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DigiTrans: Exploring the new Austrian test region for automated driving in transport logistics

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Abstract

In Europe, several test sites have recently been opened to validate automated driving functions. However, there are limited initiatives for freight transport and logistics compared to passenger transport. The aim of this paper is to demonstrate how a test region for automated transport logistics can be built up in Austria. A profound feasibility study was conducted to investigate organisational, technical and economic requirements for a successful implementation and operation of the test region. A stakeholder consultation process was set up to collect specific needs of various target groups, including interviews, focus groups and workshops. Overall, the results of the feasibility study show that automated driving in the area of transport logistics is a highly important topic, which is supported by industry and shows profitable potential. Based on the study results, future work will comprise the planning, implementation and operation of the actual test region within a time frame of at least five years.

Keywords: Automated driving; logistics; testing; feasibility study; stakeholder consultation

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Nomenclature

2.5D	Term used to describe the attempt to render three-dimensional images in two dimensions, through the addition of depth perception
AGV	An Automated Guided Vehicle is a portable robot that follows specific markers (wires, magnets, lasers) for navigation. They are mostly used in transport logistics
CAN-bus	A Controller Area Network is a vehicle bus standard devised to connect independent electronic control units with each other, facilitating communication and other functions
V2I	Vehicle to infrastructure communication is the wireless exchange of data between vehicles and infrastructure
V2V	Vehicle to vehicle communication is the wireless exchange of data between nearing vehicles

1. Introduction

Automated and connected driving offers high potential and diverse opportunities to improve future transport and mobility in terms of safety, efficiency and sustainability. Research activities focusing on the development of vehicles and its components need to be complemented by appropriate testing and validation procedures with strong support for the legal implications. There is a large number of ongoing research projects funded by the European Commission that address various challenges of automated road transport. The main focus points towards validation and verification procedures, either on public roads or in virtual environments. For example, the German project PEGASUS (Project for the establishments of generally accepted quality criteria, tools and methods as well as scenarios and situations for the release of highly automated driving functions) aims to develop procedures for testing automated driving functions in order to facilitate the rapid implementation of automated driving into practice (Pütz et al, 2017). Also the ENABLE-S3 (European initiative to enable validation for highly automated safe and secure systems) project will add important verification and validation technology staples, which are required to ensure the dependability of automated driving (Beglerovic et al., 2017). Worldwide, automated transport tests are being initiated. In Europe, several test sites have been opened to validate automated driving functions. Twenty states of the USA have allowed public testing and Japan aims to introduce automated road traffic by 2020. However, there are limited initiatives for freight transport and logistics compared to passenger transport.

This article presents the method and findings of a feasibility study to define a test environment for automated driving functions in freight transport and logistics in Austria. The concept development includes test levels such as simulation, testing in defined and controlled laboratory environments as well as driving on real-world test tracks. The feasibility study also encompasses the development of a business model for the phases of setup and operation of the testing environment. The aim of this paper is to demonstrate how an Austrian test region for automated transport logistics can be built up in terms of infrastructure needs and economic aspects. Along with the support of the Austrian federal and local government officials, the needs of industry and research organizations were used as a basis for development. A return on investment period of 5 years is expected for the test environment. The paper is structured as follows: Chapter 2 presents the methodology of the feasibility study, including a description of various stakeholder consultation exercises. The main aspects and requirements for the test region are explained in Chapter 3, followed by a discussion on organizational and economic issues as part of the business model and services offered (see Chapter 4). Ultimately, Chapter 5 concludes the paper with final remarks and considerations for future work.

2. Approach

2.1. Initial idea

Austria aims to become a global player in the competitive field of automated driving. In this context, Austria’s government has decided to support, among other initiatives, the development of test environments for vehicle automation. It is envisaged that the region will be funded for the first 5 years and afterwards will have economic independence for continuation of projects, without additional funding.

Upper Austria is one of the nine states of Austria and benefits from a high density of industry organizations with interest in vehicle automation. Therefore, with the support of the local state government, it was decided that this location would be appropriate for developing a test region for automated transport logistics. The topics listed below were identified as needs in the field of automated logistic transport and should therefore be accomplished in the test region.

- Automation of in- and outbound logistics
- Automation of multimodal transport and handling of cargo
- Automatic maneuvering of special vehicles at company premises, ports, or airports
- Automation related to the last-mile and municipal scenarios

2.2. Stakeholder consultation

In order to gather the specific needs and requirements of stakeholders as well as identify and consolidate a list of relevant use cases that the test region should focus on, a stakeholder consultation process was conducted in three stages. First, a workshop was organized to identify the needs of stakeholders in terms of relevant and preferred use cases, benefits expected, technological and economic challenges to be addressed. The second stage consisted of a round of interviews with experts from different types of organizations. Finally, focus groups were conducted to streamline and define the final list of use cases to be investigated and tested at the test region.

2.2.1. Workshop

In an initial step, stakeholders that were interested in the development of an Austrian test region for automated and connected driving participated in a workshop held in December 2016. The 47 participants included technology providers (hard- and software), automotive industry, road and motorway operators, automotive suppliers, logistic providers, and public servants responsible for regional road/city infrastructures.

The format of the workshop was developed on the principle of "world café". Stakeholders were divided into four groups and rotated around each "café table" relating to the different topics identified in the area of automated transport logistics. Overall two table rounds were conducted with the table facilitators presenting selected results in a final plenary session. The following questions guided the "café" discussions: (i) What are potential application cases or scenarios relevant for their organization? (ii) What are concrete challenges and needs related to factors such as technology, infrastructure, and general conditions regarding economic, social and legal issues? (iii) Which benefit(s) do they expect for their organization? What is important and what is necessary for my organization? A summary of results is presented below, per topic.

Automation of in- and outbound logistics

Two types of relevant use cases were identified: short range in-bound logistics and long distance freight transport between distribution centers. Type 1 refers to transport routes of approximately one kilometer. These routes typically include public roads and areas of companies' premises. Freight transport needs to be carried out between distribution centers of logistics service providers and adjacent industrial enterprises, or between nearby operating sites of a manufacturer. In the discussion, general requirements were identified such as: 24 hours/7 days applicability, low noise emission, automated refueling, automated freight loading and unloading, ensuring public acceptance in the region, ensuring freight safety and failure safety, certification and testing of automated solutions.

The second type - long distance freight transport between distribution centers – refers to truck platooning applications relevant for logistics service providers and vehicle manufacturers. Use cases of platooning aim to link distribution centers, for example. In this context, different road types and the transition between them, i.e. motorway - federal road - company premises, need to be taken into account. The management of the drivers' shortage due to the reduction of necessary driver personnel, the reduction of personnel costs in the long term, the increase in transport capacities and the reduction of fuel costs were stated as potential benefits.

Automation of multimodal transport and handling of cargo

Participants discussed the automation of multimodal transport and transshipment in the context of port areas, i.e. ship-rail-truck, and cities, i.e. rail-bus-truck-passenger car-aircraft. The following potential applications were identified: switched shuttle services, e.g. between distributors and port areas, autonomous loading and unloading between different modes of transport and autonomous distribution networks. In this context, a variety of challenges were discussed, ranging from legal aspects, technical interoperability (V2V, V2I), development approaches for testing autonomous vehicles, end-to-end supply chain considerations and safety aspects. The identified opportunities and benefits of automation include increasing security and efficiency, developing new business models and reducing costs.

Automatic maneuvering of special purpose vehicles at company premises, ports, or airports
Two types of relevant use cases were identified– autonomous freight transport at company sites e.g. swap body, trailer, etc. and delivery scenarios considering different 'Automated Guided Vehicle (AGV) maturity'. The first type relates, for example, to the movement of swap bodies with special trucks or the autonomous rigging of trailers at company sites. The discussion included 'support processes' such as automated refueling/charging process e.g. fuel cell, battery replacement by robots, or the handling of technical failures and order peaks by means of a 'parallel infrastructure' of conventional vehicles and teams.

The second type deals with the takeover of trailers or semi-trailers at interfaces of road sections and with operating areas exhibiting a different 'AGV-readiness'. For example, a guide or the truck driver could take over an autonomous vehicle at the factory gate (analogous to shipping) or a special vehicle could take over the trailer. Participants raised important issues such as the certification or the approval of AGV maturity at road sections. In addition, the digital infrastructure i.e. geographic information system data and vehicle-related data (e.g. vehicle geometry, steering behavior) were discussed.

Automation related to the last-mile and municipal scenarios
Within this discussion, two use cases were found promising – versatile, easy-to-use light commercial vehicles for the support of municipal cleaning and maintenance activities, and special purpose automated vehicles for delivery in urban areas. The first type includes the use of automated special purpose vehicles for road or sidewalk cleaning, as well as snow clearing or grass mowing. Vehicles used to carry out these tasks exhibit the following characteristics: they employ slow speeds as well as relatively easy to plan routes, they may be operated during non-core working times and they operate at times with little traffic (nighttime), which increases the feasibility in the urban environment. Therefore, urban operators can act more flexibly by increasing capacities at short notice (e.g. use for snow clearing), taking into account occupational safety (e.g. in night operation). Furthermore, intelligent strategies for route planning and fleet management can be included.

The second type refers to freight delivery in cities. Small and agile driverless vehicles could move more easily through pedestrian zones. In this case, the flexible applicability was emphasized in the discussion, which enables the usage outside typical working hours.

2.2.2. Interviews

The second stage of the stakeholders' consultations consisted of a round of interviews that were conducted in February 2017. These interviews were intended to refine and to finalize the list of use cases as well as to further gather the interest of the organizations related to the test region and its usefulness. The interviewees could be broadly separated into two categories – stakeholders interested in the specific use cases to be investigated at the test region and stakeholders which would be more interested in the overall resulting data and results, independent of the specificities of the use cases. Overall, 30 interviews were conducted and included a range of questions related to the strategic role of automated driving for their organization, the expected usefulness and the expected technological requirements towards automated driving.

The interview results confirmed the findings of the workshop and provided more insight into the role of automated driving in the stakeholders' organizations. The first category of stakeholders, which included automotive and technology providers has an optimistic view on the maturity of automated technologies, e.g. truck platooning. However, they also remarked that the success of automated driving applications will depend on resolving legal aspects, building public awareness related to certain applications, and to clearly defining the functionality of automated vehicles within the design of efficient logistics procedures. Stakeholders also explicitly stressed the importance of the return on investment as well as the efficiency and sustainability improvement. The second category of stakeholders painted a more cautious picture regarding today's abilities of automated driving.

The results of the interviews allowed the development of the final list of use cases to be investigated at the test region. Moreover, stakeholders pointed out the benefits of this area, as a test region supports them by adequately evaluating their selected use cases with respect to technology acceptance criteria such as safety, usefulness or performance expectancy. In addition, they considered the knowledge exchange between different technology providers as vital. They also expected a test region to be beneficial as a communication platform between diverse, interdisciplinary stakeholders for drawing realistic expectations towards automated driving applications.

2.2.3. Focus Groups

In a third step, focus groups related to the defined uses cases were conducted in March 2017. The focus groups aimed at consolidating the use cases and define the required elements of the envisioned test region for each use case. The following questions guided the discussions: (i) Which logistics processes / parts of a process should be automated?, (ii) How should the automation be conducted – sudden vs. stepwise?, (iii) How should the implementation of automated driving at an organization be conducted – what are intended time horizons of companies?, (iv) Which test region elements (e.g. simulation tools, test areas, data collection) are required at what time?, (v) When are potential participants of the test region prepared to deliver certain supporting elements (e.g. automated vehicle)?

Figure 1 presents the results of the stakeholder consultations in terms of the defined use cases, as well as the step-wise test levels preferred by the stakeholders for the test region. The use cases include freight transport over long distance using the motorway as well as short-distance transport (e.g. between different parts of a factory that are connected through communal roads). Furthermore, logistics processes during multimodal transport & cargo handling (as well as maneuvering) are investigated as to the efficiency and acceptability of automation. The use of automated vehicles for delivery within urban areas and communal services (street and snow clearing on roads and walkways) is also promising and thus should be investigated.

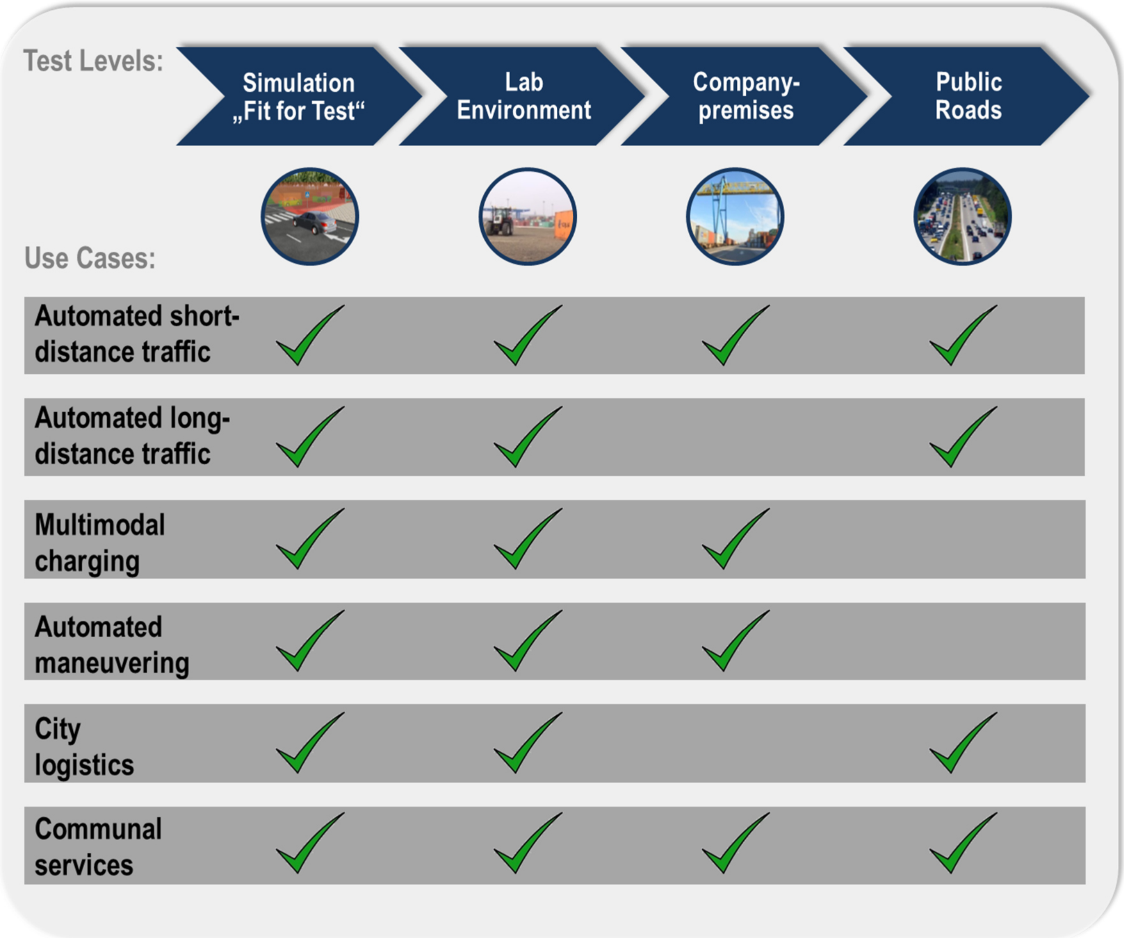

Figure 1: Use cases and test levels

3. Designing an Austrian test region for automated transport logistics

Corresponding to the complexity of technological components, along with the legal, societal and psychological issues of safety critical automated driving systems and operational procedures in the transport logistics domain, a test region has to provide all the relevant infrastructure equipment and support services needed to test the systems, as to come to defining conclusions regarding the fulfillment of all functional, technological and safety and security related requirements.

A test environment for automated mobility in logistics should provide a large range of services: test design, data collection, equipment installation, operation and support and evaluation. Several test levels should be offered in a comprehensive test environment: early tests of virtual prototypes should be enabled through simulation, while first observations of functional systems prototypes should be done within versatile and standardized laboratory conditions.

Based on the stakeholder consultations, as well as on the expertise of the project consortium, the planning of the test region as well as its requirements in terms of equipment, mapping, data, location, IT infrastructure, safety and security was formulated.

3.1. Test design

Testing automated transport logistics systems means defining and performing scenarios that represent the real world procedures as much as possible. As the identified use cases are diverse in terms of scenario, systems and environmental conditions, it was soon evident that simulation would be the preferred testing method, limiting the number of physical tests. For that reason, various kinds of simulation tools will be available at the test region and should be offered to customers, together with support for scenario modelling. Modelling should comprise scenarios including vehicles, roads, city areas, factory premises, various objects including humans, buildings and environmental conditions (e.g. weather) based on artificial or mixed recorded and modelled scenes.

Another approach to reduce testing effort is to test on component level as much as possible. In order to reduce risks, all automated transport logistics procedures will first be tested on a private test area prior to public grounds (real-world streets, etc.). In this case, the private test area will be the company premises of one or several project partners. Additional test grounds may be added later on in the course of extensions of the test region due to additional logistics use cases and test scenarios (e.g. factory, airport/ port, railway and city).

3.2. Test mapping

Performing physical tests implies identifying and tracking vehicles, persons and various objects such as traffic signs very accurately, in many cases with a centimeter level precision. This requires an accurate map, i.e. 3D or at least 2.5D of the environment. This map has to be prepared in advance and will be part of the services provided by the project consortium, but can also be provided as a map generating service. These maps will be sufficiently accurate in order to allow the localization and orientation of objects and comprise a classification of all static objects relevant for the use cases and the corresponding scenarios. In addition, the test ground will be equipped with sensor systems (e.g. cameras), signs, specific markers, test obstacles, etc. as needed, together with software processing and fusing of the data (e.g. image processing for object classification and tracking).

3.3. IT infrastructure

As there are various data sources and huge amounts of data to be processed, the IT infrastructure is one of the backbones of the project and the test region itself. Appropriate computing power, i.e. servers, and communication infrastructure, i.e. cable and radio based, will be set up in order to process and fuse the data and derive conclusions as to the correctness of performed scenarios. There are at least three major data sources that need to be combined: infrastructure data (e.g. sensors along the street, factory or city premises), data coming from the tested vehicle or machinery (provided by a customer) and data from another vehicle or system provided by the test region needed to flexibly supervise the vehicle under test. The latter will be equipped with specific sensors for accurate tracking. Various other data sources may be used in addition e.g. online traffic and environmental data or street maps and maps of organization premises.

3.4. Safety and security

A test-campaign will, generally, start with the analysis of possible risks and based on the functional requirements, the identified risks and standards will be taken into account in the definition of test-scenarios to be performed. In DigiTrans, this process will be supported by experts experienced in functional safety, security and standardization. The goal is to create a safety check list comprising all the arguments needed to show that a system is safe.

In addition to the safety aspects, security is of essential importance due to the large amount of critical data to be handled. Two aspects will be considered. On the one hand, state of the art security mechanisms will be established in order to guarantee data integrity and availability within the IT infrastructure of the test region and data exchange between partners of the project. On the other hand, security risk and combined safety and security co-analysis will be offered by consortium experts.

3.5. HMI and user experience

The following services and activities are foreseen for the Human Machine Interface (HMI) and user experience aspects in the test environment:

- Early development of scenarios, methods and criteria

Before each HMI and user experience test of an automated vehicle, key objectives and criteria (such as safety, workload, trust and engagement) will need to be defined. To support this, pre-prepared instruction materials and building blocks for the definition of test scenarios, test criteria and applicable methods should be offered..

- Test instrumentation for vehicles

A large variety of vehicle types are involved in logistics and their levels of current and future automation are differing. This also necessitates different testing instrumentation. For vehicles types that are still partly run by a human driver or operator, instruments for the measurement of user experience and acceptance (such as eye tracking and specialized inventory systems) and of driving behavior (e.g. by reading out the CAN-Bus) should be installed in test vehicles.

- Test instrumentation for the vehicular environment

Automated driving in logistics is not limited to the immediate interaction with vehicles through drivers, but it also has large impacts on the overall workflows in the corporate logistics environment. The safety of other traffic participants on the organization premises or on public roads is paramount. In order to capture relevant interactions of automated logistics vehicles with these user groups, the behavior of all important actors, i.e. drivers, loaders and logistics managers, as well as other road users, should be captured on video and further sensors embedded in the environment.

- Test instrumentation for monitoring and control

The usage of automated guided vehicles (AGV) in the logistics sector entails a transition of responsibilities from the driver to a control center that surveys vehicle movements and that allows interventions by human operators (Cardarelli et al. 2015). In such a setting, operators need to be enabled to make configurations, to fully overview the situation from different perspectives, and to quickly apply modifications in vehicle behavior.

4. Economic and organizational feasibility

Apart from the technical feasibility, the planning of the test region implied also evaluating the economic and organizational suitability, entailing the framing of a business model for the set-up and operation phases. As mentioned in the previous chapters, the test region will comprise an extensive range of use cases, scenarios and services, i.e. test design, data collection, equipment installation, operation and support, and evaluation, which have to be calculated both at expenses and income side.

For the successful implementation and operation of the test environment, an operator-oriented organization is envisaged. This operator organization is responsible for handling different projects corresponding to the use cases and would represent the interests of approximately 40 associated partners. The organization to be established will be economic-oriented and will comprise a mix of corporate and scientific partners that will ensure that the economic orientation remains the focus of the activities. Figure 2 presents a breakdown of the organizational structure developed for the test region. Research and development will represent 45% and be comprised of three scientific partners (AIT Austrian Institute of Technology (AIT), Linz Center of Megatronics (LCM) and University of Applied Sciences Upper Austria Research & Development (FHOÖ F&E)). Industry will also represent 45% and will be mainly related to the specific use cases to be tested at the selected environment. The leading association will have the last 10%. It is intended that the lead of this test region will be done in a simple and efficient manner and will comprise economic and commercial management as well as an overall strategic supervision.

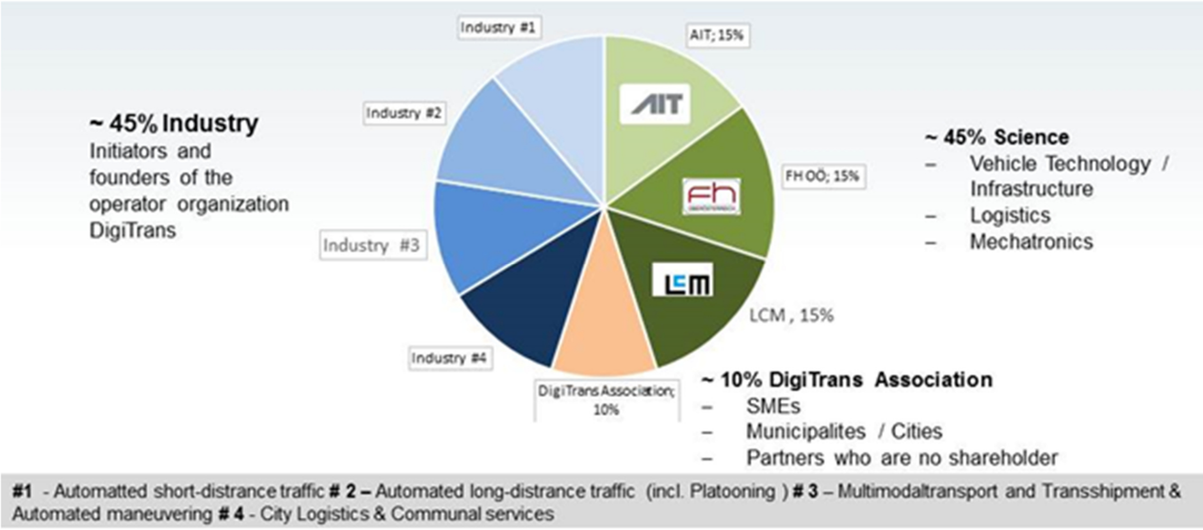

Figure 2: Organization of the test region DigiTrans

Table 1 summarizes the total investment & operation cost planning for the running of the test region over the next 5 years. It must to be mentioned that 50% of the costs will be financed through grants of the executing organizations of the Austrian Federal Ministry for Transport, Innovation and Technology (Bmvit) and of the local government of the region Upper Austria.

Table 1: Total cost estimation for a 5 year project duration

Name of the cost category	**total costs per category in % of total cost**
HMI	2%
Fit for Test	9%
Laboratory environment	37%
Business premises	14%
Public roads	8%
Operation DigiTrans Ltd.	30 %
Total (100%)	**7.500.000,00 €**

Overall, the results of the feasibility study show that automated driving in the area of transport logistics is an important topic which is supported by industry and shows profitable potential. The summary of the financial situation was presented conservative and with a high safety coefficient. Bearing in mind the potential project situation, a breakeven before the end of the considered period of time of five years can be expected from today’s view.

Figure 3 presents a breakdown of the services that will be offered by the project consortium, as to ensure the successful planning, organization and accomplishment of automated testing of transport logistics in a test environment. Consortium experts will plan and coordinate the test region activities together with customers and support all phases from system analysis, test design and performance to the evaluation of the results as well as impact analysis based on data gathered and processed during the tests. Apart from the technical support advice will be provided regarding the formal approval of tests based on the legal framework in Austria. Contacts to experts concerning societal, ethical and psychological issues related to automation will also be considered.

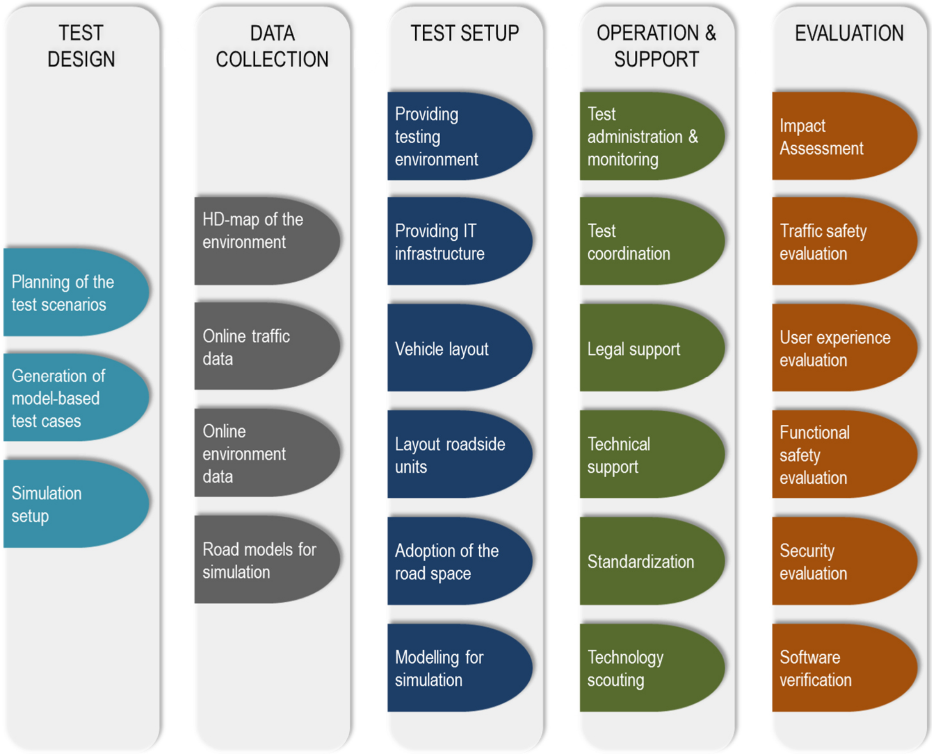

Figure 3: Services that will be offered at the test region

5. Conclusions

This paper presented the technical, organizational and economic feasibility of developing a test region for automated driving in transport logistics. The concept development includes test levels such as simulation, testing in defined and controlled laboratory environments as well as driving on real-world test tracks. There is a large variability of possible operational procedures (multimodal driving / transport, collecting, (un)loading of goods) in the logistics domain. Different applications require specific tests and corresponding infrastructure equipment. In the next step, the use cases identified in this study will be tested in various scenarios, which will be done through collaboration of government, industry and research.

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