Autonomous Vehicles to Evolve to a New Urban Experience

DELIVERABLE

D8.3 First Iteration Economic impact

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Acronyms

ADS	Automated Driving Systems
AI	Artificial Intelligence
API	Application Protocol Interface
ASCT	Autonomous Shuttle for Collective Transport
AV	Autonomous Vehicle
BMM	Business Modelling Manager
CAV	Connected and Autonomous Vehicles
CB	Consortium Body
CERN	European Organization for Nuclear Research
D7.1	Deliverable 7.1
DC	Demonstration Coordinator
DI	The department of infrastructure
DMP	Data Management Plan
DSES	Department of Security and Economy Traffic Police
DTU test track	Technical University of Denmark test track
EAB	External Advisory Board
EC	European Commission
EC	European Commission
ECSEL	Electronic Components and Systems for European Leadership
EM	Exploitation Manager
EU	European Union
EUCAD	European Conference on Connected and Automated Driving
F2F	Face to face meeting
FEDRO	Federal Roads Office
FEDRO	(Swiss) Federal Roads Office
FOT	(Swiss) Federal Office of Transport
GDPR	General Data Protection Regulation
GIMS	Geneva International Motor Show
GNSS	Global Navigation Satellite System
HARA	Hazard Analysis and Risk Assessment
IPR	Intellectual Property Rights
IT	Information Technology
ITU	International Telecommunications Union
LA	Leading Author
MEM	Monitoring and Evaluation Manager
OCT	General Transport Directorate of the Canton of Geneva
ODD	Operational Domain Design
OEDR	Object And Event Detection And Response
OFCOM	Federal Office of Communications
PC	Project Coordinator
PEB	Project Executive Board
PGA	Project General Assembly
PRM	Persons with Reduced Mobility
PSA	Group PSA (PSA Peugeot Citroën)
PTO	Public Transportation Operator
PTO	Public Transport Operator
PTS	Public Transportation Services
QRM	Quality and Risk Manager
QRMB	Quality and Risk Management Board
RN	Risk Number
SA	Scientific Advisor
SAE Level	Society of Automotive Engineers Level (Vehicle Autonomy Level)
SAN	Cantonal Vehicle Service
SDK	Software Development Kit
SMB	Site Management Board
SoA	State of the Art
SOTIF	Safety Of The Intended Functionality
SWOT	Strengths, Weaknesses, Opportunities, and Threats.
TCO	Total-Cost-of-Ownership
TM	Technical Manager
UITP	*Union Internationale des Transports Publics*
WP	Work Package
	Work Package Leader
WPL	

Executive Summary

The AVENUE project aims to design and carry out full scale demonstrations of urban transport automation by deploying fleets of autonomous mini-buses in European cities. Within the project, the Work Package 8 (WP8) aims to evaluate the environmental, economic and social implications of implemented urban and suburban autonomous full-scale demonstrators. Subsequently, the sustainability of urban road transport automation can be assessed.

This deliverable 8.3 Economic impact evaluation, describes the overall economic studies and analysis targeting a successful implementation of businesses for autonomous vehicles for collective urban transport, as well as, it sheds light on the potential economic benefits and impacts of the urban automated vehicle fleets in cities.

We first provide the theoretical a conceptual basis for the Economic Impact Evalation, and then we present the methodology upon which the Total-Cost-of-Ownership (TCO) calculator is defined. For the TCO calculations we take into account both macro and micro economic data. For the macro economic data we consider the general benefits for the society, while for the micro et take into account the operational costs that will be used for the operator business plans.

1. Introduction

AVENUE aims to design and carry out full-scale demonstrations of urban transport automation by deploying, for the first time worldwide, fleets of autonomous minibuses in low to medium demand areas of 4 European demonstrator cities (Geneva, Lyon, Copenhagen and Luxembourg) and 2 to 3 replicator cities. The AVENUE vision for future public transport in urban and suburban areas, is that autonomous vehicles will ensure safe, rapid, economic, sustainable and personalised transport of passengers. AVENUE introduces disruptive public transportation paradigms on the basis of on-demand, door-to-door services, aiming to set up a new model of public transportation, by revisiting the offered public transportation services, and aiming to suppress prescheduled fixed bus itineraries.

Vehicle services that substantially enhance the passenger experience as well as the overall quality and value of the service will be introduced, also targeting elderly people, people with disabilities and vulnerable users. Road behaviour, security of the autonomous vehicles and passengers' safety are central points of the AVENUE project.

At the end of the AVENUE project four year period the mission is to have demonstrated that autonomous vehicles will become the future solution for public transport. The AVENUE project will demonstrate the economic, environmental and social potential of autonomous vehicles for both companies and public commuters while assessing the vehicle road behaviour safety.

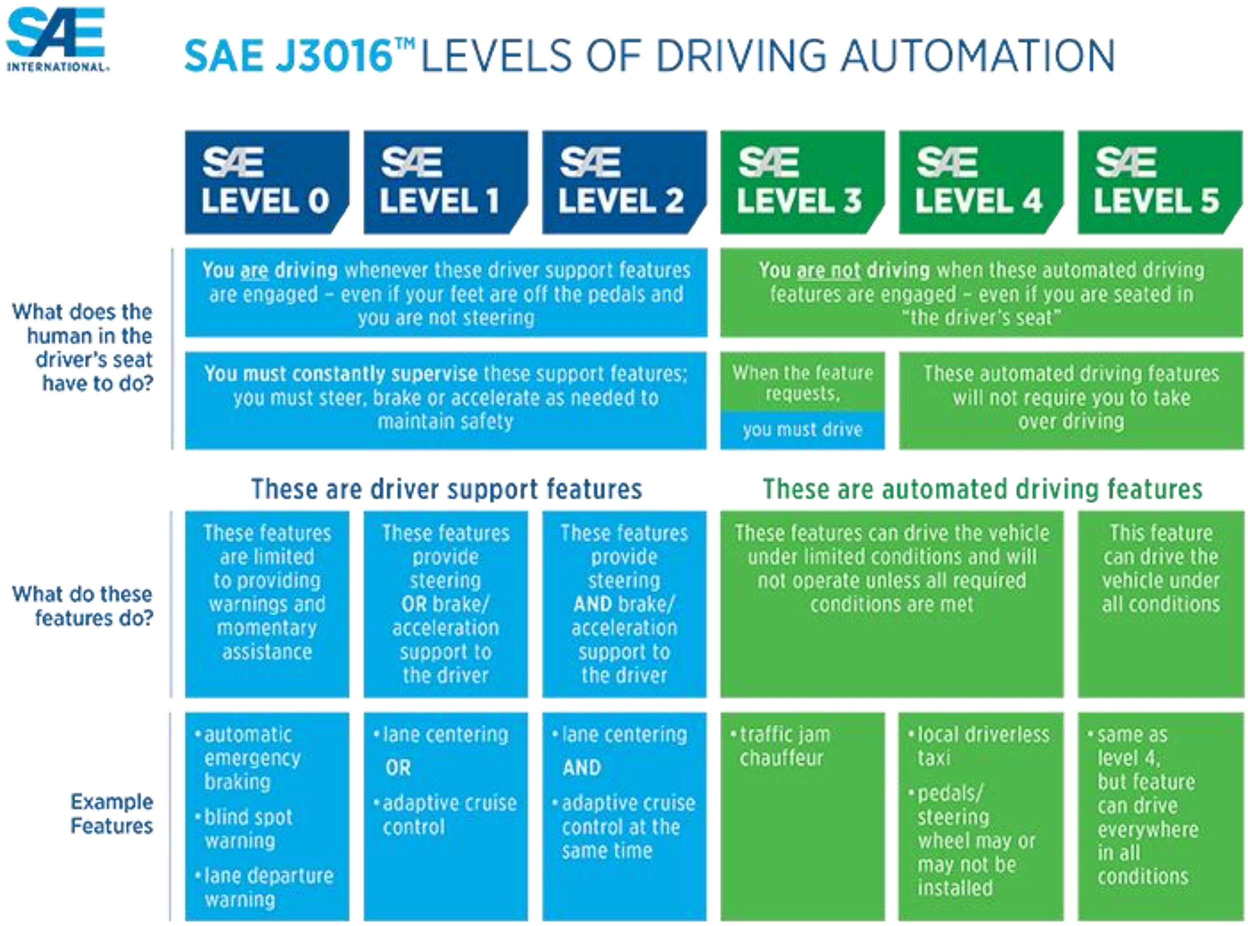
1.1 On-demand Mobility

Public transportation is a key element of a region's economic development and the quality of life of its citizens.
Governments around the world are defining strategies for the development of efficient public transport based on different criteria of importance to their regions, such as topography, citizens' needs, social and economic barriers, environmental concerns and historical development. However, new technologies, modes of transport and services are appearing, which seem very promising to the support of regional strategies for the development of public transport.
On-demand transport is a public transport service that only works when a reservation has been recorded and will be a relevant solution where the demand for transport is diffuse and regular transport is inefficient.
On-demand transport differs from other public transport services in that vehicles do not follow a fixed route and do not use a predefined timetable. Unlike taxis, on-demand public transport is usually also not individual. An operator or an automated system takes care of the booking, planning and organization.
It is recognized that the use and integration of on-demand autonomous vehicles has the potential to significantly improve services and provide solutions to many of the problems encountered today in the development of sustainable and efficient public transport.

1.2 Autonomous Vehicles

A self-driving car, referred in the AVENUE project as **an Autonomous Vehicle** (**AV**) is a vehicle that is capable of sensing its environment and moving safely with no human input. The choice of Autonomous vs Automated was made in AVENUE since, in the current literature, most of the vehicle concepts have a person in the driver's seat, utilize a communication connection to the Cloud or other vehicles, and do not independently select either destinations or routes for reaching them, thus being “automated”. The automated vehicles are considered to provide assistance (at various levels) to the driver. In AVENUE there will be no driver (so no assistance will be needed), while the route and destinations will be defined autonomously (by the fleet management system). The target is to reach a system comprising of vehicles and services that independently select and optimize their destination and routes, based on the passenger demands.

In relation to the SAE levels, the AVENUE project will operate SAE Level 4 vehicles.



1.2.1 Autonomous vehicle operation overview

We distinguish in AVENUE two levels of control of the AV: micro-navigation and macro-navigation. Micro navigation is fully integrated in the vehicle and implements the road behaviour of the vehicle, while macro-navigation is controlled by the operator running the vehicle and defines the destination and path of the vehicle, as defined the higher view of the overall fleet management.

For micro-navigation Autonomous Vehicles combine a variety of sensors to perceive their surroundings, such as 3D video, LIDAR, sonar, GNSS, odometry and other types sensors. Control software and systems, integrated in the vehicle, fusion and interpret the sensor information to identify the current position of the vehicle, detecting obstacles in the surround environment, and choosing the most appropriate reaction of the vehicle, ranging from stopping to bypassing the obstacle, reducing its speed, making a turn etc.

For the Macro-navigation, that is the destination to reach, the Autonomous Vehicle receives the information from either the in-vehicle operator (in the current configuration with a fixed path route), or from the remote control service via a dedicated 4/5G communication channel, for a fleet-managed operation. The fleet management system takes into account all available vehicles in the services area, the passenger request, the operator policies, the street conditions (closed streets) and send route and stop information to the vehicle (route to follow and destination to reach).

1.2.2 Autonomous vehicle capabilities in AVENUE

The autonomous vehicles employed in AVENUE fully and autonomously manage the above defined, micro-navigation and road behaviour, in an open street environment. The vehicles are autonomously capable to recognise obstacles (and identify some of them), identify moving and stationary objects, and autonomously decide to bypass them or wait behind them, based on the defined policies. For example with small changes in its route the AVENUE shuttle is able to bypass a parked car, while it will slow down and follow behind a slowly moving car. The AVENUE vehicles are able to handle different complex road situations, like entering and exiting round-about in the presence of other fast running cars, stop in zebra crossings, communicate with infrastructure via V2X interfaces (ex. red light control).
The shuttles used in the AVENUE project technically can achieve speeds of more than 60Km/h. However this speed cannot be used in the project demonstrators for several reasons, ranging from regulatory to safety. Under current regulations the maximum authorised speed is 25 or 30 Km/h (depending on the site). In the current demonstrators the speed does not exceed 23 Km/h, with an operational speed of 14 to 18 Km/h. Another, more important reason for limiting the vehicle speed is safety for passengers and pedestrians. Due to the fact that the current LIDAR has a range of 100m and the obstacle identification is done for objects no further than 40 meters, and considering that the vehicle must safely stop in case of an obstacle on the road (which will be “seen” at less than 40 meters distance) we cannot guarantee a safe braking if the speed is more than 25 Km/h. Note that technically the vehicle can make harsh break and stop with 40 meters in high speeds (40 -50 Km/h) but then the break would too harsh putting in risk the vehicle passengers. The project is working in finding an optimal point between passenger and pedestrian safety.

1.3 Preamble

Regarding the definition and successful implementation of businesses with autonomous electric vehicles, it is necessary to conduct the analysis & planning of essential modules of a business design concept. Therefore, detailed status quo and prospective analysis will help to propose future scenarios as well as business model innovation by M48.

The economic analysis of the used autonomous electric vehicles will thus focus first on business viability. Therefore, a comparison of the demonstrators will be conducted via a Total-Cost-of-Ownership (TCO) calculation taking into account internal cost of autonomous programs (CaPex and OpEx for transport operator, municipality and users) as well as externalities (cost of pollution, noise, time, …). On the other side, savings through mobility on demand - this means when citizens use the shuttle only when they need it - will be estimated.

The task 8.3 aims at identifying direct and indirect costs and savings as well as cost drivers and hidden costs (e.g. cleaning costs or vandalism in vehicles without drivers) can be clearly identified and evaluated as a basis for the development of a business plan to evaluate the economic viability of autonomous vehicles as a part of an integrated public transport system.

The economic benefits of the urban automated vehicle fleets for users and potential users will be evaluated. The possible improvements of journey time and the possible substitution of traditional individual transport modes like cars will be analysed.

The economic effects on cities will be assessed and compared with other cities in Europe and the rest of the world (e.g. C40 cities): possible adaptation and investments in infrastructure like charging stations, software and other costs; free up of parking space through substitution of private cars; possible need of special lines; extension of transport services to narrow roads or urban areas with week infrastructure, possible growing attractiveness of suburban areas; possible job effects through evaluation of job cuts (e.g. drivers) and job creation (e.g. operator) etc.

The evaluation of economic impact is supported with four parallel tasks which are presented in the following 3 sections of the document:

1. Analysis of macro trends that may impact the deployment of autonomous vehicle for collective transport in order to identify business opportunities.
2. Design of a macro-data calculator in order to investigate and simulate the potential effects and external costs reduction by deploying autonomous vehicle fleets in cities. The methodology will be described more in detail in chapter 3.
3. Based on the Total Cost of Ownership methodology (TCO), a dimensioning tool will also be proposed in order to help decision makers to calculate the ideal fleet size for the deployments as well as to the CAPEX and OPEX of the operations as well as the local externalities, integrating all these results and providing answers and future scenarios for transport operators, users as well as the collectivity. The methodology will be described more in detail in chapter 3.

2 Analysis of macro trends

2.1 Methodology

Future trends can be defined by various attributes of knowledge as well as change. Hereby it is important to remark that trends (in the narrow sense) are defined as an extrapolation from the present to the future. Other future elements are constants/paradigms (unchanged facts), news (speculations), contradictions (sound opinions or suppositions of alternatives), uncertainties (supposition of unfocused changes), and chaos/wildcards (creative, unconventional speculations). In the following the term ‘trends’ will be used in the wider sense comprising all types of future elements in accordance with the colloquial usage (e.g. trend radar).

Regarding the future of ASCTs there is a Gartner hype cycle representation (see figure 1) showing the recent/current positions of technologies for autonomous driving as well as electric vehicles and infrastructure, autonomous driving, connected vehicles and charging infrastructure and other relevant modules for an ASCT-system. This shows that most of the modules for connected vehicles are still in the phase of disillusionment and only slowly ramping up the slope of enlightenment.

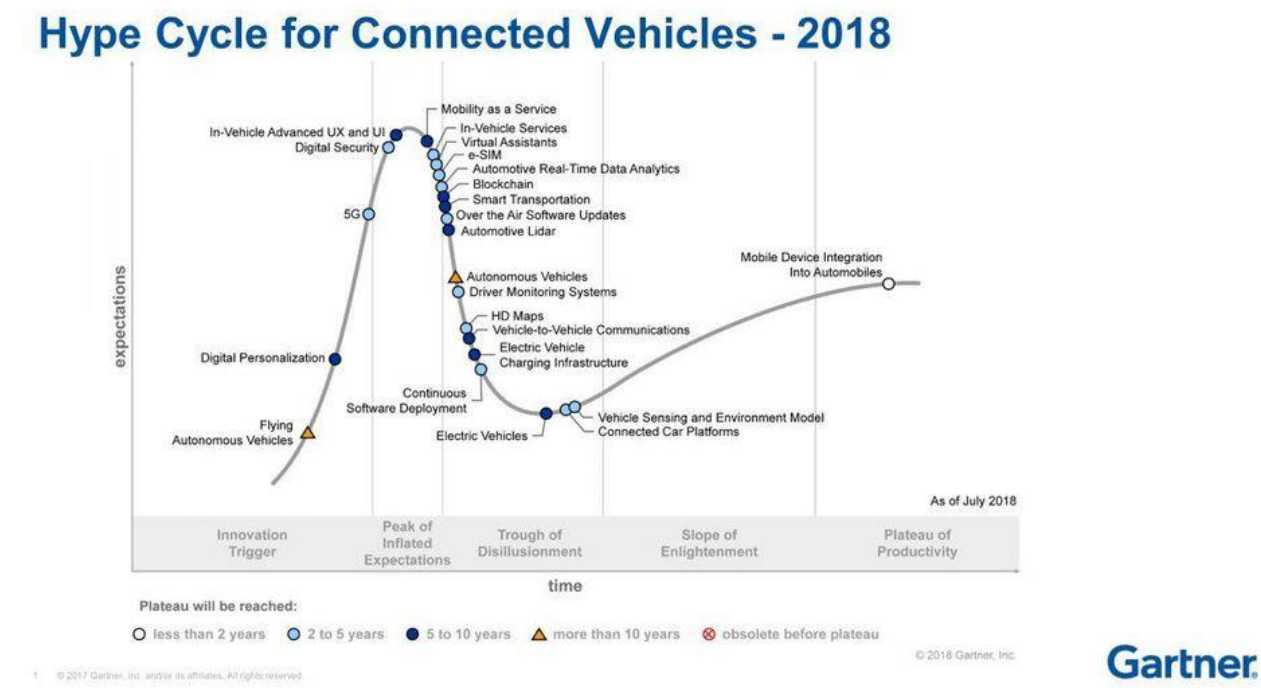


Figure 1: Gartner Hype Cycle for Connected Vehicles[1]

Four main source categories for future trends are identified (see figure 2):

1. People mass transportation
2. Urban & suburban/ rural transportation areas
3. Autonomous electrical transport
4. General relevant future developments

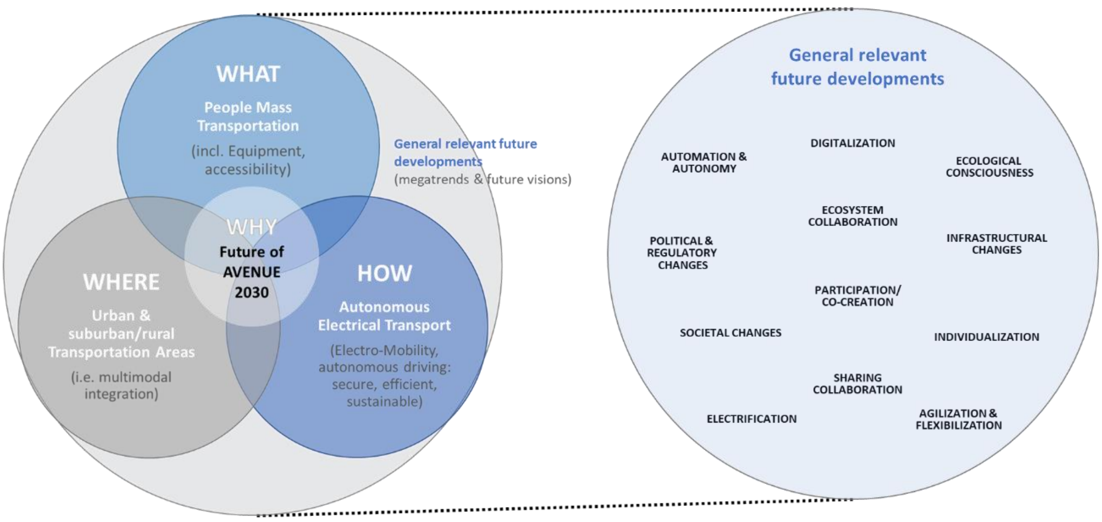


Figure 2: 'Future of AVENUE 2030' – Future Mobility Trend Cluster

[1] Ramsey, Mike. (2018-08-14). Retrieved 2019-08-02, from https://www.forbes.com/sites/enroute/2018/08/14/autonomous-vehicles-fall-into-the-trough-of-disillusionment-but-thats-good/#2d6c7bb27b5a

2.2 Main evolution factors for ASCT

The following figure 3 shows the main trends identified for the category 'autonomous electrical transport'.[2]

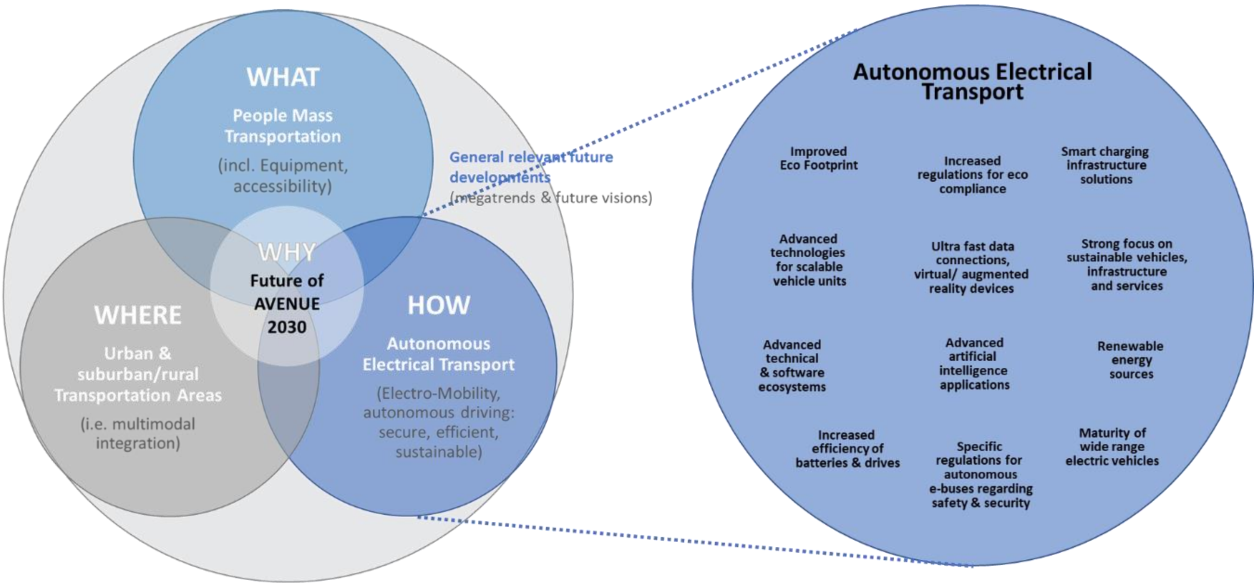


Figure 3: Future Mobility Trend Cluster for ASCTs

The following figure 4 shows the main trends identified for the category 'people mass transportation'.[3]

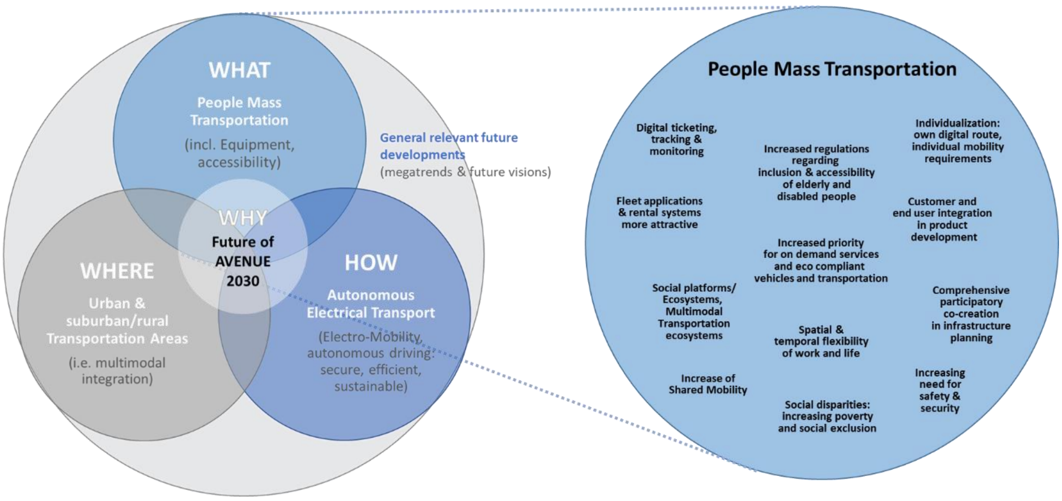


Figure 4: 'Future of AVENUE 2030' – zoom on People Mass Transportation

Based on the identification of the future trends for AVENUE 2030 within the resource categories the results can be transferred into the 'trend radar'. The trend radar is a graphical representation of all future trends for AVENUE 2030 structured by PESTLE-like (politics, economics, society, technology,

[2] See appendix for literature references
[3] See appendix for literature references

legislation, ecology/environment) segments on the one hand and concentric circles (high, medium, low) representing the impact/ relevance on the future of AVENUE 2030. (see figure 5)

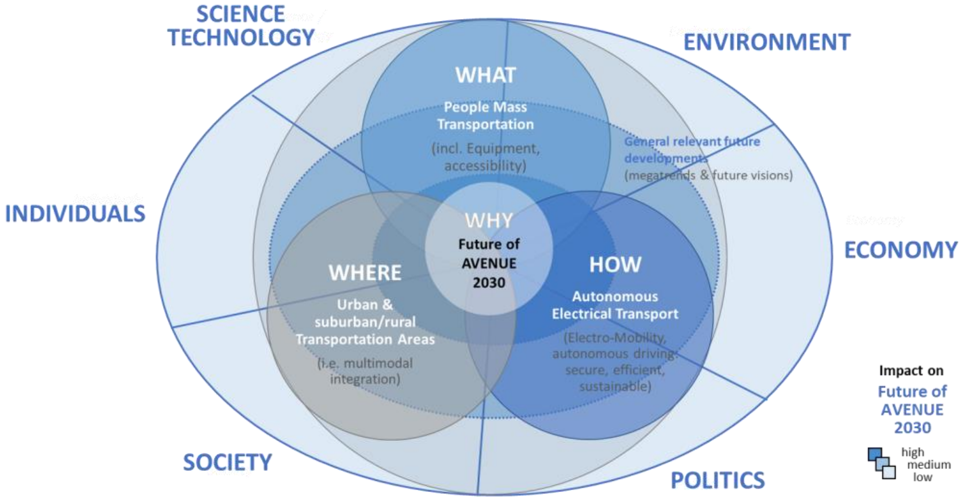


Figure 5: Future Mobility Trend Cluster for ASCTs trend radar

The characterization of the trend radar segments are displayed in figure 6 below.

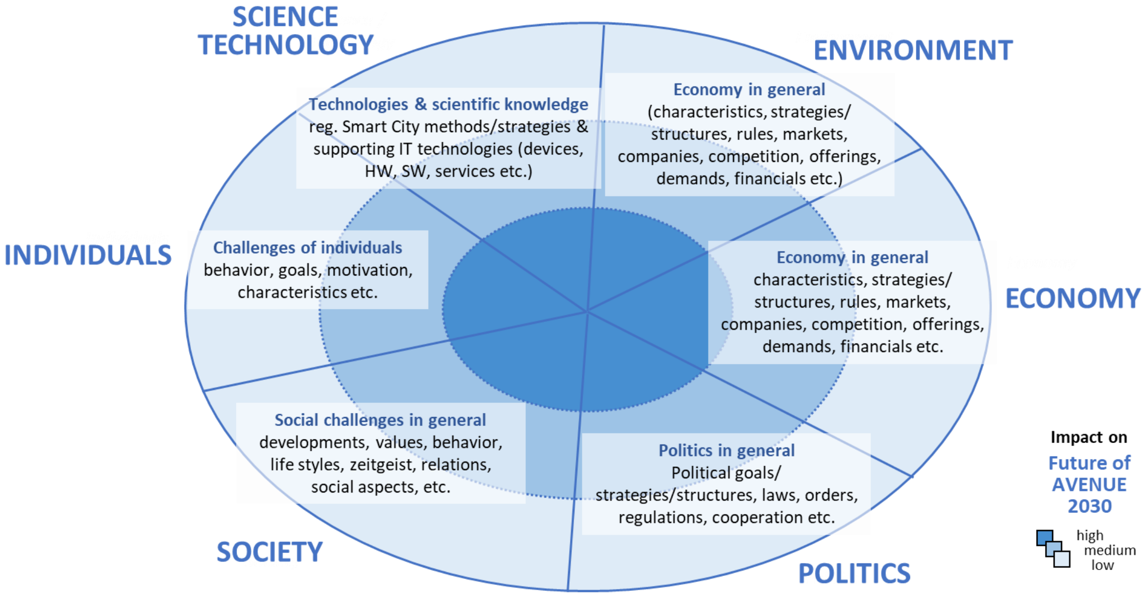


Figure 6: General Characterization of Trend Radar Segments

This methodology and characterizations allow the transfer of identified trends from the source categories into a trend radar representation as shown in figure 7 and 8.

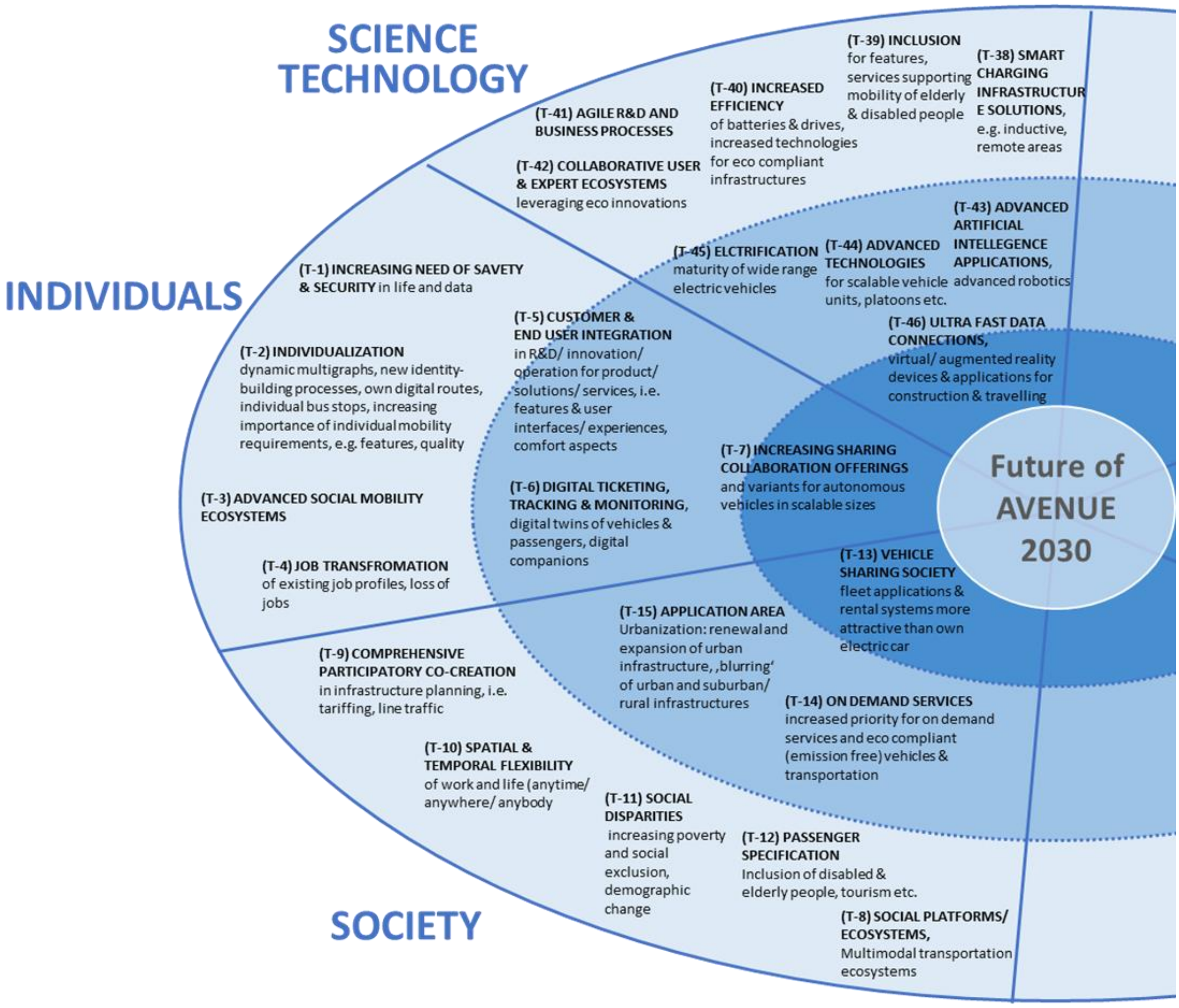


Figure 7: The ASCTs Trend Radar[4]

[4] See appendix for literature references

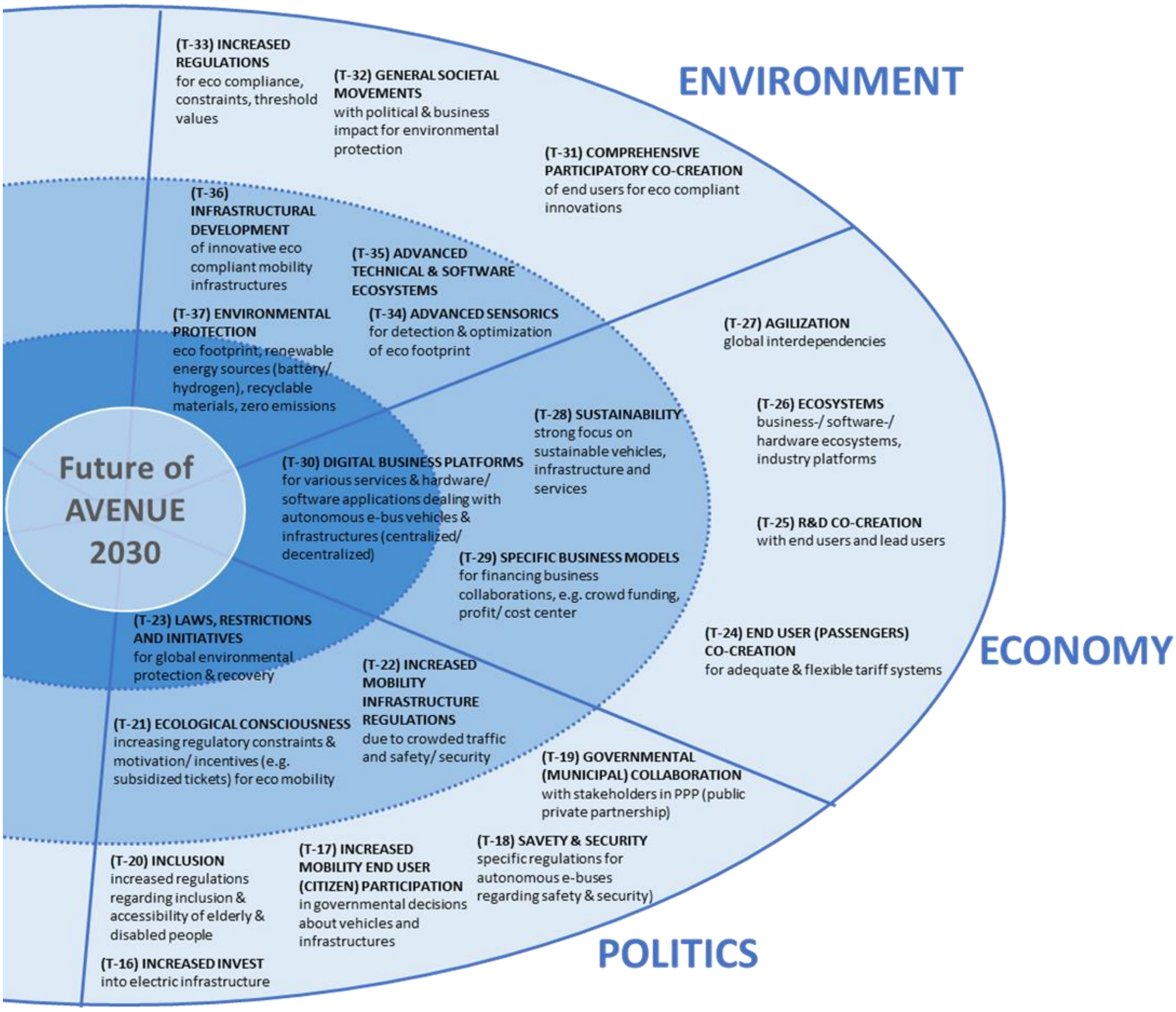


Figure 8: The ASCTs Trend Radar[5]

The trends of each trend radar segment and across have been condensed/ clustered into higher level macro-trends as basis for subsequent derivation of a future vision for AVENUE 2030. (see figure 9)

[5] See appendix for literature references

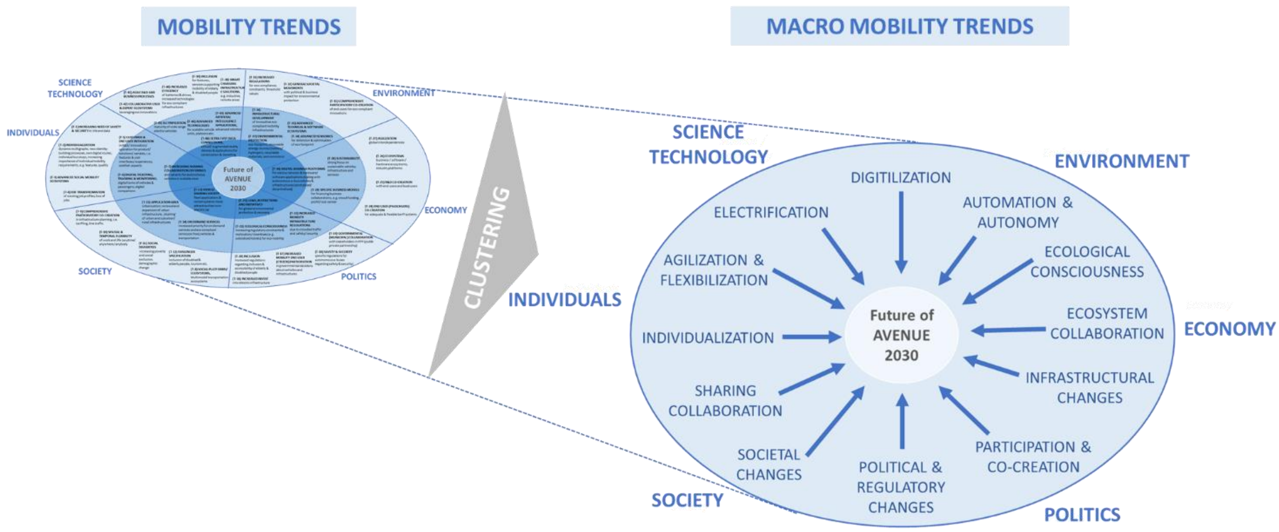


Figure 9: Clustering of most relevant mobility trends for ASCTs

The radar cab be developed in the following matrix representing an overview of all trends from the trend radar segments which are clustered into the respective macro-trend – vice versa it can be identified which macro-trend has an impact on the respective trend radar segment as shown in figures 10 and 11.

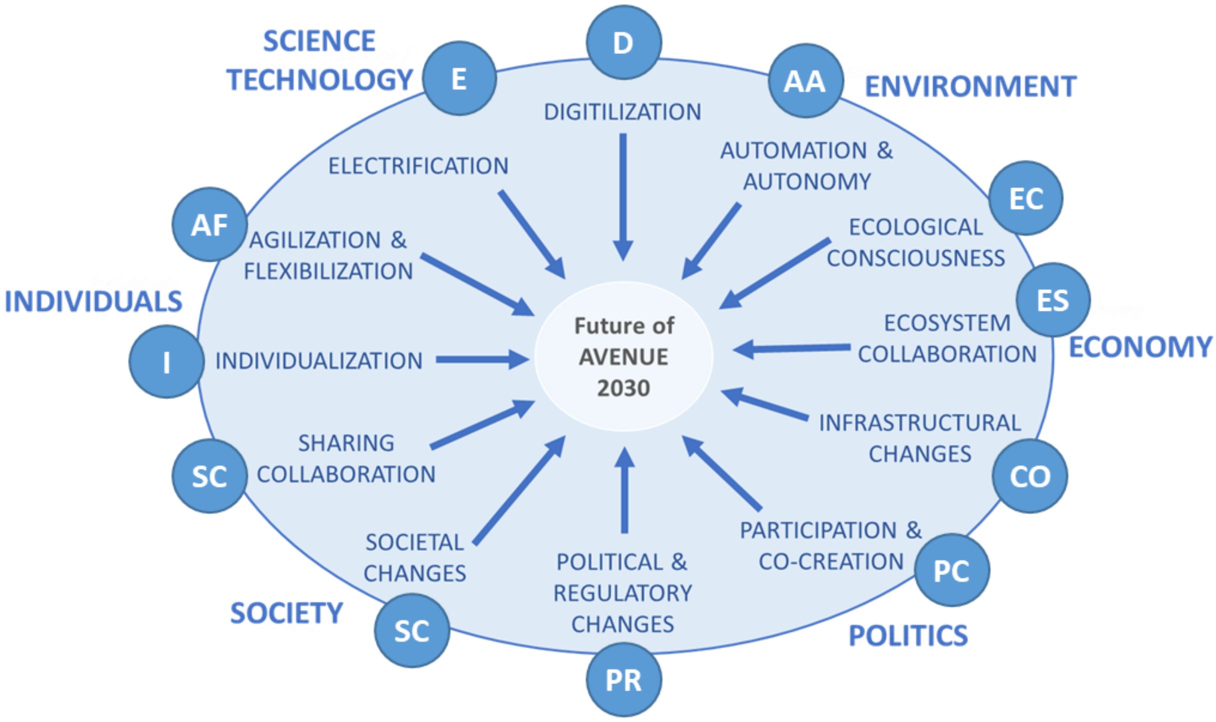


Figure 10: Mobility trend radar for ASCTs

Short Cut	GENERAL TREND	INDIVIDUALS/ PASSENGERS	SOCIETY/ SOCIAL ENVIRONMENT	SCIENCE/ TECHNOLOGY
D	DIGITALIZATION	Digital ticketing, tracking and monitoring, digital twins of vehicles & passengers, digital companions		Ultra fast data connections, virtual/ augmented reality devices & applications for construction & traveling
AA	AUTOMATION & AUTONOMY	Transformation of existing job profiles, loss of jobs		Advanced artificial intelligence applications, advanced robotics
EC	ECOLOGICAL CONSCIOUSNESS		On demand services, Increased priority for eco compliant (emission free) vehicles & transportation	Increased efficiency of batteries & drives, Increased technologies for eco compliant infrastructures
ES	ECOSYSTEM COLLABORATION	Advanced Social Mobility Ecosystems	Social platforms/ecosystems, multi-modal transportation ecosystems	Advanced Technical & Software ecosystems
IC	INFRASTRUCTURAL CHANGES		Urbanization: renewal and expansion of urban infrastructure, „blurring" of urban and suburban/ rural infrastructures	Smart charging infrastructure solutions (e.g. inductive, remote areas)
PC	PARTICIPATION & CO-CREATION	Customer & end-user integration in R&D/ innovation/operation for product/ solutions/services (i.e. features & user interfaces/experience)	Comprehensive participatory co-creation in infrastructure planning (tariffing, line traffic)	
PR	POLITICAL & REGU-LATORY CHANGES	Increasing need of safety & security (life & data)		
SC	SOCIETAL CHANGES		Social disparities: increasing poverty and social exclusion; demographic change, inclusion of disabled and elderly people	Advanced specific technologies for features, services supporting mobility of elderly & disabled people
CO	SHARING COLLABORATION	Increasing sharing collaboration offerings / variants for autonomous vehicles in scalable sizes	Fleet applications and rental systems more attractive than own electric car	Advanced technologies for scalable vehicle units (platoons, etc.)
I	INDIVIDUALIZATION	Dynamic multigraphs, new identity building processes, own digital routes, increases importance of individual mobility requirements (e.g. features quality)		
AF	AGILIZATION & FLEXIBILIZATION		Spatial and temporal flexibility of work and life (anytime/anywhere/anybody)	Agile R&D & business processes
E	ELECTRIFICATION			Maturity of wide range electric vehicles

Figure 11: Mobility Trend Matrix for ASCTs

Short Cut	GENERAL TREND	ENVIRONMENT/ ECOLOGY	ECONOMY/ BUSINESS	POLITICS/ REGULATIONS
D	DIGITALIZATION	Advanced Sensorics for detection & optimization of Eco footprint	Digital business platforms for various services & hardware/software applications dealing with autonomous e-bus vehicles & infrastructure	
AA	AUTOMATION & AUTONOMY			Specific regulations for autonomous e-buses regarding safety & security, etc.
EC	ECOLOGICAL CONSCIOUSNESS	Eco footprint, renewable energy sources, recyclable materials, zero emissions	Strong Focus on sustainable vehicles, infrastructure and services	Increasing regulatory constraints & motivation/incentives (e.g. subsidized tickets) for eco mobility
ES	ECOSYSTEM COLLABORATION	Collaborative user & expert ecosystems leveraging Eco Innovations	Business-/ Software-/ Hardware ecosystems, industry platforms	Governmental (municipal) collaboration with stakeholders in PPP (public private partnerships)
IC	INFRASTRUCTURAL CHANGES	Development of innovative eco compliant mobility infrastructures	R&D co-creation with end users and lead users	Increased mobility infrastructure regulations due to crowded traffic & safety/security
PC	PARTICIPATION & CO-CREATION	Comprehensive participatory co-creation of End Users for eco compliant innovations	End User (Passenger) co-creation for adequate & flexible tariff systems	Increased mobility end user (citizen) participation in Governmental decisions about vehicles & infrastructure
PR	POLITICAL & REGU-LATORY CHANGES	Increased regulations for eco compliance (constraints, threshold values)		Laws, restrictions & initiatives for global environmental protection & recovery
SC	SOCIETAL CHANGES	General societal movements with political & business impact for Environmental protection		Increased regulations regarding inclusion & accessibility of elderly & disabled
CO	SHARING COLLABORATION		Specific business models for financing business collaboration (e.g. crowd funding)	
I	INDIVIDUALIZATION			
AF	AGILIZATION & FLEXIBILIZATION		Global interdependencies	
E	ELECTRIFICATION			Increased invest into electric infrastructure

Figure 12: Mobility Trend Matrix for ASCTs

2.3 Vision Statements & Scenarios

The main goal of the trend radar analysis is the identification of vision for ASCTs. Therefore, it is necessary to identify motivating vision statements, which are not too far in the future to be demotivation for realisation and at the same time not too close to the present to be achieved easily. In this sense the vision and its statements should create a creative tension for motivation. (see figure 13)

D	… provides **digital** twins / platforms / applications / services & businesses
AA	… provides **autonomous vehicles and automated infrastructures** (e.g. charging)
EC	… strictly emphasizes on **renewable energies and construction materials** as well as **zero emission technologies**
ES	… is an integral & profitable module of suburban/ rural and urban multimodal mobility networks supporting **technical, social and business ecosystems**
CO	… provides solutions for '**blurring' urban & suburban/ rural** transportation infrastructures as well as power charging infrastructures
PC	… enables the **participatory co-creation** & evolution of all relevant stakeholders (i.e. customers/end-users) during innovation/ R&D/ operation in planning/ decisions & implementation of the solution (i.e. features & user interfaces/ experience)
PR	… anticipates **political directions & regulations** regarding the upcoming transportation system / technologies and related safety & security aspects
SC	… adapts **societal changes** like accessibility for aging society, disabled & immobile people and other special mobility requests
I	… supports **individual behavior of passengers** (anytime/ anywhere/ anybody) as well as individual transportation requests/ services
AF	… supports **agile & flexible offering solutions & businesses** for any demand
SC	… covers the **demand for collaboration at shared transportation**
E	… enables **electrically powered minibus vehicles and infrastructures**

Figure 13 - Derivation of Vision Statements for AVENUE 2030

The vision of future for ASCT, which results from the above-mentioned vision statements, aims the general goal to be the **No. 1 provider of trendsetting autonomous e-minibus solutions**, …

- designing **individualized, comprehensive, scalable, fully automated & digitized concepts** (vehicles, infrastructure, services) in close co-creation with all relevant stakeholders
- for any **people transportation purposes & applications** (passenger types, use cases)
- with **maximum sustainability footprint** (ecological, social and economic)
- providing **maximum value to all stakeholders** (WIN-WIN, especially passengers)
- enabling technological & business innovations of a **multimodal transportation system**
- **filling a critical gap** of an exponentially growing **ecosystem of transportation partners.**

Future scenarios are virtual/fictitious representations of future ecosystems including all relevant actors/stakeholders, activities/relations, constraints and other relevant impact factors. Within future scenarios potential future passenger use cases can be identified.

Future (business) hunting fields represent thematic areas of promising business activities (action fields/ business search fields/ innovation fields) wherein concrete business opportunities or business use cases can be identified.

From a systematic point of view, it is useful to primarily regard the higher granularity level of identifying future scenarios and deriving future hunting fields here from. In a second step concrete passenger use cases can be derived and selected from the future scenarios and equally concrete business opportunities/ business use cases can be derived and selected from hunting fields on the one hand and passenger use cases on the other hand. (see figure 14)

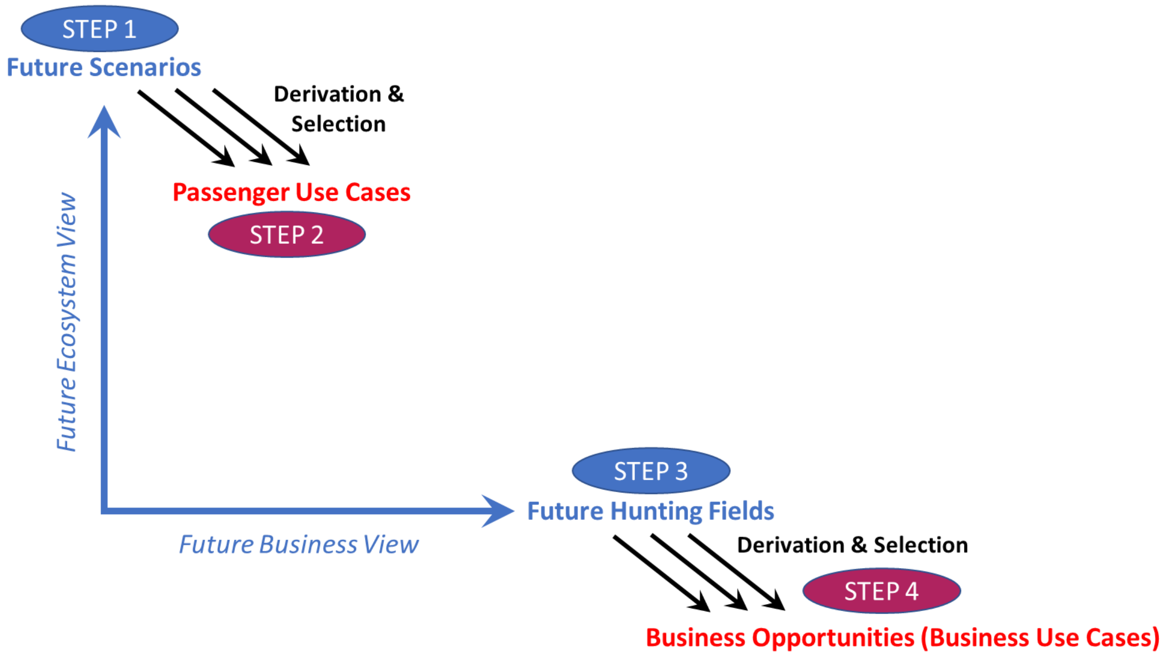


Figure 14: General Scenario Design Systematics

A pragmatic methodology for deriving future scenarios can be provided by the identification of bi- or multipolar/contradictory/alternative future elements (trends in a wider sense). These will be positioned within the 'Wilson matrix' by their degree of uncertainty as well as the degree of (strategic) importance. Those bipolar trends with a high degree of uncertainty and importance are candidates for dimensions of a future scenario matrix. (see figure 15)

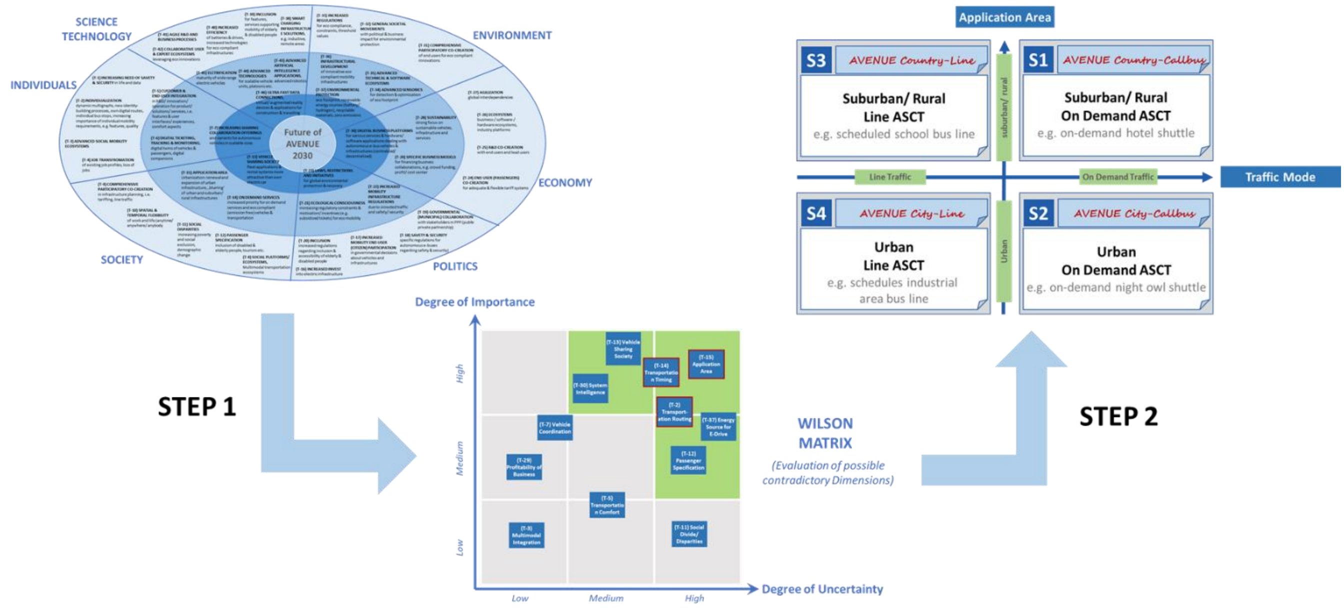


Figure 15: From Future Trend Radar to Future Scenarios

An alternative method to the two-dimensional matrix representation for defining future scenarios in a suitable (deterministic) way, could also be to arrange more bipolar dimensions within a 'spider net'-representation, and identify multiple future scenarios (scenario profiles) in a more open way. For the reason of identifying only a limited number of significant and determined (by dimensions) future scenarios, it is useful to select the matrix method for the further procedure. (see figure 16)

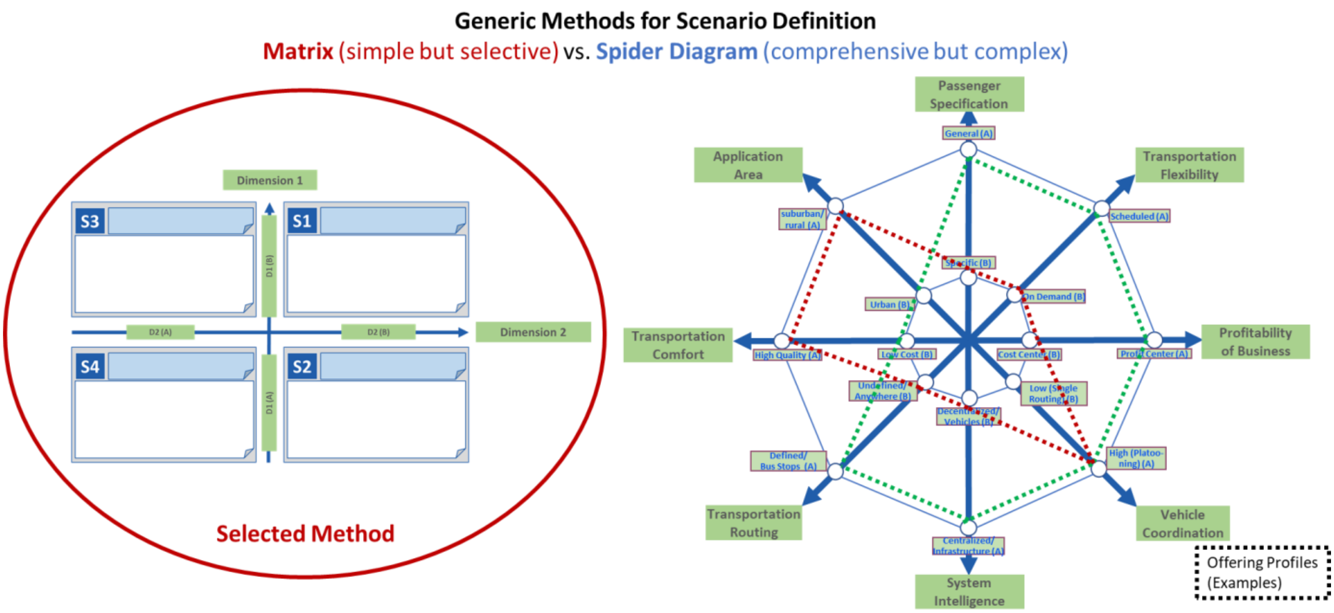


Figure 16: Alternative generic Methods for Scenario Definition

The following possible contradictory (bi-/tripolar) dimensions (blue boxes; D-x) for scenario definition has been identified and attributes (green boxes) have been defined. (see figure 17).

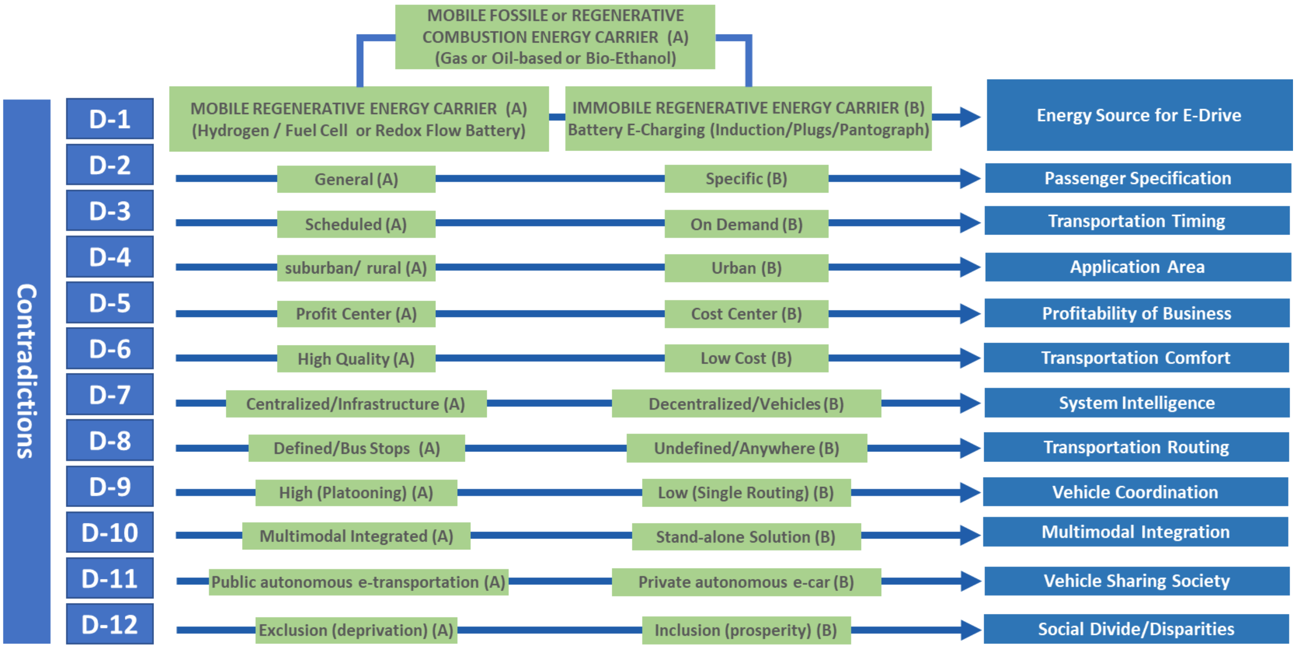


Figure 17: Identification of possible bi- or multipolar (contradictory) Dimensions (criteria & attributes) for Scenario Definition

According to the methodology described before the dimensions have been positioned within the 'Wilson matrix'. Alternative two-dimensional matrix combinations from the dimensions have been tested towards meaningful and reasonable characterizations of future scenarios for AVENUE. Among these dimension candidates the selected dimensions are: D-4 (application area); D-8 (transportation routing) and D-3 (transportation timing) as shown in figure 18.

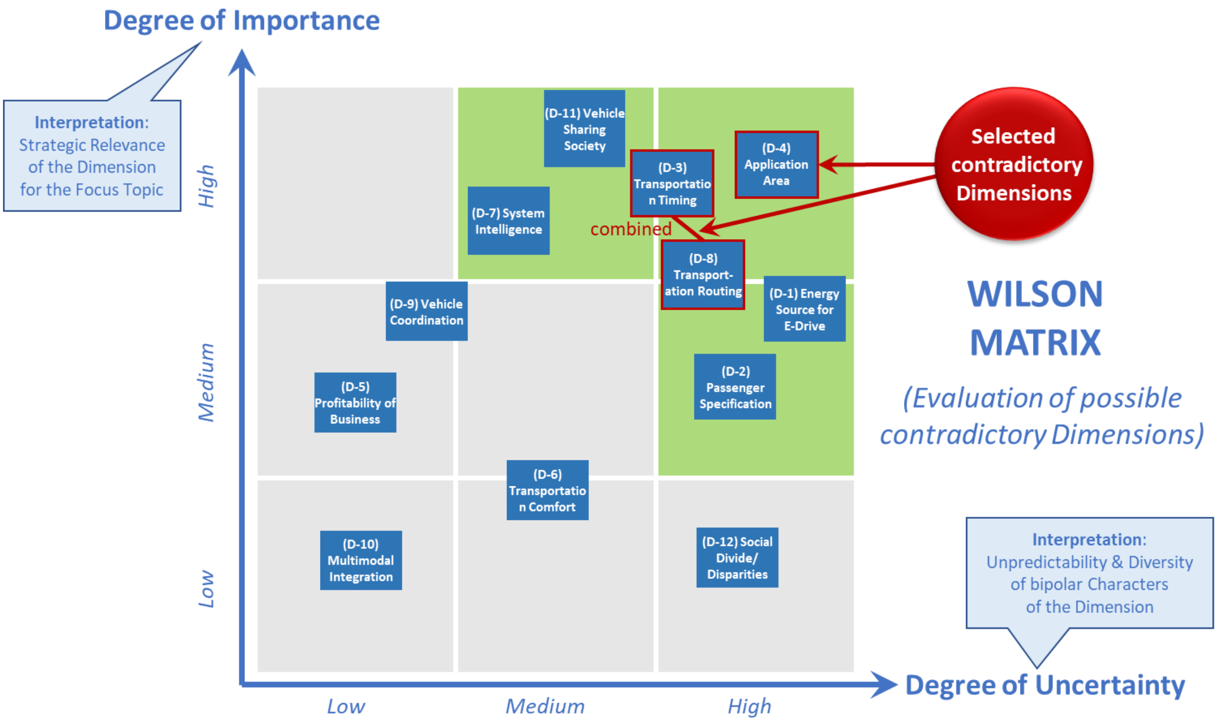


Figure 18: Prioritization and Selection of contradictory Dimensions for Scenario Definition[67]

Various discussions have led to the insight that besides the dimension 'application area' (D-4) it is pragmatic to combine D-3 (transportation timing) and D-8 (transportation routing) into one integrated dimension titled as 'traffic mode' (D-13). The bipolar attributes of traffic mode are as shown in figure 25:

a) Line traffic (scheduled/defined bus stops)
b) On-demand traffic (on-demand/anywhere)

[6] In accordance with Pillkahn, Ulf. (2008) Using Trends and Scenarios for Strategy Development. S. 202. Erlangen: Publicis Kommunikationsagentur GmbH.

[7] Wilson, Ian; Morrison, James (2003-08-23) The Strategic Management Response to the Challenge of Global Change. Retrieved 2019-08-02, from http://horizon.unc.edu/courses/papers/Scenario_wksp.asp

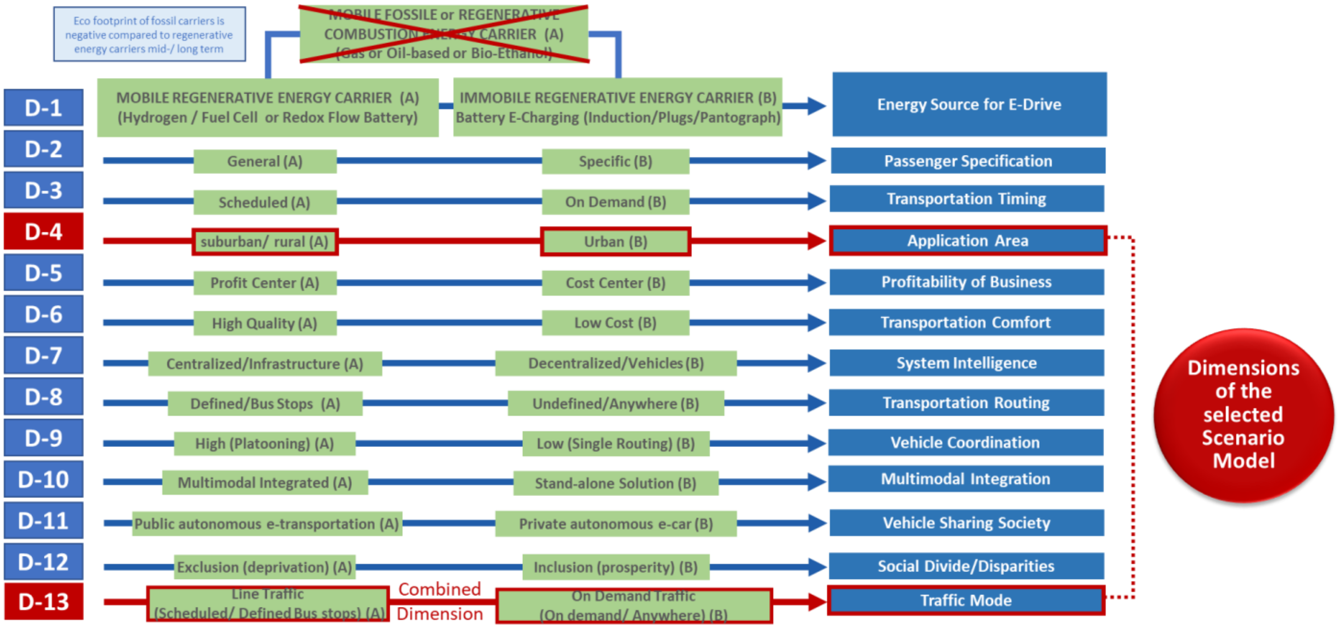


Figure 19: Relevant contradictory dimensions for scenario definition

These two dimensions (D-8, D-13) spread out the final future scenario matrix, which will be utilized further on. For each scenario concise titles have been identified. (see figure 20)

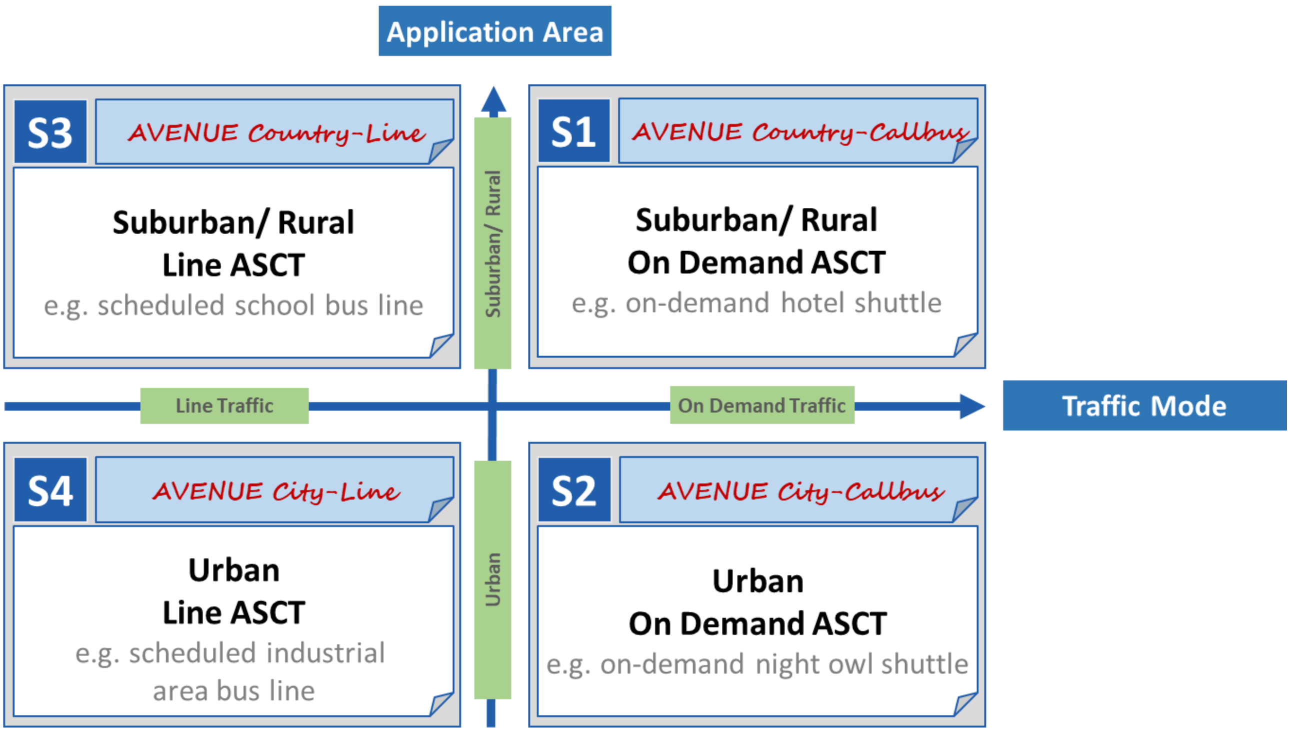


Figure 20: Selected Scenario Model for defining 4 Future Scenarios

The following examples and descriptions can be assigned to the different future scenarios above. (see figure 21)

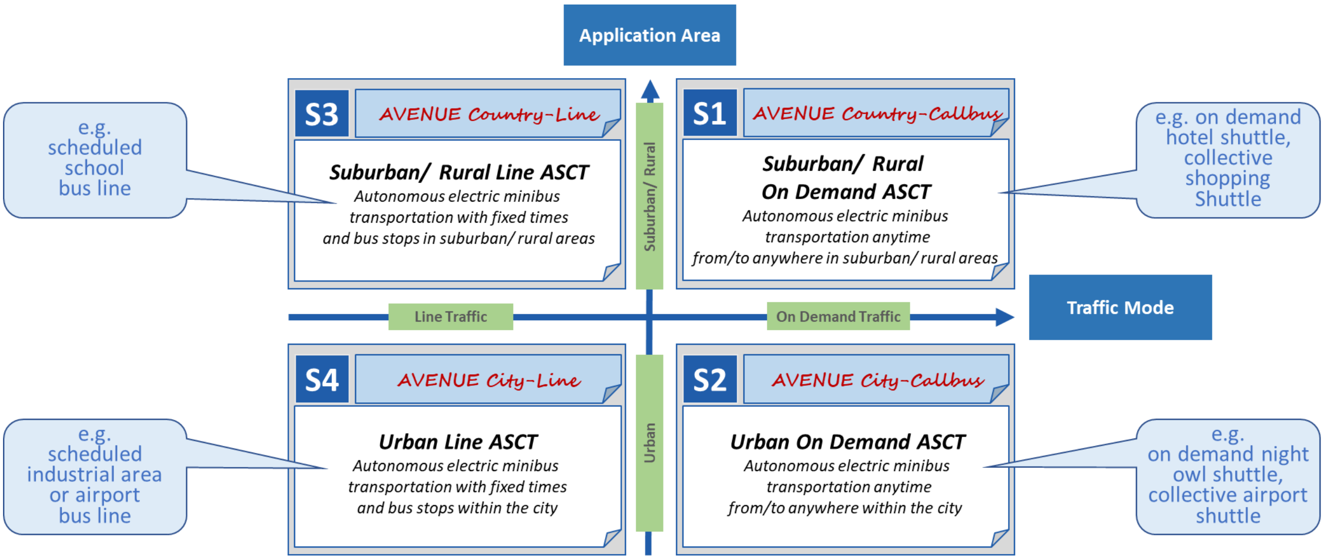


Figure 21: Characterization of selected Future Scenarios

These archetypical scenarios can be discussed and characterized in more detail and scenario charters have been elaborated (see figures 22-25).

Scenario S1: AVENUE Country-Callbus

General Characteristics & Key Message

Autonomous electric minibus transportation anytime from/to anywhere in suburban/ rural areas

- **‚Blurring' of urban and suburban/ rural infrastructures** (AVENUE not restricted to cities)
- Vehicles prepared for **long distances** (reliability, passenger equipment, evtl. platooning)
- Unpredictable **road infrastructure** (requires: more engine power, vehicle equipment, etc.)
- Specific **route optimization rules/software** (distant living passengers, etc.)
- **Increased standby fleet (evtl. rural based) of buses** for unpredictable demand necessary

General Impact & Vision for AVENUE

Impact: suburban/ rural on demand ASCT supports individual behavior of passengers (anytime/anywhere/anybody) as well as individual transportation requests/services

Vision: AVENUE is the accepted, individually flexible, emission free, secure, inexpensive and comfortable transportation solution for rural & suburban areas complementary to other transportation modes (missing link) and with seamless multimodal integration

SWOT Analysis

Strengths: Good connection for weak infrastructure areas, solution for disabled and elderly people without own car

Weaknesses: Weak internet/mobile infrastructures, slow data connections in suburban/ rural areas, challenging Fleet-Management: time/locations/charging

Threats: Competitor services (Taxi, Uber,…), own autonomous electric car

Chances: Increased transportation comfort for disabled and elderly people, integration into multimodal transportation platforms & ecosystems

PROs for the probability for scenario occurrence

- Increasing **number of elderly people** in suburban/ rural areas
- Increasing demand for **individualized mass transportation** services
- High **capacity & need for infrastructural changes** and developments

CONs for the probability for scenario occurrence

- Most people in suburban/ rural areas are used to possess their **own cars due to immediate flexibility**
- **Time-consuming way of transportation** due to unknown number of in-between bus stops, low speed, low capacity of seats

Main Triggers & Drivers

- **Importance of suburban/ rural mobility** for individuals
- Increased **priority for on-demand services** and **eco compliant** (emission free) vehicles and transportation
- **Increasing attractivity of individualized mass transportation and rental systems** compared to own autonomous electric cars
- Spatial and temporal **flexibility of work and life**
- Suboptimal **charging & road infrastructure** (remote area charging points, no special bus lanes, etc.)

Success & Risk Factors for AVENUE

Success Factors: Subsidized suburban/ rural transportation concepts, convincing of suburban/ rural people for advantages (cost, security, comfort, timely/location flexibility, etc.) of AVENUE, satisfying individual customer needs (luggage, availability, etc.), multimodal integration with various preferences (time-efficient, eco-friendly, cost-effective)

Risk Factors: Passengers can not plan their arrival and in-between bus stops, low confidence / waiting times & less comfort than own electric cars, unprofitable areas are not served, missing multimodal integration

Stakeholder Strategies & Behavior

Passengers: Individual scheduling of daily life mobility possible (anytime, anywhere, anybody)

Transportation System Owners (Government / Private Companies): Subsidizing public suburban/ rural transportation, private BOOT companies offer ASCT transportation only in selective suburban/ rural areas (profitability)

AVENUE Solution Providers: Development of suburban/ rural mobility and charging station infrastructures, different technical specifications of ASCTs (long distance batteries, stronger engine, different equipment)

Other Stakeholders (Routing App provider, customer service): Development of Specific route optimization SW for suburban/ rural areas

Figure 22: Characterization of Scenario S1: AVENUE Country-Callbus

Scenario S2: AVENUE City-Callbus

General Characteristics & Key Message

Autonomous electric minibus transportation anytime from/to anywhere within the city

- Specific **route optimization rules/software** (more road construction sites, more one-way lanes, priority for bus lanes, etc.)
- Routing SW requires **ultra-quick response times** to passenger requests (e.g. via app)
- More vehicle interaction with other traffic participants (e.g. e-scooters, hover-boards, e-bikes, other autonomous vehicles & robots)
- **Increased standby fleet of buses** for unpredictable demand necessary

General Impact & Vision for AVENUE

Impact: Urban on demand ASCT supports individual behavior of passengers (anytime/anywhere/anybody) as well as individual transportation requests/services

Vision: AVENUE is the accepted, individually flexible, emission free, secure, inexpensive, sustainable and comfortable transportation solution for urban areas with supporting function of other transportation opportunities and multimodal integration

SWOT Analysis

Strengths: Satisfy the needs of an ecological thinking society, supports individual flexibility in work and life; price advantage compared to private transportation

Weaknesses: Lower flexibility than other transportation services like Uber (longer waiting periods,…)

Threats: Other services (Taxi, Uber,…), own electric autonomous car, existing scheduled transportation

Chances: integration into complex multimodal transportation platforms & ecosystems

PROs for the probability for scenario occurrence

- Increasing need of individual transportation services
- Possible use of existing infrastructure
- Increasing need for sustainable products and services

CONs for the probability for scenario occurrence

- Huge number of competitor like individual taxi services, existing public transportation system
- Increasing number of application developments for cars (parking slot searching, autonomous driving)
- No obvious advantage of an autonomous driving bus during day-time

Main Triggers & Drivers

- Increased priority for on demand services and eco compliant (emission free) vehicles and transportation
- Urbanization: renewal and expansion of urban infrastructure
- Individualization: increasing importance of individual mobility requirements
- Fleet applications and rental systems more attractive than own autonomous electric car
- Spatial and temporal flexibility of work and life

Success & Risk Factors for AVENUE

Success Factors: Individual transportation service and supports ecological thinking society

Risk Factors: Fast and easy AVENUE application management; immature software does not create added value by time-consuming collecting of passengers

Stakeholder Strategies & Behavior

Passengers: Individual scheduling of daily life mobility possible (anytime, anywhere, anybody)

Transportation System Owners (Government / Private Companies):

AVENUE Solution Providers: Provision of software that functions perfectly and guarantees the rapid processing of passenger data

Other Stakeholders (App provider, customer service): Development of specific software for urban traffic and for passenger requests via app; provision of customer service for specific needs

Figure 23: Characterization of Scenario S2: AVENUE City-Callbus

Scenario S3: AVENUE Country-Line

General Characteristics & Key Message

Autonomous electric minibus transportation with fixed times and bus stops in suburban/ rural areas

- Insufficient **power infrastructure** (remote area power stations, etc.)
- Prepared for **long distances** (reliability, passenger equipment)
- Unpredictable **road infrastructure** (more engine power, vehicle equipment)
- Specific **on-time optimization rules/software** (no delays, additional buses/platooning, etc.)

General Impact & Vision for AVENUE

Impact: ASCTs make suburban and rural areas attractive again by providing transport solutions for areas with weak infrastructure

Vision: AVENUE provides an eco-friendly and innovative solution for areas with normally weak infrastructure; it is an alternative and also a complement to existing means of transport

SWOT Analysis

Strengths: Additional transportation service for weak infrastructures, satisfy the needs of eco-friendly customers, less dependency for people without a car/ driving license

Weaknesses: Low flexibility of time and place

Threats: Other transportation services, competitors; little acceptance due to high degree of innovation concerning elderly people

Chances: Expansion of traffic in low-traffic regions leads to increased attractiveness of the region

PROs for the probability for scenario occurrence

- Additional transportation support for weak infrastructure areas
- Increasing need for safety and security aspects

CONs for the probability for scenario occurrence

- Most of the suburban/ rural population owns their own cars because of flexibility and time-saving aspects
- Necessary infrastructure development is unworkable

Main Triggers & Drivers

- 'Blurring' of suburban/ rural and urban infrastructures
- Fleet applications and rental systems are more attractive than own autonomous electric car
- Increased priority for eco compliant (emission free) vehicles and transportation
- Strong focus on sustainable vehicles, infrastructure and services
- Increasing regulatory constraints/ incentives for eco mobility
- Increasing need of safety and security

Success & Risk Factors for AVENUE

Success Factors: targeted use at night events, clubbing, support shuttle for special occasions/ events, multimodal integration with various preferences (time-efficient, eco-friendly, cost-effective, number of vehicle changes)

Risk Factors: no real improvement of the traffic situation due to only sporadic use and hard-to-reach minibus stations

Stakeholder Strategies & Behavior

Passengers: more focus on public transportation due to new possibilities (ASCT); especially for people without a car/ driving license

Transportation System Owners (Government / Private Companies): useful integration in existing infrastructure; support of new and innovative public transport in contrast to private transport

AVENUE Solution Providers: establish useful schedules; availability of more vehicles (standby-fleets) for special events/ occasions

Other Stakeholders (other transport providers): multimodal integration of the new and innovative transportation provider

Figure 24: Characterization of Scenario S3: AVENUE Country-Line

Scenario S4: AVENUE City-Line

General Characteristics & Key Message

Autonomous electric minibus transportation with fixed times and bus stops within the city

- **Complex traffic situation** for ASCT (construction sites, other road users, narrower streets)
- **Always-on-time and reliable** transportation service connected with an app, which allows the passenger to **track the vehicle in real time** on its way to the stop

General Impact & Vision for AVENUE

Impact: Urban ASCTs complement the public transport and therefore provide a denser and more reliable network of transportation

Vision: AVENUE is the accepted, emission free, secure, inexpensive, sustainable and comfortable transportation solution for urban areas, which is always on time and reliable

SWOT Analysis

Strengths: Scheduled bus line; provides denser and more reliable network of transportation, agile application of vehicles enables flexibility in traffic planning

Weaknesses: Lower flexibility for individual passengers

Threats: Other transportation services, highly developed private autonomous electric cars, possible obstacles discourage passengers from using the vehicles

Chances: denser and more reliable network of transportation enables public transport to be the better alternative

PROs for the probability for scenario occurrence

- increasing demand for sustainable products and services
- possible use of existing infrastructure

CONs for the probability for scenario occurrence

- Time consuming way of travelling because of low speed
- Huge number of other transportation service providers

Main Triggers & Drivers

- Increased priority for eco compliant (emission free) vehicles and transportation with regard to air pollution in cities (eco footprint, renewable energy sources, recyclable materials, zero emission)
- Urbanization: more people on less space require stable infrastructure
- Increased mobility infrastructure regulations due to crowded traffic and safety/ security

Success & Risk Factors for AVENUE

Success Factors: Eco-friendly transportation service, no driver necessary (night-services and highly frequented routes), additional transportation service (shuttles in industry areas, universities, airport, shopping areas…), collaboration with industry partners, multimodal integration with various preferences (time-efficient, eco-friendly, cost-effective, number of vehicle changes)

Risk Factors: high competition from other transport providers; challenge of adding value to existing scheduled services, missing multimodal integration

Stakeholder Strategies & Behavior

Passengers: passengers rely on scheduled bus line and use connected app to always use the best public transport solution

Transportation System Owners (Government / Private Companies): integration into already existing transportation platforms; provision of multimodal, flexible transport connection

AVENUE Solution Providers: cooperation with government and private companies to fully integrate ASCTs in the urban transportation system; provision of a software that interacts with other apps/systems used for public transport

Other Stakeholders (other transport companies, customer service): cooperation and multimodal integration

Figure 25: Characterization of Scenario S4: AVENUE City-Line

The previously characterized archetypical scenarios represent alternative AVENUE application situations which can be applied either singularly or as a combination in real world situations like the AVENUE 6 Use Case Pilot Locations in Geneva (Belle Idee, Merin), Lyon, Kopenhagen and Luxembourg (Contern, Pfaffenhofen). The construction and discussion of basic generic scenarios as conditions for the Passenger Use Cases - identified in the next chapter - are precondition for the further development of future attractive Business Hunting Fields including promising Business Opportunities for AVENUE.

This systematical top down approach for AVENUE (from general trends via archetypical scenarios to the portfolio of potential attractive business hunting fields and opportunities) is the basis for the practical application at the AVENUE pilot Use Cases mentioned above. These elaborations – to be conducted in the next deliverable - include the detailed analysis of the systemic and economic situation of the AVENUE Pilot Use Case sites (e.g. vehicles, passengers, infrastructure, transportation demand & constraints, competition, B2B customers, etc.) and their ecosystem, the matching of the situation with the archetypical scenarios and the definition of individual business strategies and business models using the preidentified set of business opportunities for AVENUE.

2.4 Passenger Use Cases

For a first discussion basis the following personas identified by the AVENUE partner Keolis have been analysed in order to define relatively disjunct passenger groups reasonable for ASCTs. (see figure 26)

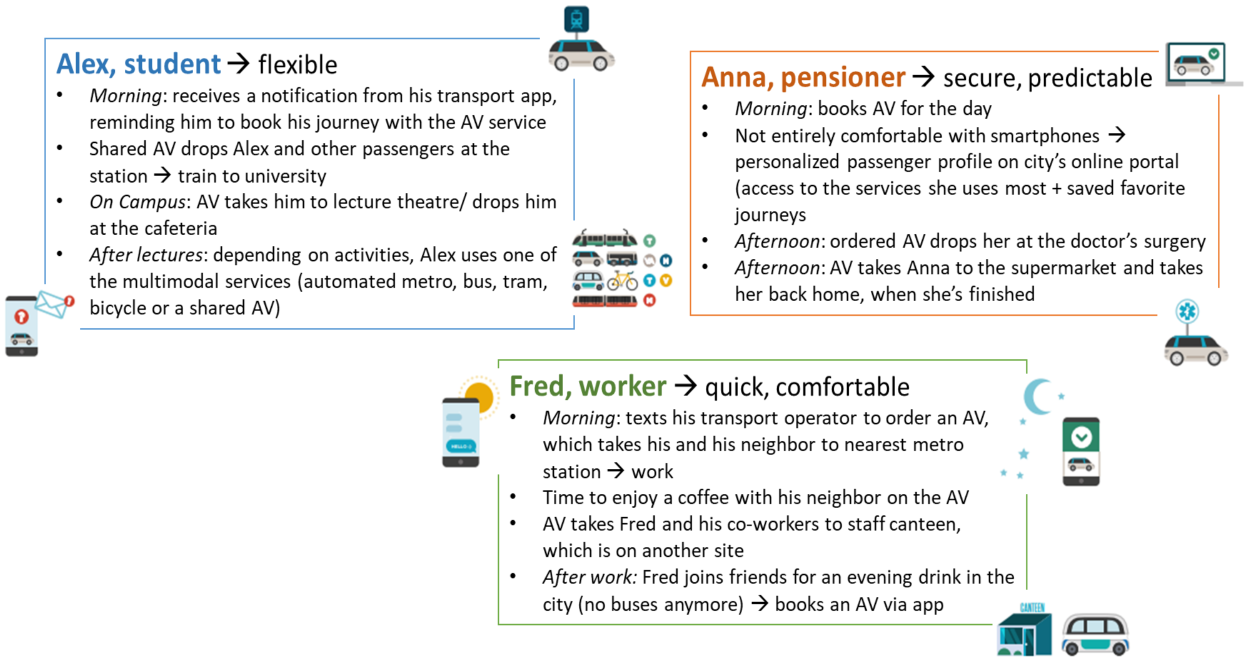


Figure 26: Examples for Passenger Personas from Keolis[8]

[8] Keolis (2018) Keolis autonomous shuttles offer. Retrieved 2019-08-02 from https://www.keolis.com/sites/default/files/atoms/files/nav_autonomes_2017_uk_vdef_0.pdf

Based on these preliminary considerations the following segmentation model has been defined to characterize the passenger groups relevant for AVENUE. For this model two dimensions were chosen (see figure 27):

- Transportation priority: mandatory for daily mobility and conduction of life and work
- Transportation needs: special or standard vehicle equipment and configuration of vehicles/services/infrastructure is required for mobility

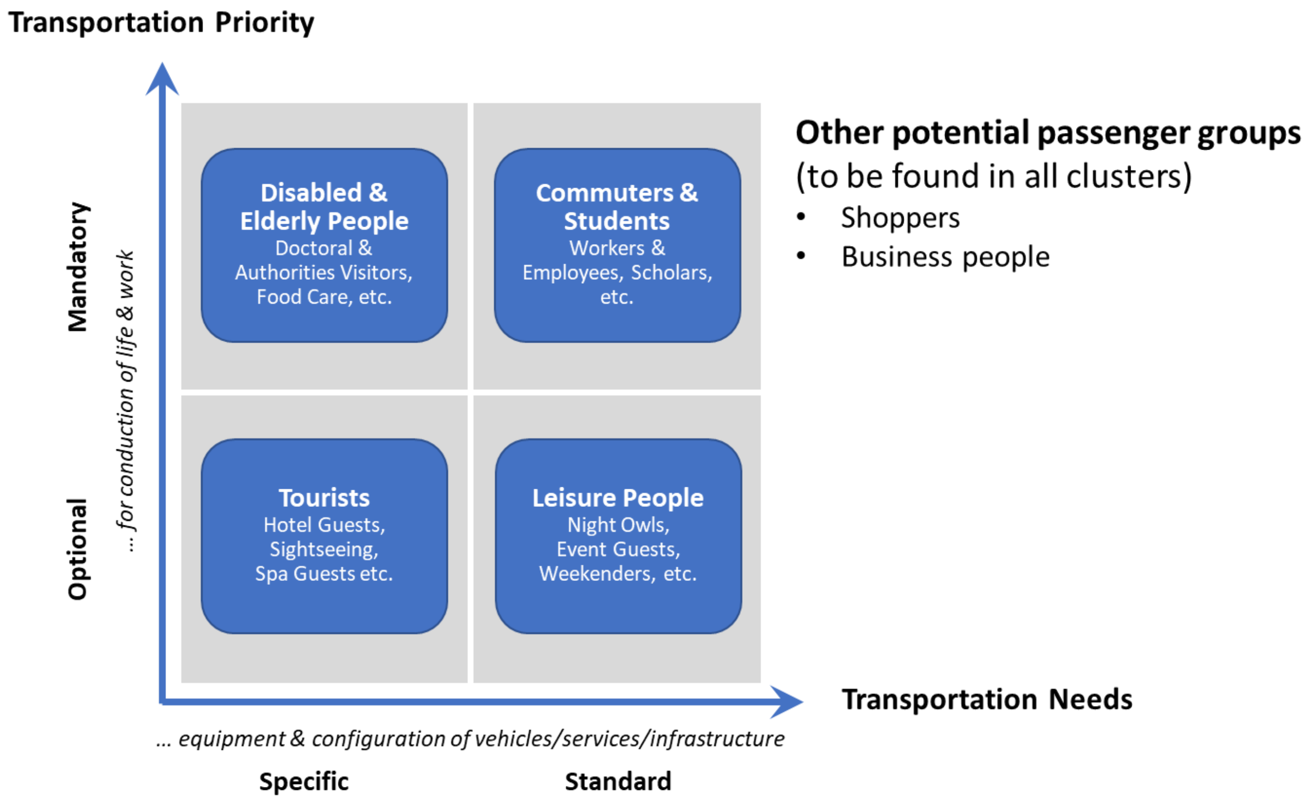


Figure 27: Classification of passenger groups

In an alternative spider-diagram representation two further dimensions can be added and passenger group profiles can be extended:

1. Time of transportation: defined/predictable or undefined/unpredictable time of mobility demand
2. Modal integration of transportation: unimodal or multimodally integrated form of transportation from starting point to destination

Referring to figure 27 the defined passenger groups can be characterized in detail by these four dimensions (see figure 28).

	Vehicle Equipment	Time	Modality	Transportation Priority
Disabled & Elderly People Doctoral & Authorities Visitors, Food Care, etc.	Need Space for rollators, wheel chairs, bags, emergency buttons, companions, special signals	Any time during the day, out of rush hour	Depends on destination (unimodal: nursing bus, senior/disabled people bus – multimodal: last mile service)	Mandatory (Generally no individual car)
Commuters & Students Workers & Employees, Scholars, etc.	No special equipment	Rush hours in the morning, noon and finishing time / early evening	Depends on destination (School/Workers bus)	Mandatory (Transport to/from work/school)
Leisure People Night Owls, Event Guests, Weekenders, etc.	No special equipment	Evening hours, night time, weekends	Multimodal, Unimodal (on demand)	Depends: Optional (Leisure Activities), Mandatory (Events)
Tourists Hotel Guests, Sightseeing, Spa Guests etc.	Luggage space, information services, etc.	Any time during day and night	Depends on destination (unimodal: airport shuttle, round trips, multimodal: city trips)	Depends: Optional (Sightseeing), Mandatory (Arrival/Departure)

Figure 28: Characterization table of passenger groups

2.5 Hunting Fields

Hunting fields are represented by a cluster of identified business opportunities relevant for AVENUE (bottom-up approach). On the other hand hunting fields can be systematically derived from a business planning model suggested by Abell[9], where the three dimensions: customer (groups) / domains / needs, tasks / challenges / problems, technologies/offerings/competencies define areas of potential business activities with multiple business opportunities.

The generic AVENUE diagram and main data flows as well as the overall architecture representation from the AVENUE proposal is a valuable source of inspiration for business opportunities that can be clustered to hunting fields later on. (see figure 29)

[9] Abell, Derek F. (1980). Defining the Business: The Starting Point of Strategic Planning. Prentice Hall

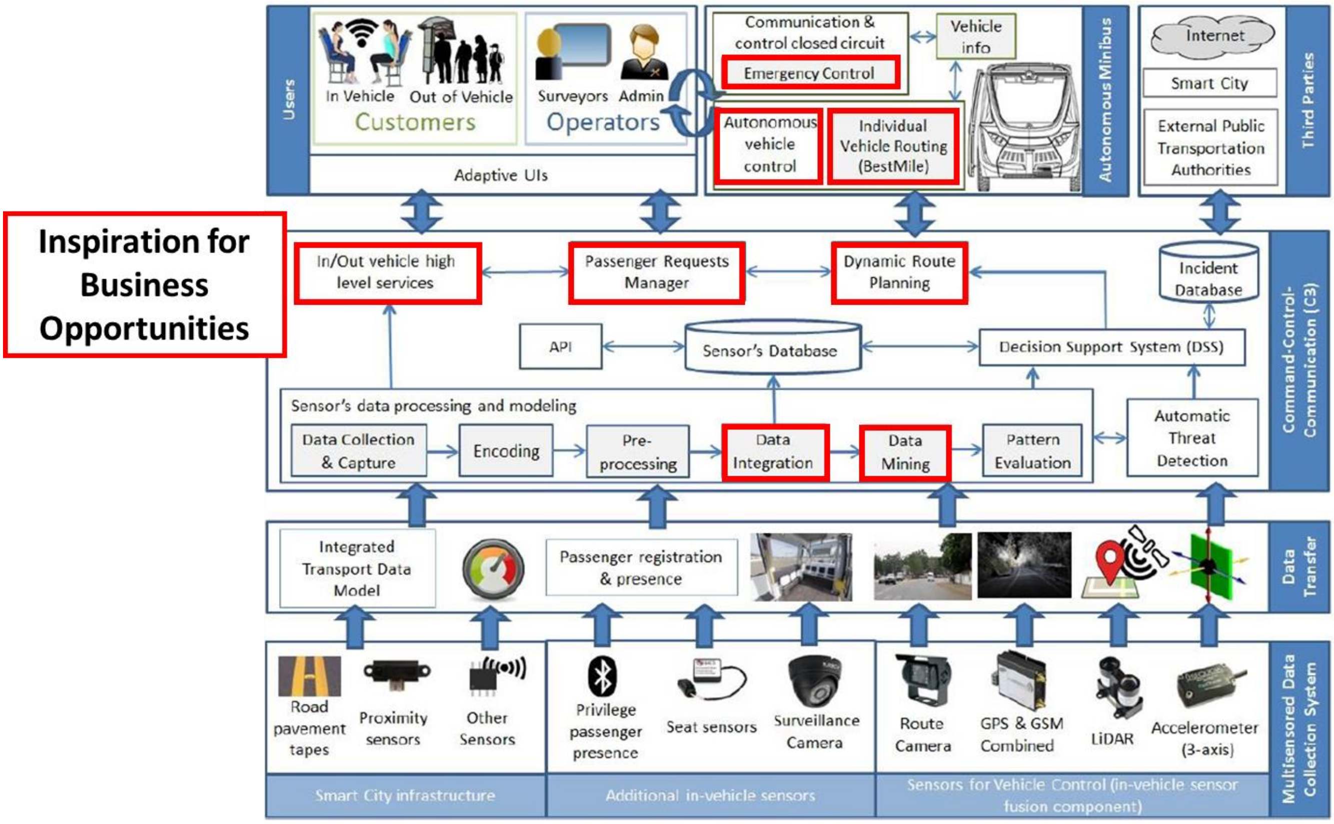


Figure 29: Inspiration Source for Business Opportunities - the AVENUE overall architecture[10]

These elaborations are the basis for a preliminary big picture of a collection of business opportunities (blue bubbles) which have been clustered thematically in a suitable way to hunting fields (green bubbles) according to the three-dimensional matrix representation (see figure 30).

[10] H2020 AVENUE Project Proposal (07-2017) Autonomous Vehicles to evolve to a New Urban Experience. S.14

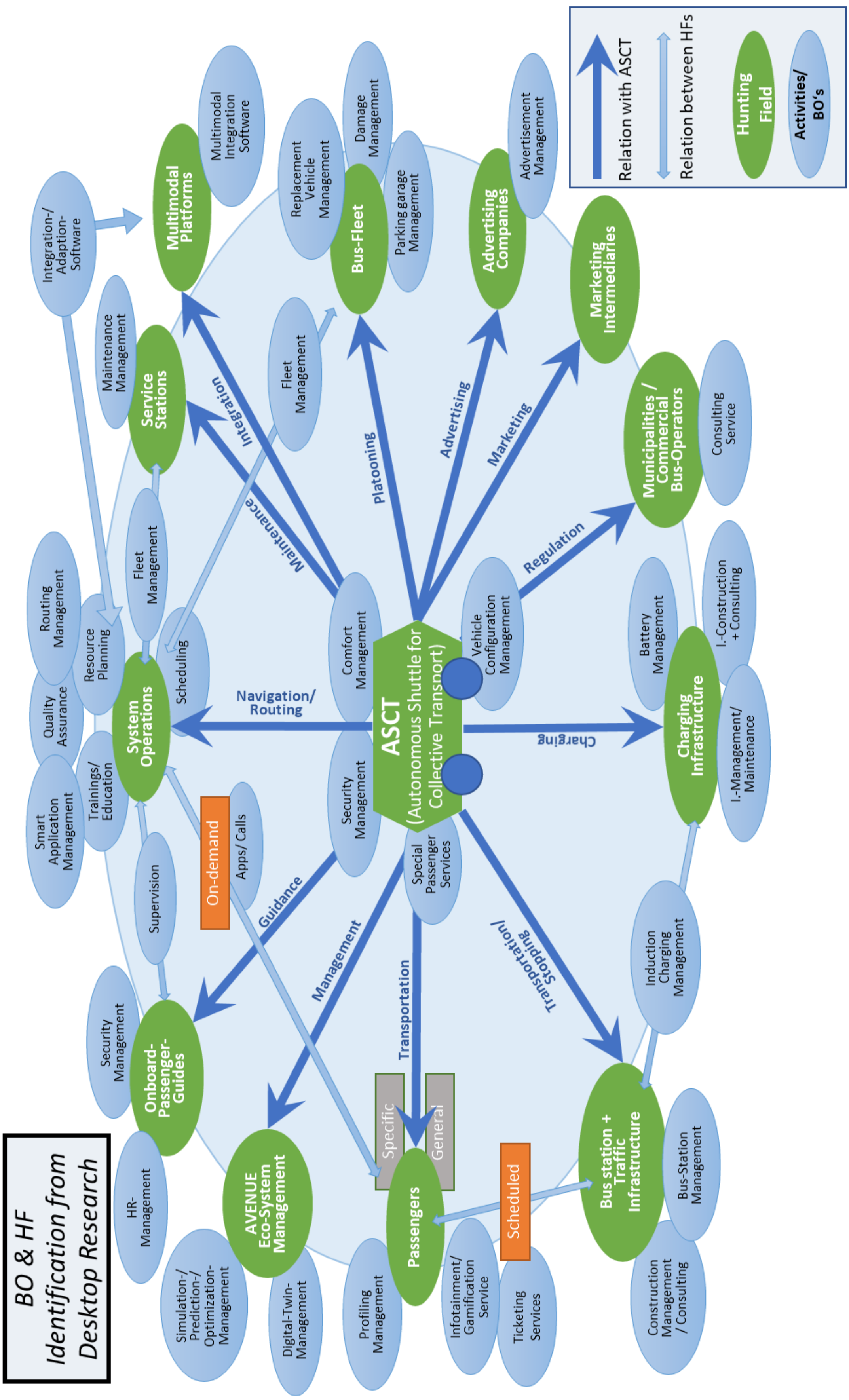


Figure 30: Identification of Business Opportunities & Clustering of Hunting Fields

In a more structured representation these hunting fields and business opportunities are displayed below. Among these identified business opportunities, the following selection seems to be promising for future profitable businesses. (see figures 31 and 32)

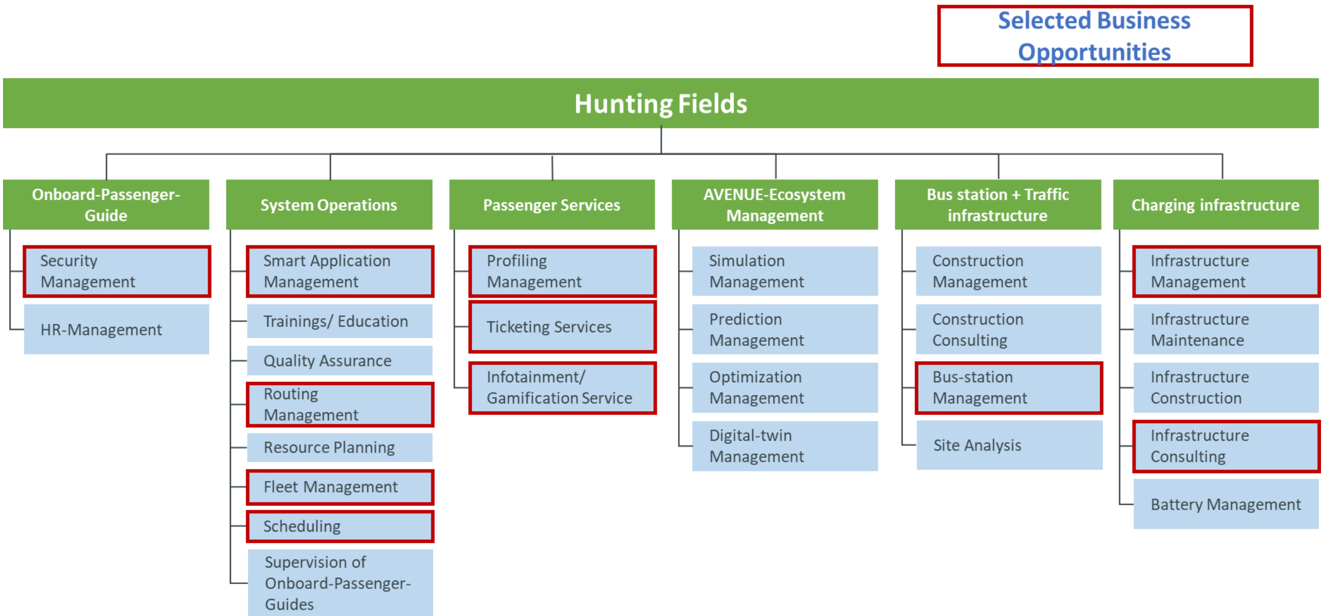


Figure 31: Structured Representation of Business Opportunities & Hunting Fields (1/2)

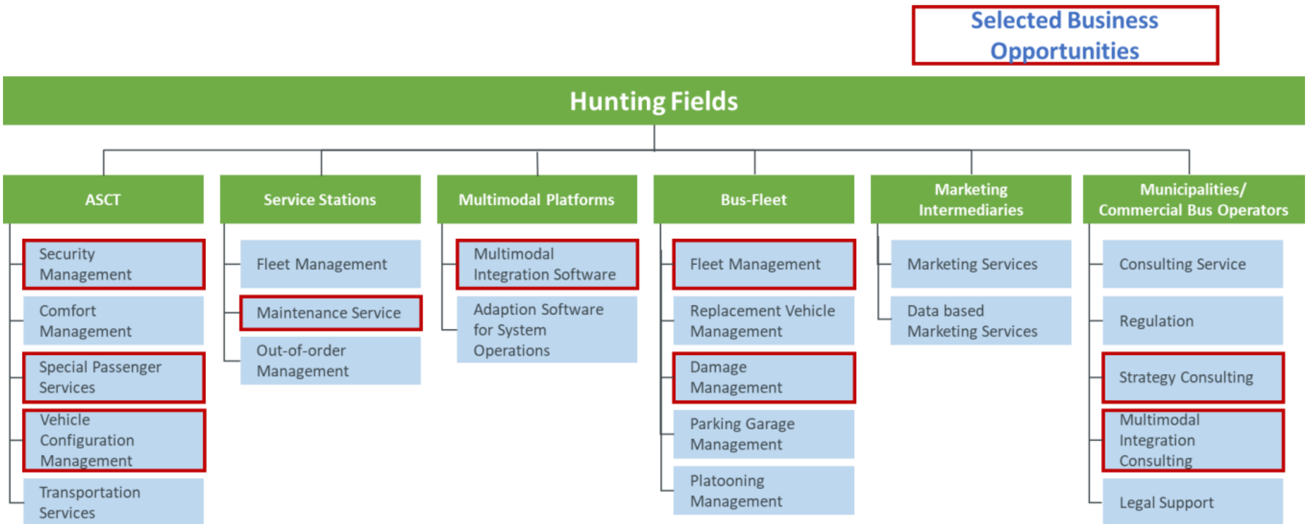


Figure 32: Structured Representation of Business Opportunities & Hunting Fields (2/2)

The subsequent business planning models and pragmatic elaborations were precondition for further methodology of complexity reduction which is necessary to focus on only a few business opportunities which can be strategically planned and tested in the future.

In this sense the selected hunting fields and the herein selected business opportunities can be characterized with regard to the passenger use cases (see figure 33).

Hunting Fields & Business Opportunities (Future Business View)	Selected HFs	Selected BOs	Passenger Use Cases (Future Ecosystem View)			
			Country Call for elderly/ disabled people	City Call for leisure purposes	Country Line for commuters/students	City Line for tourists
HF1 PS	Passenger Service	Ticketing Service	Tickets via callcenter, website, in the vehicle	Ticketing via app	Ticket subscription (App, print)	Ticket purchase (App, print)
		Profiling Management	Profiling for special needs (wheelchair ramp, signals for blind people etc.)	Estimation of people attending an event	Creation of groups (students, commuters) regarding start of working/ school time	cooperation with travel agencies regarding sightseeing spots, booking capacity
		Infotainment/ Gaimification Service	Special bus stop and transport connection informations for disabled people	Gamification offerings for kids, integrated iPads for entertainment (painting, gaming), sound system	Gamification offerings for students, morning news	Special information offerings regarding sightseeing spots, futher scheduled line traffic
HF2 IM	Infrastructure Management	Charging Station Management	Large scale expansion of charging infrastructure, overnight charging	Extension of the existing charging infrastructure, daytime charging and in between the services	Large scale expansion of charging infrastructure, overnight charging or outside rush hour	Extension of the existing charging infrastructure, charging in between services
		Bus-Station Management			Extension and utilization of existing bus-stations, integration of the locations in the App	Extension and utilization of existing bus-stations, coordination with other traffic participants, i.e. buses
		Maintenance and Damage Management	Construction of decentralized service stations, available mechanics for unpredictable damages, call buttons inside the bus, maintenance after service	Construction of centralized service stations, maintenance of all buses in a common service station	Construction of decentralized service stations, available mechanics for unpredictable damages, call buttons inside the bus, maintenance after service	Construction of centralized service stations, maintenance of all buses in a common service station
		Infrastructure Consulting	Intensive consulting regarding expansion of the infrastructure, provide the requirements for on-demand services, e.g. sensorics	Consulting regarding utilization possibilities of existing buslines and infrastructure, providing requirements for on-demand services	Consulting regarding expansion of the infrastructure and utilization possibilities of existing bus stations	Consulting regarding utilization possibilities of existing busstations and infrastructure
HF3 SO	System Operation	Smart Application Management		Ticketing, information, ordering, bus location	Ticketing, timetable, information, bus location, delays	Ticketing, timetable, information for tourist attraction, bus location, delays, furhter connections
		Routing Management	Fast adaption of passenger requests, individual routes, no determined bus stops	Fast adaption of passenger requests, individual routes, no determined bus stops, higher complexity due to various traffic participations	Definition of bus stops, defined routes, punctuality management	Definition of bus stops, defined routes via hotspots, punctuality management
		Fleet Management	platooning for senior events	platooning in case of a special event, high frequentation around public transport stations for fast availability	platooning during rush hour	Platooning during holidays/ special events
		Scheduling			Timetable adapted to volume of passengers	Timetable adapted to volume of passengers
HF4 ASCT	ASCT	Security Management	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed
		Special Passenger Services	Callcenter, on demand on board passenger guide for disabled people	Advertising display with special offers/ prices (cooperations with shopping centers)	News ticker, gaming applications, tutoring via displays	interactive city cards and informations, recommandations via App
		Vehicle Configuration Management	Accessability, luggage space for wheel chairs, emergency buttons	Luggage space for stroller, shopping bags, snack bar, sound box	Power sockets for laptops/ handy, available standing places	Sound system, lugagge space for suitcases, headphones for city informations, interactive displays
HF5 MCBO	Municipalities/ Commericial Bus Operators	Strategy Consulting	Implementation of ASCT in weak infrastructure areas first	Implementation of ASCT to contribute to the relief of road transport, additional innovative service offering to enhance the attractiveness of a city	Special ticketing offerings, support of weak infrastructure areas which are located far away from public transport stations, additional public transportation service	Innovative, tourist attracting transportation service for cities, special ticketing offerings in combination with tourist attractions
		Multimodal Integration Consulting	Multimodal integration not necessary, because of on-demand door-to-door services	Connection to the public transport system to offer last-mile services, system integration in public transport App	Multimodal integration in public transport App due to connection timetables, adapted schedules to reach subway/ train/ bus in time	Multimodal integration in public transport App, avoiding of overlaps with other tourist buslines

Figure 33: Assignment of Hunting Fields to Scenario Use Cases – Identification of most attractive Business Opportunity Clusters across Scenario Use Cases

The different hunting fields (HF1 – HF5) from the table above will be described more precisely in the following figures 34 - 38. These characterizations are built up by the following question modules:

a) Why: what are the challenges or reasons that justify this as a significant hunting field
b) What: what are the solutions and benefits that can cover these challenges
c) How: how are these solutions built up (functions/applications)
d) Benefit: what are the added values or advantages that the solution provides to the customers and passengers

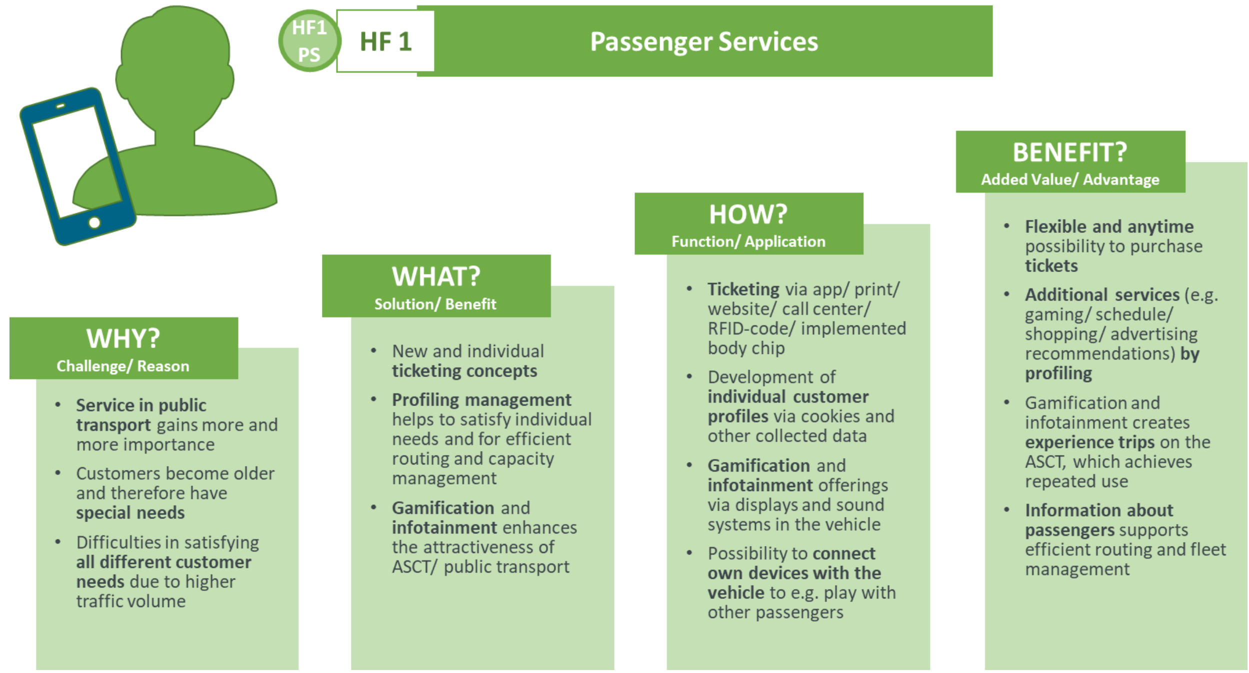


Figure 34: Description of Hunting Field – Passenger Services

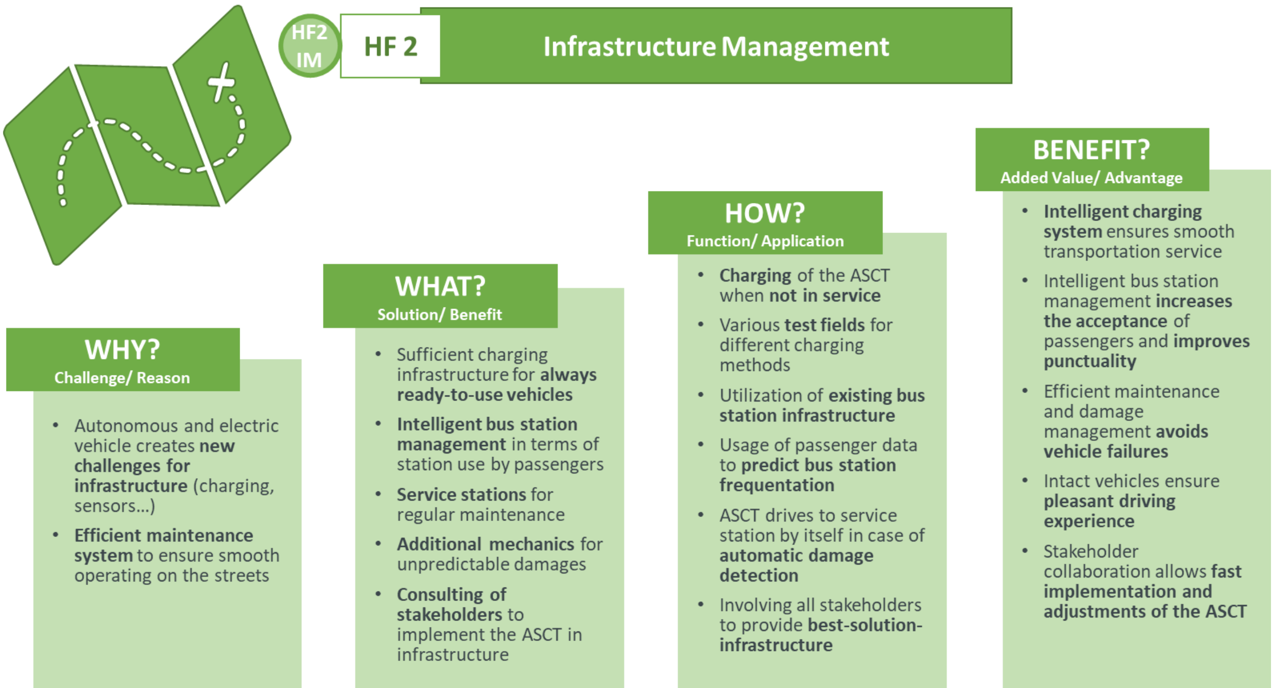


Figure 35: Description of Hunting Field – Infrastructure Management

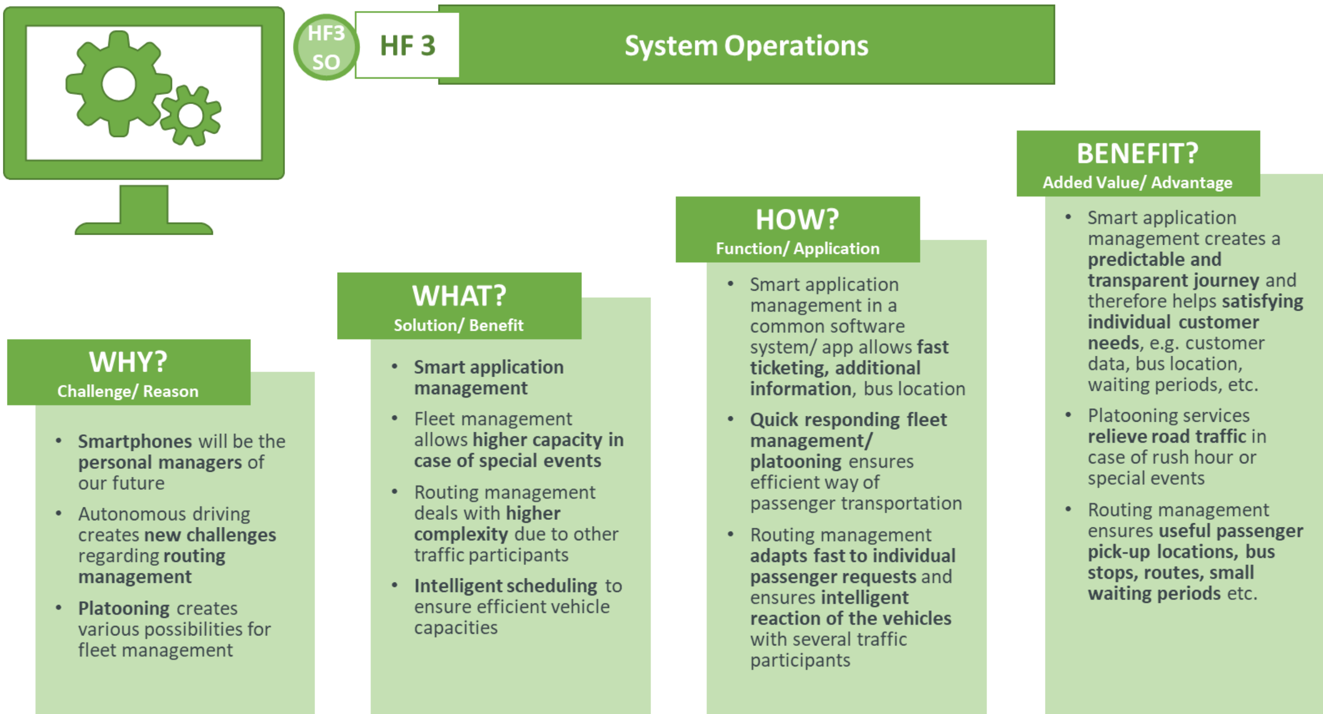


Figure 36: Description of Hunting Field – System Operations

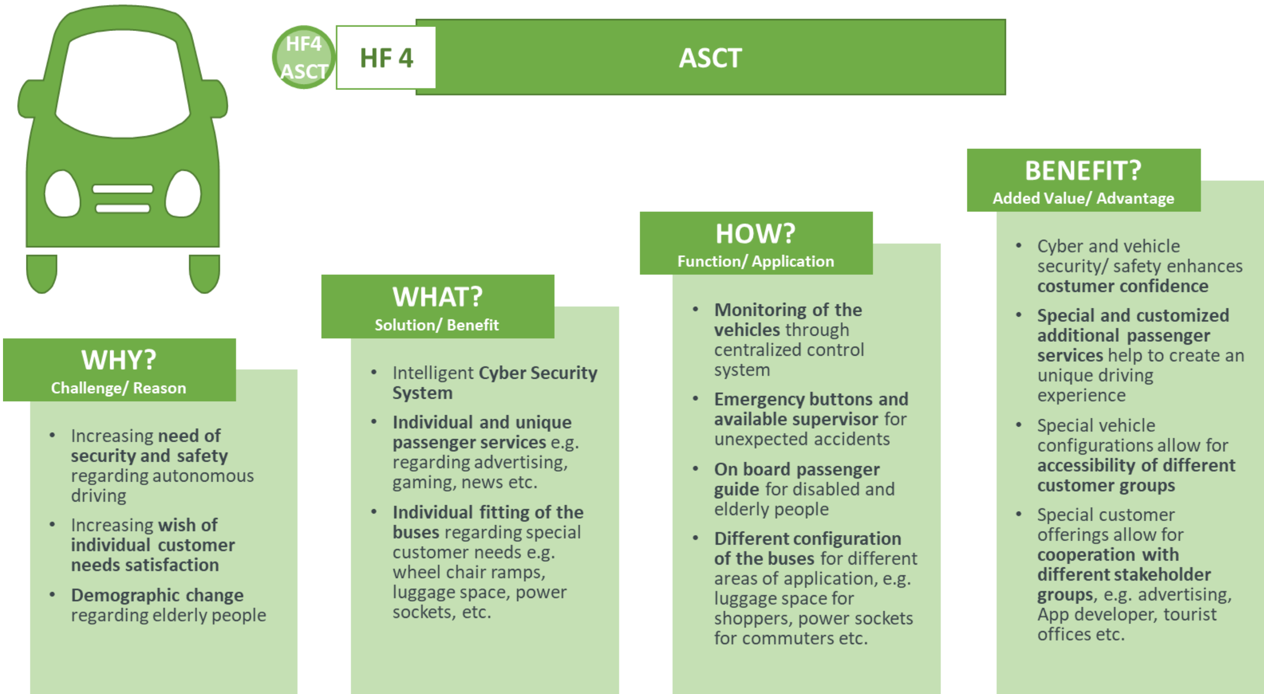


Figure 37: Description of Hunting Field – ASCTs

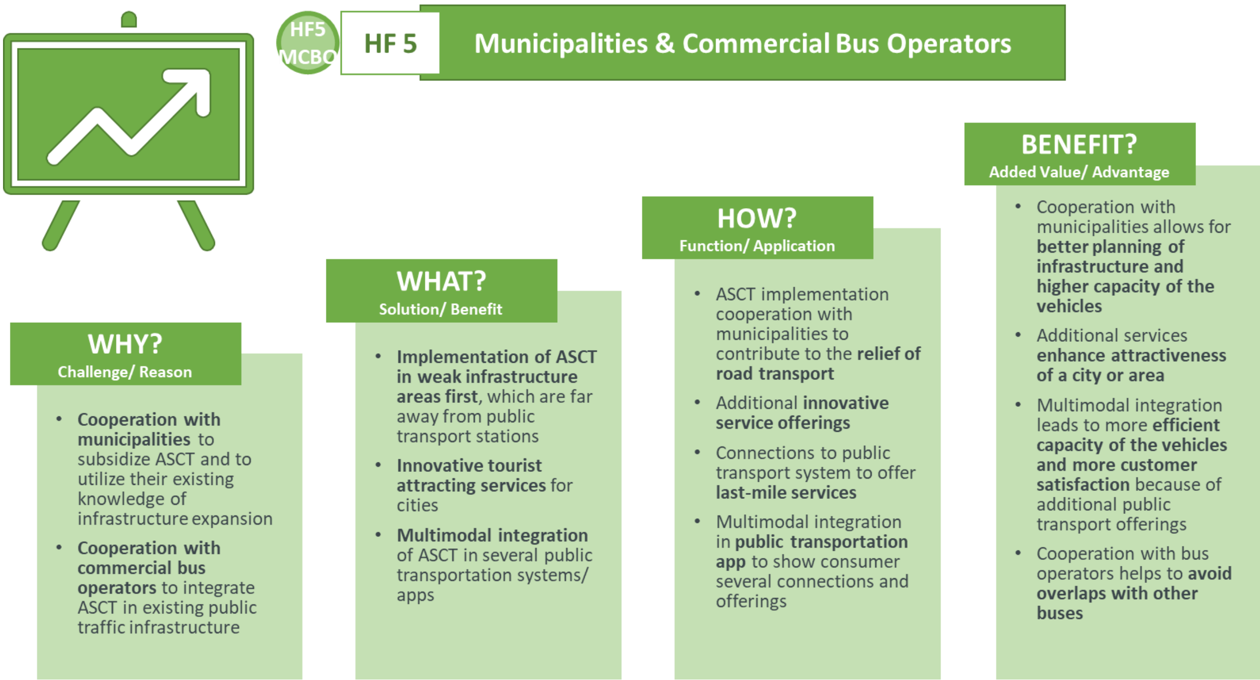
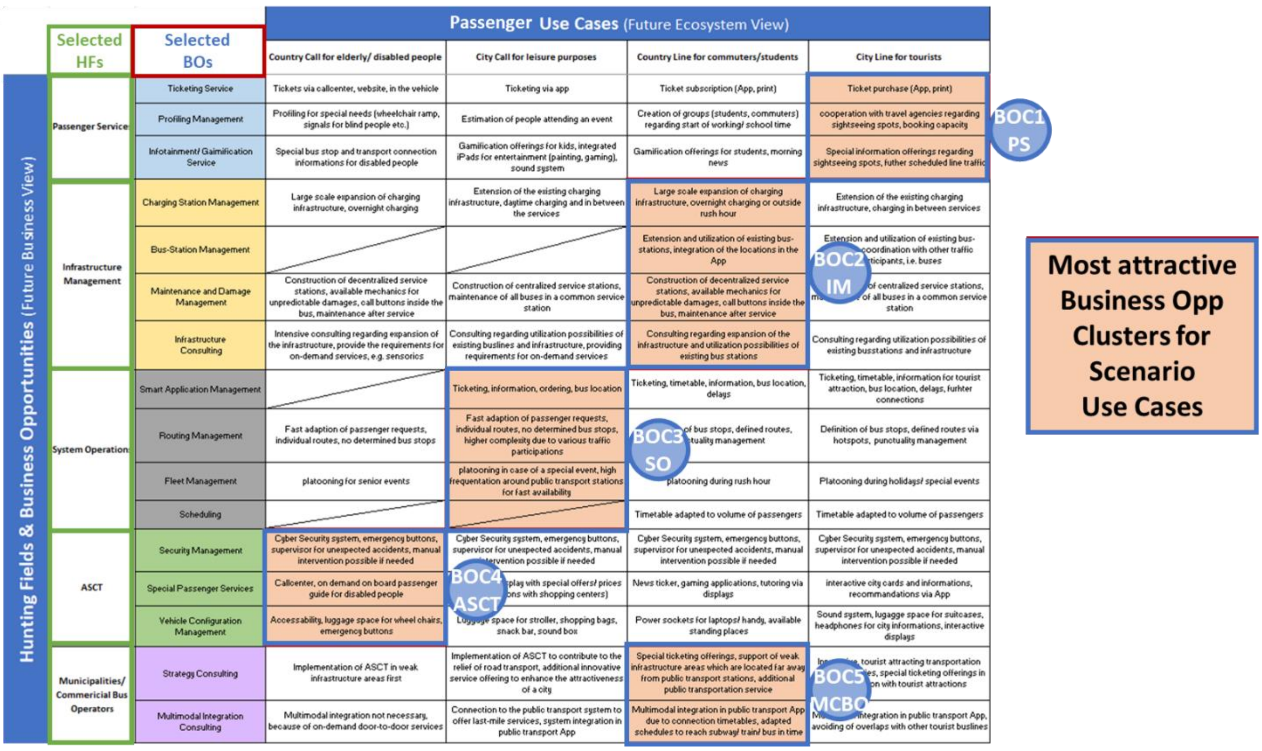


Figure 38: Description of Hunting Field – Municipalities & Commercial Bus Operators

2.6 Business Opportunities

In the following figure 39 the selected business opportunities (blue bubbles; BO1-BO5) can be characterized with regard to the passenger use cases identified in figure 33.



Hunting Fields & Business Opportunities (Future Business View)

Selected HFs	Selected BOs	Passenger Use Cases (Future Ecosystem View): Country Call for elderly/ disabled people	City Call for leisure purposes	Country Line for commuters/students	City Line for tourists
Passenger Service	Ticketing Service	Tickets via callcenter, website, in the vehicle	Ticketing via app	Ticket subscription (App, print)	Ticket purchase (App, print)
	Profiling Management	Profiling for special needs (wheelchair ramp, signals for blind people etc.)	Estimation of people attending an event	Creation of groups (students, commuters) regarding start of working/ school time	cooperation with travel agencies regarding sightseeing spots, booking capacity
	Infotainment/ Gaimification Service	Special bus stop and transport connection informations for disabled people	Gamification offerings for kids, integrated iPads for entertainment (painting, gaming), sound system	Gamification offerings for students, morning news	Special information offerings regarding sightseeing spots, futher scheduled line traffic
Infrastructure Management	Charging Station Management	Large scale expansion of charging infrastructure, overnight charging	Extension of the existing charging infrastructure, daytime charging and in between the services	Large scale expansion of charging infrastructure, overnight charging or outside rush hour	Extension of the existing charging infrastructure, charging in between services
	Bus-Station Management			Extension and utilization of existing bus-stations, integration of the locations in the App	Extension and utilization of existing bus- … coordination with other traffic …ticipants, i.e. buses
	Maintenance and Damage Management	Construction of decentralized service stations, available mechanics for unpredictable damages, call buttons inside the bus, maintenance after service	Construction of centralized service stations, maintenance of all buses in a common service station	Construction of decentralized service stations, available mechanics for unpredictable damages, call buttons inside the bus, maintenance after service	… of centralized service stations, m… of all buses in a common service station
	Infrastructure Consulting	Intensive consulting regarding expansion of the infrastructure, provide the requirements for on-demand services, e.g. sensorics	Consulting regarding utilization possibilities of existing buslines and infrastructure, providing requirements for on-demand services	Consulting regarding expansion of the infrastructure and utilization possibilities of existing bus stations	Consulting regarding utilization possibilities of existing busstations and infrastructure
System Operation	Smart Application Management		Ticketing, information, ordering, bus location	Ticketing, timetable, information, bus location, delays	Ticketing, timetable, information for tourist attraction, bus location, delays, furhter connections
	Routing Management	Fast adaption of passenger requests, individual routes, no determined bus stops	Fast adaption of passenger requests, individual routes, no determined bus stops, higher complexity due to various traffic participations	… of bus stops, defined routes, …tuality management	Definition of bus stops, defined routes via hotspots, punctuality management
	Fleet Management	platooning for senior events	platooning in case of a special event, high frequentation around public transport stations for fast availability	platooning during rush hour	Platooning during holidays/ special events
	Scheduling			Timetable adapted to volume of passengers	Timetable adapted to volume of passengers
ASCT	Security Management	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual …tervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed	Cyber Security system, emergency buttons, supervisor for unexpected accidents, manual intervention possible if needed
	Special Passenger Services	Callcenter, on demand on board passenger guide for disabled people	…play with special offers/ prices …ons with shopping centers)	News ticker, gaming applications, tutoring via displays	interactive city cards and informations, recommandations via App
	Vehicle Configuration Management	Accessability, luggage space for wheel chairs, emergency buttons	Lu… space for stroller, shopping bags, snack bar, sound box	Power sockets for laptops/ handy, available standing places	Sound system, lugagge space for suitcases, headphones for city informations, interactive displays
Municipalities/ Commericial Bus Operators	Strategy Consulting	Implementation of ASCT in weak infrastructure areas first	Implementation of ASCT to contribute to the relief of road transport, additional innovative service offering to enhance the attractiveness of a city	Special ticketing offerings, support of weak infrastructure areas which are located far away from public transport stations, additional public transportation service	In… tourist attracting transportation …es, special ticketing offerings in …on with tourist attractions
	Multimodal Integration Consulting	Multimodal integration not necessary, because of on-demand door-to-door services	Connection to the public transport system to offer last-mile services, system integration in public transport App	Multimodal integration in public transport App due to connection timetables, adapted schedules to reach subway/ train/ bus in time	M… …ntegration in public transport App, avoiding of overlaps with other tourist buslines

Figure 39: Assignment of Hunting Fields to Scenario Use Cases – Identification of most attractive Business Opportunity Clusters across Scenario Use Cases

Among the different business opportunity clusters from the figure above we describe two BOs more precisely in the following figures. These characterizations are built up by the following question modules:

a) Why: what are the challenges or reasons that justify this as a significant business opportunity cluster
b) What: what are the solutions and benefits that can cover these challenges
c) How: how are these solutions built up (functions/applications)
d) Benefit: what are the added values or advantages that the solution provides to the customers and passengers

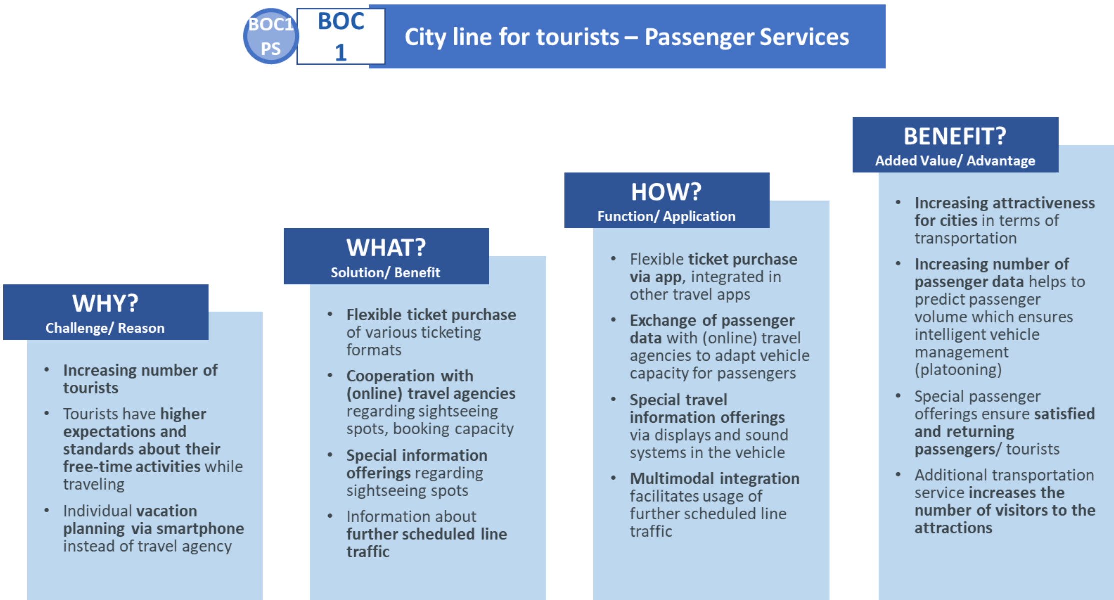


Figure 40: Description of Business Opportunity Cluster – City Line for tourists / Passenger Services

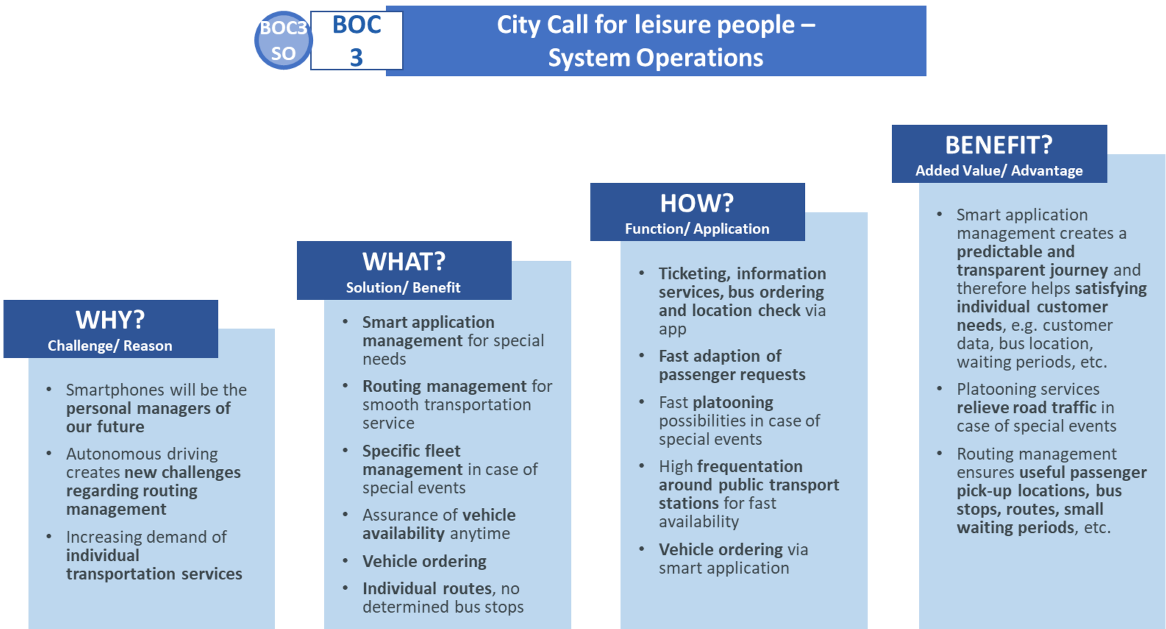


Figure 41: Description of Business Opportunity Cluster – Leisure / system operations

2.7 Business Use Cases

Business use cases are graphical or verbal representations of business workflows related to a dedicated business opportunity and embedded within a business ecosystem. There are pictures for status-quo business use cases and future business use cases. The clarification or planning of business use cases is precondition for deriving business strategies and business models. The following modules and aspects of business use cases are essential for further business planning.

The business ecosystem where business use cases are embedded can be categorized into three granularity levels: the global business ecosystem, the competition business ecosystem, and the offering business ecosystem. The conceptional basis for business use cases is the initial representation of the business offering ecosystem architecture displayed in the AVENUE proposal. (see figure 42)

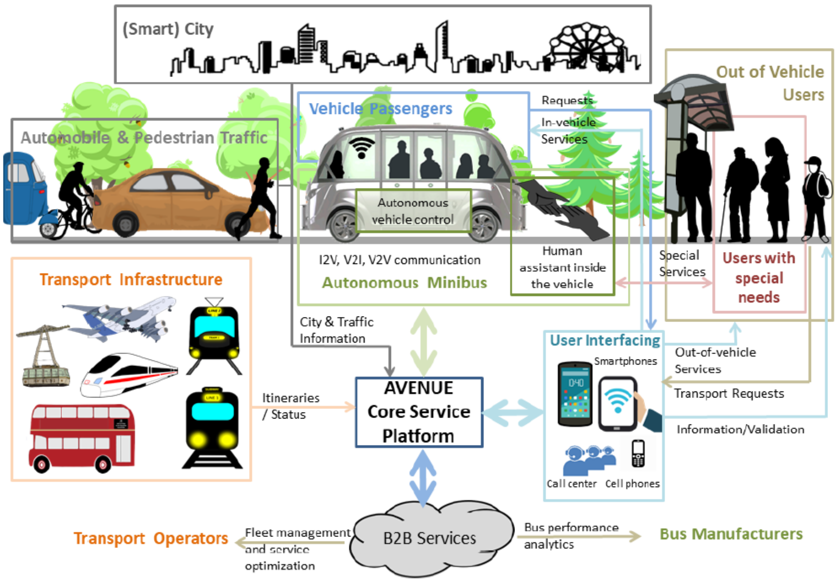


Figure 42: AVENUE Conceptional Architecture (from H2020 Proposal) as inspiration for Business Ecosystem[11]

Based on this initial representation it is useful to propose and design of the AVENUE offering ecosystem in a way where main offering components (platform, ASCT, infrastructure, services) are systemically displayed including the assignment of current or future actors within the ecosystem. (see figure 43)

[11] H2020 AVENUE Project Proposal (07-2017) Autonomous Vehicles to evolve to a New Urban Experience. S.4

The central challenge of an offering business ecosystem is to answer the questions:

- which components (e.g. offerings, features, etc.) should be included into a platform provided by AVENUE
- which components should be offered to the customer as optional offerings by AVENUE
- which components should be offered to the customer or provided (supplied/subcontracted) to AVENUE by external core partners (close cooperation with bilateral contracts)
- which components should be offered to the customer by external peer partners (loose cooperation by registering on the AVENUE platform).

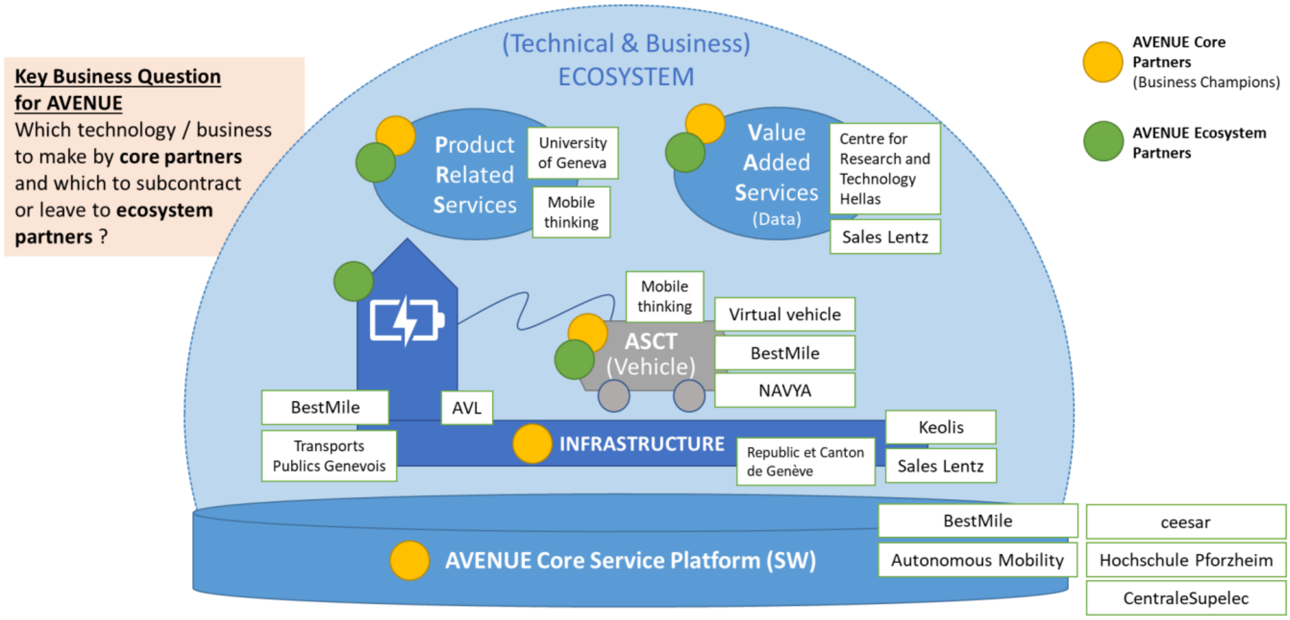


Figure 43: AVENUE System Partners within AVENUE Business Ecosystem

From a general and high-level point of view AVENUE business use cases have to regard to different stages/ focuses of the business system:

1. Main focus are the business opportunities and business models regarding the relationship between the AVENUE business champions and the AVENUE business customers and operational users
2. Extended focus are the business opportunities and business models regarding the relationship between the AVENUE business customers and the AVENUE end users (passengers)

Both focuses have to be regarded and integrated into the definition of business use cases. (see figure 44)

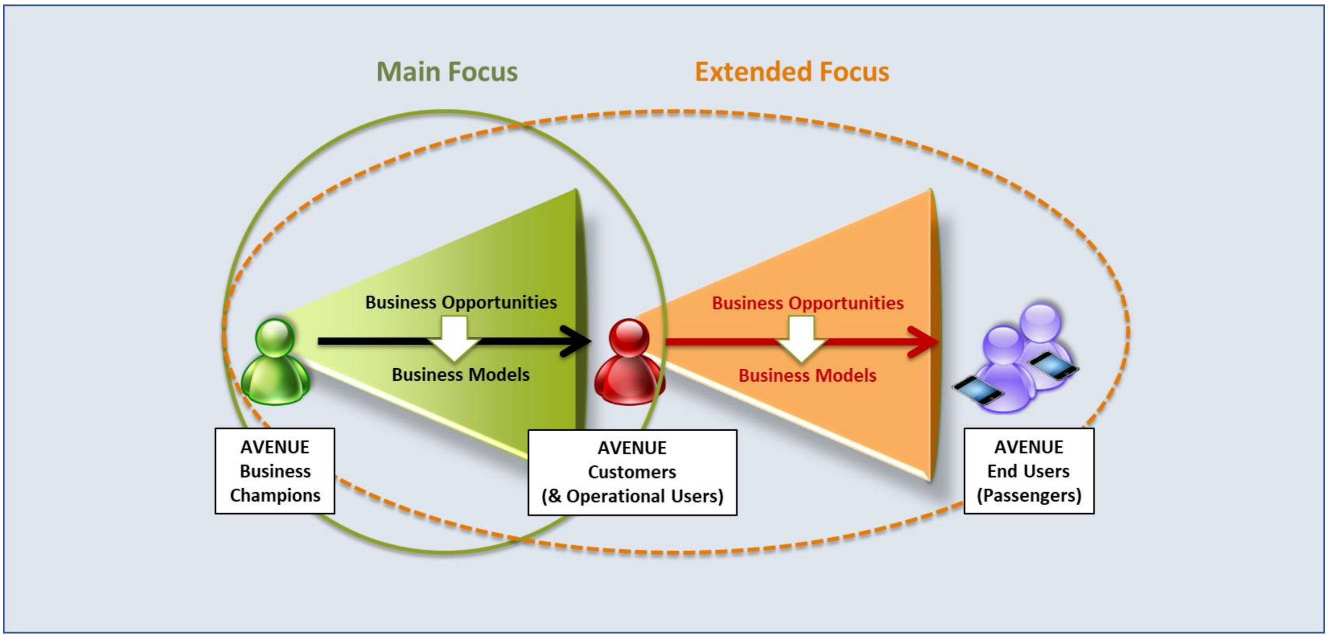


Figure 44: Two stages of AVENUE Business Focuses

Whereas business opportunities and business models are planned to provide the AVENUE offerings to the AVENUE business customers and end users (forward approach), the requirements from the end users and business customers have to be elicited equally from those two systemic stage partners. (see figure 45)

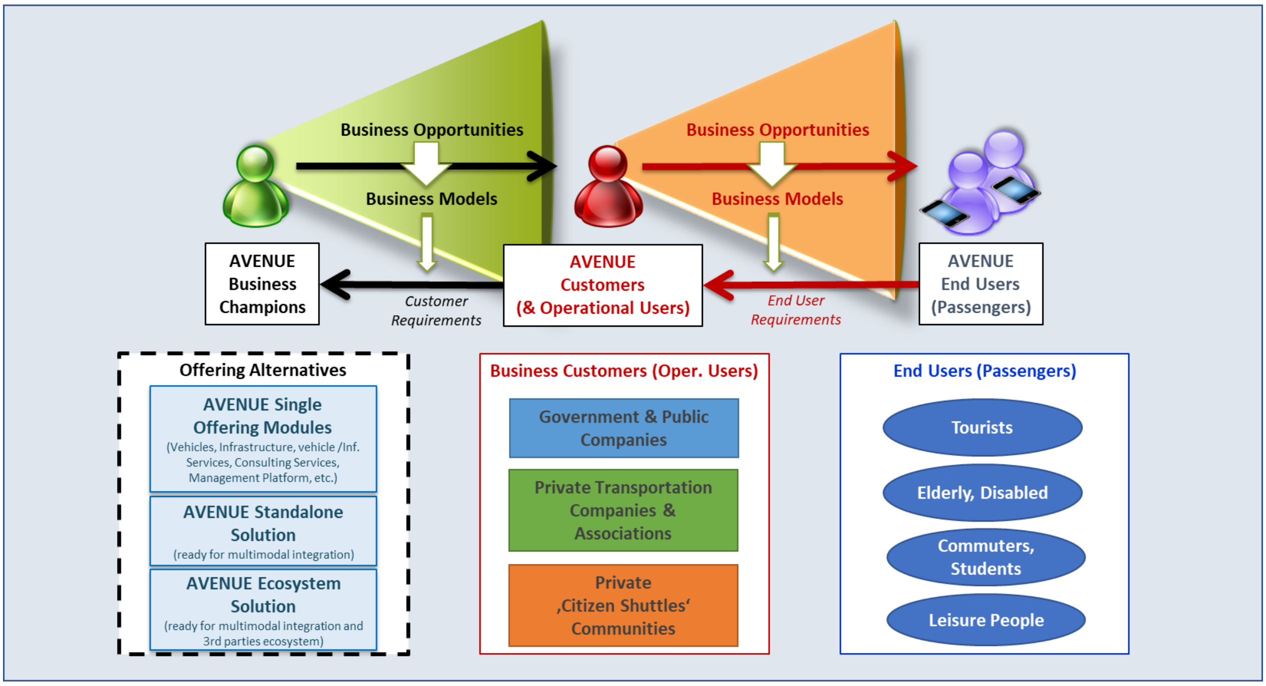


Figure 45: General AVENUE Business Actors & Offerings

From a generic point of view on the AVENUE business value chain there are three general business type options relevant for the AVENUE providers (business champions):

1. A2G business (between AVENUE providers and government – business customers are e.g. municipalities, public transportation companies or their private subcontracted companies)

2. A2S business (between AVENUE providers and AVENUE solution providers – business customers are e.g. private solution integrators or private operating companies)
3. A2O business (between AVENUE solution providers and AVENUE operators – business customers are e.g. value-added or product-related service providers, software providers)

Currently it is not intended for AVENUE providers to enter a direct business with AVENUE passengers. (see figure 33)

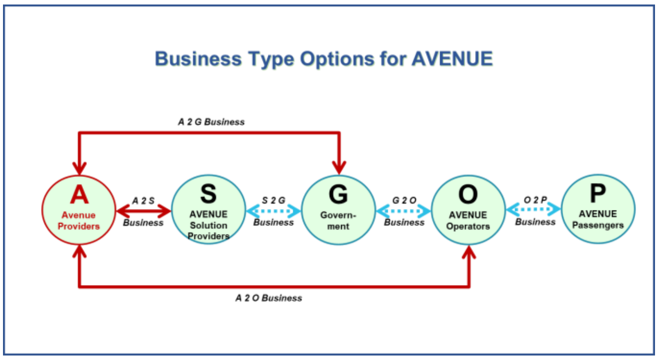


Figure 46: The AVENUE Business type options

Obstacles & Risks

Complementary to the identification of business success factors it is equally important for the design of business use cases to have detailed information about general obstacles and risks for AVENUE. (see figure 47).

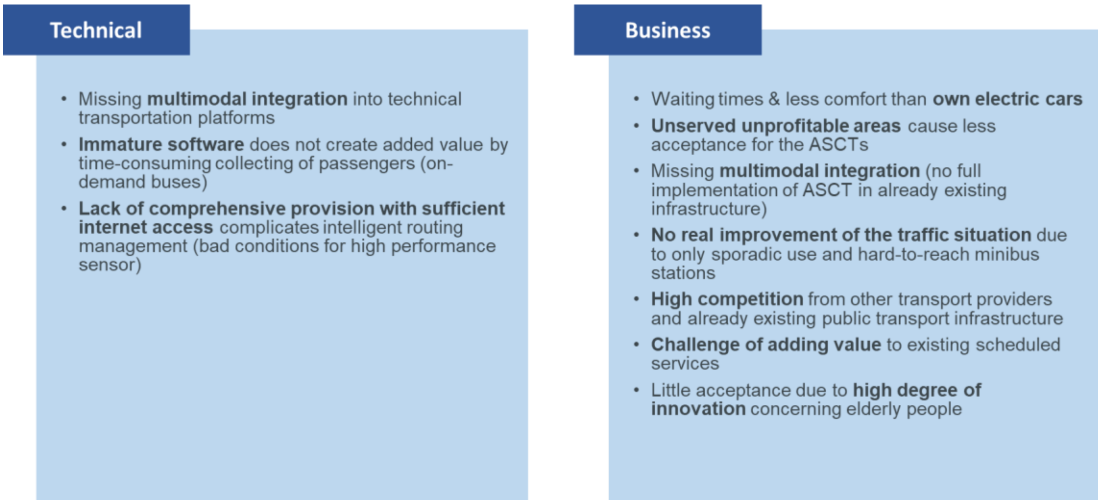


Figure 47: General AVENUE Obstacles & Risks as basis for deriving business strategies

Success Factors

Important general information for designing business use cases for AVENUE is the knowledge about general technical and business success factors. (see figure 48)

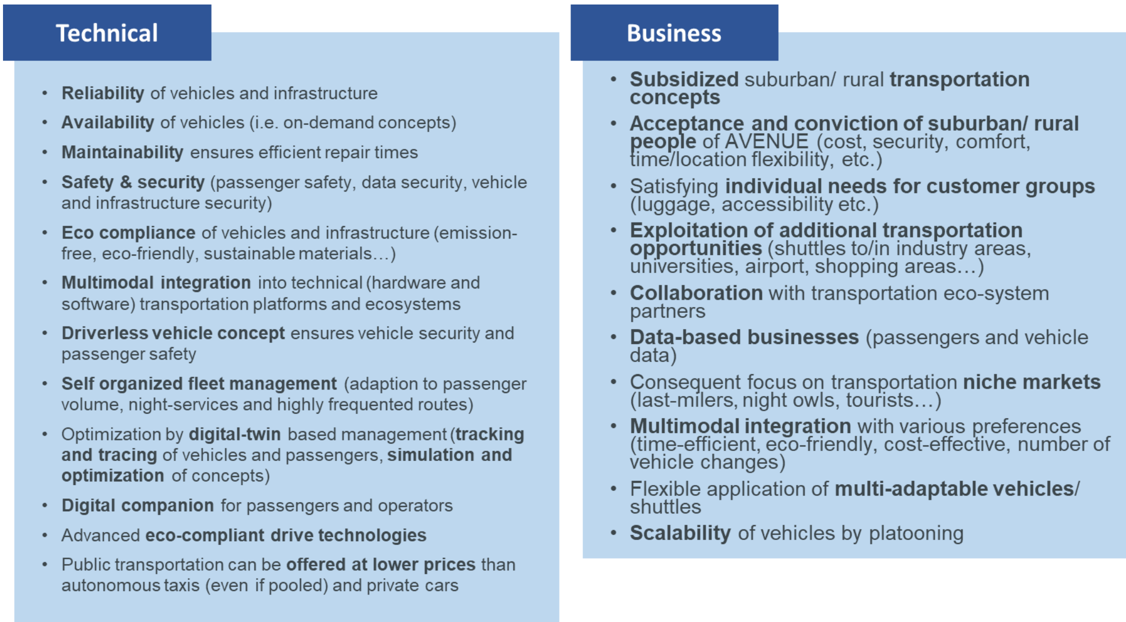


Figure 48: General AVENUE Success Factors as basis for deriving business strategies[12]

Stakeholder Analysis

Important information for the design of business use cases (and later on business models) is the identification and analysis of the business stakeholders and their according stakes (goal/interests, needs, benefits). (see figure 49)

[12] Bösch, Patrick; Becker, Felix et al. (2017) Cost-based analysis of autonomous mobility services. Retrieved 2019-08-07, from https://www.sciencedirect.com/science/article/pii/S0967070X17300811?via%3Dihub

Role	Goal/ Interest	Needs	Benefits
Passengers	Transportation from A to B for specific target groups, comfort	Specific passenger services, costumer support	Higher acceptance and usage of vehicles by providing innovative and special service
Municipalities	Intact public infrastructure, less road traffic	Infrastructure consulting, integration of all demographic groups	Useful integration in public transport increases attractiveness of public transport
Software Provider	Usage of smart applications, vehicle fully integrated in software service	Cooperation and transparent communication with vehicle and solution provider	Intact software ensures smooth vehicle operations
Mobility Platforms	Vehicle fully integrated in mobility platform	Access to all relevant data, cooperation with software provider	Integration in mobility platforms make usage of ASCTs easier
Telecommunication Companies	Technology and software providers use strong network provided by telecommunication companies	Reliable contract for their services	Strong network is needed to provide smooth vehicle operations
Insurance Company	Insurance contract for vehicles	Reliable contract for their services	Reliable and cost-effective insurance services
Vehicle Provider	High acceptance of vehicles	Cooperation with software and solution providers, data about passenger needs and infrastructure	Provision of well functioning vehicles which meet specific needs
Infrastructure Provider/ Construction Company	Provision of intact infrastructure by one company	Information about specific needs	Expansion of infrastructure leads to smooth transportation service and useful usage of vehicles
Maintenance/ Service Company	Well organized damage and maintenance management	Intelligent detection of damages and self-driving vehicle to service station	Prevention of vehicle failure through intact maintenance and service system
Marketing Intermediaries/ Advertising Company	Displays for advertisement in the vehicles	Data including passenger information to adapt advertisement to passengers' interests	Advertisement in vehicles generates additional revenue
Mobility Association	Multimodal integration of ASCTs	Routing management consulting, passenger information	Multimodal integration makes it easy to use ASCTs in addition to other transportation services
Data Business Provider	Collection of passenger and vehicle data	Access to smart application and vehicle data	Passenger and vehicle data provide important information to control e.g. the fleet management to adapt number of vehicles to passenger volume
Operating Business (private/ public)	Well functioning ticketing system and vehicle management	Cooperation with software and vehicle providers	Operating business has experience in integrating ASCT into existing infrastructure in an economically viable way
Technical Inspection Organization	Regular technical inspection	Online information about vehicle status	Assures that the vehicles meet all technical standards

Figure 49: Analysis of Business relevant Stakeholders

Business Use Case Canvas & Business Planning Outlook

The following canvas template will be used for describing business use cases based on business opportunities. This Business Use Case description as well as the according elaborations on business strategies, business models and rough go-to-market concepts will be subject of further operational elaborations.

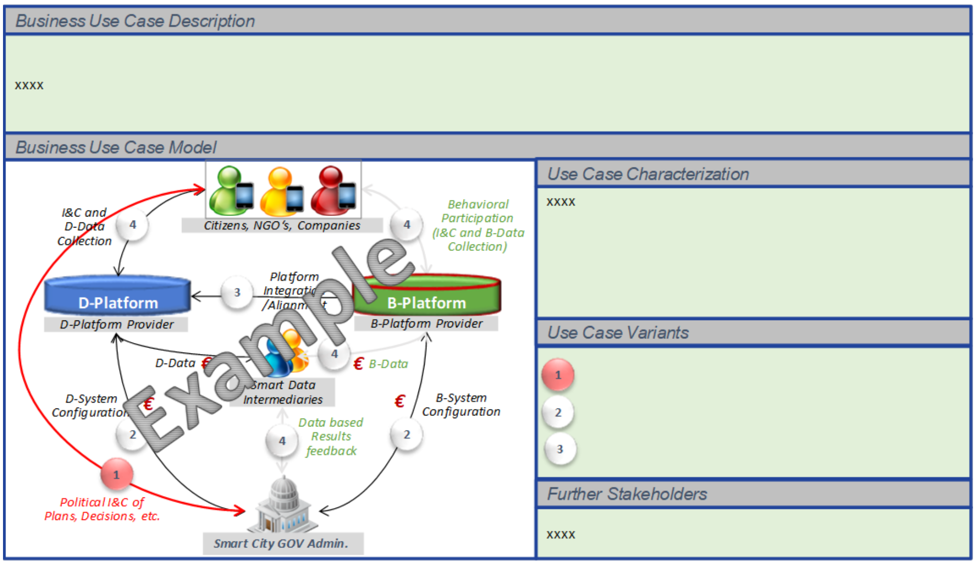


Figure 50: Business use case canvas

As an outlook on further research activities for AVENUE the following sub work-packages are intended: (see figure 51)

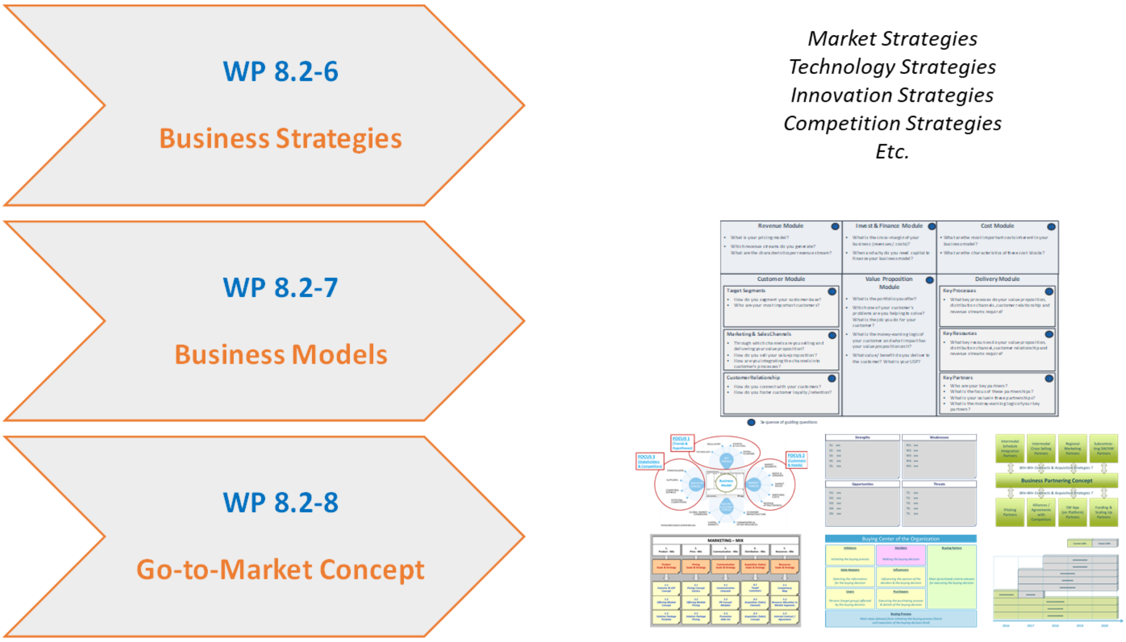


Figure 51: Outlook on further research activities (next deliverable)

An essential module within Business Models and Go-to-Market Concepts will be the 'Cost Model' as a systemic representation of all strategic cost factors of a Business Model. This is supported by quantitative calculations (see next chapter: TCO calculator) and are e.g. basis for profitability and cost/benefit analyses.

3 TCO Calculator

A Total cost of ownership (TCO) approach will be deployed to design a tool giving a global economic simulation of the impact of deployments with Autonomous Shuttles for Collective Transport. The TCO calculator operates at 2 levels: level 1 integrates macro data (e.g.: global costs for the collectivity) and level 2 integrates micro data (e.g.: local costs for the transport operator or local cost for the collectivity).

3.1 Macro-data calculator

In this section, a macro-data calculator will be proposed in order to investigate and simulate the potential effects and external costs reduction by deploying shared autonomous electric vehicle fleets in cities, taking into account the different future mobility scenarios designed.

The term external cost is defined by Markandya (1998) as "the costs arising from any human activity that are not accounted for in the market system". For example, in the transport sector external costs are related to traffic jam, air pollution, noise, GHG emissions and climate change impacts, and so on. The external costs, are also known as externalities, and it refers to the economic concept of uncompensated social or environmental effects (Eltis, 2014).

In 2018 the European Commission presented main findings on the external costs of EU transport. The study pointed out the total external costs of transport estimated around € 1,000 billion annually, which corresponds to almost 7% of EU 28 GDP (CIVITAS Initiative, 2019). The environmental costs, e.g. noise, air pollution, well-to-tank and habitat damage, represent under one-half of total external costs, followed by accidents (29%) and congestion (27%) (Polis, 2018).

The calculator here proposed aims to assess and compare the performance and effects of autonomous electric vehicles in European cities as well as worldwide. As results, it intends to add new data and findings addressing how this new technology can contribute to tackle the external costs of mobility in urban areas.

3.1.1 Methodology

For this study, an analytical model has been developed to simulate the impacts of shared autonomous electric vehicle fleets as an alternative to the individual mobility in cities.

Simulations will take into account the following elements: scenarios for adoption of autonomous vehicles and fleet size, user acceptance, the energy consumption, emission of particulate matter, nitrogen oxides, carbon footprint of different classes of vehicles, among others.

And the main effects on transport externalities will be estimated in order to tackle congestion, accidents, parking cost and free up spaces.

The methodology for calculation has been based on three main references (see on references table):

- Braun et al. (2019): to define potential mobility scenarios in cities with regards to autonomous vehicles;
- Fournier et al. (2017): to calculate the performance and cost of Autonomous-Electric Vehicles;

- Fournier et al. (2017, 2018) and Roos and Siegmann (2018) for the sustainability impact and externalities calculation.

The calculator will be applied in the four AVENUE target cities: Copenhagen, Geneva, Lyon, Luxembourg.

3.1.2 The calculator

As a first step, the definition of the potential scenarios is an initial step to determine the impact of the diffusion of autonomous shared vehicles in cites. These scenarios have to be defined among AVENUE partners: ECP, Siemens, HSPF and Etat de Genève. The scenarios of the diffusion of the shuttles will impact differently the cities, therefore, the following scenarios are currently discussed (see also Braun et al. (2019)):

- Business as usual scenarios (ICEV and individual mobility, basis scenario);
- Business as usual scenario with EV (EV and individual mobility with AV);
- Car sharing for individual mobility;
- Car sharing and ride sharing, comprising car pooling and the shuttle ride sharing;
- Car sharing, ride sharing and public transport (to be defined)

In addition, these scenarios should take into account the different modal splits and mobility goals in each target city, as well as the diffusion of autonomous bus shuttles.

The calculator will also take into account the first results of the social surveys conducted in the cities in the context of the '8.3 Social Impact'. Hence, the results from the Representative Surveys, User' Surveys and interview with Operators are a crucial source of information to consider the potential changes in mobility behaviour and consequently determine the future modal share and scenarios in the demonstrator cities. It is also important to acknowledge that the user's acceptance and the user's willingness to incorporate autonomous vehicles (with or without human presence on board) in their mobility routine will affect the diffusion levels and the scenarios for deployment. Therefore, the surveys become an important gauge to estimate different impacts.

For instance, the following questions integrated in the Representative and User Survey:

- What would you be willing to pay to use autonomous e-minibuses in general?
- How important is it to you that there is a supervisor on board the autonomous e-minibus?
- Imagine that autonomous e-minibuses were to become on demand, how willing would you be to reduce the use of your own car?

Such questions will feed the economic analysis and shape the mobility scenarios for deployment of autonomous e-minibuses.

As a second step, in order to calculate the external costs and benefits of introducing shared autonomous electric vehicle fleets in cities, the following externalities are currently discussed to be integrated in the model:

- Potential of vehicle savings (integrated in user costs evaluation)
- Potential cost savings of accident prevention (in Euro, p.a.)
- Potential cost savings of congestion avoidance (in Euro, p.a.)

- Potential cost savings of parking cost reduction (in Euro, p.a.)
- Potential parking space savings in square meters (no cost evaluation)
- Potential cost savings of reduced emissions (CO_2e) (in Euro, p.a.)
- Potential cost savings of reduced emissions (NO_x) (in Euro, p.a.)
- Potential cost savings of reduced emissions (PM) (in Euro, p.a.)
- Potential increase of QALY (Quality-Adjusted Life Year)

3.2 Micro-data calculator

An evaluation tool of costs and gains for local level of where the service will be deployed is being designed. The aim is to assist local decision makers (such as Municipalities, Public Transport Operators and other interested stakeholders) on whether or not implement services with Autonomous Shuttles in a given area by considering their overall cost structures and their local externalities (such as effects on local congestion, pollution, accidents and noise).

Understanding and evaluating the macro-data calculations and its impacts for the overall scope of a specific area is a fundamental and a pivotal part for the proper implementation of the business models proposed by the AVENUE project, however, it is only part of the equation.

For the complete economic framework proposed in this deliverable, it is also fundamental to analyze the cost and gain of the service, that is: micro costs and gains of the deployment in a specific area. In this regard, the analysis should be able to identify the cost drivers, integrating investment costs (CaPex) as well as functional costs (OpEx) for transport operators, users as well as the collectivity.

Based on the Total Cost of Ownership approach (TCO) direct and indirect costs, savings as well as cost drivers and hidden costs will be clearly identified and evaluated as a basis for the development of a business plan to evaluate the economic viability of autonomous vehicles as a part of an integrated public transport system.

The TCO, "Total cost of ownership", has to be evaluated, integrating different figures; the evaluation TCO takes into accounts the following concept that are to be estimated (none exhaustive list).

Investment	**Prospective**	**Operating costs**	**Business models**
Asset Asset Lifecycle	Ownership Life Depreciable Life Economic Life Service Life	Obvious Cost Hidden Cost Cost Savings Opportunity Cost	Resource Base Model Activity Base Model Cash Flow Estimates Incremental Cash Flow

Finally, we will propose a simulation tool that will help to understand the total costs of deploying a service with autonomous shuttles in a given area over its whole life-span.

3.2.1 Methodology

A simulation tool is being designed to allow the overall dimensioning of the service to be deployed as well as the creation of future scenarios. This tool will be comprised of three main separate but complementary elements:

1) **Dimensioning tool:** this first element has the aim of assisting decision makers on identifying the ideal fleet size for their envisioned service in a given area with a given population size.
   The service area can be urban, peri-urban or rural where public transport is already existent (in which case the autonomous shuttle would act as a complementary service) or in areas where the autonomous shuttle will be offered as a completely new service. Furthermore, within those areas the zoning could range from residential, commercial, industrial to mixed and therefore the number of potential users may vary accordingly.
   This fleet size dimensioning tool will give the option for decision makers to estimate the fleet size based on demand (whether there is already an estimate on the number of passengers) or on supply (where the new service will be created and demand is unknown) and it will take into account several elements in the calculation, such as: the average route length, the average operational speed, the average layover time, the shuttle's capacity, the load factor, the shuttle's battery range and autonomy, the number of operating hours, the frequency of the service, the presence or not of a human operator on board, the service access proximity (or granularity of service points), as well as, data on the territory for the demand and supply sides.
   The dimensioning calculation tool is currently being developed and validated by ECP along Keolis and TPG and further details will be detailed in future deliverables.

2) **Local externalities calculation tool:** Once the service's operating environment and fleet size have been defined, it is possible to move on to calculations of the local external impacts arising from the deployment.
   That is, the calculation of the local impact on the number of modal-shifts towards the service (the rate of people who have stopped using other passive modes of transport - such as private vehicles - to use the shuttle service). The shuttle's impacts on levels of congestion, pollution, noise and number of accidents.
   The local externalities calculations tool is yet to be developed and validated, further details will be given in future deliverables.

3) **CAPEX and OPEX calculation tool:** As for the calculation of local externalities, once the size of the fleet and its service perimeter have been defined, it is possible to make a simulation of the total costs for the execution of the service.
   This simulation should entail the total of Capital Expenditures (CAPEX) as well as the total of annual Operation Expenditures (OPEX) and, the possible sources of benefits (gains).
   An in-depth qualitative analysis of all cost-sources as well as gain-sources is being developed with the aim of serving as an "instruction manual" for decision makers on what costs and gain sources they should consider for their own deployments. In parallel an excel document to address the calculation of such costs and gains is also being developed and its preliminary version is further detailed in the next subsection 3.2.2.
   An expanded and complete version of the CAPEX and OPEX calculation tool will be detailed in future deliverables.

This simulation tool is being developed on a context-based approach. As a starting point, we take into account the experimentations being carried out in the Lyon pilot-site. We are working alongside with Keolis and gathering data and hypothesis from both the ongoing Confluence deployment as well as for the yet-to-start Décines deployment (AVENUE project).

The methodology for calculation has been based on the following main references (see references table for details):

- Litman (2019) - Evaluating Public Transit Benefits and Costs: Best Practices Guidebook;
- Litman (2019) – Autonomous Vehcile Impementation Predictions;
- Ongel et al. (2019) – Economic Assessment of Autonomous Electric Microtransit Vehicles;
- Bösh et al. (2018) - Cost-based analysis of autonomous mobility services;
- Henderson et al. (2017) – Feasibility of Electric Autonomous Vehicles on Ohio State University Campus;
- Kalakuntla (2017) – Adopting autonomous bus to a transit agency: a cost-benefit analysis;
- ANTP (2017) – Custo dos serviços de transporte público por ônibus: instruções práticas;
- Quinet et al. (2013) - Évaluation socioéconomique des investissements publics.

Similarly, to the macro-data calculator, this simulation tool will be applied in the all four cities where the AVENUE pilot project is being implemented. Starting in Lyon and being refined and improved with data and hypothesis from the other three cities in collaboration with each city transport operator as well as the other related AVENUE partners.

3.2.2 CAPEX and OPEX calculation tool

The initial draft of the calculator is comprised of five different tabs (spreadsheets) on excel. It is worth highlighting that the calculator is still being developed, thereby the hypotheses, indicators and values are not final.

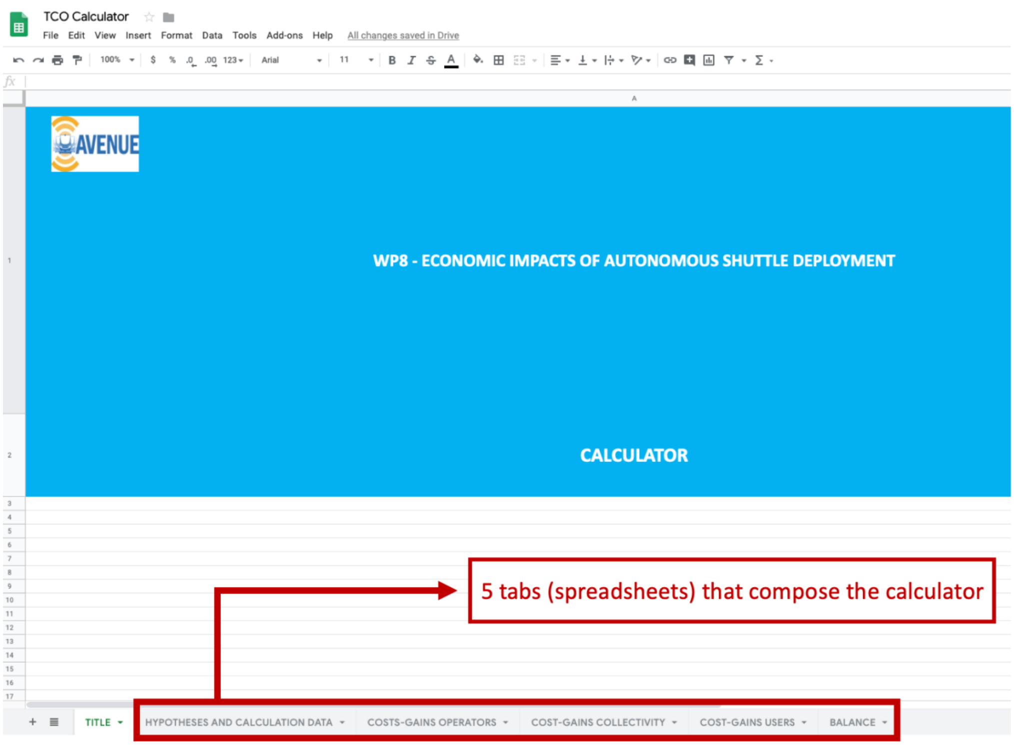


Figure 52: ICC calculator spreadsheets

The first spreadsheet – named as: hypotheses and calculation data – entails a set of hypothesis (not exhaustive) about the possible transfer of uses to the shuttles, about the transfer of expenses and, about financial valuation. For each proposed hypothesis, a possible mode of calculation as well as the mode of valuation is also proposed. This spreadsheet aims to act as an introductory analytical lens to foster and generate insights for the completion of the following tabs in the TCO calculator.

	A	B	C
1	HYPOTHESES AND CALCULATION DATA		
2			
3	Perimeter of effects: community, users, transport operator		
4			
5	Hypotheses about uses	MODE OF CALCULATION	VALUATION
6	Use tranfer from bus (public transport) to the autonomous shuttle		
7	Use transfer from private vehicle to the autonomous shuttle	Litman (2019, p.30) - shifting from driving to transit saves fuel and oil, which typically total about 10¢ per vehicle-mile reduced. In addition, depreciation, insurance and parking costs are partly variable, since increased driving increases the frequency of vehicle repairs and replacement, reduces vehicle resale value, and increases the risks of crashes, traffic and parking citations. These additional mileage-related costs typically average 10-15¢ per mile, so cost savings total 20-25¢ per vehicle-mile reduced.	
8	Use transfer from soft modes of transport (walking, scooters, byclicles, etc) to the autonomous shuttle		
9			
10			
11			
12	Hypotheses concerning the transfer of expenses	MODE OF CALCULATION	VALUATION
13	Reduction of salary costs by eliminating shuttle drivers		
14	Training Costs for Remote Shuttle Drivers in Central Coordination		
15			
16			
17			
18	TUTATIONAL VALUES FOR FINANCIAL VALUATION	MODE OF CALCULATION	VALUATION
19	Average cost of a private vehicle per kilometer		€ 0.3 / km traveled
20	Time saving valuation per person and per hour on a work day		
21	Time saving valuation per person and per hour on a leisure day		
22	Valuation of comfort gain per person		
23	Valuation of traffic decongestion	1 vehicle kilometer removed provides 0.125 hour gain to other vehicles	
24	Cost of a parking space	Amortization of the cost of creating a parking space and operating costs	3620 € / year in Paris, 1890 € / year in small crown, 460 € / year in big crown
25	Valuation of community attractiveness	Valuation of land	

Figure 53: Hypotheses and calculation data spreadsheet

The following three spreadsheets are aimed at detailing the costs (CaPex - investments and, OpEx - annual exploitation costs) and gains for each of the described stakeholder (operators, collectivity and users). For each identified cost (and gain) a qualitative analysis is first made as a way to leverage possible quantitative metrics for valuation.

All data will be quantified and valuated: for example, for the users' data such as the feeling of comfort or travel time reduction will be estimated in euros; for the city, for example, infrastructure costs, will also be estimated in euros. This estimation will be based on official public ratios.

Several calculations of the sheets 2 to 4 are linked to the hypothesis and calculation modes inserted in the sheet 1. Each user of the calculator has to adapt the hypothesis and evaluation modes to the specific situation to be evaluated. Indeed, hypothesis and calculation data may widely vary between Lyon, Geneva and any other site.

	A	B	C	D
1				
2	COST ANALYSIS - GAINS FOR TRANSPORT OPERATORS			
3				
4	COST ANALYSIS FOR TRANSPORT OPERATORS			
5				
6	INVESTMENTS (capital expenses)			
7	Nature	Qualitative analysis	Quantitative analysis	Valuation
8	Installation of site:	road work, shuttle support system (station and platform), shuttle mainenance site, shuttle storage site		
9	Road work	construction and infrasctructure work (signs, traffic lights, roudabouts, etc).		500000
10	Shuttle support system (station and platform)	Is it included in road work (line 10)???		
11	Shuttle maintenance site	space for physical repairs and for software fixes and updates (in Lyon confluence, maintenance site and storage site are t		
12	Shuttle storage site	garage for non-operating hours	ask Sytral	80000
13	Costs related to the project management	project management studies and implementati	ask Sytral/Keolis for details	286000
14	Layout of public spaces	maybe these investiment is made by the community or by the city??		
15	Purchase of autonomous shuttle	for the experimenations the shuttles are paid by AVENUE project. But as a regular		512000
16	Shuttle fleet management system	software for managing the shuttles fleet operat	ask Keolis/h2020 team - ask best	50000
17	TOTAL OF INVESTMENTS			1428000
18				
19				
20	ANNUAL EXPLOITATION COSTS (operation expenses)			
21	Nature	Qualitative analysis	Quantitative analysis	Valuation
22	Staff costs:			
23	Formation of shuttle operator	training and instructions for the operators that	ask Sytral/keolis for details	10000
24	Salary of operators	annual salary of operators	ask Sytral/keolis for details	224000
25	Salary of security personel (person inside the navette or stations all times)	annual salary of employees	ask Sytral/keolis for details	56000
26	Salary of supervisors	annual salary of employees	ask Sytral/keolis for details	45000
27	Assurances	annual assurance per shuttle	ask Sytral/keolis for details	3000
28	Energy costs	annual energy expenses for each shuttle (battery recharge)		1,800
29	Shuttle + software maintenance costs	annual maintenance costs with information systems and software updates		10000
30	Parc Navya (supervision/maintenance)			720000
31	Costs of incivility	annual costs with degratation/vandalism (research on RATP/SNCF documents)		
32	Management of personal data and computer security	data issues about personal data for users who c	ask BestMile/ WHIM / UBIGO	
33	Marketing	ask Sytral/keolis for details	ask Sytral/keolis for details	5000
34	Communication/ sensibilisation	Investment or annual cost? are the values correct? is it a one-time communicatio		50000
35	Transfert des navettes	annual costs of shuttle's transport to and from	ask Sytral/keolis for details	6000
36	Amortization of investments	rate of amortization	check in Quinnet report	
37	TOTAL OF ANNUAL EXPLOITATION COSTS			1130800
38				
39				
40	GAIN ANALYSIS FOR TRANSPORT OPERATORS			
41				
42	Nature	Qualitative analysis	Quantitative analysis	Valuation
43	Annual growth in the number of passengers on the shuttle perimeter	stimation for Decine. Also ask if they have data on the confluence		
44	Annual marketing of statistical data collected in the shuttles	Ask WHIM or UBIGO if they commercialize the data of the users. If they capitalize upon the data.		
45	Image effect, annual revenue growth beyond the shuttle perimeter			
46				
47	TOTAL OF ANNUAL GAINS			0

Figure 54: Example of the spreadsheet for costs and gains for the transport operator (still under development)

At this first step we do not take into account new gain resulting from new uses of the autonomous shuttle such as goods delivery or transport of injured people or…; this will be taken into account accordingly to the consolidation of uses scenarios as programmed at section 1.

At last, the final spreadsheet of the ICC calculator brings the final balance of all costs and gains for the transport operators, collectivity and users. Therefore, by analysing this particular spreadsheet, it is possible to identify the main sources of costs and revenues for each stakeholder and from that, proceed with the necessary adjustments and strategic decisions for the proper functioning of the proposed business models (e.g., profit-oriented, subsidized, etc.).

BALANCE OF DEPLOYMENT OF AUTONOMOUS TRANSPORT IN URBAN ENVIRONMENT			
COSTS		**GAINS**	
INVESTMENT			
Transport operator	1428000	Transport operator	0
Community	0	Community	0
TOTAL OF INVESTMENT COSTS	1428000	Users	0
OPERATION			
Transport operator	1130800		
Community	0		
Users	0		
TOTAL OPERATING COSTS			
Amortization of investments	285600		
TOTAL COSTS	**285600**	**TOTAL GAINS**	**0**

Figure 55: Micro costs calculator final balance of costs and gains

In addition, similarly to what has been done by ANTP (201), a PDF manual will also be created as a way to assist the different stakeholders to correctly implement and make the calculations. Furthermore, an empirical summary with the application of the method is also to be developed (with empirical data from the experimental cities in the AVENUE project).

4 Conclusion and Research agenda

This deliverable aimed at describing the overall economic studies and analysis targeting a successful implementation of businesses for ASCTs, as well as, shedding light on the potential economic benefits and impacts of the urban automated vehicle fleets in cities.

Regarding the definition and successful implementation of business models with ASCTs, we first carried out an analysis of macro trends, which has led to the creation of a trend radar. The trends of each trend radar segment and across have been condensed/ clustered into higher level macro-trends as basis for subsequent derivation of a future vision for AVENUE 2030.

Next, a series of vision statements was created which allowed the proposition of passenger use cases. Some selected attractive use cases were: S1) Country callbus for elderly and disabled people; S2) City callbus for leisure purposes; S3) Country line for commuters and students and; S4) City line for tourists.

A series of hunting fields were also described (e.g.: passenger services; infrastructure management; system operations; ASCTs and; municipalities and commercial bus operators). Linking together the use cases with the hunting fields have led to the identification of several business opportunities for the AVENUE project, such as: BOC1) City line for tourists – passenger services; BOC2) Country line for commuters/students – infrastructure management; BOC3) city call for leisure people – system operations; BOC4) country call for elderly/disabled people – ASCT and; BOC5) country line for commuters/students – municipalities/commercial bus operators.

An initial analysis of the success factors as well as an analysis of obstacles and risks was also carried out as well as a stakeholder analysis and a competitor analysis by the following strategic parameters. As future steps, a business use canvas template will be used for describing business use cases based on the business opportunities. This will be subject of an AVENUE expert workshop to be conducted in the near future.

Regarding the economic impacts, a simulation tool is being designed on both macro and micro level will be applied in the four cities of the AVENUE project.

For a macro-data calculator, an analytical model is under development to simulate and investigate the impacts of ASCTs fleets, as an alternative to the individual mobility in cities. Simulations will take into account: scenarios for adoption of autonomous vehicles and fleet size, the energy consumption, emission of particulate matter, nitrogen oxides, carbon footprint of different classes of vehicles as well as other relevant externalities and potential cost savings.

For a micro-data calculator, the analysis is based on the Total Cost of Ownership (TCO) approach and is aimed at identifying the savings (gains) and cost drivers, integrating investment costs as well as functional costs for transport operators, users as well as the collectivity. In this sense a set of hypothesis and indicators are being developed via context-based approach (starting with the Lyon Décines deployment – being assisted by KEOLIS) as a way of better understanding and refining the variables to be used in the valuation. Individual spreadsheets are being created for the valuation of costs and gains for: 1) transport operators; 2) users (commuters) and, 3) collectivity. At last, a final spreadsheet brings the final balance of all costs and gains for all stakeholders analysed. The tool will help simulate the global economic impact of ASCT deployment at a local level and therefore be a decision making aid for local policy makers to take their decision

Future research agenda will also include the refinement and application of the calculators in all four cities of the AVENUE project as well as promoting a coherent integration with the identified business models.

This deliverable presents the methodology and tools that are under development. Next deliverable will present more quantitative results regarding as well scenarii as calculation tools.

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APPENDIX

ID	Future Element	Category	Key Words	Description	Author	Link / Document title	Page/s
T-1	SAVETY & SECURITY	Individuals/ Passengers	Political & Regulatory Changes	Increasing need of safety and security in life and data	ADAC (8.Sicheres Reisen)	https://www.adac.de/verkehr/mobilitaets-trends/mobilitaet-2040/implikationen/agenda-10/	
T-2	INDIVIDUALIZATION	Individuals/ Passengers	Individualization	Dynamic multigraphs, new identity-building processes, own digital routes, increasing importance of individual. mobility requirements, e.g. features, quality	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
					ADAC (2.Multimodalität)	https://www.adac.de/verkehr/mobilitaets-trends/mobilitaet-2040/implikationen/agenda-10/	
T-3	SOCIAL MOBILITY ECOSYSTEMS	Individuals/ Passengers	Ecosystem Collaboration	Advanced social mobility ecosystems	ADAC (2.Multimodalität)	https://www.adac.de/verkehr/mobilitaets-trends/mobilitaet-2040/implikationen/agenda-10/	
T-4	JOB TRANSFORMATION	Individuals/ Passengers	Automation	Automation leads to a transformation of existing jobs and/ or loss of jobs	Handelsblatt	https://www.handelsblatt.com/unternehmen/management/digitaletransformation/oecd-studie-zur-zukunft-des-arbeitsmarktes-digitalisierung-gefaehrdet-millionen-von-jobs-welche-besonders-betroffen-sind/21217278.html?ticket=ST-5477091-14gGF66Evn4SOhoCeJ44-ap5	
T-5	CUSTOMER & END USER INTEGRATION	Individuals/ Passengers	Participation	Customer and end user integration in R&D/ innovation/ operation for product/ solutions/ services, i.e. features & user interfaces/ experiences	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
T-6	DIGITAL TICKETING, TRACKING & MONITORING	Individuals/ Passengers	Digitalization	Digital ticketing, tracking and monitoring, digital twins of vehicles and passengers, digital companions	init - innovation in traffic systems SE	https://www.initse.com/dede/news-events/knowledge-database/articles/1st-eclipse-hackathon-in-karlsruhe/initiativ2-digitaltickets.html	
T-7	SHARING COLLABORATION OFFERINGS	Individuals/ Passengers	Sharing Collaboration	Increasing sharing collaboration offerings and variants for autonomous vehicles in scalable sizes	Nationale Plattform Elektromobilität (S13.)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.13
T-8	SOCIAL PLATFORMS/ECOSYSTEMS	Society/ Social Environment	Ecosystem Collaboration	Social platforms/ ecosystems, multimodal transportation ecosystems	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
					InnoZ-Zukunftsfenster: Disruptive Transformation der Mobilitätswelt (S.3)	https://www.innoz.de/sites/default/files/zukunftsfenster_innoz_2017_web_0.pdf	S.3
T-9	PARTICIPATORY CO-CREATION	Society/ Social Environment	Participation	Comprehensive participatory co-creation in infrastructure planning, i.e. tariffing, line traffic	Nationale Plattform Elektromobilität (S.15)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.15
T-10	SPATIAL & TEMPORAL FLEXIBILITY	Society/ Social Environment	Agilization & Flexibilization	Spatial and temporal flexibility of work and lief (anytime/ anywhere/ anybody), digital assistance systems, increasing collaboration and ownership	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
					ADAC (4.Mobiles Arbeiten)	https://www.adac.de/verkehr/mobilitaets-trends/mobilitaet-2040/implikationen/agenda-10/	
T-11	SOCIAL DISPARITIES & INCLUSION	Society/ Social Environment	Societal Changes	Social disparities: increasing poverty and social exclusion, demographic change, inclusion of disabled and elderly people	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
T-12	PASSENGER SPECIFICATION	Society/ Social Environment	Societal Changes	Inclusion of elderly and disabled people, consideration of sepcific needs (tourism, commuter, etc.)	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
T-13	VEHICLE SHARING SOCIETY	Society/ Social Environment	Sharing Collaboration	Fleet applications and rental systems are more attractive than own electric/ autonomous car	Technische Universität Dresden	https://www.innoz.de/sites/default/files/tagungsband_mobilitaet_und_kommunikation.pdf	
T-14	ON DEMAND SERVICES	Society/ Social Environment	Ecological Consciousness	Increased priority for on demand services and eco compliant (emission free) vehicles and transportation	Nationale Plattform Elektromobilität (S.15)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.15
T-15	INFRASTRUCTURAL CHANGES	Society/ Social Environment	Infrastructural Changes	Urbanization: renewal and expansion of urban infrastructure, 'blurring' of urban and suburban/ rural infrastructure	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	
T-16	ELECTRIC INFRASTRUCTURE	Politics/ Regulations	Electrification	Increased invest into electric infrastructure	Nationale Plattform Elektromobilität (S.4,7)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.4,7
T-17	INCREASED MOBILITY END USER PARTICIPATION	Politics/ Regulations	Participation	Increased mobility end user (citizen) participation in governmental decisions about vehicles and infrastructures	Nationale Plattform Elektromobilität (S.9)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.9
T-18	SAVETY & SECURITY	Politics/ Regulations	Automation/ Autonomy	Specific regulations for autonomous e-buses regarding safety and security	ADAC (8.Sicheres Reisen)	https://www.adac.de/verkehr/mobilitaets-trends/mobilitaet-2040/implikationen/agenda-10/	
T-19	GOVERNMENTAL COLLABORATION	Politics/ Regulations	Ecosystem Collaboration	Governmental (municipal) collaboration with stakeholders in PPP (public private partnership)	Nationale Plattform Elektromobilität (S.4)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.4,7
T-20	INCLUSION	Politics/ Regulations	Societal Changes	Increased regulations regarding inclusion and accessability of elderly and disabled people	Inklusion 2025, Dr.Eckard Störmer	http://www.z-punkt.de/uploads/files/263/2014-10-aktion-mensch-magazin_inklusion2025.pdf	
T-21	ECOLOGICAL CONSCIOUSNESS	Politics/ Regulations	Ecological Consciousness	Increasing regulatory constraints and motivation/ incentives (e.g. subsidized tickets) for eco mobility	Nationale Plattform Elektromobilität (S.6)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.6
T-22	MOBILITY INFRASTRUCTURE REGULATIONS	Politics/ Regulations	Infrastructural Changes	Increased mobility infrastructure regulations due to crowded traffic and savety/ security	Nationale Plattform Elektromobilität (S.7)	http://nationale-plattform-elektromobilitaet.de/fileadmin/user_upload/Redaktion/NPE_Fortschrittsbericht_2018_barrierefrei.pdf	S.7
T-23	LAWS, RESTRICTIONS AND INITIATIVES	Politics/ Regulations	Political and regulatory Changes	Laws, restrictions and initiatives for global environmental protection & recovery	z-punkt	http://www.z-punkt.de/themen/artikel/megatrends	