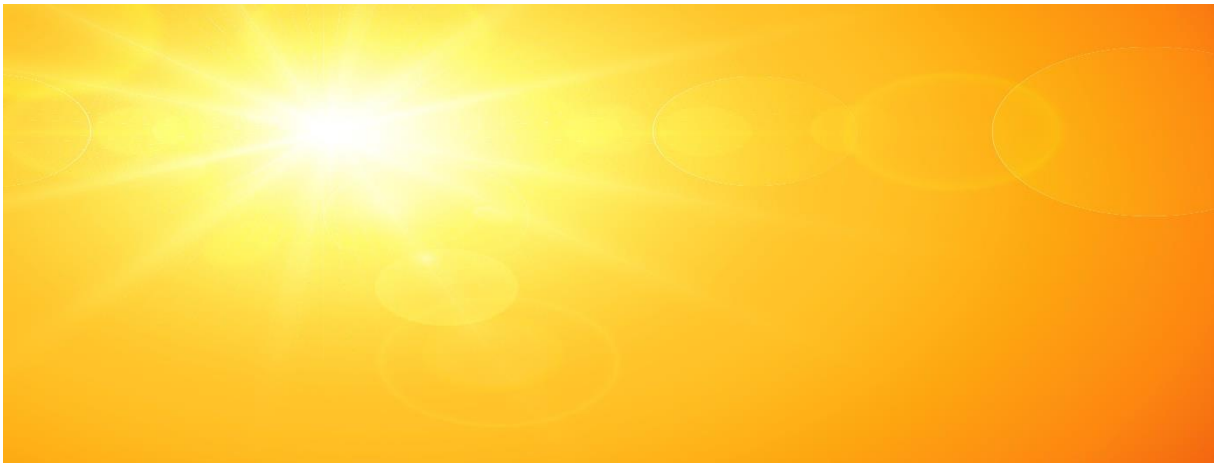
This observation has not been linked to specific news items but refers to important developments.

### 3.18.2 OBS_FP_4* Autonomous ships to be rolled out

DESCRIPTION* Autonomous ships to be rolled out in order to decrease environmental impact of shipping and hardship in employment, especially in maritime transport.

This observation has not been linked to specific news items but refers to important developments.

## 3.19 MC_19* Renewables (solar/wind) for direct propulsion instead of fuel



DESCRIPTION* This meta-cluster bundles together clusters related to alternative power sources of mobility. As low oil prices and increasing power prices are a significant threat to the further uptake of alternative fuels, on-board power generation from renewable sources could lead to a crucial break-through.

This meta-cluster covers the following clusters:

CL_AT_3* Solar photovoltaics as a solution for individual electrified applications

CL_FP_5* Lifecycle analysis on vehicle design

CL_RL_3* Wind propulsion for ships

### 3.19.1 CL_AT_3* Solar photovoltaics as a solution for individual electrified applications

DESCRIPTION* With the rise of transport electrification and the latest advances in photovoltaics (PV) technologies, the use of the latter can provide a solution both for static recharging applications but also in mobile applications being featured on vehicles. Applications of vehicles that use PV to provide range extension are already available but their evolution could have an impact on all transport modes supporting further transport electrification.

This cluster is based on the following news items:

I46* Will solar PV power the railways of the future?

I53* Solar-powered electric forecourts will charge EVs in 10 minutes

I75* Efficient solar roof for electric cars

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[2] https://www.umweltbundesamt.de/themen/wasser/gewaesser/meere/nutzung-belastungen/schifffahrt#textpart-1

[3] https://www.rivieramm.com/news-content-hub/news-content-hub/hydrogen-fuel-cells-becoming-viable-in-maritime-sector-56714

### 3.19.2 CL_FP_5* Lifecycle analysis on vehicle design

DESCRIPTION* Goal of reducing the overall environmental impact of transport and introduce vehicles that have not only low in-use impacts, but also minimised production and end-of-life impacts.

This cluster is based on the following news items:

I62* Wind propulsion for passenger ships

I69* Wind propulsion cruise ship

I75* Efficient solar roof for electric cars

I80* New electric motor could boost efficiency of EVs, scooters, and wind turbines

### 3.19.3 CL_RL_3* Wind propulsion for ships

DESCRIPTION* Novel wind propulsion systems are being introduced in waterborne transport applications as an alternative to common practices using fossil fuel towards a decarbonised transport system. For example, "*Tres Hombres Shipping*" from the Netherlands claims to be the world's first modern "emission free" shipping company, which transports already since 10 years cargo 99 % emission free over sea and have a focus on products which do not compete with local produce[4]. "*Sailcargo*", based in Costa Rica, is building and will operate a combustion-free cargo sailing vessel by synthesising old-world ship building techniques with avant-garde energy and propulsion systems design[5]. Moreover, "*Star Clippers*" runs three modern luxury wind driven cruise ships[6].

This cluster is based on the following news items:

I62* Wind propulsion for passenger ships

I69* Wind propulsion cruise ship

## 3.20 CL_AT_4* Waste, by-products and natural elements for fuels

DESCRIPTION* Low-emission alternative energy for transport is one potential lever towards transport decarbonisation. The use of alternative sources of energy is being researched entering also other scientific domains not necessarily closely linked to transport.

This cluster is based on the following news items:

I7* Renewable diesel blend stocks from wet bio-waste

I18* Discovery adapts natural membrane to make hydrogen fuel from water

I19* New sustainable way to turn forestry waste into transport fuels and chemicals

[4] https://www.treshombres.eu
[5] https://www.sailcargo.org
[6] https://www.starclippers.com

I40* Interest grows in waste-to-energy for cruise liners, as new solutions emerge

I41* Plant scraps are the key ingredient in cheap, sustainable jet fuel

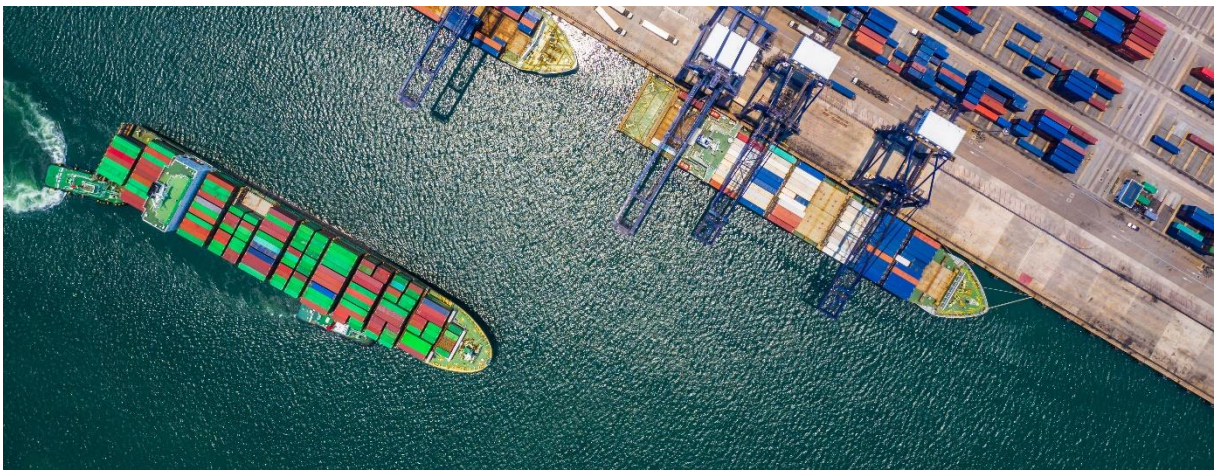
I65* Carbon-neutral fuel made from sunlight and air

## 3.21 OBS_BC_3* Social differentiation/disparities

DESCRIPTION* AI and automation powered gadgets could increase the gap between social classes. The poorest parts of our society could struggle even more as low level jobs are replaced by robots. Violence could explode. This observation aims at preventing transport options from exacerbating inequalities.

This observation has not been linked to specific news items but refers to important developments.

## 3.22 CL_FP_6* Autonomous ships



DESCRIPTION* Autonomous ships will be rolled out, making sailors' hard jobs unnecessary, especially on maritime routes, decreasing environmental impacts of shipping and increasing safety.

This cluster is based on the following news items:

I38* World's first fully autonomous freight ship

I48* Port-Liner's fully electric autonomous container barges to launch this August

I55* UK underground trains retro-fitted with fuel cells

I84* roundAround: the world's first dynamic 'bridge' made of autonomous boats

## 3.23 MC_23* Automation to maintain current system with less externalities


DESCRIPTION* This meta-clusters looks at the economics of transitioning towards automated transport.

This meta-cluster covers the following clusters:

CL_GH_4* Different autonomous vehicles

CL_AO_4* Enhance automation and autonomous transport

### 3.23.1 CL_GH_4* Different autonomous vehicles

DESCRIPTION* This cluster refers to all news articles dealing with automated transport, addressing fleets, vehicles and equipment.

This cluster is based on the following news items:

I56* GM patent to retro-fit vehicles with autonomous capability

I71* Autonomous following trucks

I74* Autonomous delivery robot

I77* Autonomous pick up parking system

I78* End to end autonomous truck delivery

### 3.23.2 CL_AO_4* Enhance automation and autonomous transport

DESCRIPTION* This cluster focuses on the impact of removing human errors from transport through the introduction of new technologies and automation. A series of externalities, triggered by humans, could be avoided, as for instance in the cases of congestion due to user behaviour or of road accidents. Fatalities related to the use or maintenance of transport infrastructures could also be avoided.

This cluster is based on the following news items:

I1* Piston engine returns as hybrid

I20* Boeing’s autonomous passenger air vehicle completes first flight

I25* Self-driving cars, robots: Identifying AI 'blind spots'

I37* Driverless maglev train concept capable of 200km/h

I38* World's first fully autonomous freight ship

I42* Smart city concept based on autonomous vehicle fleets

I47* Autonomous vehicle testing in the UK to be powered by O2’s 5G network

I48* Port-Liner’s fully electric autonomous container barges to launch this August

I51* System to legally test GPS spoofing vulnerabilities in automated vehicles

I71* Autonomous following trucks

I74* Autonomous delivery robot

I77* Autonomous pick up parking system

I78* End to end autonomous truck delivery

I88* People are renting cars but not driving them

## 3.24 CL_AT_5* Unorthodox modelling & testing for autonomous vehicles

DESCRIPTION* Many novel transport-related applications go beyond traditional solutions both in terms of performance or user involvement (e.g. autonomous and automated mobility) that existing testing or certification methods cannot necessarily cover. In this context, innovative methods for testing and certifying innovative technologies can provide support towards faster progress and deployment.

This cluster is based on the following news items:

I16* Tunnel based mobility

I25* Self-driving cars, robots: Identifying AI 'blind spots'

I47* Autonomous vehicle testing in the UK to be powered by O2's 5G network

I51* System to legally test GPS spoofing vulnerabilities in automated vehicles

I54* System to fill the gaps of information from connected cars

I68* Cellular vehicle to everything project

I79* Georgia to trial Panasonic's V2X platform along 'The Ray' I-85 testbed

The following table summarises the outcome of the workshop, namely the positioning of meta-clusters on time horizon and STRIA roadmaps: Their interconnections are investigated by means of network maps, while those highlighted were prioritised and analysed in depth.

**Table 1.** Mapping of meta-clusters according to STRIA roadmap and time horizon

| Time horizon | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Long term >10y.** | OBS_BC_3 | MC_19 | | **MC_23** | **MC_9** | CL_EB_1<br>CL_FM_3 MC_3 | OBS_BC_2 |
| | **Medium term 5-10y.** | CL_FP_6 | CL_AT_4 | **MC_17** | **MC_15**<br>CL_FP_1 | CL_BC_5 | CL_MCG_3<br>MC_7 | |
| | **Short term <5y.** | CL_AT_5 | MC_18 CL_FM_1 | | MC_13 CL_JG_1 | OBS_EB_3 | MC_8 MC_1 | |
| | | **CAT** | **ALT** | **ELT** | **VDM** | **NTM** | **SMO** | **INF** |
| | | **STRIA roadmaps** | | | | | | |

List of meta-clusters (prioritised in bold)

MC_1* Insurance as enabler for new technologies

CL_BC_1* Weather extreme events to impact mobility

MC_3* Individualisation, diversification and interconnection of transport modes for minimising efforts and time

CL_FM_3* Widening the scope of aviation - moving closer to urban mobility

CL_EB_1* Hope or hype?

CL_MCG_3* Opening of markets to new passengers and users

MC_7* Artificial intelligence leading to optimisation at system level

MC_8* Safety, security and use of drones, small scale use/niches calling for regulations

**MC_9* Radical solutions to replace cars in urban environments**

OBS_EB_3* User-based valuation of transport services

CL_BC_5* Connectivity & automation to reduce individual freedom of mobility

CL_FP_1* Vehicle design for new usage, ownership and business model

MC_13* Integrated design innovations for vehicles and their ancillary systems

CL_JG_1* Competitiveness losses of leading EU rail manufacturers

**MC_15* Fleet modernisation through retrofitting**

CL_FM_1* Alternative propulsion for aircraft

**MC_17* Electrification and escalation of power demand**

MC_18* Reduction of maritime pollution

MC_19* Renewables (solar/wind) for direct propulsion instead of fuel

CL_AT_4* Waste, by-products and natural elements for fuels

OBS_BC_3* Social differentiation/disparities

CL_FP_6* Autonomous ships

**MC_23* Automation to maintain current system with less externalities**

CL_AT_5* Unorthodox modelling & testing for autonomous vehicles

Source: JRC, 2019.

# 4 Prioritised meta-clusters results

The meta-clusters that were prioritised by the workshop participants after the final positive voting were further processed and analysed by ad hoc created participant groups according to their respective backgrounds. A realistic and an extreme scenario were developed for each meta-cluster and potential consequences were identified as a future scenario. The four prioritised subjects are presented below.

## 4.1 Fleet modernisation through retrofitting

Realistic

Development of more solutions with relevance to automated and electric vehicles, but at a limited pace and scale with limited uptake: still at niche level.

Extreme

The impacts of an economic recession or low car sales could make retrofitting solutions much more attractive.

Consequences

- Low impact at realistic scenario.
- Central and local governments to provide incentives for retrofitting to upgrade the existing vehicle stock.
- Link to insurance schemes. Insurance policies to be readjusted according to each vehicle type of upgrade.

## 4.2 Electrification and escalation of power demand

Realistic

Gradual uptake of electric vehicles, accompanied by continued decarbonisation of power generation. Capacity will still be able to serve demand without any radical changes (increase of solar and wind energy production).

Extreme

Much faster electric vehicle uptake that will cause demand to increase radically with an impact on power generation and the grid. Risk of potential increase of fossil fuel use since low emission alternatives will not be sufficient to cover the increased demand.

Consequences

- Price increases
- Air quality issues and rise of GHG emissions caused at extreme scenario due to the increase of fossil fuel consumption for power generation
- Policy measures for immediate decarbonisation to become necessary (e.g. European Green Deal)
- Incentives for low-emission alternative fuels for power generation to become necessary
- Higher taxation of electricity and higher costs
- Increased inequalities because of higher costs
- Higher incomes for companies and organisations related to electricity

## 4.3 Radical solutions to replace cars in urban environments

Realistic

Minimising or replacing car use in urban areas can play a key role towards transport decarbonisation. This transition will require the adoption of solutions that will lead to a paradigm shift in urban mobility and transport. This transition will be based on an increased use of public transport and green modes, including the adoption of traffic calming measures, the creation of more pedestrian zones and better bicycle infrastructure in city centres. New business models can also have a supporting role in minimising the need for movement or the use of private cars (e.g. increased teleworking or the use of car sharing for trips outside centres). Measures focusing on car ownership and use can also have a significant role (e.g. increased car use taxation, road pricing, lower speed limits).

Extreme

In an extreme scenario, radical measures could remove cars from urban centres. A ban in the use of cars in cities could be one solution, while another would be the channelling of all cars towards underground/tunnel mobility. On the other hand, these measures would trigger a high increase of public transport and mass transport that should be accompanied by appropriate measures to ensure high levels of service and user satisfaction.

Consequences

- Change in city centre retail business (it could be more if more people walk on the streets, potential buyers, or less if the access is too difficult)
- Higher house value in city centre.
- Higher value of parking spaces
- Car users must plan ahead
- Increase use of public transport
- Less air and noise pollution
- Less total traffic in city
- More green and public spaces

## 4.4 Automation to maintain current system with less externalities

Realistic

Higher vehicle automation will come with higher market price, while the trend of moving from privately-owned vehicles to higher mobility as a service/car sharing will continue. Fully automated vehicles will be available on the market only in the long run. This transition will require more/different rules and regulations (e.g. who is responsible in case of an accident), more testing facilities, higher awareness of cutting edge technology, and higher original equipment manufacturer (OEM) investment in research and innovation.

Extreme

Everyone will own a fully automated car that is very cheap in an extreme but not necessarily positive scenario. Following another course, automation can lead to absence of privately-owned vehicles and less vehicles on the road, thus leading to overall less externalities, including no congestion, less pollution, almost disappearance of accidents and economic benefits including lower insurance prices.

Consequences

- Risk of higher inequalities
- Risk of higher congestion, which might trigger health related issues
- Higher security risks (e.g. for health, political and extreme events)
- Change in travel time behaviour, increase in commuting distances (i.e. increase in number of km travelled)

# 5 Conclusions

TRIMIS is an open-access transport policy-support tool developed and managed by the JRC to support the implementation of STRIA. One of the main objectives of TRIMIS is to provide a forward-oriented support to transport research and innovation governance by using foresight in its technological and socioeconomic assessment process related to transport R&I.

The JRC has already developed, inter alia, a capacity for foresight through a horizon scanning exercise that aims to support policy making at European level. Within the TRIMIS framework, horizon scanning is applied through a structured and systematic collaborative exercise that contributes to the identification of new and emerging transport-related technologies and trends, with a potential future impact on the transport sector. Furthermore, it supports the assessment of current and future research needs, and provides transport related insights to the broader European Commission foresight system contributing to a higher-level strategic framework also covering the transport domain.

As part of this process, on 26 September 2019 the TRIMIS team, with support from the Unit for Knowledge Management and the EU Policy Lab of the JRC organised the 1st TRIMIS Horizon Scanning Session. It aimed at gathering insights from various transport experts with different backgrounds and make sense of previously collected, transport-related horizon scanning items through a process that could provide indications on relevant trends, new drivers of change, weak signals, discontinuities or shocks/'wild cards'/sudden unexpected events/'black swans'.

The goal is to provide useful technical insights regarding emerging trends and evaluate the potential of transport technologies. The session outcomes presented in this report will also serve as a basis for discussion with policy/decision-makers that would like to incorporate further forward-oriented elements in their activities. The results of this foresight process will inform policies related to transport R&I by highlighting trends in transport innovation.

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## List of abbreviations and definitions

| | |
|---|---|
| 3D | Three-Dimensional |
| 5G | 5th Generation Mobile Communications Technology |
| AI | Artificial Intelligence |
| ALT | Low-Emission Alternative Energy for Transport |
| AV | Automated Vehicle |
| CAT | Cooperative, Connected and Automated Transport |
| CAV | Connected and Automated Vehicle |
| CCAM | Cooperative, Connected and Automated Mobility |
| CL | Cluster |
| DG MOVE | Directorate-General for Mobility and Transport |
| DG RTD | Directorate-General for Research and Innovation |
| EC | European Commission |
| ELT | Transport Electrification |
| EU | European Union |
| EV | Electric Vehicle |
| GHG | Greenhouse Gas |
| GM | General Motors |
| GPS | Global Positioning System |
| HGV | Heavy Goods Vehicle |
| I | Item |
| INF | Transport Infrastructure |
| JRC | Joint Research Centre |
| LNG | Liquefied Natural Gas |
| MC | Meta-Cluster |
| $NO_x$ | Nitrogen Oxides |
| NTM | Network and Traffic Management Systems |
| OBS | Observation |
| OEM | Original Equipment Manufacturer |
| PV | Photovoltaics |
| R&I | Research and Innovation |
| SMO | Smart Mobility and Services |
| $SO_x$ | Sulphur Oxides |
| STRIA | Strategic Transport Research and Innovation Agenda |
| TRIMIS | Transport Research and Innovation Monitoring and Information System |
| UAV | Unmanned Aerial Vehicle |
| UK | United Kingdom |
| V2X | Vehicle-to-Everything |
| VDM | Vehicle Design and Manufacturing |

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## Annexes

### Annex I. List of horizon scanning items

1 Piston engine returns as hybrid

2 Solid-state airplane with no moving parts

3 Portable rapid EV Charger

4 Precision landing kit for drones

5 Pop-Up on street EV chargers

6 Connected kerb EV charger

7 Renewable diesel blendstocks from wet bio-waste

8 Hybrid-electric aircraft performance tests

9 New scheduling system could help reduce flight delays

10 Sensor fusion and tracking toolbox

11 Surtrac - Intelligent traffic signal control

12 Blackberry traffic technology service

13 Researchers use jiggly Jell-O to make powerful new hydrogen fuel catalyst

14 Autonomous vehicle design begins to change direction

15 Street level imagery

16 Tunnel based mobility

17 Hyundai unveil a 'walking' car design

18 Discovery adapts natural membrane to make hydrogen fuel from water

19 New sustainable way to turn forestry waste into transport fuels and chemicals

20 Boeing autonomous passenger air vehicle completes first flight

21 Drones shown to make traffic crash site assessments safer, faster and more accurate

22 Carbon-Ion battery delivers ultra-fast charging & zero degradation

23 BUSBOT - Solar powered information technology

24 Block-VN: A distributed blockchain based vehicular network architecture in smart city

25 Self-driving cars, robots: Identifying AI 'blind spots'

26 Tesla patents new battery cell for faster charge, better longevity, and lower cost

27 Electric road systems trial for HGVs in Germany

28 Hydrogen fuel cell HGV designed specifically for Europe

29 Hydrogen fuel cell regional passenger aircraft

30 Advanced external and internal air-bag design

31 Expanding the use of silicon in batteries, by preventing electrodes from expanding

32 Energy-storing carbon fibre finds use in automotive sector

33 Route to carbon-negative cars

34 Fuel-cell technology with double the voltage

35 3D printing in the railway sector with Deutsche Bahn

36 Weather-responsive intersections could ease traffic congestion

37 Driverless maglev train concept capable of 200km/h

38 World's first fully autonomous freight ship
39 Loop-based urban mobility solution
40 Interest grows in waste-to-energy for cruise liners, as new solutions emerge
41 Plant scraps are the key ingredient in cheap, sustainable jet fuel
42 Smart city concept based on autonomous vehicle fleets
43 Maritime fuel cell propulsion will need electric optimisation
44 Engineers develop concept for hybrid heavy-duty trucks
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46 Will solar PV power the railways of the future?
47 Autonomous vehicle testing in the UK to be powered by O2's 5G network
48 Port-Liner's fully electric autonomous container barges to launch this August
49 Artificial intelligence used for traffic prediction
50 Active safety features in passenger vehicles
51 System to legally test GPS spoofing vulnerabilities in automated vehicles
52 AI cuts Dubai bus accidents by more than half
53 Solar-powered electric forecourts will charge EVs in 10 minutes
54 System to fill the gaps of information from connected cars
55 UK underground trains retro-fitted with fuel cells
56 GM patent to retro-fit vehicles with autonomous capability
57 New manganese hydride molecular sieve hydrogen storage technology
58 New first and last mile transport service
59 New unmanned ship design
60 Urban flying vehicle study launched
61 China unveils prototype for new high-speed bullet train
62 Wind propulsion for passenger ships
63 Funding boost for innovative flight concept known as the "Flying-V"
64 New suspended transport system nears commercial application
65 Carbon-neutral fuel made from sunlight and air
66 Interconnected car dash-cameras used to improve urban GPS accuracy
67 In-cabin monitoring with radar
68 Cellular vehicle to everything project
69 Wind propulsion cruise ship
70 'Drone train' completes first trial
71 Autonomous following trucks
72 Highly-efficient compressed air systems for ships
73 Air quality sensors integrated into active traffic management system
74 Autonomous delivery robot
75 Efficient solar roof for electric cars
76 India makes advances on world's first passenger hyperloop system

77 Autonomous pick up parking system
78 End to end autonomous truck delivery
79 Georgia to trial Panasonic's V2X platform along 'The Ray' I-85 testbed
80 new electric motor could boost efficiency of EVs, scooters, and wind turbines
81 Cost-effective fuel cell technology
82 Innovative valve train in internal combustion engine
83 Smart ticketing for rail travel
84 roundAround: the world's first dynamic 'bridge' made of autonomous boats
85 Plans to develop a state-of-the-art hybrid-electric aircraft
86 Hydrogen from nuclear power could be a new source of low carbon energy
87 Blue Moon lunar lander promised for a 2024 delivery
88 People are renting cars but not driving them
89 Terminal tourism - plane spotting, restaurants, art also lure non-travellers
90 Floating cities to cope with rising sea levels
91 Safe car wash app for modern day slavery
92 Brain controlled film
93 Green strategies for cities are causing 'ecological gentrification'
94 From experience to transformational economy
95 Ecological grief
96 Plastic to ride: Indonesians swap bottles for bus tickets
97 Man-made moon to shed light on Chengdu in 2020
98 Commercial delivery drones create noise nuisance for residents

## Annex II. Links and interconnections between meta-clusters, clusters and observations

During the workshop, participants' aggregated news items into clusters and observations. Those were subsequently aggregated into meta-clusters, as reported in chapter 3. However, these outputs (meta-clusters, clusters and observations) may further relate to each other. The following tables summarises possible links between the various outputs of the workshop, also outside the structure of chapter 3.

**Table 2.** Links between meta-clusters, clusters and observations

| | MC_1 | CL_AM_1 | CL_AM_2 | OBS_MCG_1 | CL_BC_1 | MC_3 | CL_FP_2 | OBS_BC_2 | CL_MCG_2 | CL_AO_1 | OBS_BC_4 | CL_FM_3 | CL_EB_1 | CL_MCG_3 | MC_7 | CL_MCG_4 | CL_AT_1 | CL_AT_6 | MC_8 | CL_GH_1 | CL_FP_3 | MC_9 | CL_FM_2 | CL_EB_2 | OBS_EB_3 | CL_BC_5 | CL_FP_1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MC_1** | | X | X | X | | | | | | | | | | | | | | | X | X | | | | X | | | |
| **CL_AM_1** | X | | X | | X | | | | | | | | X | | | | | | | | | | | | | | |
| **CL_AM_2** | X | X | | X | X | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_MCG_1** | X | | X | | | | | | | | | | | | | | | | X | | | | | | | | |
| **CL_BC_1** | | X | X | | | | | | | X | | X | | X | | | | | X | | | X | X | | | | X |
| **MC_3** | | | | | | | X | X | X | X | X | | X | X | X | | | | X | | | X | | | X | X | X |
| **CL_FP_2** | | | | | | X | | X | X | | X | | | | | | | | | | | | | | | X | |
| **OBS_BC_2** | | | | | | X | X | | | | | | X | | X | | | | X | | | | | | | | X |
| **CL_MCG_2** | | | | | | X | X | | | | | | | | | | | | X | | X | | | | | | |
| **CL_AO_1** | | | | | X | X | | | | | | | | | X | | | | | | | | | | | X | |
| **OBS_BC_4** | | | | | | X | X | | | | | | X | | X | | | | X | | | | | | | X | X |
| **CL_FM_3** | | | | | X | | | | | | | | | | X | | | | X | X | | X | | | | | |
| **CL_EB_1** | | X | | | | X | | X | | | X | | | | | | | | | | | | | X | | | |
| **CL_MCG_3** | | | | | X | X | | | | | | | | | X | | | | | | | | | | X | | |
| **MC_7** | | | | | | X | | X | | X | X | X | | X | | X | X | X | | | | | X | | X | X | |
| **CL_MCG_4** | | | | | | | | | | | | | | | X | | | | X | | | | | | | | |
| **CL_AT_1** | | | | | | | | | | | | | | | X | | | | | | | | | | | | X |
| **CL_AT_6** | | | | | | | | | | | | | | | X | | | | | | | | | | | | X |
| **MC_8** | X | | | X | X | X | | X | X | | X | X | | | | X | | | | X | X | X | X | X | | | |
| **CL_GH_1** | X | | | | | | | | | | | X | | | | | | | X | | | X | | | | | |
| **CL_FP_3** | | | | | | | | | X | | | | | | | | | | X | | | | | | | | |
| **MC_9** | | | | | X | X | | | | | | X | | | | | | | X | X | | | X | X | | X | |
| **CL_FM_2** | | | | | X | | | | | | | | | | X | | | | X | | | X | | | | | |
| **CL_EB_2** | X | | | | | | | | | | | | X | | | | | | X | | | X | | | | | X |
| **OBS_EB_3** | | | | | | X | | | | | | | | X | X | | | | | | | | | | | X | |
| **CL_BC_5** | | | | | | X | X | | | X | X | | | | X | | | | | | | X | | | X | | X |
| **CL_FP_1** | | | | | X | X | | X | | | X | | | | | | X | X | | | | | | X | | X | |
| **MC_13** | | X | | | X | | | X | | | | | | | X | | X | X | X | X | | X | | X | | | |
| **CL_AM_3** | X | | | | | | | | | | | | | | X | | | | X | | | | | | | | |
| **CL_GH_2** | X | | | | | X | | | | | | | | | | | | | X | | | X | | | | | |
| **CL_AO_3** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_JG_1** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MC_15** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_EB_4** | | | | | | | | | | | | | | | | | | | | | | | | | | | X |

| | MC_1 | CL_AM_1 | CL_AM_2 | OBS_MCG_1 | CL_BC_1 | MC_3 | CL_FP_2 | OBS_BC_2 | CL_MCG_2 | CL_AO_1 | OBS_BC_4 | CL_FM_3 | CL_EB_1 | CL_MCG_3 | MC_7 | CL_MCG_4 | CL_AT_1 | CL_AT_6 | MC_8 | CL_GH_1 | CL_FP_3 | MC_9 | CL_FM_2 | CL_EB_2 | OBS_EB_3 | CL_BC_5 | CL_FP_1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CL_AT_2** | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **CL_FM_1** | | | | | | | | | | | | X | | | | | | | X | | | X | | | | | |
| **MC_17** | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| **CL_EB_5** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AO_2** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MC_18** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_RL_2** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_FP_4** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MC_19** | | | | | | | | | | | | | X | | | | | | | | | | | | | | |
| **CL_AT_3** | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **CL_FP_5** | | | | | | | | | | | | | | | | | | | | | | | | | | X | |
| **CL_RL_3** | | | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **CL_AT_4** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_BC_3** | | | | | | X | | | | | | | | X | | | | | | | | | | | X | X | |
| **CL_FP_6** | | | | | | | | X | | | | | | | | | | | | | | | | | | | |
| **MC_23** | | | | | | | | X | | | X | | X | | | | | | | | | | | | | | |
| **CL_GH_4** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AO_4** | | | | | | X | | | | | | | X | | X | | | | | | | | | | | X | |
| **CL_AT_5** | | | | | X | | | X | | | | | | | | | | | X | X | | | | | | X | X |

Source: JRC, 2019.

**Table 3.** Links between meta-clusters, clusters and observations (follow).

| | MC_13 | CL_AM_3 | CL_GH_2 | CL_AO_3 | CL_JG_1 | MC_15 | CL_EB_4 | CL_AT_2 | CL_FM_1 | MC_17 | CL_EB_5 | CL_AO_2 | MC_18 | OBS_RL_2 | OBS_FP_4 | MC_19 | CL_AT_3 | CL_FP_5 | CL_RL_3 | CL_AT_4 | OBS_BC_3 | CL_FP_6 | MC_23 | CL_GH_4 | CL_AO_4 | CL_AT_5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MC_1** | | X | X | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AM_1** | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AM_2** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_MCG_1** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_BC_1** | X | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **MC_3** | | | X | | | | | | | | | | | | | | | | | | X | | | | X | |
| **CL_FP_2** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_BC_2** | X | | | | | | | | | | | | | | | | | | | | | X | X | | | X |
| **CL_MCG_2** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AO_1** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_BC_4** | | | | | | | | | | | | | | | | | | | | | | X | | | | |
| **CL_FM_3** | | | | | | | | | X | | | | | | | | | | | | | | | | | |
| **CL_EB_1** | | | | | | | | | | X | | | | | | X | | | | | | X | | X | | |
| **CL_MCG_3** | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| **MC_7** | X | X | | | | | | | | | | | | | | | | | | | | | | | X | |
| **CL_MCG_4** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AT_1** | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AT_6** | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MC_8** | X | X | X | | | | | | X | | | | | | | | | | | | | | | | | X |
| **CL_GH_1** | X | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **CL_FP_3** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **MC_9** | X | | X | | | | | | X | | | | | | | | | | | | | | | | | |
| **CL_FM_2** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_EB_2** | X | | | | | | | | | | | | | | | | | | | | | | | | | |
| **OBS_EB_3** | | | | | | | | | | | | | | | | | | | | | X | | | | | |
| **CL_BC_5** | | | | | | | | | | | | | | | | | | X | | | X | | | | X | X |
| **CL_FP_1** | | | | | | | X | X | | | | | | | | | X | | X | | | | | | | X |
| **MC_13** | | X | X | X | | | X | X | | | X | | X | X | | | X | | X | | | | | | | |
| **CL_AM_3** | X | | | | | X | | | | | | | | | | | | | | | | | | | X | X |
| **CL_GH_2** | X | | | | | | | | | | | | | | | | | | | | | | | | | X |
| **CL_AO_3** | X | | | | | X | | | X | | | | | | | | | | | | | | X | | | |
| **CL_JG_1** | | | | | | X | X | | | | | | | | | | | | | | | | | | | |
| **MC_15** | | X | | X | X | | X | X | | | X | X | X | X | | X | X | | X | | | X | X | | | X |
| **CL_EB_4** | X | | | | X | X | | | | | | | | | | X | | | | | | | | | | |
| **CL_AT_2** | X | | | | | X | | | X | | | | | | | | | | | X | | X | | | | |
| **CL_FM_1** | | | | X | | | | X | | X | X | X | X | X | | X | | | | X | | | | | | |
| **MC_17** | | | | | | | | | X | | X | X | X | X | | X | | | | | | | | | | |
| **CL_EB_5** | X | | | | | X | | | X | X | | | X | | | X | | | | X | | | | | | |
| **CL_AO_2** | | | | | | X | | | X | X | | | X | | | X | | | | X | | | | | | |

| | MC_13 | CL_AM_3 | CL_GH_2 | CL_AO_3 | CL_JG_1 | MC_15 | CL_EB_4 | CL_AT_2 | CL_FM_1 | MC_17 | CL_EB_5 | CL_AO_2 | MC_18 | OBS_RL_2 | OBS_FP_4 | MC_19 | CL_AT_3 | CL_FP_5 | CL_RL_3 | CL_AT_4 | OBS_BC_3 | CL_FP_6 | MC_23 | CL_GH_4 | CL_AO_4 | CL_AT_5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **MC_18** | X | | | | | X | | | X | X | X | X | | X | X | X | | | X | X | | X | X | | | |
| **OBS_RL_2** | X | | | | | X | | | X | X | | | X | | | X | | | | X | | X | X | | | |
| **OBS_FP_4** | | | | | | | | | | | | | X | | | | | | | | | | | | X | |
| **MC_19** | | | | | | X | X | | X | X | X | X | X | X | | | X | X | X | X | | | | | | |
| **CL_AT_3** | X | | | | | X | | | | | | | | | | X | | | | | | | | | | |
| **CL_FP_5** | | | | | | | | | | | | | | | | X | | | | | | | | | X | |
| **CL_RL_3** | X | | | | | X | | | | | | | X | | | X | | | | X | | | | | | |
| **CL_AT_4** | | | | | | | | X | X | | X | X | X | X | | X | | | X | | | | | | | |
| **OBS_BC_3** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_FP_6** | | | | | | X | | X | | | | | X | X | | | | | | | | | | | X | X |
| **MC_23** | | | | X | | X | | | | | | | X | X | | | | | | | | | | | X | |
| **CL_GH_4** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **CL_AO_4** | | X | | | | | | | | | | | | | X | | | X | | | | X | X | | | |
| **CL_AT_5** | | X | X | | | X | | | | | | | | | | | | | | | | X | | | | |

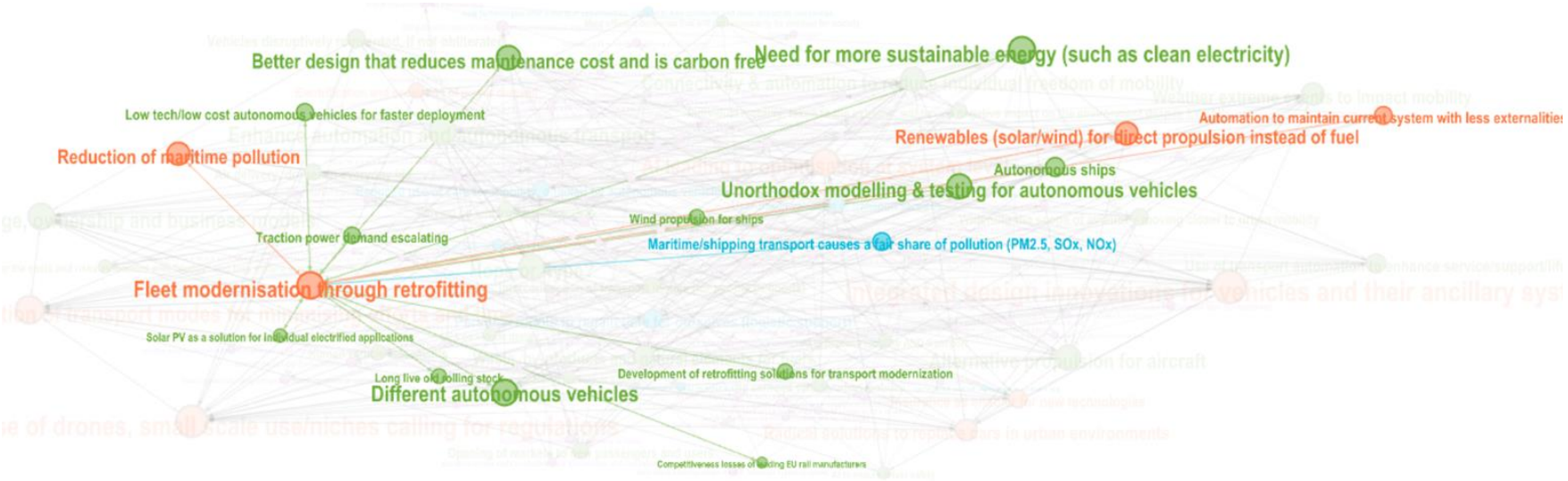
Source: JRC, 2019.

Based on the above links and the workshop outputs, as reported under chapter 3, the overall connections between items, observations, clusters and meta-clusters can be visualised through a network map (figure 3). More focused visualisations are then feasible, looking into specific meta-clusters (shown in orange, as displayed in figure 4), specific clusters (shown in green, as displayed in figure 5), specific items (shown in purple, as displayed in figure 6) or specific observations (shown in blue in all following figures).

**Figure 3.** Overall view of the network map.

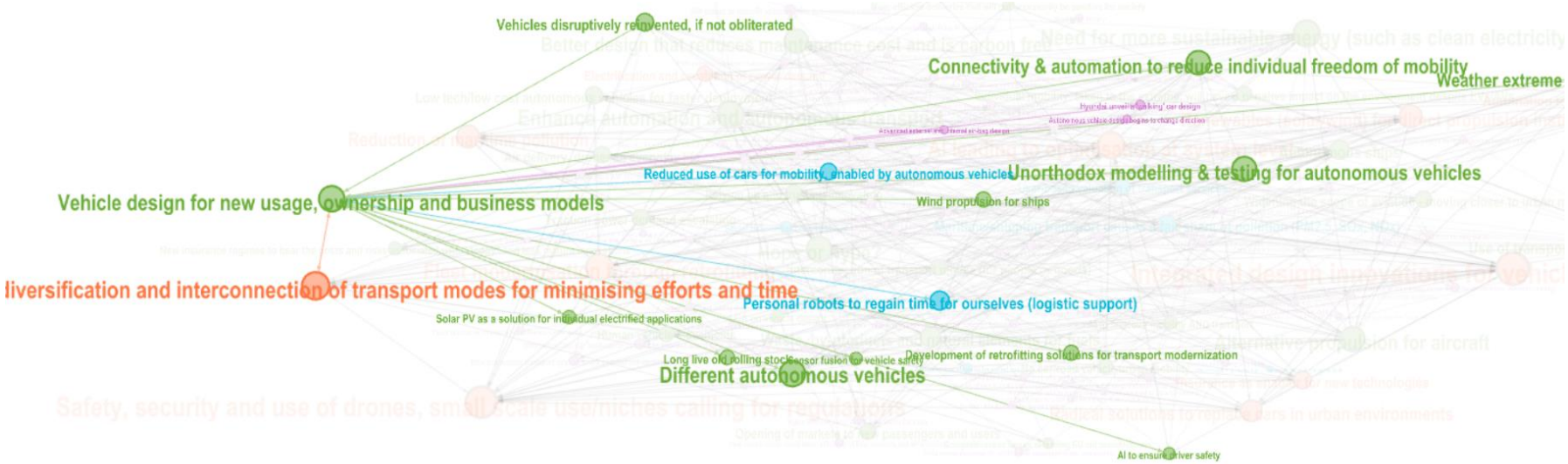

Source: JRC, 2019.

**Figure 4.** Network map focus on meta-cluster "Fleet modernisation through retrofitting".



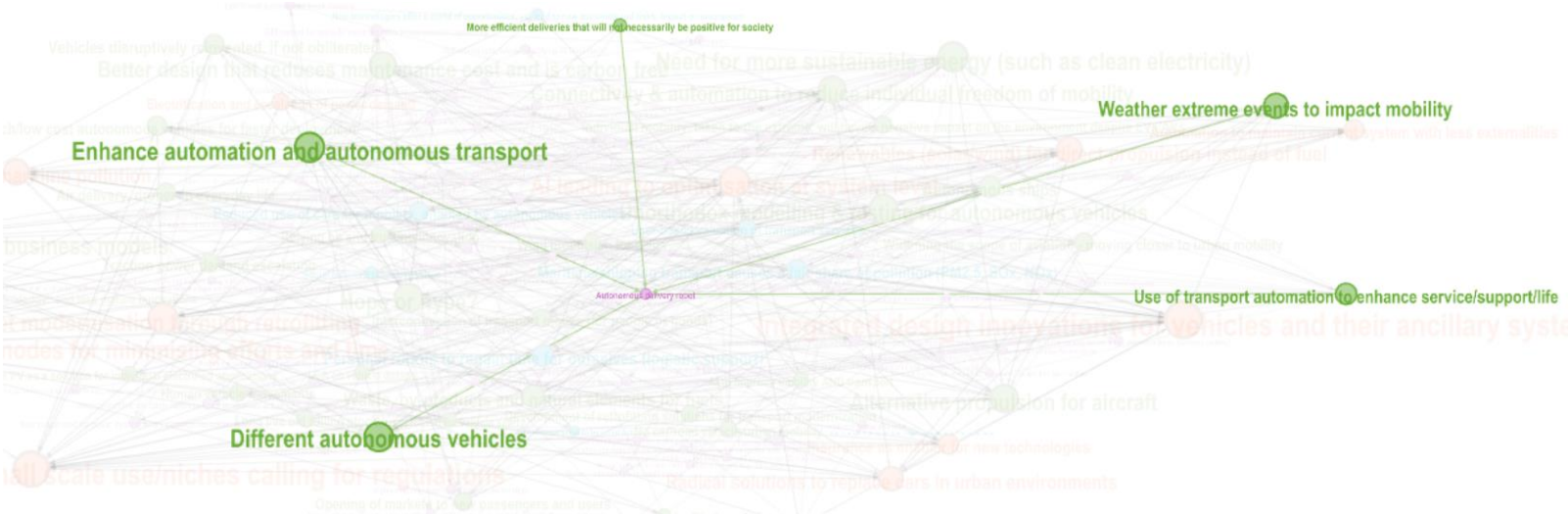

Source: JRC, 2019.

**Figure 5.** Network map focus on cluster "Vehicle design for new usage, ownership and business model".




Source: JRC, 2019.

**Figure 6.** Network map focus on item "Autonomous delivery robot".




Source: JRC, 2019.

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