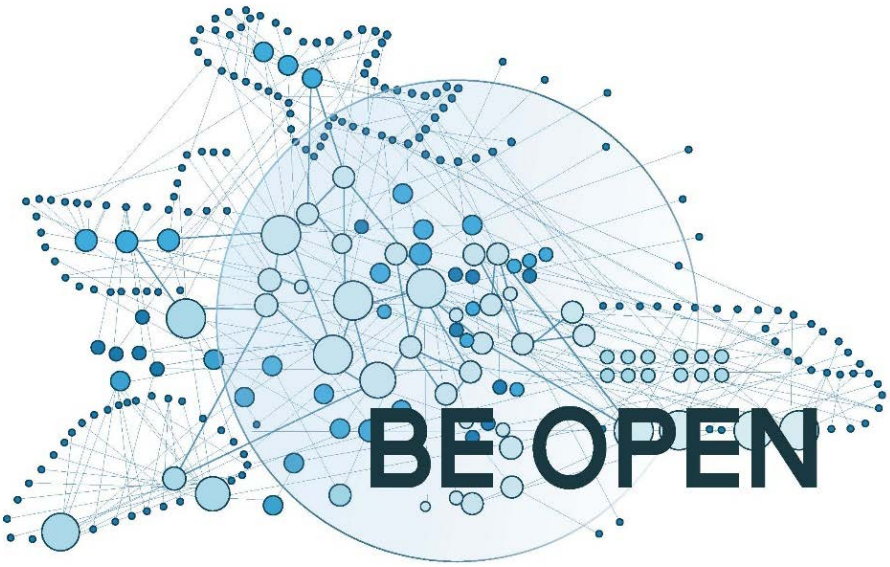

European forum and oBsErvatory for OPEN science in transport

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D1.3 Use case catalogue for future research

Final

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Abbreviations

ADDS	Aviation Digital Data Service
AEROBI	AErial RObotic System for In-Depth Bridge Inspection by Contact project
ANSP	Air Navigation Service Provider
ARRB	Australian Road Research Board
API	Application Programming Interface
ATC	Air Traffic Control
CBA	Cost Benefit Analysis
CSIR	Council for Scientific and Industrial Research – South Africa
DAS	Driving Assistance System
DCA	Defence Communications Agency
DLR	German Aerospace Center
EASA	European Authority in aviation safety
EATEO	European Association of Aviation Training and Educational Organisations
ELIPTIC	Electrification of Public Transport in Cities project
EOSC	European Open Science CLoud
ESS	Energy Storage System
EU	European Union
EURNEX	European rail Research Network of Excellence
FAA	Federal Aviation Administration
FEHRL	Forum of European National Highway Research Laboratories
FHWA-TFHRC	Turner-Fairbank Highway Research Center – Federal Highway Administration
FLOW	Furthering Less Congestion by Creating Opportunities For More Walking and Cycling project
GB	Great Britain
GIS	Geographic Information System
GNSS	Global navigation satellite system
GSM-R	Global System for Mobile Communications – Railway
HUMANIST	European Network for Research on Human Factors in Transport

I2V	Infrastructure to Vehicle
IM	Infrastructure Manager
IMO	International Maritime Organisation
IT	Information technology
ITS	Intelligent Transport Systems
KPI	Key Performance Indicator
LNG	Liquefied Natural Gas
MaaS	Mobility-as-a-service
MIRAVEC	Modelling Infrastructure influence on RoAd Vehicle Energy Consumption project
MOMENTUM	Modelling Emerging Transport Solutions for Urban Mobility project
MRE	Marine Renewable Energy
NAP	National Access Point
NDT	Non Destructive Testing
NETIVEI	National Transport Infrastructure Company – Israel
NGOs	Non-Governmental Organisations
NI	North Ireland
OPEUS	Modelling and strategies for the assessment and OPtimisation of Energy USage aspects of rail innovation project
PPPs	Public-private partnerships
PQM	Project quality management
RIS	River Information Services
RO	Regulatory Organisation
SKILLFUL	Skills and competences development of future transportation professionals at all levels project
TCO	Total Cost of Ownership
TOPOS	Transport fOrum / Observatory for Promoting Open Science
TRL	Technology Readiness Level
UC	User case
UITP	International Association of Public Transport
US	United States

V2I	Vehicle to infrastructure
VRU	Vulnerable Road Users
WEGEMT	European Association of Universities in Marine Technology
WP	Work package

Executive summary

This report follows the previous deliverables in WP1 of the BE OPEN project and completes the preliminary work aiming at establishing a common understanding in the research context related to transport. Based on the use cases defined in Task 1.3, this deliverable carried out a systematic review of current scientific production for all transport modes (road, rail, air, water, cross-modal) by assessing the activity of Technology Platforms and main influential research organizations which participate in the BE OPEN project regarding Open Science. The conducted work took into account different positioning based on the attributes and/or roles (i.e. public/private, operators, industries etc.) as well as the outcomes of the review activities, by describing and classifying all relevant use cases affecting current and future research trends and related industrial developments in the transport arena. Gaps and recommendations have then been identified and proposed for the next steps of the Project.

The document is structured as follows: after the introductory section, the methodology is outlined in section 2. Section 3 reports the analysis of research trends, future use cases, gaps and recommendations per transport mode (Public Transport, Aviation, Maritime, Shared mobility, Road Transport) and references are reported in section 4.

1 Introduction

BE OPEN targets the promotion, regulation and standardization of Open Science in transport research through

- developing a framework of common understanding for realizing Open Science services that will provide technical interoperability, data and information interoperability and legal interoperability;
- developing the TOPOS forum and observatory for different stakeholders to support an evidence-based dialogue;
- providing a roadmap and concrete guidelines for operationalising Open Science services and guide key actors on how to adopt and adapt Open Science services in their research workflows; and
- designing a Code of Conduct for adopting them considering the main legal and security issues for their implementation.

Work towards these impacts constitutes the kernel of the project; as each one of them corresponds directly to one or more of the projects' main objectives.

For this purpose both the TOPOS forum and observatory shall be developed to determine the different key actors on the basis of the "framework of common understanding", as well as the "Inventory of Open Science sources" that provides detailed information for all transport modes (i.e. road, rail, water, air) and setting the basis for analysing the existing Open Science services and research data infrastructures (with special focus on the EOSC). The aforementioned "framework of common understanding" indicates that a systematic analysis of actors, terminology and scenarios should be conducted in order to identify focused objectives and needs of key actors in transport research.

The key actors in transport research have been already defined within the D1.1 (i.e. industry, research community, and public authorities) and the aim of this deliverable is to provide an extensive catalogue of use cases for future research in transport by assessing all transport modes (road, rail, air, water, cross-modal). A group of experts will be used to assess how innovation uptakes are adopted in different transport modes and representatives of Technology Platforms and main influential organizations will provide their evaluation based on their significant experience. The overall goal is to provide relevant recommendations for the definition of future Open Science services and infrastructures in transport research.

2 The approach

In order to elaborate meaningful use cases and interrelate them with present and future research trends, a specific methodology was developed and applied within the D1.3.

The overall work took into account all transport modes and different positioning of key actors based on their attributes and/or roles:

- Railway Transport
- Public transport
- Air Transport
- Maritime transport
- Shared Mobility
- Road Transport

and for each of them 6 competence areas were used (following the deliverables D1.1 and D1.2 of the BE OPEN project):

1 **Legal/ Regulatory**: regulations, action plans, policy instruments and incentives;
2 **Technological**: new technologies and innovation applied to transport for technological improvements;
3 **Transport planning**: sustainable transport vision for reducing impact to the environment, economy and society;
4 **Business modelling:** description of means and methods a company applies to earn revenues projected in its plans;
5 **Socio-economic**: accessibility of transport and basic services;
6 **Environmental**: delivering substantial socioeconomic benefits and at the same time lowering impacts on the environmental system.

Based on the official definition of Jacobson et al., 1990, a **use case** is used in this deliverable to describe the purpose for which actors interact with a system (i.e. transport mode) to achieve a

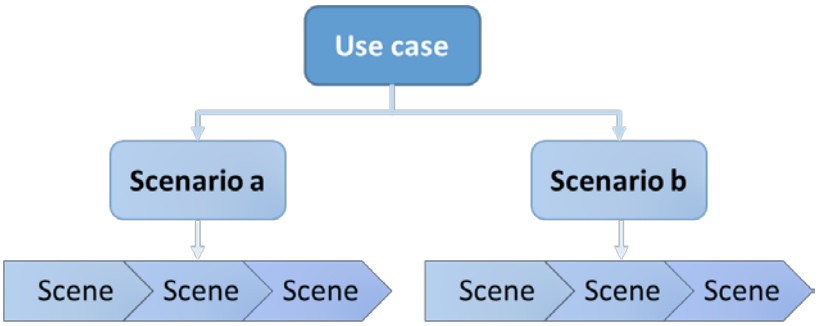

Figure 1: Use case structure

defined goal. It includes several scenarios consisted of many scenes (Figure 1) and it has been formalized in the discipline of transport research in the form of standards (i.e. competence areas). As such, each use case refers to a certain competence area and is related to a specific transport mode.

Even though starting from the same scene, different scenarios can be envisaged based on the specific goals that each involved actor may have. The **scenario** (Figure 2) is a chronological sequence of scenes describing a temporal development based on events and actions. Within a scenario, goals and intentions of actors get apparent can be defined as a situation that can occur in a particular context.

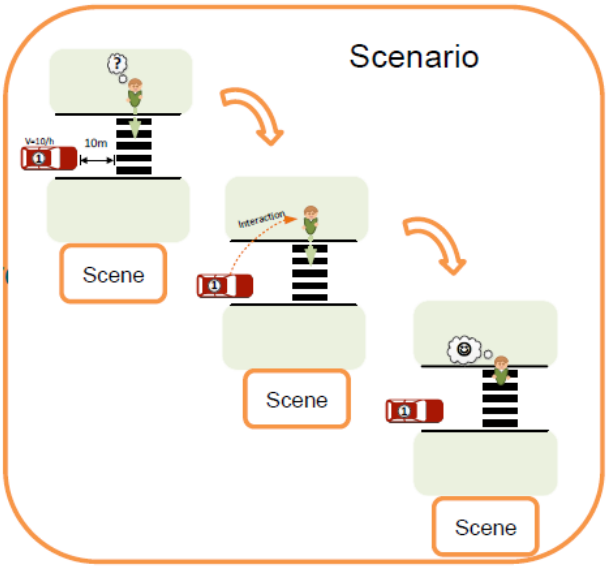

Figure 2: Scenario structure

At a lowest level, a **scene** (Figure 3) can be defined as a situation that is occurred in a particular context. It describes relevant "scenery" (i.e. everything presents within a static snapshot) considering goals and values characterizing that specific circumstance. It shows a specific moment in the considered environment and it has to consider the relationship of all involved entities to each other.

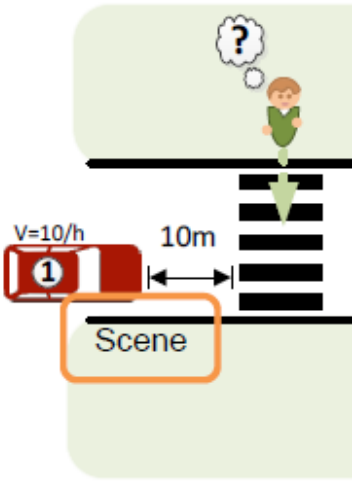

Figure 3: Scene structure

To sum up,

- **scenes** are situations occurring in particular contexts. Scenes show a snapshot in the considered environment and consider the relationship of all involved entities;
- **scenarios** are chronological sequences of scenes describing a temporal development based on events and actions. Within a scenario, goals and intentions of actors get explicit;
- **use cases** are combination of several scenarios, sometimes alternatives that fully materialise needs and objective of actors in a descriptive and structured mode.

The proposed **modelling approach** used in **a bottom-up mode**, utilizing scenes, scenarios and use cases that present needs and objectives in terms of services, applications, infrastructure, policies and regulations identifying a general transport condition in a determined area. Representatives of DLR and HUMANIST (i.e. Technology Platforms that stand for Industry sector), of FEHRL, EATEO, WEGEMT, and EURNEX (i.e. main influential Research Organizations) and of UITP (i.e. public authorities) that have the experience and expertise as presented bellow provided significant input for successfully addressing them.

Group of experts in transport sector

- **DLR:**
  - DLR Chamber represents more than 800 companies, from start-ups to multi-nationals, connecting over 50 industry sectors through a membership programme designed to engage every level and discipline.
- **HUMANIST:**
  - Research centres, universities and SMEs active in Human Machine Interface across transport modes;
  - 22 members from 15 countries.
- **FEHRL:**
  - National research and technical institutes from across Europe;
  - 31 member associates from non-European countries provide FEHRL with strong links to the considerable research capacity available globally (i.e. NETIVEI from Israel, CSIR from South Africa, TFHRC-FHWA from USA, ARRB from Australia).
- **EATEO:**
  - Common forum for European aviation training and aviation education providers;
  - 25 members from EU and US countries.
- **WEGEMT:**
  - European Association of Universities in Marine Technology and related sciences;
  - 40 Universities in 17 countries.
- **EURNEX:**
  - Leading rail researchers from scientific institutions and universities all over Europe;
  - 44 members from 20 countries.
- **UITP:**
  - association representative of the urban, suburban and regional passenger public transport operators and organising authorities;
  - 1400 members from 96 countries.

The group of experts in transport sector also participated in Task 1.3 and they identified the following use cases:

Table 1: Use Cases identified per transport mode and per competence area

Mode of transport	Competence area	Use cases
Rail	Business modelling	A rail supplier implements an innovation in their manufacturing process (UC1)
	Environmental area	Infrastructure manager (IM) wants to update the pricing scheme for the use of the rail infrastructure (UC2)
	Legal/ Regulatory area	International freight rail traffic between country A and B (UC3)
	Socio-economic area	Public authorities want to improve accessibility of handicapped population to the rail transport (UC4)
	Technological area	Reduction of noise produced by traffic rail in adjacent properties to tracks (UC5)
	Transport planning area	Rail operator wants to offer a new passenger rail service (UC6)
Public Transport	Business modelling	Shift2Maas: how the integrated mobility services can help MaaS schemes (UC7)
	Environmental area	OPEUS: identify the ways to optimise energy consumption at railways (UC8)
	Legal/ Regulatory area	Shift2MaaS: research on how to deploy the new mobility services in cities and urban environment (UC9)
	Socio-economic area	Establishment of a data-driven sector: Public transport to agree on a common approach concerning data-sharing for urban mobility (UC10)
	Technological area	ELIPTIC - recharging of electric vehicles using tram catenaries (UC11)
	Transport planning area	MOMENTUM - Update transport models to properly account for new mobility options (UC12)
Air Transport	Business modelling	An engine aircraft manufactures decides to produce electric engines for the aircrafts (UC13)
	Environmental area	A major airport hub wants to update the pricing scheme for the use of its infrastructure (UC14)
	Legal/ Regulatory area	Air Taxi between country A and B (UC15)
	Socio-economic area	Public authorities want to improve accessibility of population that has fear of flight, to the air transport (UC16)
	Technological area	Reduction of noise and emissions produced by aircrafts (UC17)
	Transport planning area	Aviation company wants to offer a new passenger service experience (UC18)
Maritime Transport	Business modelling	Shipyard installs new production equipment (UC19)
	Environmental area	building ("silent") vessels (ships, submarines etc.) equipped with underwater noise mitigation technology (UC20)

Mode of transport	Competence area	Use cases
	Legal/ Regulatory area	Ferry crossing between NI and GB after BREXIT (UC21)
	Socio-economic area	New ferry service between mainland and small island community (UC22)
	Technological area	Sections of the ship made of composite materials (UC23)
	Transport planning area	Ship owner/operator buys an LNG propelled vessel (UC24)
Shared Mobility	Business modelling	Shared mobility operator wants to set shared vehicles in a city (UC25) Shared mobility operator wants to integrate a MaaS scheme (UC26)
	Environmental area	Reduced congestion to reduce emissions (UC27)
	Legal/ Regulatory area	Mixed traffic management (UC28)
	Socio-economic area	User acceptance of automated driving (UC29)
	Technological area	Create a resilient transport system (UC30)
	Transport planning area	Accessible & available mobility outside cities (UC31)
Road Transport	Business modelling	SKILLFUL: develop skills and competences for the transport workforce (UC32)
	Environmental area	MIRAVEC - identify ways to reduce energy consumption and CO2 emissions from road transport (UC33)
	Legal/ Regulatory area	Regulatory frameworks for Electrified and Automated Transport in Europe (UC34)
	Socio-economic area	Improve the safety and comfort of pedestrians and to increase their visibility (UC35)
	Technological area	AEROBI - low flying unmanned robots with arms for inspection of bridges (UC36)
	Transport planning area	FLOW - assessing the ability of walking and cycling measures to reduce congestion in European cities (UC37)

To this end, a systematic assessment conducted in order to:

- Define main **research trends** identified by main actors and clustered per competence area;
- Identify **research topics** listed in previous research work programmes and grouped per type of resource used;
- Identify **gaps** (issues not addressed by current research activities);
- Provide **recommendations** for future scientific work.

The outcomes are presented in detail in section 3.

3 Transport stakeholders needs and objectives

3.1 Railway transport

3.1.1 Research trends

The Research Trends for railway transport (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 2).

Table 2: Research Trends for railway transport per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Intelligent mobility & infrastructure	Water and air pollution
Inter-modality infrastructures	Decarbonization
Interoperability	Green rail
Capacity management and optimization	Recycling & new applied materials for rail construction
Improving the performance and the attractiveness of passenger and freight vehicles	Low frequency substation noise based on research in other sectors
Knowledge management system on PQM and the application of simulation methods	Electromagnetic pollution, noise and vibration not only on board but also on ground
Life cycle cost (e.g. in relation to maintenance)	Noise, vibration and corrugation
	Energy consumption and saving in electrified and diesel traction system
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Rail market liberalization	Socio-economic impacts/user/public acceptance
Actions from regulators and policy makers that could help to improve railway performance	Stakeholders requirements
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock	Security (systems and users)
Railway system management	Occupational health and safety
	Prevention of terrorism
	Technical and operational safety
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Traffic accidents mitigation (Human errors)	Risk analysis and assessment
Catenary	Transport system efficiency/Urban mobility solutions
Railway structures, cutting and embankments	Mixed traffic environments
Signaling and control systems	Network efficiency assessment
Line-side equipment	Improving detecting and sensing capabilities
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Wheel/rail interface	Main drivers of demand and costs in railway
Switches and crossing, level crossing	Satellite systems – Collaborative constellations
Ticketing and payment/refund systems	Research into the optimization of GSM-R network to remove capacity constraints

TECHNOLOGICAL AREA	TRANSPORT PLANNING AREA
Compatible ticketing systems across borders and urban transit legs	Potentials and limitations of quality of service rendered by railways to the various market segments
Cooling vehicle and stations	Operational planning and management
Development new lightweight and low noise freight wagons	Modelling and simulation
Hot versus cold braking benefits	Maintaining and enhancing safety and reliability
Technologies for Compact Sensors	Information systems (passenger, freight remote diagnostics, predictive maintenance, traffic management)
New technology for security psychological aspects of security	Safety and security management
Intelligent mobility	Track including subgrade and rail
Safety impact of maintenance	Maintenance procedure
Functional analysis and designing of system architecture and components relationships	
Research and development to improve methods of assessment	
Incident/accident database and learning	
Active safety and passive safety requirements and assessment	
Electrical power distribution	
Signaling compatibility	
Interlocking	
Influence of weather conditions on railway operation	
Remote condition monitoring	

Research topics (BE OPEN, 2019) for the railway transport are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.

The following table (Table 3) presents the derived research trends per type of resource used.

Table 3: Research Trends for railway transport based on previous research (BE OPEN, 2019)

ORIGINAL RESEARCH DATA
Automated transport
Quality of transport system and service
Growing of mobility demand
ITS applications
Growing of quality of life through transport
Shared mobility

ORIGINAL RESEARCH DATA
Economic impact of railway sector
Infomobility
Traffic congestion
Control systems
Safety constrains
Increasing safety
Sustainable urban Systems
Urban environment
OPERATIONAL DATA
Transport accidents, safety and security
Objective zero fatalities
Interoperability of transport systems
Transport network and plans
On-demand public transport
DATA FROM PUBLIC RESEARCH
Development of critical technologies
Pollution emissions reduction
Technological prospects
Incentives
Organizational structures
EU Directives
System competitiveness
Sustainable use of resources
Cooperation between manufactures
Environmental efficiency
Traffic engineering
Integrated urban plan
Design of vehicles
Environmental friendly transport
National regulatory
Vehicle efficiency
Integration with other transport modes
Payment systems
Land use
Dedicated infrastructure
Mobility service for people and goods
Clean vehicle fleets
Rational use of motorized transport
Increase capacity of infrastructure
Global warming
Electric vehicles
Total cost of ownership

DATA FROM PUBLIC RESEARCH
Information services
Sustainable transport
Competitive transport
Social service
Alternative fuels
Railway electrification
Eco-innovation
Navigation systems for optimized planning and routing
Emissions abatement
Cleaner fuels
Business modelling
Traffic engineering
Emerging technologies
Mobility integration
Vulnerable road users
Policy makers
Roadmap for emerging technologies
Innovative forms of urban transport
Private-public partnership
Carbon footprint
Green business
Integrated business models
Noise pollution
Modal shift
ITS technologies
Fully integrated management systems
Regulatory framework
Smart city planning
Public participation
Propulsion system
Mitigation of climate change
Dependence on fossil fuels
Forward-looking activities
Innovation powertrain
Common standards and procedures
Adverse health effects
New materials and processes
Emission reduction
Hybrid vehicles
Social impacts
Multi-disciplinary collaborations
Process automation

DATA FROM PUBLIC RESEARCH
Robust transport systems
CBA
Personalized/smart services
Environmental Impact Assessment
Transport demand
Accessibility
Urban simulation models
Seamless mobility
Economic growth
Productivity of the system
Demographic trends
City Logistics
Cultural heritage
Business model for mobility
Urban design
Transport governance
Inclusive and affordable transport

3.1.2 Use Cases

3.1.2.1 Socio-economic area (UC4)

An indicative socio-economic case study for railway transport is the **"Public authorities want to improve accessibility of handicapped population to the rail transport"** and the corresponding objective is to facilitate the access of handicapped passenger, of any disability, to rail transport. As such, the following needs should be addressed:

- to assess the status of the stations/rolling stock regarding the accessibility;
- to check the regulations linked to the accessibility at international, national and regional level;
- to define the target to be achieved;
- to create a budget for executing the approved plan;
- to create a plan to implement the measurements (tender, time frame, etc.);
- to force railway companies to order wagons with the disability seats options.

Two possible scenarios provided for the aforementioned case study:

1. ***Public authorities agreed on a plan with the infrastructure management***

Regarding the first scenario, the involved stakeholders are mainly transport networks, commercial transport and logistics industry players, research centres and universities, national policy makers as well as regional policy makers, NGOs and community organizations and last but not least citizens.

In this context, the following tasks should be implemented:

- Rail stations can be reached by all citizen groups easily (e.g. handicap people, elder people, people with disabilities, mentally disabled etc.);
- public-private partnerships for investment in railway infrastructure;
- renovation of all rail stations.

2. ***Public authorities agreed on a plan with the rail operator to adapt the rail vehicles***

The stakeholders of the second scenario involve transport networks, commercial transport and logistics industry players, aviation manufacturers, international aviation organizations, research centres and universities, national and regional policy makers, NGOs and community organizations, and citizens.

In this scenario, the following tasks should be implemented:

- Smooth adaptation of new rail vehicles to the existing rail network;
- public-private partnerships for investment in railway infrastructure;
- implementation of a decision-making framework for the adjustment of timetables and new rail vehicle inflatration.

3.1.2.2 Business modelling (UC1)

An indicative case study in the business modelling area for railway transport is the **"Rail supplier implements an innovation in their manufacturing process"** and the corresponding objective is to improve the competitiveness of the company by introducing technological innovations. As such, the following needs should be addressed:

- to identify which train suits better to introduce the innovation;
- to alternate the production process (e.g. time required for finishing the element, resources required, work flow);
- to allocate time and resources which will be dedicated to train existing and new employees;
- to select the proper introduction of the innovative system via the adjustment of set of parameters.

Two possible scenarios provided for the aforementioned case study:

1. ***The innovation is introduced for the production of an individual train model***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, national policy makers as well as international policy makers, NGOs and community organizations.

In this context, the following tasks should be implemented:

- producers choose the type of rail vehicle;
- adaptation of manufacturing line according to a specific rail vehicle model;
- selection of a group of employees to be trained for the production operations of a specific rail vehicle;
- the innovation is evaluated by defining a set of key performance indicators (KPIs).

2. ***The innovation is introduced for all train models***

The stakeholders of the second scenario involve commercial transport and logistics industry players, national policy makers as well as international policy makers, NGOs and community organizations.

In this scenario, the following tasks should be implemented:

- adaptation of the whole manufacturing line according to a specific rail vehicle model;
- all employees are instructed to follow the new manufacturing process;
- the innovation is evaluated by defining a set of key performance indicators (KPIs).

3.1.2.3 Environmental area (UC2)

An indicative case study in the environmental area for railway transport is the **"Infrastructure manager wants to update the pricing scheme for the use of the rail infrastructure"** and the corresponding objective is to charge the real cost of infrastructure to the rail operators and final users (e.g. passengers) so that each train route becomes profitable. As such, the following needs should be addressed:

- to find out at which kilometre point must the pantograph be lowered;
- to determine the maximum speed allowed in this track section;
- to groupage the different voltages and the different characteristics of each network.

Two possible scenarios provided for the aforementioned case study:

1. ***Rail infrastructure pricing will include environmental externalities***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, national policy makers as well as international policy makers.

In this context, the following tasks should be implemented:

- to lower the locomotive pantograph before voltage changes at the border;
- to raise the locomotive pantograph after voltage changes at the border;
- Freight train stops shortly before or after the border.

2. ***Rail infrastructure pricing will not include additional factors***

The stakeholders of the second scenario involve commercial transport and logistics industry players, national policy makers as well as international policy makers.

In this scenario, the following tasks should be implemented:

- Locomotive certified for running in country A is uncoupled;
- The infrastructure management will update the pricing system for the elements selected;
- Rail operators must be informed of any changes made.

3.1.2.4 Legal & regulatory area (UC3)

An indicative legal/regulatory case study for railway transport is the **"International freight rail traffic between country A and B"** and the corresponding objective is to facilitate the international freight

transport by removing obstacles to the interoperability. As such, the following needs should be addressed:

- to find out at which kilometre point must the pantograph be lowered;
- to determine the maximum speed allowed in this track section;
- to groupage the different voltages and the different characteristics of each network;
- to know the available sidings for a train stop;
- possibly to use a certified locomotive;
- common timetable for the shunting operations with the service providers.

Two possible scenarios provided for the aforementioned case study:

1. ***Locomotive is certified for running in both countries***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players.

In this context, the following tasks should be implemented:

- to lower the locomotive pantograph before voltage changes at the border;
- to raise the locomotive pantograph after voltage changes at the border.

2. ***Locomotive is not certified for running in both countries***

The stakeholders of the second scenario involve commercial transport and logistics industry players, national policy makers as well as international policy makers.

In this scenario, the following tasks should be implemented:

- Freight train stops shortly before or after the border;
- Locomotive certified for running in country A is uncoupled;
- Locomotive certified for running in country B is uncoupled;
- Freight train stops enters the country B.

3.1.2.5 Technological area (UC5)

An indicative case study for railway transport technological area is the **"Reduction of noise produced by traffic rail in adjacent properties to tracks"** and the corresponding objective is to offer the new service at a competitive price and maximize profits. As such, the following needs should be addressed:

- to identify the required train characteristics (e.g. number of seats, energy consumption, dimensions, approximate price) and the number of vehicles needed;
- to examine and decide financial resource to be compromised and contract conditions (with maintenance included in the contract or not) for the tender/leasing contract;
- to agree with the supplier on the delivery conditions (e.g. place, time).

Two possible scenarios provided for the aforementioned case study:

1. ***Plan for the implementation of rolling stock with lower noise emissions***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, national policy makers as well as international policy makers.

In this context, the following tasks should be implemented:

- to set the maximum emission level allowed for rolling stock;
- to analyse the rolling stock elements with higher noise emission potential;
- to improve the key elements of acoustical properties.

2. ***Plan for the installation of noise insulation measurements in the affected properties***

The stakeholders of the second scenario involve commercial transport and logistics industry players.

In this scenario, the following tasks should be implemented:

- to set the maximum noise level allowed at adjacent properties;
- to analyse the possible measures;
- to implement measures to reduce the noise level in the properties.

3.1.2.6 Transport planning area (UC6)

An indicative case study in the transport planning area for railway transport is the **"Rail operator wants to offer a new passenger rail service"** and the corresponding objective is to offer the new service at a competitive price and maximize profits. As such, the following needs should be addressed:

- to identify the required train characteristics (e.g. number of seats, energy consumption, dimensions, approximate price) and the number of vehicles needed;
- to examine and decide financial resource to be compromised and contract conditions (with maintenance included in the contract or not) for the tender/leasing contract;
- to agree with the supplier on the delivery conditions (e.g. place, time).

Two possible scenarios provided for the aforementioned case study:

1. ***Rail operator purchases new rolling stock***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, national policy makers as well as international policy makers.

In this context, the following tasks should be implemented:

- to analyse the market of rail;
- to publish a tender with the required specifications;
- a new train will be delivered to the rail operator.

2. ***Rail operator leases the rolling stock***

The stakeholders of the second scenario involve commercial transport and logistics industry players.

In this scenario, the following tasks should be implemented:

- to contact leasing companies of rolling stock;
- the rail operator and leasing company will negotiate prices and conditions for the new material;
- the leasing company will lease the train for an agreed period of time.

3.1.3 Evaluation of Research Trends and Topics fulfilling present transport needs in railway sector

Studying the current research trends for railway sector (as presented in Table 2) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 4).

Table 4: Research trends and topics for railway transport based on Use cases and previous research (BE OPEN, 2019)

SOCIO ECONOMIC AREA
ASSESS ACCESSIBILITY
Accessibility
Urban environment
Land use
Urban design
PRESENT REGULATIONS
EU Directives
National regulatory
Regulatory framework
TARGET ACHIEVED
Mobility service for people
Social service
Vulnerable road users
Social impacts
Personalized services
SPECIFIC BUDGET
Sustainable use of resources
Land use
SPECIFIC PLAN
Growing of quality of life through transport
Safety constrains
Sustainable use of resources
Social service
Common standards and procedures
Inclusive and affordable transport

BUSINESS MODELLING AREA
SERVICE AND KIND OF TRAINS FOR INNOVATIONS

Capacity management and optimization
Improving the performance and the attractiveness of passenger and freight vehicles
SERVICE AND KIND OF TRAINS FOR INNOVATIONS
Knowledge management system on PQM and the application of simulation methods
Cooling vehicle and stations
Development new lightweight and low noise freight wagons
Functional analysis and designing of system architecture and components relationships
Cooperation between manufactures
REORGANIZATION OF INDUSTRIAL PROCESS AND SERVICE PROVISION
Actions from regulators and policy makers that could help to improve railway performance
Life cycle cost (e.g. in relation to maintenance)
Operational planning and management
EMPLOYEES TRAINING
Occupational health and safety
Technical and operational safety
Socio-economic impacts/user/public acceptance
COMMERCIAL AND LOGISTICS ADAPTATION
Interoperability
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
Functional analysis and designing of system architecture and components relationships
Potentials and limitations of quality of service rendered by railways to the various market segments
Mobility service for people and goods
NEW CERTIFICATIONS AND LICENSES
Rail market liberalization
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
EU Directives
National regulatory
Policy makers

ENVIRONMENTAL AREA
KMS WHERE SERVICE OPERATED IN IM NETWORK
Rail market liberalization
Inter-modality infrastructures

Improving detecting and sensing capabilities
Research into the optimization of GSM-R network to remove capacity constraints
OPERATING SPEED FOR EACH TRAIN IN NETWORK SECTION
Improving the performance and the attractiveness of passenger and freight vehicles
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
Signaling and control systems
Mixed traffic environments
Influence of weather conditions on railway operation
Vehicle efficiency
VOLTAGES AND CHARACTERISTICS EACH PART OF IM NETWORK
Actions from regulators and policy makers that could help to improve railway performance
Railway system management
Railway structures, cutting and embankments
Switches and crossing, level crossing
Safety constrains
Dedicated infrastructure
Increase capacity of infrastructure
IMPACT OF TRAINS ON INFRASTRUCTURE LINE
Wheel/rail interface
Noise, vibration and corrugation
Energy consumption and saving in electrified and diesel traction system
Transport system efficiency/Urban mobility solutions
Maintenance procedure
Traffic congestion

LEGAL & REGULATORY AREA
BORDERS MANAGEMENT
Rail market liberalization
Railway system management
Improving detecting and sensing capabilities
Information systems (passenger, freight remote diagnostics, predictive maintenance, traffic management)
Control systems
Multi-disciplinary collaborations

EU Directives
National regulatory
Interoperability of transport systems
INFRASTRUCTURE CHARACTERISTICS FOR INTERMODALITY
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
Inter-modality infrastructures
Interoperability
Railway structures, cutting and embankments
Catenary
Signaling and control systems
Line-side equipment
Signaling compatibility
ITS applications
Cooperation between manufactures
Traffic engineering
Dedicated infrastructure
INFRASTRUCTURE OPERATIONAL CAPACITY
Capacity management and optimization
Improving the performance and the attractiveness of passenger and freight vehicles
Electrical power distribution
Modelling and simulation
Network efficiency assessment
Safety constrains
Increase capacity of infrastructure
FAIR OPERATIONAL DISTRIBUTION AND INFRASTRUCTURE MANAGEMENT
Actions from regulators and policy makers that could help to improve railway performance
Stakeholders requirements
Operational planning and management
Mixed traffic environments
Main drivers of demand and costs in railway
Knowledge management system on PQM and the application of simulation methods
System competitiveness
Transport governance
Competitive transport
Business modelling

Private-public partnership
Regulatory framework

TECHNOLOGICAL AREA
USEFUL TRAIN CHARACTERISTICS
Wheel/rail interface
Development new lightweight and low noise freight wagons
Electromagnetic pollution, noise and vibration not only on board but also on ground
Noise, vibration and corrugation
Improving the performance and the attractiveness of passenger and freight vehicles
Track including subgrade and rail
Noise pollution
Environmental Impact Assessment
NEGOTIATE CONDITIONS ABLE TO SOLVE PROBLEMS
Low frequency substation noise based on research in other sectors
Socio-economic impacts/user/public acceptance
Stakeholders requirements
Occupational health and safety
Increasing safety
Urban environment
Social service
Policy makers
Regulatory framework
Common standards and procedures
Social impacts
EVALUATION ECONOMIC AND FINANCIAL CONDITIONS
Main drivers of demand and costs in railway
Potentials and limitations of quality of service rendered by railways to the various market segments
Intelligent mobility & infrastructure
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
Quality of transport system and service
CONSIDERATION OF ALTERNATIVE SOLUTIONS
Technical and operational safety
Transport system efficiency/Urban mobility solutions
Improving detecting and sensing capabilities
Modelling and simulation

Technological prospects
Environmentally friendly transport
Eco-innovation
Forward-looking activities
CONSIDERATION OF ALTERNATIVE SOLUTIONS
Innovation powertrain
New materials and processes
Personalized/smart services
Urban simulation models

TRANSPORT PLANNING AREA
NECESSARY TRAIN CHARACTERISTICS
Provide scientific and technical foundation for innovative solutions and supporting the establishment of new standards for rolling stock
Wheel/rail interface
Development new lightweight and low noise freight wagons
Transport system efficiency/Urban mobility solutions
Main drivers of demand and costs in railway
Potentials and limitations of quality of service rendered by railways to the various market segments
Information systems (passenger, freight remote diagnostics, predictive maintenance, traffic management)
Design of vehicles
Vehicle efficiency
Innovation powertrain
LEASING OR PURCHASE
Railway system management
Research and development to improve methods of assessment
Economic impact of railway sector
Incentives
Vehicle efficiency
Total cost of ownership
Competitive transport
Business modelling
CBA
Business model for mobility
REORGANIZATION OF MAINTENANCE PROCEDURES
Life cycle cost (e.g. in relation to maintenance)

Information systems (passenger, freight remote diagnostics, predictive maintenance, traffic management)
Maintenance procedure
REORGANIZATION OF MAINTENANCE PROCEDURES
Vehicle efficiency
New materials and processes
TRACKS ANALYSIS AND REORGANIZATION
Transport system efficiency/Urban mobility solutions
Mixed traffic environments
Network efficiency assessment
Operational planning and management
Information systems (passenger, freight remote diagnostics, predictive maintenance, traffic management)
Capacity management and optimization
Transport network and plans
System competitiveness
Traffic engineering
Increase capacity of infrastructure
Transport demand
Productivity of the system
Inclusive and affordable transport

3.1.4 Gaps identification and Recommendations for railway sector

In order to develop rail transport, there is a need for the following issues that are not yet addressed:

- Support accessibility analysis for handicapped users in railway sector supporting the scheme of urban environment and the land design more or less "friendly" for people with mobility problems and considering also the European Commission decision of adopting the PRM TSI. Emphasis should be given on the interface between transport services and infrastructures and people with mobility problems and limitations.
- Enhance sustainable use of resources, realization of systems with the right safety features and implementation of more inclusive and affordable systems in the mandatory standards and procedures for infrastructures development.
- Research on new innovative vehicles more efficient and customized to users' needs.
- Foster cooperation between manufacturers, policy makers and operators in order to develop new standards, new architectures and new mobility services.
- Analyze socio-economic acceptance as well as employees' adaptation of new standards, new architectures and new mobility services.
- Provide training scheme to enhance skills to employees in order to deal with new standards, new architectures and new mobility services.
- Analyze railway logistics and provide proper policies at a European level and beyond.

- Study an electrified system or/and ecological vehicles for railway sector in order to promote environmentally friendly solutions.
- Emphasis on legal and regulatory issues in order to address national barriers at a European and international level.
- Enhance interoperability to promote intermodal and cross-border systems both for passenger and freight rail transport.
- Develop new and alternative technologies considering how to be introduced and taken-up in the market maximizing also societal value.
- Enhance infrastructure in an attempt to increase capacity of railway stations (length and quantity of trains) and lines.

3.2 Public Transport

3.2.1 Research trends

The Research Trends for public transport (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 5)

Table 5: Research Trends for public transport per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Urban mobility solutions	Traffic congestion
Business plan for mobility	Mixed traffic environments
Shared mobility	Batteries for electric driving, regenerative braking, alternative power sources
Intelligent mobility & Infrastructures	
Inter-modality infrastructures	
Integrated ticketing systems	
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Policy and regulatory needs	Vulnerable road users
Decarbonisation	Circular economy in transport
Public Private Partnership	User/public acceptance
	Land use and transport interaction
	Pricing and externalities
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
	Fitness to drive
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Connected automated driving technology	Transport system efficiency
IT connectivity	Facilitation to city centres access
Traffic accidents mitigation	Services provision from hub-to-hub
Electrical and automated vehicles	Urban mobility solutions
Safety measures & requirements	Network efficiency assessment
Big data, Artificial Intelligence and their applications	Streamlining the infrastructure for more efficient land use such as removing bottlenecks, building flyovers and reducing the number of level intersections

V2I and I2V communications	Traffic modelling
Pricing and payment systems	Traffic control
Improve standards for noise, emissions and diesel engines	
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Innovative maintenance	
Communication and positioning technologies	
Fatigue behaviour	

Research topics (BE OPEN, 2019) for the public transport are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.
- The following table (Table 6) presents the derived research trends per type of resource used.

Table 6: Research Trends for public transport

ORIGINAL RESEARCH DATA
Social impacts
Economic development
Safety constraints
Sustainable urban systems
Design of vehicles
Private public partnership
Innovation and competitiveness
Innovative forms of urban transport
Increase use of public transport
Green vehicles
Electric vehicles
Automated transport
Resilient transport systems
Seamless mobility
ORIGINAL RESEARCH DATA
On demand public transport
Personalised/smart services
OPERATIONAL DATA
Competitive transport
Effective transport management systems
Traffic congestion
Collective transport
Interoperability of transport systems
Transport network
DATA FROM PUBLIC RESEARCH

Emissions reduction
Environmental constrains
Sustainable urban systems
Design of vehicles
DATA FROM PUBLIC RESEARCH
System competitiveness
Development of critical technologies
Environmental friendly transport
Integration with other transport modes
Accessibility
Vehicles efficiency
Integrated urban plan
Urban simulation models
ITS infrastructures
Dedicated infrastructures
Emissions abatement
Co-modality/Intermodality
More comfortable transports
Increase use of public transport
Eco-innovation
Mobility integration
Alternative fuels
Innovation and competitiveness
Fully integrated management systems
Vulnerable road users
Business models for urban mobility
Navigation and control systems for optimised planning and routing
Shared mobility
Energy consumption reduction
Common standards and procedures
Adverse health effects
Dependence on fossil fuels
Transport demand
Mitigation of climate change
Automated road transport
Robust transport systems
Social service
Demographic trends
Environmental Impact Assessment
Innovative powertrains

3.2.2 Use Cases

3.2.2.1 Socio-economic area (UC10)

An indicative socio-economic case study for public transport is the **"Establishment of a data-driven sector: Public transport to agree on a common approach concerning"** and the corresponding objective is to encourage the public transport sector to become data-driven through embracing an open data policy. As such, the following needs should be addressed:

- to have an overview of business models for data sharing
- to measure the impact for lack of a governance framework and the impact of open data policies

Two possible scenarios provided for the aforementioned case study:

3. ***Establishment of sectorial principles with regards to the framework for data-sharing in the field of urban mobility***

Regarding the first scenario, the involved stakeholders are mainly existing and potential public transport operators, national policy makers as well as regional policy makers and last but not least citizens.

In this context, the public transport operators should focus on the assessment and agreement of recommendations on divergent approaches to data, data sharing and open data.

4. ***Continuation with sectorial approach towards open data***

The stakeholders of the second scenario involve existing and potential public transport operators, national policy makers as well as regional policy makers and last but not least citizens.

In this scenario, the public transport operators should focus on the continuation with the promotion of open data.

3.2.2.2 Business modelling (UC7)

An indicative case study in the business modelling area for public transport is the **"Shift2Maas: how the integrated mobility services can help Mobility as a Service (MaaS) schemes"** and the corresponding objective is to increase the passenger awareness of the public transport sector potential and optimize a schedule to provide a seamless travel experience. As such, the following needs should be addressed:

- to have access to the data of other operators and their services
- to be able to publish this data for other stakeholders
- to make the information for travel companions, journey planners and booking systems easily accessible to everyone
- to create an integrated ticket between different operators

Two possible scenarios provided for the aforementioned case study:

3. ***Transport Service Providers join the interoperability framework***

Regarding the first scenario, the involved stakeholders are mainly transport networks plus research and university communities. In this context, the Transport Service Providers could register in the ecosystem, create relevant datasets and publish the available data sets to the asset management authority.

4. ***Transport Service Providers create agreements in contractual management marketplace***

The stakeholders of the second scenario involve stakeholders are mainly transport networks, community organizations, researchers, students and citizens in general.

In this scenario, the following tasks should be implemented:

- Service Providers to make agreements with local, regional and national operators for long-distance connections
- User buys an integrated MaaS ticket based on the established arrangements.

3.2.2.3 Environmental area (UC8)

An indicative case study in the environmental area for public transport is the **"OPEUS: identify the ways to optimise energy consumption at railways"** and the corresponding objective is to have a competitive advantage amongst foreign competitors. As such, the following needs should be addressed:

- To Improve energy consumption indicators of the vehicle
- To have a tool that enables the comparison of different vehicles (like EU eco-labelling)
- To compare a set of different vehicles and implement the appropriate technologies to these vehicles
- To optimise driving and energy consumption in the network

Two possible scenarios provided for the aforementioned case study:

3. ***Manufacturer uses a modelling tool to evaluate, improve and optimise the energy consumption in vehicles***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, national policy makers as well as citizens.

In this context, the following tasks should be implemented:

- manufacturer evaluates the number of on board Energy Storage System (ESS) needed for train;
- Create eco-labelling system based on research and analysis;
- Manufacturer evaluates the impact of different novel technologies on the energy consumption of the vehicle.

4. ***Operator uses a modelling tool to improve energy consumption at the network***

The stakeholders of the second scenario involve commercial transport and logistics industry players, national policy makers as well as citizens.

In this scenario, the rail transport operator based on the modelling and analysis of parameters decides to improve and implement a Driving assistance systems (DAS).

3.2.2.4 Legal & regulatory area (UC9)

An indicative legal/regulatory case study for public transport is the **"Shift2MaaS: research on how to deploy the new mobility services in cities and urban environment"** and the corresponding objective is to create a holistic and reliable environment for the presentation of new services. As such, the following needs should be addressed:

- Operators to have access in all necessary data (e.g. API descriptions, GIS files, etc.) and a new system to be established.

Two possible scenarios provided for the aforementioned case study:

3. ***Mandatory publications of datasets by the local public transport operators***

Regarding the first scenario, the involved stakeholders are mainly public transport operators, national policy makers as well as regional policy makers and last but not least citizens.

In this context, the following tasks should be implemented:

- National access points (NAPs) collect data for local transport operators;
- NAPs publish data in a specialised database system;
- IT developers and third-party service use the data for developing the holistic system under specified terms and conditions.

4. ***Public transport operators do not share their datasets publicly***

The stakeholders of the second scenario involve public transport operators, national policy makers as well as regional policy makers and last but not least citizens. In this scenario, the external IT development stakeholders should develop a travel companion based on the available data and online ticketing systems that may not be complete.

3.2.2.5 Technological area (UC11)

An indicative case study for public transport technological area is the **"ELIPTIC - recharging of electric vehicles using tram catenaries"** and the corresponding objective is to provide electrification solutions for the public transport in cities. As such, the following needs should be addressed:

- to identify the permits for reselling energy;
- to examine the potential training schemes for staff and tram drivers;
- to access data coming from the energy charging points.

Two possible scenarios provided for the aforementioned case study:

3. ***Opportunity recharging of electric buses using tram catenaries***

Regarding the first scenario, the involved stakeholders are mainly public transport operators, power suppliers and national transport authorities.

In this context, the following tasks should be implemented:

- to pilot test electric buses with smaller battery capacity due to increase in opportunity charging;
- to test the network reliability as the number of electric buses increase.

4. ***Opportunity recharging of electric buses and cars using tram catenaries***

The stakeholders of the second scenario involve public transport operators, power suppliers and national transport authorities.

In this scenario, the following tasks should be implemented:

- to analyse electric car market due to the additional charging stations in urban areas
- to implement technologies that put higher priority in electric buses rather than cars and analyse the road transport behaviour of vehicles.

3.2.2.6 Transport planning area (UC12)

An indicative case study in the transport planning area for public transport is the **"MOMENTUM - Update transport models to properly account for new mobility options"** and the corresponding objective is to acquire a better knowledge of the impact of emerging mobility services and technologies and optimize the passenger throughput in urban areas. As such, the following needs should be addressed:

- to collect all publicly available data provided by the public transport operators and private service stakeholders;
- to define structural changes for future implementation;
- to increase awareness of passengers profiles in public transport for research purposes.

Two possible scenarios provided for the aforementioned case study:

3. ***Data provided by private services providers through specific collaboration agreements***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players (MaaS operators, electric vehicle sharing providers) and local public transport authorities. In this context, public transport authorities can tailor its strategy and services in order to include new mobility solutions.

4. ***Data not provided by private services providers so transport models are not complete***

The stakeholders of the second scenario involve commercial transport and logistics industry players (MaaS operators, electric vehicle sharing providers) and local public transport authorities.

In this scenario, the following tasks should be implemented:

- Investigate market share of relevant digital technologies implemented in the electric vehicle prototypes;
- Investigate passengers' behaviour patterns by adjusting the information provided inside the public transport vehicles and receive online feedback from them.

3.2.3 Evaluation of Research Trends and Topics fulfilling present transport needs in public transport sector

Studying the current research trends for public transport sector (as presented in Table 5) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 7).

Table 7: Research trends and topics for public transport based on Use cases and previous research (BE OPEN, 2019)

SOCIO ECONOMIC AREA
AVAILABLE PARTNERS
Private public partnership
Business models for urban mobility
Common standards and procedures
ACCESS TO DATA AND SERVICES
Integration with other transport modes
ITS infrastructures
Fully integrated management systems
ABILITY TO SHARE DATA
Interoperability of transport systems
Integration with other transport modes
Co-modality/Intermodality
Fully integrated management systems
Common standards and procedures
INFORMATIONS EASY TO BE FOUND
Increase use of public transport
Seamless mobility
On demand public transport
Competitive transport
Environmental friendly transport
Accessibility
ITS infrastructures
On demand public transport
ABILITY TO CREATE AN INTEGRATE SYSTEM
Innovative forms of urban transport
Increase use of public transport
Seamless mobility
Personalised/smart services
Transport network
Sustainable urban systems
Development of critical technologies
Integration with other transport modes
Integrated urban plan
Mobility integration
Navigation and control systems for optimised planning and routing
Shared mobility

It is interesting to underline trends that show in more than one business modelling needs:

- Common standards in: Available partners and Ability to share data;
- Interoperability of transport systems in: Access to data and services and Ability to share data;
- Integration with other transport modes in: Access to data and services and Ability to share data;
- ITS infrastructures in: Access to data and services and Information easy to be found;
- Fully integrated management systems in: Access to data and services and Ability to share data;
- Increase use of public transport in: Information easy to be found and Ability to create an integrated system;
- Seamless mobility in: Information easy to be found and Ability to create an integrated system.

BUSINESS MODELLING AREA
BUSINESS MODELS FOR DATA SHARING
Shared mobility
Intelligent mobility & Infrastructures
Integrated ticketing systems
Connected automated driving technology
IT connectivity
Big data applications
V2I and I2V communications
Communication and positioning technologies
Co-modality/Intermodality
On demand public transport
Personalised/smart services
Automated transport
IMPACTS FOR LACK OF GOVERNACNE FRAMEWORK
Policy and regulatory needs
Public Private Partnership
System competitiveness
Common standards and procedures
IMPACTS OF OPEN DATA POLICIES
Pricing and payment systems
Traffic accidents mitigation

User/public acceptance
Traffic congestion
Mixed traffic environments
Transport system efficiency
Traffic modelling
Traffic control
Pricing and externalities
IMPACTS OF OPEN DATA POLICIES
Innovative maintenance
Decarbonisation
Automated transport
Resilient transport systems
Collective transport
Interoperability of transport systems
Sustainable urban systems
Vehicles efficiency
Mitigation of climate change

ENVIRONMENTAL AREA
ENERGY CONSUMPTION INDICATORS OF VEHICLE
Network efficiency assessment
Pricing and externalities
Common standards and procedures
Environmental Impact Assessment
Emissions abatement
Eco-innovation
Energy consumption reduction
TOOLS ENABLE COMPARISON OF DIFFERENT VEHICLES
Innovative powertrains
Big data, Artificial Intelligence and their applications
Improve standards for noise, emissions and diesel engines
Innovative maintenance
Urban mobility solutions
Safety constraints
Green vehicles
Emissions reduction
Environmental constrains
Design of vehicles

Accessibility
Vehicles efficiency
More comfortable transports
NOVEL TECHNOLOGIES FOR REDUCTION ENERGY CONSUMPTION
Batteries for electric driving, regenerative braking, alternative power sources
NOVEL TECHNOLOGIES FOR REDUCTION ENERGY CONSUMPTION
Innovative maintenance
Fatigue behaviour
Land use and transport interaction
Electrical and automated vehicles
Eco-innovation
Alternative fuels
Innovative powertrains
SYSTEMS FOR OPTIMIZATION DRIVING AND ENERGY CONSUMPTION IN NETWORK
Transport system efficiency
Fatigue behaviour
Fitness to drive
Intelligent mobility & Infrastructures
Streamlining the infrastructure for more efficient land use such as removing bottlenecks, building flyovers and reducing the number of level intersections
Communication and positioning technologies
V2I and I2V communications
Navigation and control systems for optimised planning and routing
ITS infrastructures
Environmentally friendly transport
Network efficiency assessment

LEGAL & REGULATORY AREA
LEGAL FRAMEWORK FOR MaaS
Policy and regulatory needs
Public Private Partnership
Safety constraints
Environmental constrains
Innovation and competitiveness

REGULATORY FRAMEWORK FOR DATA PUBLICATION AND TREATMENT
Common standards and procedures
POLICIES FOR SUPPORTING ALTERNATIVE MOBILITY
Decarbonisation
Environmental constrains

TECHNOLOGICAL AREA
INNOVATIVE SOLUTIONS FOR RECHARGING VECHICLES
Intelligent mobility & Infrastructures
Inter-modality infrastructures
IT connectivity
Electrical and automated vehicles
V2I and I2V communications
Batteries for electric driving, regenerative braking, alternative power sources
Innovative forms of urban transport
Green vehicles
Personalised/smart services
ITS infrastructures
Dedicated infrastructures
POLICIES FOR SUPPORTING ELECTRIC OPPORTUNITIES
Policy and regulatory needs
Decarbonisation
Circular economy in transport
Pricing and externalities
Mitigation of climate change
Eco-innovation
TRAINING CAMPAIGNS FOR USERS AND STAFF
User/public acceptance
POLICIES FOR RESELLING ENERGY
Public Private Partnership
Connected automated driving technology
Circular economy in transport
Pricing and externalities
Energy consumption reduction
Eco-innovation
ACCESS TO CHARGING SYSTEM DATA

Connected automated driving technology
IT connectivity
Big data, Artificial Intelligence and their applications
V2I and I2V communications
ACCESS TO CHARGING SYSTEM DATA
Communication and positioning technologies
Shared mobility

TRANSPORT PLANNING AREA
COLLECTION OF DATA FROM PT OPERATORS AND PRIVATE PROVIDERS
Intelligent mobility & Infrastructures
Public Private Partnership
IT connectivity
Big data, Artificial Intelligence and their applications
V2I and I2V communications
Communication and positioning technologies
Mobility integration
NEW MOBILITY PLANNING SOLUTIONS AND TECHNOLOGIES
Shared mobility
Intelligent mobility & Infrastructures
Integrated systems
Electrical and automated vehicles
Connected automated driving technology
Navigation and control systems for optimised planning and routing
TOOLS FOR ANALYSIS OF NEW SOLUTIONS' IMPACTS AND BENEFITS
Network efficiency assessment
Traffic modelling
Business plan for mobility
Policy and regulatory needs
Pricing and externalities
Social impacts
Common standards and procedures
Environmental Impact Assessment

INTERFACE WITH PASSENGERS AND STAKEHOLDERS
Public Private Partnership
Vulnerable road users
User/public acceptance
Social service

3.2.4 Gaps identification and Recommendations for public transport sector

In order to develop public transport, there is a need for the following issues that are not yet addressed:

- Foster collaboration between transport and mobility service providers in order to support Mobility as a Service (MaaS) schemes.
- Disseminate new approaches to mobility that utilize technology and digitalization, where there is no more space for individual, small and limited players but where everything is linked and connected. It will be necessary to increase the diffusion of these new technologies and business models. This will support users explaining to them these new services and reluctant players in order to be competitive and survive in future market.
- Develop a governance framework for encouraging collaboration among stakeholders regarding data sharing and big data analysis. Collaboration between public authorities and policy makers is fundamental for arguments related to fair and ethical regulation of data management and, in parallel, a set of precise rules that do not excessively constrain the potentiality that can derive from these data analyses.
- Incentivize the involvement as much as possible of all the actors that can operate and influence the field of public transports. This often is not present for a direct refusal of related actors due to fears for these digital innovations. This reluctance is often due to either an ignorance for this kind of new business models or to fear of losing control to sensitive and industrial data.
- Develop a complete and unique system for comparison of energy efficiency for different kind of vehicles in order to provide a complete analysis of the most efficient vehicles.
- Analyze the driving style and modality in order to study the reduction of energy inefficiencies.
- Develop legal and regulatory schemes and incentives for the migration to alternative transport systems and to the consideration of mobility as a service. Provide adequate and precise framework of rules and incentives in relation to innovative mobility systems.
- Support the integration of different transport systems using technological developments.
- Analyze the impact of innovation technologies to relevant stakeholders and end users.

3.3 Air Transport

3.3.1 Research Trends

The Research Trends for air transport (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 8).

Table 8: Research Trends for air transport per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Harmonize the European Intermodal Education & Training Curriculum	Research in air emissions and noise pollution
Future Airport Layout	Optimising fuel burn
System and journey resilience	Inflight refuelling
BUSINESS AREA	**ENVIRONMENTAL AREA**
integrated information, communication, navigation and surveillance platform	Affordable alternative energy
Small launch space vehicles showing a promising commercial potential	Aviation's climate impact
Develop New Methods of Intermodal Learning and Training.	Adapt to climate change
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Efficient and effective policy and regulatory frameworks which ensure a global level playing field	Increasing safety
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Harmonisation of the Security Policy Framework	Small Aircraft and Personal Air Transport
Alternative aircraft configurations	Organization and management of mobility and global transport system with GNSS, not only for navigation but also for tracking and tracing of vehicles
Alternative Propulsion	
Alternative Aircraft Systems	
Air Traffic Control (ATC)	
Design, manufacture and certify for safety	
Augmented reality systems	
Proactive safety management programmes	

Research topics (BE OPEN, 2019) for the air transport are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.

The following table (Table 9) presents the derived research trends per type of resource used.

Table 9: Research Trends for air transport

ORIGINAL RESEARCH DATA
Transport regulation
Integration with other transport mode
ITS applications
Intermodal travel information
Information services
OPERATIONAL DATA
Aviation Accidents/Incidents
Zero fatalities
Emissions reduction
Traffic congestion
Increasing safety
OPERATIONAL DATA
Effective transport management system
Cost-effectiveness and productivity for ANSPs in Europe
Economic impact
Increased efficiency
Job creation
Public participation
Resilient transport systems
Aviation Weather Service
Zero fatalities
Aviation Digital Data Service (ADDS)
Airworthiness
DATA FROM PUBLIC RESEARCH
Development of critical technologies
Growing of mobility demand
Increasing safety
Integration with other transport modes
Interoperability
Vehicle efficiency
Rational use of motorised transport
Clean maintenance
Emissions abatement
Alternative and cleaner fuels
More efficient transport
Eco-innovation
Fully integrated management systems
Navigation and control systems for optimised planning and routing
Adverse health effects
Dependence on fossil fuels
Competitiveness

Accessibility
Forward-looking activities
Air quality
Multi-disciplinary collaborations
New materials and processes

3.3.2 Use Cases

3.3.2.1 Socio-economic area (UC16)

An indicative socio-economic case study for air transport is the **"Public authorities want to improve accessibility of population that has fear of flight, to the air transport"** and the corresponding objective is to facilitate the access of handicapped passenger, of any disability, to air transport. As such, the following needs should be addressed:

- to assess the status of the airports regarding the accessibility;
- to check the regulations linked to the accessibility at international, national and regional level;
- to define the target to be achieved;
- to create a budget for executing the approved plan;
- to create a plan to implement the measurements (tender, time frame, etc.);
- to force aviation companies to order aircrafts with the disability seats options.

Two possible scenarios provided for the aforementioned case study:

5. ***Public authorities agreed on a plan with the airport authorities***

Regarding the first scenario, the involved stakeholders are mainly transport networks, commercial transport and logistics industry players, research centres and universities, national policy makers as well as regional policy makers, NGOs and community organizations and last but not least citizens.

In this context, the following tasks should be implemented:

- airports can be reached by all citizen groups easily (e.g. handicap people, elder people, people with disabilities, mentally disabled etc.);
- public-private partnerships for investment in airport infrastructure;
- renovation of all airports.

6. ***International Aviation authorities agreed on a plan with the airplane manufactures to include special seats for handicapped people***

The stakeholders of the second scenario involve transport networks, commercial transport and logistics industry players, aviation manufacturers, international aviation organizations, research centres and universities, national and regional policy makers, NGOs and community organizations, and citizens.

In this scenario, innovative adaptation of aircraft interior in order to be used on demand by persons of any disability could be defined as the main task that should be implemented. For example, people

with claustrophobia may employ virtual reality in order to believe that they are in an environment that suits them, or for people with autism that in principle are afraid of flying to identify the proper mechanism in order to make them feel comfortable during flight.

3.3.2.2 Business modelling (UC13)

An indicative case study in the business modelling area for air transport is the **"Engine aircraft manufacturers decide to produce electric engines for the aircrafts"** and the corresponding objective is to improve the competitiveness of the company by introducing a new state of the art electric aircraft engine. As such, the following needs should be addressed:

- the production process is reorganised (e.g. time required for finishing the element, resources required, work flow);
- Work time must be dedicated to the employees training;
- An emergency plan with the minor losses for the company is required;
- Reconsideration of the initial decision should be considered by the company.

Two possible scenarios provided for the aforementioned case study:

5. ***Company changes all production line only to electric engines***

Regarding the first scenario, the involved stakeholders are mainly transport networks and commercial transport and logistics industry players, research centres and universities, national policy makers (DCAs), as well as international policy makers (FAA, EASA, etc.).

In this context, the following tasks should be implemented:

- producers choose the type of the new engines;
- adaptation of manufacturing line according to the specific engine model;
- selection of a group of employees to be trained for the production operations of a specific engine.

6. ***Company starts the production of electric engines but also produces the traditional engines as well***

The stakeholders of the second scenario involve transport networks, commercial transport and logistics industry players, research centres and universities, national policy makers (DCAs), as well as international policy makers (FAA, EASA, etc.).

In this scenario, the following tasks should be implemented:

- the whole production chain in the factory is adapted;
- The factory employees are instructed to follow the new manufacturing process.

3.3.2.3 Environmental area (UC14)

An indicative case study in the environmental area for air transport is the **"A major airport hub wants to update the pricing scheme for the use of its infrastructure"** and the corresponding objectives are to charge the real cost so the cost of the electric driven aircrafts to be covered by the

conventional aircrafts and decide the profit margins as per shareholder's decision. As such, the following needs should be addressed:

- A sustainable business plan is needed. It must be figure out how much the fees should decrease for electric aircraft and how much they must be increased for conventional aircrafts;
- The increase margin should be decided based on the policy of the airport shareholders.

Two possible scenarios provided for the aforementioned case study:

1. ***New pricing schemes will include environmental factors***

Regarding the first scenario, the involved stakeholders are mainly transport networks and commercial transport and logistics industry players.

In this context, the following tasks should be implemented:

- Companies that their fleet has electric driven aircrafts will have reduced prices and free of charge charging facilities;
- Conventional aircrafts will pay increased tax that will cover the reduced expenses of the electrical aircrafts.

2. ***Airport infrastructure pricing schemes will not include any other factors***

The stakeholders of the second scenario involve transport networks and commercial transport and logistics industry players. In this scenario, air transport involved stakeholders should implement a flat pricing scheme, in which an increase will take place for any type of aircraft.

3.3.2.4 Legal & regulatory area (UC15)

An indicative case study in the legal/regulatory air transport area is the **"Air Taxi between country A and B"** and the corresponding objective is to facilitate the cross country transport using low cost and fast means. As such, the following needs should be addressed:

- to inform ATC when entering in the other countries aerospace;
- to tune their radio frequencies to the ATC of the other country;
- to find a station to land from where to continue with the other transportation mean.

Two possible scenarios provided for the aforementioned case study:

1. ***Air Taxi is certified to fly in both countries***

Regarding the first scenario, the involved stakeholders are mainly transport networks and commercial transport and logistics industry players. In this context, Air taxi passes the borders and continue its flight to the destination.

2. ***Air Taxi is not certified to fly in both countries***

The stakeholders of the second scenario involve transport networks, commercial transport and logistics industry players, research centres and universities, national policy makers (DCAs), as well as international policy makers (FAA, EASA, etc.).

In this scenario, the following tasks should be implemented:

- Air taxi should land at the borders of country A and the passengers to continue to their destination with another air taxi;
- Air taxi should land at the borders of country A and the passengers to continue with train.

3.3.2.5 Technological area (UC17)

An indicative case study in the technological area for air transport is the **"Reduction of noise and emissions produced by aircrafts"** and the corresponding objective is to make areas near airports viable for all citizens and the aircrafts environmental friendly. As such, the air transport stakeholders need to develop innovative aircrafts with environmental friendly engines and low noise and emissions.

Two possible scenarios provided for the aforementioned case study:

1. ***Incorporation of aircrafts with electric engines or aircrafts with new engines options***

Regarding the first scenario, the involved stakeholders are mainly transport networks and commercial transport and logistics industry players.

In this context, the following tasks should be implemented:

- Set the maximum emission level allowed;
- Improvement of acoustical properties of the key elements.

2. ***Plan for the installation of noise insulation measurements in the affected properties***

The stakeholders of the second scenario involve transport networks and commercial transport and logistics industry players.

In this scenario, the following tasks should be implemented:

- Set the maximum noise level allowed at adjacent properties;
- Analysis of the possible measures;
- Implementation of the measures to reduce the noise level in the properties.

3.3.2.6 Transport planning area (UC18)

An indicative case study in the transport planning area for air transport is the **"Aviation company wants to offer a new passenger service experience"** and the corresponding objective is to offer the new service at a competitive price and maximize profits. As such, the following needs should be addressed:

- to identify the required aircraft characteristics (e.g. number of seats, energy consumption, approximate price) and the number of aircraft required;

- examine and decide financial resources to be compromised and contract conditions (with maintenance included in the contract or not) for the tender/leasing contract;
- agreed with the supplier the delivery conditions (e.g. place, time).

Two possible scenarios provided for the aforementioned case study:

1. ***Aviation company buys new aircrafts***

Regarding the first scenario, the involved stakeholders are mainly transport networks and commercial transport and logistics industry players.

In this context, the following tasks should be implemented:

- Analysis of the modern aircraft markets;
- Publications of tenders with required specifications.

2. ***Aviation company leases new aircrafts***

The stakeholders of the second scenario involve transport networks and commercial transport and logistics industry players.

In this scenario, the following tasks should be implemented:

- Contact potential leasing aircraft companies;
- Negotiation of prices, terms and conditions of the new leased fleet and the agreed timeframe.

3.3.3 Evaluation of Research Trends and Topics fulfilling present transport needs in aviation sector

Studying the current research trends for air transport sector (as presented in Table 8) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 10).

Table 10: Research trends and topics for air transport based on Use cases and previous research (BE OPEN, 2019)

SOCIO-ECONOMIC AREA
Meeting societal and market needs
Ensuring safety and security
Efficient security and boarding measures trough enhanced system predictability
Promote flying as the safest mode of transport
Ensuring safety and security:
Passenger Data protection
Maintain the safety level
Ensure and promote higher security rules by developing efficient Cyber security rules and monitoring the risks
BUSINESS AREA

Maintaining and extending industrial leadership
Promote open and fair market for aircraft
Integration and deployment of new technologies: Electrical aircraft and Drones
Competitive products, leading-edge design and system integration
Knowledge the benefits of Big Data technologies and Artificial Intelligence
Joint collaboration, implementation and coordination in definition of European research and innovation strategies
Identification of stakeholders involved: Industry, Research Organisation, Education and science Facility, Government and public authority, other, regulatory unit (EASA)
Support and enforce talent pool of students
Stimulate the interest of children and motivate students to pick up interest in aerospace engineering by different international program and commercial
Promote carrier in aviation by creating an clear overview of opportunities
Reduce gender bias in the field of aviation and encourage girls to take aeronautical degree
BUSINESS AREA
Maintaining and extending industrial leadership
Joint collaboration, implementation and coordination in definition of European research and innovation strategies
Prioritising research, testing capability and education
TECHNOLOGICAL AREA
Prioritising research, testing capability and education
Innovative aircraft design, certification, operation and maintenance
Faster up-take and implementation of new technology
Investment in the research and Innovation to answer the environmental goals
LEGAL/REGULATORY AREA
Maintaining and extending industrial leadership
Ease the Certification procedure and foster Regulatory framework
New generation of standards – harmonized Certification process
Enhance cooperation between private public partnership in local as well as international level
ENVIRONMENTAL AREA
Protecting the environment and energy supply
Reduction of environmental impact in global level

Major reduction of CO2 emissions and NOx emissions
Sustainable Alternative Fuels
Aircraft development
Aircraft movements emission free - taxiing
Prioritisation of environmental action plans and establishment of global environmental standards
Analyse and predictability of extreme weather
TRANSPORT PLANNING AREA
Comparable and reliable travel data
Multimodal use of transport
Interoperable and networked systems for seamless air transport
Reduction of delays
Knowledge the benefits of Big Data technologies and Artificial Intelligence

3.3.4 Gaps identification and Recommendations for aviation sector

In order to develop air transport, there is a need for the following issues that are not yet addressed:

- Enhance technological innovation in designing aircrafts in order to reduce the environmental impact and invest into sustainable environment as the long-life expectancy of an aircraft, around 25 years, make it a challenge in the aviation sector.
- Foster cooperation with between scientists and regulatory units in order to regulate and certify new technology without jeopardising security and safety issues. As such, regulatory units are aware of technology development and start preparation actions to ease the certification process and would allow deploying new technology or processes faster.
- Fragmentation of European Sky is one of the problems to cause congestion in the airspace and therefore delays in the air traffic. The difference in the implemented procedures, based on country is making implementation of new technology and new services time-consuming. Further development of Single European Sky needs to be fostered, to harmonise the procedures and therefore reduce the delays in the air traffic management.
- For the travellers, the journey resilience, punctuality and predictability are important. Better connected Europe must be put in place to fulfil the customer's needs. To achieve that, connection between different modes of transport need to be created. This includes information exchange as well as relevant infrastructure development in order to create seamless transport network. Moreover, the change of concept could be considered, to build up transport network passenger centric, instead transport mode centric.
- Enhance Cyber security and make the best use of the available data and digitalisation to develop new and sustainable technologies. Furthermore, investigate how to make better use of available data and to connect it with other transport modes. This would enable efficient exchange of information, reduce delays and would make journeys more resilient.
- Foster cooperation at national and international level for the aviation sector. Support innovation and research in aviation sector to remain on the competitive level. *There is currently a gap comparing with US, where the investment is more than 4 time higher than in*

Europe. 2018, the investment for Europe, for civil aeronautics was 9€bn, comparing to land and naval, where the investment was 4€ bn. To maintain the Europe's leadership in transport, including aviation, the investments in the research and innovation, needs to be fostered.

3.4 Maritime Transport

3.4.1 Research Trends

The Research Trends for maritime transport (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 11).

Table 11: Research Trends for maritime transport per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Digital technologies to change business models	Alternative fuels and renewable energy sources
Integration of logistics	Local and global air emissions
Risk management	Environmental monitoring
Innovative Supply-Chain Design based	Water and noise pollution
BUSINESS AREA	**ENVIRONMENTAL AREA**
	Blue growth development
	Green retrofitting
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Regulatory local and international framework	Pricing and externalities
	Circular economy
	Offshore infrastructure & living
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Vessel automation and vessel autonomy	Intermodal Transport (Short Sea Shipping, Inland Shipping, Deep Sea Shipping)
Smart grid & smart sensors	Improving the interaction between long distance freight transport and urban freight
Offshore infrastructure & living	Maritime spatial planning
Automated ships	Sea main routes and the efficient integration with ports
Industry 4.0, big data & blockchain	Sea hubs and the motorways of the sea
Security systems	Land services and inland terminals
ICT and River Information Services (RIS)	

Research topics (BE OPEN, 2019) for the maritime transport are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.

The following table (Table 12) presents the derived research trends per type of resource used.

Table 12: Research Trends for maritime transport

ORIGINAL RESEARCH DATA
Emission reduction
ITS applications
Alternative fuels
Environmental efficiency
Regulatory framework
Hybrid vehicles
Innovative logistics solutions
OPERATIONAL DATA
Common standards and procedures
Safety and security
Innovative freight systems
Interoperability of transport systems
Blockchain
Social impacts
DATA FROM PUBLIC RESEARCH
Control system
Electric vehicles
Autonomous vehicles
Design of vehicles
Propulsion system
Clean fuels
Process automation
New materials and processes
Productivity
Adverse health effects
Forward-looking activities
Sustainable urban systems
Competitiveness
Policy instruments
Multi-disciplinary collaborations
Noise pollution
Dependence on fossil fuels
Social service
Value creation
Integrated business model
Resilient transport system
Inclusive and affordable transport
Robust transport systems
Zero emissions

Process automation

3.4.2 Use Cases

An indicative socio-economic case study for maritime transport is the **"New ferry service between mainland and small island community"** and the corresponding objective is to encourage the maritime transport sector to improve socio-economic growth between small communities and improve their transport links. As such, the following needs should be addressed:

- to establish good communication between local authorities and port;
- to enhance cooperation between ports and local businesses;
- to capitalize additional man power for development work and operation phases.

Three possible scenarios provided for the aforementioned case study:

7. ***Existing port facilities can accommodate the extra service***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistic industry players along with national public authorities and international policy makers (European Commission).

In this context, the following tasks should be implemented:

- test whether new services disrupt the current ones;
- to create a common timetable between port authorities and companies.

8. ***Existing port facilities need to be upgraded to cope with extra service***

The stakeholders of the second scenario involve national policy makers, NGOs and community organizations and last but not least citizens.

In this scenario, the following tasks should be implemented:

- to create a common timetable between port authorities and companies;
- to minimize the travel disruptions.

9. ***No port facilities exist***

The stakeholders of the second scenario involve national policy makers, NGOs and community organizations and last but not least citizens.

In this context, the following tasks should be implemented:

- to create a common project management plan between port authorities and companies;
- construction and development of required facilities;
- to create a collaborative environment between port authorities and local entrepreneurs.

3.4.2.1 Business modelling (UC19)

An indicative case study in the business modelling area for maritime transport is the **"Shipyard installs new production equipment"** and the corresponding objective is to improve shipyard efficiency and reduce environmental health impacts. As such, the following needs should be addressed:

- to enhance cooperation between shipyard, investors and local/national authorities;
- to acquire support from equipment companies to upgrade processes and provide staff training services;
- to create and use research data from other industries on technological advances for heavy industry equipment.

Two possible scenarios provided for the aforementioned case study:

7. ***Equipment is based on previously used technology***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistic industry players along with national public authorities, NGOs and community organizations and last but not least citizens.

In this context, the following tasks should be implemented:

- Facilities upgrade and review on existing procedures;
- New training on staff members to properly handle the new equipment.

8. ***Equipment is based on new technology***

The stakeholders of the second scenario involve stakeholders are mainly commercial transport and logistic industry players along with national public authorities, NGOs and community organizations and last but not least citizens.

In this scenario, the following tasks should be implemented:

- To develop facilities that will incorporate the new equipment;
- Set up new manufacturing processes;
- Upskill staff members and familiarize them with the new equipment;
- Create an inspection mechanism as part of the new quality assurance plan.

3.4.2.2 Environmental area (UC20)

An indicative case study in the environmental area for maritime transport is the **"building ("silent") vessels (ships, submarines etc.) equipped with underwater noise mitigation technology"** and the corresponding objective is to develop innovative cost effective solutions to reduce the most harmful underwater radiated noise from shipping and provide a foundation for policy makers. As such, the following needs should be addressed:

- Develop standardised methods to measure and assess the impacts from underwater noise generated by shipping and boats;
- To establish appropriate limits of underwater noise;

- To increase understanding of the short and long term environmental impacts of underwater noise from ships and other marine vehicles;
- To identify the most harmful underwater noise characteristics.

Two possible scenarios provided for the aforementioned case study:

5. ***Certain water species in rivers and at sea are under extinction due to harmful underwater noise from ships***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistic industry players along with national public authorities, research centres and universities, NGOs and community organizations and last but not least citizens.

In this context, operators could lower the frequency of high speed boats cruise in rivers and/sea-water regions.

6. ***Effect in behaviour and health of fish, sea mammals and other kinds of marine life by underwater noise from ships and other marine vehicles***

The stakeholders of the second scenario involve commercial transport and logistic industry players along with national public authorities, research centres and universities, NGOs and community organizations and last but not least citizens.

In this scenario, the marine cruise operators in cooperation with research community and national authorities to perform underwater drills and experiments. Additionally, LNG and container carriers in larger scale could alter their sailing speed and research community could find an alternative sea location for the reproduction and establishment of different marine species.

3.4.2.3 Legal & regulatory area (UC21)

An indicative legal/regulatory case study for maritime transport is the **"Ferry crossing between NI and GB after BREXIT"** and the corresponding objective is to avoid disruption and reduce the impact of cargo transport activities. As such, the following needs should be addressed:

- Good communication between port authorities with local/national public authorities and relevant industry players;
- Regulative support from local/national public authorities to minimize disruption and speed up legal processes;
- Facilitate the available research data on new technologies for security reasons.

Two possible scenarios provided for the aforementioned case study:

5. ***No free movement of people and goods with enhanced technology***

Regarding the first scenario, the involved stakeholders are mainly transport networks, national policy makers as well as international policy makers (European Commission).

In this context, the following tasks should be implemented:

- Collaboration plan between port authorities and local/national authorities to establish specific regulatory procedures for the development of port facilities and the fast incorporation of new technologies;
- Raise public awareness on these new procedures.

6. ***No free movement of people and goods with no enhanced technology***

The stakeholders of the second scenario involve commercial transport and logistics industry players along with citizens. In this scenario, the collaboration between port and local/national authorities will evaluate the current port facilities and focus on mapping the society expectations on this matter.

3.4.2.4 Technological area (UC23)

An indicative case study for maritime transport technological area is the **"Sections of the ship made of composite materials"** and the corresponding objective is to build lighter ships and use new resources that will reduce ship construction costs and production time. As such, the following needs should be addressed:

- Ensure the new vessel will comply to all regulations and safety instructions;
- to create new inspection mechanisms for maintenance plans;
- to receive feedback from ship owners/operators/shipyards on problems faced during construction, operation and maintenance.

Two possible scenarios provided for the aforementioned case study:

5. ***Plan for increased number of inspections***

Regarding the first scenario, the involved stakeholders are mainly maritime transport industry players, national transport authorities and policy makers along with international policy makers (European Commission).

In this context, the following tasks should be implemented:

- inspections are carried out while vessel is in operation;
- Maintenance and repair is carried out without major disruption to services.

6. ***Inspection plan is not modified***

The stakeholders of the second scenario involve commercial transport and logistics industry players, research community and citizens.

In this scenario, the maritime transport industry key players should analyse the expected downtime for maintenance operations and check the effect on total profits and technical availability of the system.

3.4.2.5 Transport planning area (UC24)

An indicative case study in the transport planning area for maritime transport is the **"Ship owner/operator buys a LNG propelled vessel"** and the corresponding objective is to improve cost

effectiveness of operations and comply with international/European environmental legislation (i.e. Sulphur cap etc.). As such, the following needs should be addressed:

- to use state of the art technology propulsion engines and auxiliary machinery;
- to use Advanced Ship design methods (i.e. use dual fuel engines to account for redundancy etc.);
- to utilize advanced planned maintenance techniques and logistics to reduce life cycle cost.

Two possible scenarios provided for the aforementioned case study:

5. ***Ship stops at a port with LNG bunkering facilities***

Regarding the first scenario, the involved stakeholders are mainly commercial transport and logistics industry players, public authorities and citizens.

In this context, the following tasks should be implemented:

- Agreements between ship owner/operator and port authorities to be made;
- Evaluate the current procedures of re-fuelling, which is concurrent with off-loading and loading of cargo/passengers.

6. ***Ship stops at a small port with no LNG bunkering facilities***

The stakeholders of the second scenario involve commercial transport and logistics industry players, public authorities and citizens.

In this scenario, the following tasks should be implemented:

- Agreements between ship owner/operator and port authorities to be made;
- Evaluate the current procedures of re-fuelling, which is concurrent with off-loading and loading of cargo/passengers;
- Evaluate requirements for LNG truck loading/unloading and re-fuelling procedures.

3.4.3 Evaluation of Research Trends and Topics fulfilling present transport needs in maritime sector

Studying the current research trends for maritime transport (as presented in Table 11) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 13).

Table 13: Research trends and topics for public transport based on Use cases and previous research (BE OPEN, 2019)

BUSINESS MODELLING	TECHNOLOGICAL AREA
Process automation	Process automation
Decarbonisation	Climate change effects in maritime
Circular maritime economy	Decarbonisation

	Regulatory framework
SOCIO-ECONOMIC AREA	**ENVIRONMENTAL AREA**
Port-hinterland connectivity solutions	Noise pollution
Risk management and mitigation framework for ship and ports	Common standards and procedures
Maritime spatial planning	Policy instruments
Population growth	Propulsion system
	Hybrid vehicles
	Design of vehicles
	Environmental monitoring
TRANSPORT PLANNING AREA	**LEGAL/ REGULATORY AREA**
Decarbonisation	Innovative logistics solutions
Integrating shipping and inland navigation into seamless port and logistics operations	ITS applications
Competitiveness	Productivity
Emission reduction	Regulatory framework
Multi-disciplinary collaborations	Safety and security
Clean fuels	Social impacts
Design of vehicles	Policy instruments
Innovative logistics solutions	Multi-disciplinary collaborations
Propulsion system	Process automation
Integrated business model	

3.4.4 Gaps identification and Recommendations for maritime sector

In order to develop maritime transport, there is a need for the following issues that are not yet addressed:

- Enhance communication and collaboration between certain stakeholders. *For example, the IMO Sulphur cap has been entered into force since January 2020, even though major ship-owners associations, European and IMO member states expressed their concern with the subject regulation and said that more time was needed for a thorough assessment of the safety implications that the new regulations would create for vessels and crews.*
- Support multi-disciplinary collaboration effort in an attempt to enhance latest developments in the maritime sector which are related to greener, more knowledge based and digital economy.
- Emphasis on transversal integration of systems (i.e. technologies, infrastructures etc.) that increase readiness level (TRL) of the most promising technologies and create synergies among diverse activities (e.g. Oil & gas, MRE, deep/far sea exploitation, desalinization process, aquaculture etc.).
- Study and analyze administrative burdens and bureaucracy. *For example, the maritime equipment certification requirement is prescribed by certain regulatory organizations (RO's) and pertinent stakeholders, who still have not achieved to arrive at a system of mutual recognition. The latter create significant costs and slows down business development and economic growth in Europe.*

- Study the potential of blockchain technology which could provide a turnaround to different types of delays and inefficiencies and boost marine transport. *For example, International shipments require companies and customs officials to fill out a large number of different types of documents (most of them paper-based) to move goods from exporter to importer. This practice fails to provide real-time visibility that can cause setbacks in financial settlements.*
- Improve and study safety and security issues (i.e. prevention of accidents, safety of personnel) and security (i.e. terrorism, border control/immigration etc.).

3.5 Shared Mobility

3.5.1 Research Trends

The Research Trends for shared mobility (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 14).

Table 14: Research Trends for shared mobility per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Integrated Synchromodal Services	Land-use and transport interaction
Increase asset and infrastructure utilization by Sharing	Cleaner and more efficient vehicles
Collaboration Tools	
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Public Private Partnership	Fitness to drive
Information & data sharing policies	Land-use and transport interaction
Policy and regulatory needs	Behavioural adaption and change on safety issues
	User awareness
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Communication and positioning technologies	Inter-modal aspects of urban mobility
Cooperative systems and platforms	Risk Analysis and Management
Friendly user interfaces	Traffic control
	Traffic modelling
	Needs of users

Research topics (BE OPEN, 2019) for shared mobility are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.

The following table (Table 15) presents the derived research trends per type of resource used.

Table 15: Research Trends for shared mobility

ORIGINAL RESEARCH DATA
Safety and security
Big data analysis tool
Data analytics
Zero fatalities
Innovative systems
ITS applications
Data sharing
Passengers at the center
Inclusive and affordable transport
OPERATIONAL DATA
Rules and regulations
Road users safety
DATA FROM PUBLIC RESEARCH
Traffic congestion
Economic development
Social constrains
Competitive transport
Security
Congestion
Environmental performances
DATA FROM PUBLIC RESEARCH
Mobility integration
Accessibility
Innovation and competitiveness
Carbon footprint
Circular economy
More comfortable transport
Forward looking activities
Innovative freight delivery systems
Social service
Personalised/Smart services
Private-Public Partnership
Smart city planning
Seamless mobility
Polluting transport
Demographic trends
Environmentally friendly transport

3.5.2 Use Cases

3.5.2.1 Socio-economic area (UC29)

An indicative socio-economic use case for shared mobility is the "**User acceptance of automated driving for shared mobility"**. First, the objectives of this Use Case are to define which actions should be taken in order to increase user acceptance for automated driving in the frame of shared mobility. In order to define this, the following **needs** should be answered:

- Define the acceptable level of automation for passengers;
- Define the reasons why some levels of automations appear not to be acceptable to passenger;
- Communicate on automated driving safety.

The involved **stakeholders** are mainly researchers, mobility operators, city planning services, and the citizens.

The following tasks should be conducted:

- Study users' acceptance of automation in the frame of shared mobility;
- Define how to attract users to shared mobility automated systems;
- Communicate on automated driving safety.

3.5.2.2 Business modelling (UC25 & UC26)

Two uses cases can be described under the business modelling area for shared mobility: (i) the **"Shared mobility operator proposes services in a city"** and (ii) the "**Shared mobility operator proposing MaaS services".**

The objectives of the first Use Case are to increase mobility possibilities for passengers in the city, to optimize mobility and use of transport network and to increase users' awareness about shared mobility possibilities in the city. In order so prepare the setting up of this kind of new service in a city, the shared mobility operator should answer the following needs:

- Have contacts with the local transport authorities;
- Have access to travel data of the city in order to set the best possible plan to support citizen mobility;
- Shared mobility operator proposes MaaS services in a city;
- Have agreement with city planning allowing to make the necessary works;
- Have large dissemination means.

The involved stakeholders are mainly the mobility operators, the city planning services, the transport networks and the citizens while the main actors are the shared mobility provider, the local transport authority and the city council.

As for the setting up of the new service, the following tasks should be conducted:

- Shared mobility operator contacts city planning authorities;
- Shared mobility operator sets its mobility plan for the city;
- Shared mobility operator set agreements to set up shared vehicles areas in the city;

- Shared mobility operator sets communication plan to inform citizens of shared mobility possibility in the city.

Similarly, the objectives of the second Use Case are to optimise mobility and use of transport network and develop seamless travel for users. In order to prepare the setting up of this kind of new service in a city, the shared mobility operator should answer the following needs:

- Make contacts with already existing transport operators of the city and have access to the city needs in terms of mobility;
- Set common needs and objectives, have access to mobility data of the city;
- Be able to create an integrated ticket, have access to travel companion.

The involved stakeholders are mainly mobility operators, city planning services, transport network and citizens.

As for the setting up of the new service, the following tasks should be conducted:

- Shared mobility operator contacts already existing mobility operators in the city;
- Possibility for user to buy a Maas ticket to improve mobility in the city.

3.5.2.3 Environmental area (UC27)

The environmental Use Case for Share Mobility is about **trying to reduce emissions in city**. First, the objectives of this Use Case are to define how much reduction is needed, adapt solutions to needs, adapt city planning to reduction objectives, reduce emission without impacting citizen day-to-day mobility, inform citizens.

In order so prepare the shared mobility services in a city, the following needs should be answered:

- Have access to mobility/emission data;
- Have access to data concerning technical solutions to reduce emissions;
- Have access and means to adapt city planning;
- Have enough space in city to adapt city planning.

The involved stakeholders are mainly cities, researchers, transport managers, public transport managers, public and private mobility companies & citizens.

The following tasks should be conducted:

- Analyze emissions in a chosen city;
- Suggest new mobility solutions to reduce emissions;
- Adapt city planning;
- Set up new mobility solutions and adapt transport network;
- Inform users of new possibilities.

3.5.2.4 Legal & regulatory area (UC28)

The legal and regulatory Use Case for Share Mobility is the **mixed traffic management**. First, the objectives of this Use Case are to adapt road/city transport planning to the progressive entrance of level 4/5 vehicles on roads.

In order so prepare the shared mobility services in a city, the following needs should be answered concerning legal & regulatory area:

- National regulation about mixed traffic;
- Access to data on impact of automated vehicles on roads on the traffic & traffic planning.

The involved stakeholders are mainly governments, city planning, transport operators.

The following tasks should be conducted:

- Study the impact of automated lanes allowed on highways;
- Study the impact of automated lanes allowed in city;
- Adapt the solutions to the regulatory framework.

3.5.2.5 Technological area (UC30)

The technological Use Case for Share Mobility is about **creating a resilient transport system**. The main objective is to improve the resilience capacity of the shared mobility system.

In order to achieve this, the following needs should be answered:

- Develop resilience planning capacity: anticipating, monitoring, responding, learning;
- Train rescue services & citizen;
- Plan & know evacuation routes.

The involved stakeholders are mainly weather forecast services, city rescue services, city mayor & services, citizens.

The following situations should be studied:

- What happens with possible heavy rains conducting to traffic difficulties;
- How to proceed to evacuation of public transport due to flood;
- How to set up safe points for evacuated people.

3.5.2.6 Transport planning area (UC31)

The transport planning Use Case for Share Mobility could be **developing an accessible & available mobility outside cities**. The main objective is to improve rural people mobility.

In order to achieve this, the following needs should be answered:

- How do rural people reach city center for work;
- Why are usually first public transport stops far from rural person home (this situation leading to need a car);
- Set up new bus lines in rural areas;
- Optimize bus stops so that rural areas are equally deserved;
- Develop on-demand transport.

The involved stakeholders are mainly rural/regional authorities, public transport, regional transport planning, transport operators.

The following situations should be studied:

- What can be improved when no or few public transports exist in rural areas;
- How to develop public transport and shared mobility in rural areas.

3.5.3 Evaluation of Research Trends and Topics fulfilling present transport needs in shared mobility

Studying the current research trends for public transport sector (as presented in Table 14) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 16).

Table 16: Research trends and topics for shared mobility based on Use cases and previous research (BE OPEN, 2019)

ASSESS ACCESSIBILITY
Integrated synchromodal services
Urban environment
Land use
User friendly interface
PRESENT REGULATIONS
EU Directives
National regulatory
Regulatory framework
TARGET ACHIEVED
User awareness
Meet needs of users
Cooperative systems
SPECIFIC BUDGET
Land use
Data sharing
SPECIFIC PLAN
Infrastructure use by sharing
New adapted regulations
Data sharing policies
Public Private Partnership
Collaboration tools
Traffic control

3.5.4 Gaps identification and Recommendations for shared mobility

In order to develop shared mobility, there is a need for the following issues that are not yet addressed:

- Study and define how to develop shared mobility standards in order for each shared mobility provider to speak the same language so to ease the use of shared mobility tools for users. It is to be noticed that users will only adopt new shared mobility services if they are

understandable and easy to use at the same time than other more "classical" mobility possibilities.

- Study the accessibility and equity needs for each type of users and ensure their capacity to use tools for the information, schedule, booking, payments, especially for users facing barriers related to cost of technology use.
- Create the basis for Public-Private Partnerships and targeted investment in shared mobility modes by exploring opportunities and challenges for public transport related to technology-enable shared mobility services. These PPP will be important in order to allow the development of shared mobility, as users need to be able to use mixed mobility means to go from point A to point B. Shared mobility should be complementary to other transport modes.
- Map local assets and local needs for shared mobility in order to adapt the response to the real users' needs. Also map the local existing infrastructures that can be used for shared mobility.
- Develop ways for public stakeholders and private companies to better know each other and their respective needs in terms of data sharing in order to be able to build common business models, in accordance with users' needs for an improved shared mobility.

3.6 Road Transport

3.6.1 Research Trends

The Research Trends for road transport (BE OPEN, 2019) are clustered by area of competence (i.e. Business modelling; Environmental; Legal/Regulatory; Socio-economic; Technological; Transport planning) and presented in the following table (Table 17).

Table 17: Research Trends by Main Actors for road transport per competence area

BUSINESS AREA	ENVIRONMENTAL AREA
Shared mobility in cities	Traffic efficiency
Increase asset and infrastructure utilization	Cleaner and more efficient vehicles
Urban mobility solutions	Circular economy in transport
Facilitation to city centre access	Land use and road interaction
LEGAL/REGULATORY AREA	**SOCIO-ECONOMIC AREA**
Policy and regulatory needs	Social impacts
ITS regulatory applications	User awareness
Worldwide standards	Vulnerable road users (VRU)
Information & data sharing policies	Circular economy in transport
	Safety and security in urban mobility
	Injury data
	Fitness to drive
	Pricing and externalities
	Inclusive mobility
TECHNOLOGICAL AREA	**TRANSPORT PLANNING AREA**
Automated vehicles	Accessibility

IT connectivity	Traffic efficiency
Safety systems	Mixed traffic environments
ITS applications	Global transport system with GNSS not only for navigation but also for tracking and tracing of vehicles and cargo.
Infrastructure connectivity & support systems	Traffic modelling
Electrified road systems	Traffic control
Digital awareness & resilience	
Cooperative systems	
Smart space management	
High voltage architecture	
Safe infrastructures	
Smart devices	
Intelligent information nodes	
Transport planning systems	
Communication and positioning technologies	

Research topics (BE OPEN, 2019) for the road transport are identified and classified on the basis of the type of resource used:

- Original research data;
- Operational data directly related to research;
- Data from published transport research.

The following table (Table 18) presents the derived research trends per type of resource used.

Table 18: Research Trends for road transport

ORIGINAL RESEARCH DATA
Emissions abatment
Eco-innovation
Alternative and cleaner fuels
ITS applications
Information services
Green cars
Innovation forms of urban transport
Electric and lightweight vehicles
Automated vehicles
Innovative freight delivery systems
Innovative powertrains
Economic impacts
Passengers at the center
Inclusive and affordable transport
Air quality regulation
Advanced driver assistance systems

Zero fatalities
OPERATIONAL DATA
Design integration
Traffic congestion
Effective transport management system
Increasing safety
Increased efficiency
Blockchain
DATA FROM PUBLIC RESEARCH
Integration with other transport modes
Accessibility
Dedicated infrastructure
Total cost of ownership
Increase capacity of infrastructure
Social service
Noise pollution
More comfortable service
Vulnerable road users
Environmental impact assessment
Energy consumption reduction
Navigation and control systems for optimised planning and routing
Transport network
Demographic trends
Robust transport systems
Urban studies
DATA FROM PUBLIC RESEARCH
Congestion
Safety and security
Seamless mobility

3.6.2 Use Cases

3.6.2.1 Socio-economic area (UC35)

An indicative socio-economic case study for road transport is the **"Improve the safety and comfort of pedestrians and to increase their visibility"** and the corresponding objective is to improve the safety and comfort of pedestrians. As such, the following needs should be addressed:

- to develop policy oriented to the needs of vulnerable road users instead of individual car traffic, practiced both on national and municipal levels;
- Technical norms should be revised so that they support modern forms of streets' and public spaces' arrangement - the arrangement enabling safe pedestrian traffic and humanization of urban space.

One scenario is provided for the aforementioned case study:

10. ***Public authorities agree to a change of technical rules concerning traffic space arrangement***

Regarding the first scenario, the involved stakeholders are mainly transport networks, commercial transport and logistic industry players along with regional road authorities, NGOs and community organizations, research centres and universities and last but not least citizens.

In this context, the following tasks should be implemented:

- Implementation of small roundabouts;
- Installation of central islands for protection of pedestrians;
- Optimization of road lanes width.

3.6.2.2 Business modelling (UC32)

An indicative case study in the business modelling area for road transport is the **"SKILLFUL: develop skills and competences for the transport workforce"** and the corresponding objective is to give the transport workforce the necessary skills for the changing market. As such, the following needs should be addressed:

- The need to have competent organisations to prepare courses;
- A holistic overview of the needs in the transport industry of the future.

One scenario is provided for the aforementioned case study:

1. ***Public authorities sign agreement***

Regarding the first scenario, the involved stakeholders are mainly transport networks along with regional road authorities, NGOs and community organizations, research centres and universities and last but not least citizens.

In this context, the following tasks should be implemented:

- Curriculum is defined, developed and agreed with public authorities;
- selected staff are taken through one course;
- Regular courses are made available for all staff.

3.6.2.3 Environmental area (UC33)

An indicative case study in the environmental area for road transport is the **"MIRAVEC - identify ways to reduce energy consumption and CO2 emissions from road transport"** and the corresponding objective is to reduction of CO2 emissions from road transport. As such, the relevant stakeholders need to analyze and implement already achieved results.

One scenario is provided for the aforementioned case study:

1. ***Introduction of road infrastructure design and operation***

Regarding the first scenario, the involved stakeholders are mainly regional road authorities and national policy makers.

In this context, the following tasks should be implemented:

- road authority evaluates the impact of pavement surface characteristics on vehicle energy consumption;
- road authority evaluates the impact of road design and layout on vehicle energy consumption.

3.6.2.4 Legal & regulatory area (UC34)

An indicative legal/regulatory case study for road transport is the **"Regulatory frameworks for Electrified and Automated Transport in Europe"** and the corresponding objectives are to eliminate obstacles to seamless electric driving and transport operations in Europe and promote a positive development of electrified and automated transports. As such, the road transport involved stakeholders need to create a cooperative framework for all relevant stakeholders in national and international level.

One scenario is provided for the aforementioned case study:

1. ***Unified regulations at the European level***

Regarding the first scenario, the involved stakeholders are mainly transport networks, national/regional and international policy makers (European Commission), plus research centres and universities.

In this context, the following tasks should be implemented:

- select technologies and mobility solutions related to electrification in passenger and freight transport with the potential to disrupt current regulatory approaches, to further investigate them from a socio-economic point of view and to assess the current legal framework surrounding the solutions;
- Examine the national regulatory frameworks and governance structures and their development for selected topics e.g. automated driving; Status and approach for development of regulations, new or modified, in perspective of the current regulatory framework.

3.6.2.5 Technological area (UC36)

An indicative case study for road transport technological area is the **"AEROBI - low flying unmanned robots with arms for inspection of bridges"** and the corresponding objective is to develop an innovative system for inspecting and assessing the structural condition of in service bridges. As such, the road transport stakeholders need to permit access to their inspection systems in bridge areas that could be reached by human inspectors.

One scenario is provided for the aforementioned case study:

1. ***Inspection of non-accessible parts of a bridge***

Regarding the first scenario, the involved stakeholders are mainly transport networks, national/regional and international policy makers (European Commission), plus research centres and universities.

In this context, the following tasks should be implemented:

- Develop a flying robotic system with a specialised multi-joint arm able to place Non Destructive Testing (NDT) devices in specific places on the bridge surface;
- Develop an integrated intelligent control component that should define the orientation and lighting conditions for the cameras;
- Develop a computer vision system that will combine state-of-the-art machine learning tools to automatically detect and assess defective performance in the surface through visual inspection.

3.6.2.6 Transport planning area (UC37)

An indicative case study in the transport planning area for road transport is the **"FLOW - assessing the ability of walking and cycling measures to reduce congestion in European cities"** and the corresponding objective is to assess the impact of walking and cycling on urban congestion. As such, the following needs should be addressed:

- the measures should increase mobility in urban areas for all users;
- the measures should lead to less car traffic and faster public transport;
- the measures should result in reduced time spent in congestion.

One scenario is provided for the aforementioned case study:

1. ***Public authorities approve a Sustainable Urban Mobility Plan for the city***

Regarding the first scenario, the involved stakeholders are mainly transport networks, national/regional and international policy makers (European Commission), plus research centres and universities.

In this context, the following tasks should be implemented:

- Development of on-road protected bike lanes;
- Infrastructure improvements and lower speed limits e.g. widening of bicycle and pedestrian paths, installation of dedicated lanes for buses and lowering of speed limits.

3.6.3 Evaluation of Research Trends and Topics fulfilling present transport needs in road transport sector

Studying the current research trends for road transport sector (as presented in Table 17) with the aforementioned Use Cases, a detailed table is provided summarizing the gained results (Table 19).

Table 19: Research trends and topics for road transport based on Use cases and previous research (BE OPEN, 2019)

PEDESTRIAN COMFORT and SAFETY
Increasing safety
Accessibility
Social Service
More comfortable service
Safety and security
ENHANCE TRANSPORT WORKFORCE
Economic impacts

Urban studies
Increased efficiency
POLLUTION REDUCTION
Emissions abatment
Eco-innovation
Air quality regulation
Energy consumption reduction
REGULATORY FRAMEWORK
Electric and lightweight vehicles
Automated vehicles
Innovative freight delivery systems
Seamless mobility
TECHNOLOGICAL IMPROVEMENT
ITS applications
Information services
Increasing safety
Increase capacity of infrastructure
TRANSPORT PLANNING
Innovation forms of urban transport
Passengers at the centre
Inclusive and affordable transport
Traffic congestion
Effective transport management system
Robust transport systems
Congestion

3.6.4 Gaps identification and Recommendations for road transport sector

In order to develop road transport, there is a need for the following issues that are not yet addressed:

- Study and examine the use of alternative and cleaner fuels as well as green cars in order to enhance the environmental consciousness and mitigate negative externalities to the environment.
- Study how to mitigate noise pollution as the majority of people in Europe now residing in urban areas[1] and noise pollution affects their quality of life.
- Study and explore advanced driver assistance systems and how their uptake could help reducing road fatalities and eventually achieve zero fatalities in road transport sector.
- Analyze how to support vulnerable road users[2] (i.e. people with disabilities and/or reduced mobility) regarding road transport.
- Investigate further how blockchain could support and benefit road transport activities.

[1] https://www.europarl.europa.eu/meetdocs/2009_2014/documents/envi/pr/915/915688/915688en.pdf
[2] https://ec.europa.eu/transport/themes/its/road/action_plan/its_and_vulnerable_road_users_en

A topic that can leverage and propel significant impact is the total cost of ownership (TCO) which refers to a financial estimate that takes into account not only economic cost, but social and environmental costs/benefits as well. As such, TCO should be incorporated more in future studies to support decision making.

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