ACTION PLAN FOR THE INTEGRATION OF AUTONOMOUS ON-DEMAND RIDESHARING SHUTTLES INTO THE PUBLIC TRANSPORT SYSTEM IN A PERI-URBAN AREA IN STUTTGART REGION (GERMANY)

DELIVERABLE D.T1.2.3 ACTION PLANS FOR NEW INNOVATIVE LOW-CARBON MOBILITY SOLUTIONS & IMPROVED AIR QUALITY IN FUA	FINAL 03/2022

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Development of action plans for new innovative mobility solutions & improved air quality in FUAs

- Project overview

The Regional Association of Stuttgart (VRS) participated within the Interreg Central Europe Project Dynaxbility4CE and put its focus on gaining knowledge in the field of connected and automated driving. In particular VRS elaborated on “the Integration of autonomous on-demand ridesharing shuttles into the public transport system in a peri-urban area in Stuttgart Region” through a transport model study, conducted by the University of Stuttgart as service provider. Due to the fact that the technology of autonomous vehicles is at a stage of time where still a lot of research and development is required, transport model studies and simulations have great potential to lay ground knowledge on the impacts of such new and innovative mobility solutions. The study assumed that the autonomous on-demand shuttles drive as fast as regular cars nowadays, that the road infrastructure is completely set up to allow for autonomous driving and that passengers accept autonomous cars without objections. The ridesharing offer, simulated in three scenarios in the transport model study, served as a feeder to the regional and suburban train in the north and south of the planning area called ‘Schurwald’. The planning area is located east to the capital of Baden-Württemberg – Stuttgart and got about 50.000 inhabitants. Public transport nowadays within ‘Schurwald’ is provided by around 25 regular bus lines.

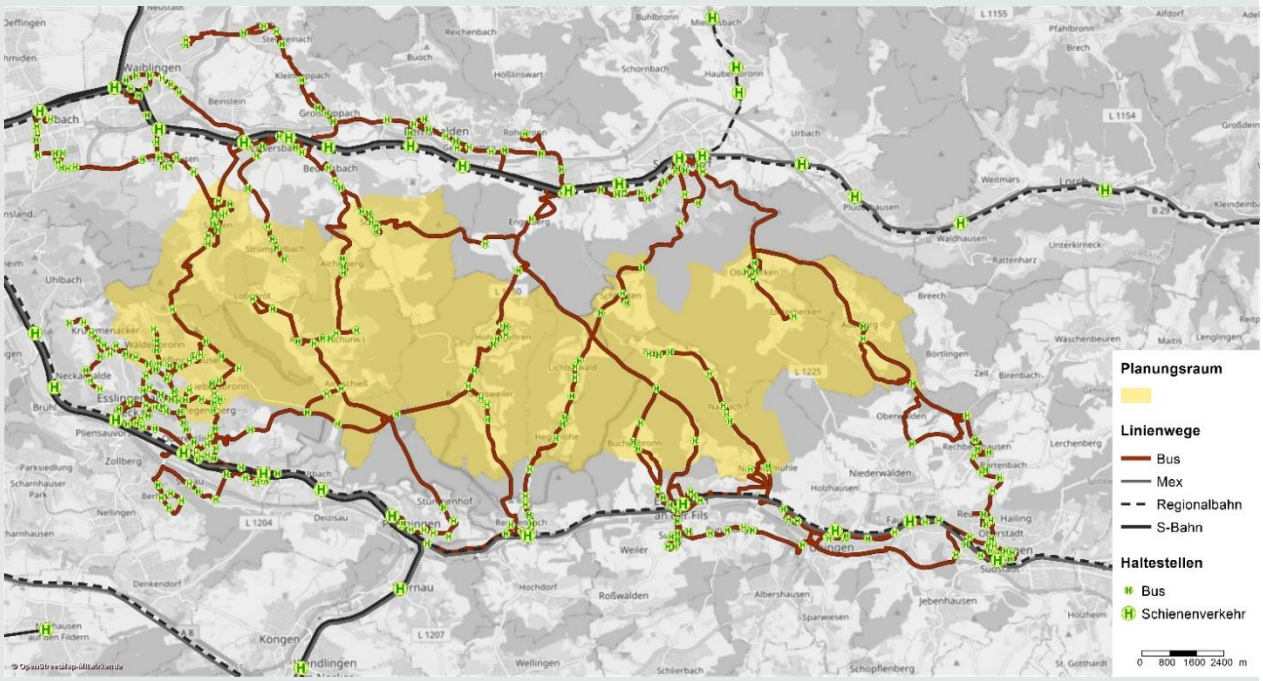

Figure 1: Planning area 'Schurwald'

As a general database for the following modelling, the regional transport model of VRS was used, which already has been developed in the year 2009/10. Methodological the service provider needed to adapt the PTV Visum transport model microscopically in order to depict the transport demand within the planning area precisely.

Three scenarios have been simulated and investigated within the planning area 'Schurwald' in the transport model study:

A	Scenario 0	Base scenario of the prognosis horizon 2030
B	Scenario 1	Substituting the regular bus lines with an implementation of the autonomous Ridesharing shuttles in 15 min. service frequency. Passengers are picked up at the regular bus stops.
C	Scenario 2	Substituting the regular bus lines with an implementation of the autonomous Ridesharing shuttles in 15 min. service frequency. Passengers are picked up at their place of choice.
D	Scenario 3	Combination of three regular bus lines and autonomous Ridesharing shuttles in 30 min. service frequency. Passengers are picked up at the regular bus stops.

- Description and objectives of the action planning process

Firstly, to define the scope and content of the three examined scenarios, VRS planned and held a scenario development workshop in 2021. The main conclusions drawn within the scenario development workshop have been of advantage for the action planning process in order to grasp synergies of the already discussed aspects, that are important to include in the scenario simulations.

Secondly, the Action Planning Process included a Workshop, done virtually by VRS, which dealt with the development of guidelines for implementing an autonomous ridesharing shuttle offer as a feeder to the public transport in the peri-urban area 'Schurwald'. In the last phase of finishing the transport model study by the University of Stuttgart, VRS already found out that scenario 3 got the biggest potential to maybe one day be implemented. That's why especially scenario 3 has been discussed properly within the Workshop. Different project partners from the Dynaxibility4CE consortium participated actively and contributed to a fruitful discussion about implementation actions and several aspects that need to be considered before implementing our examined scenario.

The main objective of the Action Plan Workshop has been to collect different perspectives and inputs from the project partners based on their knowledge, experience and especially lessons learned during the project duration. As a lot of partners already do have expertise on connected and automated driving and mobility as a service, VRS benefitted very much of the knowledge exchange and discussions. The Action Planning Process is a helpful process to recap the main conclusions and elaborate important key aspects on a more practical level.

- Relation to other project activities

Stretching the curve from VRS project activities to other project activities within Dynaxibility4CE, especially the projects of LVB (Leipziger Verkehrsbetriebe) and the City of Graz have combined fruitful knowledge. Absorbing input and learnings from LVB and Graz on a very practical level helped VRS to gain insights into the realization of mobility as a service/on-demand systems. As the LVB on-demand system "Flexa" for instance also works as an extension of the public transport, planning guidelines and operating concepts could be transferred also for VRS in case of an implementation. Moreover, the on-demand booking platform "GrazMobil" for using the flexible offer in the City of Graz is a very crucial aspect

when it comes to user communication, citizenship involvement, integration and bundling of multimodal transport modes and accessibility. These two project outputs showed well-organised best practices of the integration of flexible feeders into regular public transport services. As quite rich in experience and expertise, synergies in-between VRS, LVB and Graz have been shared throughout several workshops and contributed to the development of implementation guidelines.

Executive Summary

As a project partner within Dynaxibility4CE the Regional Association of Stuttgart focused on connected and automated driving by conducting a transport model study on 'the integration of autonomous ridesharing shuttles into the public transport system in a peri-urban area in Stuttgart Region (Schurwald)'. Both impacts and important transport planning indicators are analysed and evaluated within the project. Furthermore, this Action Plan elaborates the essential steps for implementing such innovative and flexible mobility solutions. The guidelines included within this Action Plan can serve as a handbook for improving the mobility offer especially in peri-urban areas.

1. Introduction

- Goal of the document

This paper serves as an implementation framework for the realization of an autonomous ridesharing offer, integrated into the public transport system in peri-urban spaces in the functional urban area of Stuttgart and in comparable spaces across Central Europe.

Further it should provide a checklist and guidelines for stakeholders to consider various meaningful aspects before, meanwhile and afterwards the implementation takes place. Consequently, this Action Plan enhances the abilities of stakeholders and thrives dynamism in the field of connected and automated mobility solutions.

This paper initiates the drive for implementing such innovative mobility solutions in peri-urban areas to cover also sparsely populated areas with an attractive mobility offer and therefore lead to clean air and decrease CO2 emissions in our environment.

- Scope

The scope of this Action Plan covers especially peri-urban areas in Stuttgart Region and similar areas across Central Europe in order to increase the abilities of local stakeholders to plan for future mobility solutions.

- Local process overview

With the project start in March 2020, VRS began to conceptualize and prepare a tender for conducting a traffic model study on the integration of autonomous ridesharing-shuttles into the public transport system in a peri-urban area in Stuttgart region. After the tendering process and the evaluation of several offers, VRS assigned the University of Stuttgart in the department “Lehrstuhl für Verkehrsplanung und Verkehrsleittechnik”. Several meetings with the service provider and the scenario development workshop with important stakeholders have taken place till mid of 2021.

The study on autonomous and on-demand ridesharing shuttles has been finalized in June 2021. On 21 July 2021 it was officially published during a meeting of the traffic committee of Verband Region Stuttgart (VRS). The traffic committee consists of 32 directly elected regional deputies which dealt with the study and on-demand transport offers in Stuttgart Region during the meeting on 21 July 2021. Afterwards, the study was also presented during a meeting of the technical committee of the Transport and Tariff Association of Stuttgart Region (VVS). In the beginning of August 2021, the new Passenger Transport Law (PBefG) entered into force in Germany which states that on-demand transport lies within the authority of a district or a district-free city like the City of Stuttgart. Since these new legal developments, VRS cannot implement an autonomous on-demand offer on its own which underlines VRS’ function as pacemaker and coordinator for such transport offers on a regional level.

Still VRS is in regular contact to the VVS and the districts within Stuttgart region, cooperating on several transport topics and disseminating the Schurwald-Study results to offer ground knowledge for a potential implementation.

2. Planning and policy framework

- Background

Verband Region Stuttgart (VRS) is the political entity for Stuttgart Region which is comprised by 179 municipalities including the City of Stuttgart. It came into being in 1994 following legislation adopted by the State of Baden-Württemberg. The mandatory tasks include key issues such as comprehensive regional and transportation planning, regional public transport (responsibility for the S-Bahn Stuttgart), transport management, business and tourism development. VRS operates several co-funding schemes to initiate a sustainable development in close cooperation with local entities. VRS also supports municipalities with assistance in all tasks of spatial planning and a wide range of data, analysis and strategic foresight. VRS acts as pacemaker, contact partner and mediator to keep Stuttgart Region a thriving place for business and an attractive place to live. Political steering of these activities lies with the regional assembly, a directly elected "regional parliament" - unique in Baden-Württemberg and considered a role model in terms of metropolitan governance.

- Legal framework overview and planning policy context

The Passenger Transport Law did until August 2021 not recognize flexible transport offers like on-demand transport. The until then already existing on-demand offers were implemented with reference to the experimentation clause or as type-similar traffic in the Passenger Transport Law. On 2 August 2021, an amendment of the Passenger Transport Law entered into force with the aim to create new forms of services such as flexible and demand-driven offers:

Scheduled on-demand traffic:
The districts, as the responsible bus authorities, are now able to determine within which areas and at what times the lines are to be offered as on-demand transport. They are integrated into the public transport tariff. The scheduled services have fixed stops for boarding and alighting passengers. The rides must be pre-ordered by the passenger in any case. These scheduled on-demand offers lie within the sole responsibility of the districts and district-free cities like the City of Stuttgart.

Bundled on-demand traffic:
Bundled on-demand traffic is introduced in addition to scheduled on-demand traffic. It occurs on entrepreneurial initiative and aims to bundle travel requests along a similar route. The districts, as approval authority, regulate these kinds of on-demand traffics. They set e.g. bundling quotas, limit the number of vehicles used and determine a minimum tariff. The minimum tariff must be at a sufficient distance to the public transport tariff.

As a result, VRS cannot implement on-demand offers on its own and thus has to closely cooperate with the 6 districts within Stuttgart Region.

Furthermore, the Law on Autonomous Driving in Germany entered into force on 28 July 2021. It states that fully autonomous vehicles (without the presence of a driver) are allowed to participate in public traffic, but only in pre-defined and pre-approved areas. As a result, autonomous shuttles are mainly deployed on factory sites, trade fairs, as buses on a pre-defined route or other areas with demonstrating character rather than during real-time traffic on the streets. The Law on Autonomous Driving is a temporary solution until harmonized rules on international level are in place. The Law will be reviewed and evaluated after the end of 2023. This means that the implementation of fully autonomous vehicles in an area like the “Schurwald” would nowadays legally not be possible. Nevertheless, the underlying transport model for the study has a prognosis horizon until 2030 and until

then, the technological development may allow for a legal deployment of such fully autonomous shuttles without spatial limitations.

- Related initiatives

- “AMEISE“ project: The aim of the "AMEISE - Automated Bus in Waiblingen" project is to advance the development and research of autonomous, zero-emission minibuses. The minibuses cover a fixed inner-city route of around 1.3 kilometers in the City of Waiblingen's "Ameisenbühl" area, north of the train station. VRS co-finances the second phase of the project with 250.000 Euros. The project is led by the University of Applied Sciences Esslingen.

- SSB Flex: SSB Flex is a component of the City of Stuttgart’s strategy to further strengthen local public transport, especially at times and in places where there are currently gaps in service. SSB Flex is an innovative addition to classic public transport and also an attractive alternative for owning a car. It is an on-demand ridesharing offer which is available for the whole City of Stuttgart via app in a maximum of 10 minutes if required. It operates during nighttime from Sunday until Thursday from 18:00 – 02:00 and on Fridays and Saturdays from 18:00 – 04:00.

Since VRS is the responsible authority for the S-Bahn Stuttgart, it especially focuses on the effects and potentials of connected and automated vehicles which supply an on-demand offer as feeders for rail passenger transport, especially in peri-urban areas. The main task is to examine whether connected and automated on-demand vehicles can be more cost-efficient and environmentally friendly than the current bus system and if they are able to solve the last-mile problem of public transport in peri-urban areas.

Within the project, VRS thus tries to study the effects of an on-demand offer similar to SSB Flex which is being implemented in a peri-urban instead of an urban area and also study the effects of automated vehicles which are deployed in a bigger area and not only for a specific route like it is done within the “AMEISE” project.

3. Key results and findings

Key results that emerged out of the conducted transport model study are:

1) Guarantee for basic public services: Considering functional urban areas in central Europe that include both urban and peri-urban areas, it is essential that attractive public transportation services do not only benefit urban spaces but also peri-urban or even rural spaces. Results of the conducted study showed that the simulated autonomous ridesharing vehicle offer does require higher costs due to an improved mobility offer (increase in service frequency + number of vehicles). Peri-urban and rural regions do have the characteristic of less population density. Consequently, public basic transport services very often aren’t that cost-efficient like in urban areas. A guarantee for attractive basic mobility should be given in every type of space and monetary aspects should be given a different weighting.

2) Modal Split: VRS's Schurwald study demonstrated that an improvement of the mobility offer (increase of service frequency, passenger pick-up stop points) shifts people from using the motorized individual transport (MIV) to the public transport. Comparing the basis scenario to the three simulated scenarios with the implementation of the ridesharing offer, showed that a decrease of the share of the MIV is possible. As a result, other important priorities benefit too, like air quality for example. (See figure 4)

3) Passenger kilometres: Compared to the basis scenario the three simulated scenarios generate more kilometres travelled per passenger. The explanation lies in the more regularly driving ridesharing vehicles and the attractiveness of the new mobility offer. (See figure 2)

4) Occupancy rate: Another aspect that should be highlighted is the occupancy rate of the ridesharing system. A key finding was that a bundling effect of the ridesharing system is accomplished. The results show that on average 2 passengers are sharing a ridesharing shuttle. Comparing this indicator to the occupancy rate in the MIV, which is 1,3 passengers/private car on average, makes this advantage clear. (See figure 5)

5) Automation: The automation of ridesharing vehicles provides a chance for improving traffic flows and through its feeder functionality bundles trips effectively. An important key finding that has been concluded out of the study is that such transport simulations are very crucial in order to prepare the public political sector and citizens already for automated mobility solutions. In fact, due to juridical, liability and technological issues that still need to be addressed such studies are a great opportunity to raise awareness. Dealing with several practical aspects within the action planning process and its discussions, it got clear that huge investments and preparations still are absent in Germany.

6) Integration: The study results have emphasized that especially the integration of connected and automated vehicles into the public transport system is of great importance. Cannibalising effects are avoided, and synergies are created. Besides, a tariff integration also proofed to serve the attractiveness of the ridesharing offer.

7) Energy consumption & costs: The conducted transport model study in the Schurwald area showed, that with an increase in service frequency and adequateness of a transport offer such as by ridesharing vehicles, a vast number of ridesharing vehicles is required to fulfil the rising demand. When simulating and calculating the ridesharing vehicles to be run autonomously and electrically, a lot of energy and vehicles are needed. When considering the calculation of both the involvement of the upstream chain to produce the energy and the costs for the operation itself, it gets clear that the energy consumption and costs are higher in all the three scenarios compared to the basis scenario. Nevertheless, it has to be pointed out, that with an increase of demand in public transport, it is likely to achieve a decrease in the usage and ownership of private cars which in the end also saves energy and environmental costs. (See figures 6,7,9)

8) CO2-emissions: One of the main objectives of Dynaxibility4CE is to reduce CO2 emissions with the implementation of sustainable transport solutions. Due to the increase of the amount of operating ridesharing vehicles, the required energy to run them electrically is very high. Comparing the operation of the very few Diesel buses in the basis scenario to the high number of ridesharing vehicles, the CO2 emission calculation shows an equivalent level. (See figure 8)

9) Workshop highlights: During the Action Plan Workshop it has been discussed and put an emphasis on, that such transport model studies as VRS did within Dynaxibility4CE are highly important to lay the grounds for a broader understanding of the impacts of implementing

autonomous vehicles as a feeder into the public transport system. Feeder systems do have synergies and are able to reach a lot of different groups from the whole society. Especially the combination of different transport modes has demonstrated to be quite advantageous. Furthermore, the Action Plan Workshop revealed the importance of stakeholder engagement. Especially in the case of VRS, which got planning and ordering authorities for the suburban train lines (S-Bahn) and several regional train lines but not for bus transport. In fact, the districts themselves are responsible for the bus transport. So, stakeholder engagement plays a very important role to get the relevant actors on board.

4. Action Plan towards CCAM in Stuttgart Region (Schurwald)

There are four major pillars, that need to be considered when planning to realize an implementation of such autonomous ridesharing-systems, as it has been simulated in the transport model study of VRS: **Planning, Infrastructure/Tools, Capacity Building** and **Policy**. These diagnosis elements set a frame for the analysis of several thematically underlying aspects which were also discussed during the Action Plan Workshop.

1. Planning

Organizational structure:

-Definition of planning area, concept, goal of the Ridesharing implementation, scenario development

-Definition of responsibilities, tasks

-Identifying of actors, roles -> Stakeholder mapping

-Creation of joint-understanding of CCAM & MaaS vision between actors

-Forming of cross-department unit for strategic organizational set-up

-Setting frames and organizational agreements

-Defining organizational anchor (unit/department/staff/position)

-Revealing permission procedure

-Developing a fleet management

-Tariff integration into the VVS tariff (Transport and Tariff Association of Stuttgart Region)

Information system:

-Establishment of information/data flow between coworking roles/actors

-Citizen and stakeholder participation/information/communication: -> Creating of a clear understanding which objective the concept has; demonstrating technological feasibility studies; raising awareness for ‘uncommon’ territory

-Timing the communicational dissemination of the planned implementation in an adequate time phase before realizing it; calculating time for feedback, reactions

-Inclusion of stakeholders and citizens: workshops, roundtables, info material platform

-Conceptualizing an info system for passengers/users/citizens on the ridesharing bus/shuttles and at the bus stops

Control system:

-Establishment of a permission check

-Setting up a trial/pilot contract

-Guarantee for safety control in place

-Establishment of risk/contingency plan

-Defining KPI's

Incentives:

-Offering incentives for passengers during the demo phase

-Offering incentives for passengers to get feedback on the new transport system to gain knowledge about the user acceptance and experience; for instance use the booking App of VVS to do passenger surveys

2. Infrastructure/Tools

Technology & Infrastructure:

-Procurement of automated vehicles

-Infrastructure investments/preparations: physical, digital, network

-Establishing location & facilities for the implementation: 5G communication, charging infrastructure, 'reserve' vehicles, maintenance, accessibility of vehicles, depot, control room

-Storage of information in data loggers

-Readiness of infrastructure & technology not given yet -> preparation of stakeholders and citizens for CAD by feasibility studies in transport models for e.g. to demonstrate implementations already and raise awareness

-Guarantee for safety of the emerging technology; safe environment esp. for women (because in the future there won`t be drivers)

-Platform development to book the ridesharing offer: Three main channels via App (VVS-App integration suggested), via phone hotline, via VVS website

-Developing a decentral solution for charging and parking the ridesharing vehicles meanwhile not being in operation

-Vehicles should offer features for the transportation of wheelchairs & bikes and possibilities to store luggage

-Connecting the on-demand service with micro hubs or mobility stations to create synergies for parking the vehicles, delivering parcels AND passengers when the vehicle for example isn't occupied totally -> Side effect: Could increase the cost efficiency especially in sparsely populated areas

3. Capacity Building

Tasks:

-Role & responsibility definition for a common level of understanding

-Addressing of new tasks due to new job creations

-Necessity of implementing a solid political commitment for the project realization

-Involvement of important roles within the developed scenario (like users, drivers, responsibles from the police, fire brigade, etc.) already from an early stage to benefit of multi-perspective views on requirements

People:

-Including external expertise for laying the grounds with feasibility studies and lessons learned from pilot demonstrations on cross-national level

-Definition of skills requirements / job profile of staff -> Training

-Defining target groups (also of other Ridesharing offers): commuters, pupils, leisure trips esp. during nighttime on weekends

-Defining user mapping; who would use the offer? What do they need or wish for? E.g. Wheel-chair-friendly

Development & renewal system:

-Implementing a feedback / evaluation /SWOT-Analysis procedure -> find out about user acceptance, missing aspects, etc.

-Implementing a lesson learned phase among authorities and operators

-Using adequate formats to 'transport' abstract mobility solutions -> scenario modelling and presenting to stakeholders and citizens to make AV's more imaginable in the Schurwald Region

4. Policy

Decision-making-system:

-Establishment of a clear chain / process for decision making

-Setting an anchor point for approval / validation procedure

-Risk / failure consideration -> showstopper scenario creation and definition and distribution of responsibilities and roles

5. Conclusions and recommendations for innovative low-carbon mobility planning In FUA

After completing the various project phases within 'Dynaxibility4CE' VRS draws the conclusion that, new innovative mobility solutions such as CAD and MaaS enhance political stakeholders to strengthen public transport also in peri-urban areas among FUAs in central Europe. The conducted transport model study showed that especially autonomous vehicles, functioning in a ridesharing system, allow an individualization of the population's transport demand whilst at the same time bundling passengers. Consequently, an extended comprehensive basic offer of the public transport is guaranteed for every group of society.

Besides, it turned out to work beneficially to integrate for instance ridesharing offers into the public transport system to create synergies by using it as a feeder to train lines. By closing the first and last mile gap to train lines, an environmentally friendly connection is established. It also enables the users to move around without using or even owning a car at all. The 'Schurwald study' pointed out, that it is possible to decrease the share of the private car usage by substituting it remarkably with ridesharing shuttles. Further, it is of advantage to combine on-demand systems such as ridesharing with several regular buses to save unloaded transport kilometres, energy and costs.

In order to implement such an autonomous and on-demand ridesharing shuttle, stakeholder engagement is key. Especially since the new Passenger Transport Law entered into force, clear legal guidelines for the implementation of such mobility offers have been defined. As a result, districts and district-free cities are the main responsible authorities which set the rules for scheduled and bundled on-demand offers.

6. Dissemination and exploitation plans

Within its SRMP (Sustainable Reginal Mobility Plan) VRS disseminated the underlying scenarios and main results of the transport model study in the Schurwald, conducted within Dynaxibility4CE to raise awareness in the region of Stuttgart for such innovative and fruitful mobility solutions. The SRMP is available publicly for both citizens and regional political stakeholders. Especially the regional political stakeholders are a broad and cross-linked network that is very important to be addressed for further implementations of such transport offers.

Moreover, the study as the main output within this project has been shared with the VVS (Transport and Tariff Association of Stuttgart Region) trying to get the main public transport authority on board for on-demand pilots or implementations like examined.

References

- UNIVERSITÄT STUTTGART, INSTITUT FÜR STRAßEN- UND VERKEHRSWESEN, LEHRSTUHL FÜR VERKEHRSPLANUNG UND VERKEHRSLEITTECHNIK: Study on the integration of autonomous ridesharing shuttles into the public transport system in a peri-urban area in Stuttgart Region (Schurwald), Stuttgart, 2021: https://www.interreg-central.eu/Content.Node/Dynaxibility4CE/RidesharingImSchurwald-Endbericht-VRS-V05.pdf (last downloaded 2022-02-24).

Annex

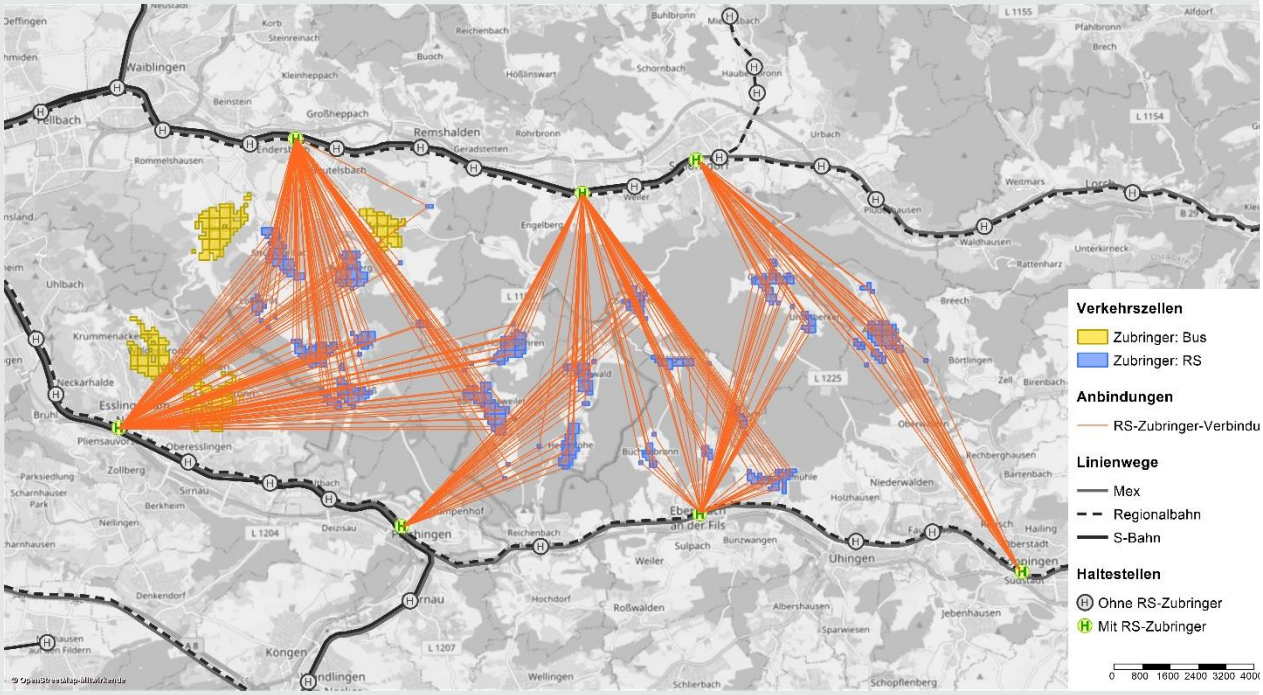

Figure 2: Simulation of scenario 1 & 2

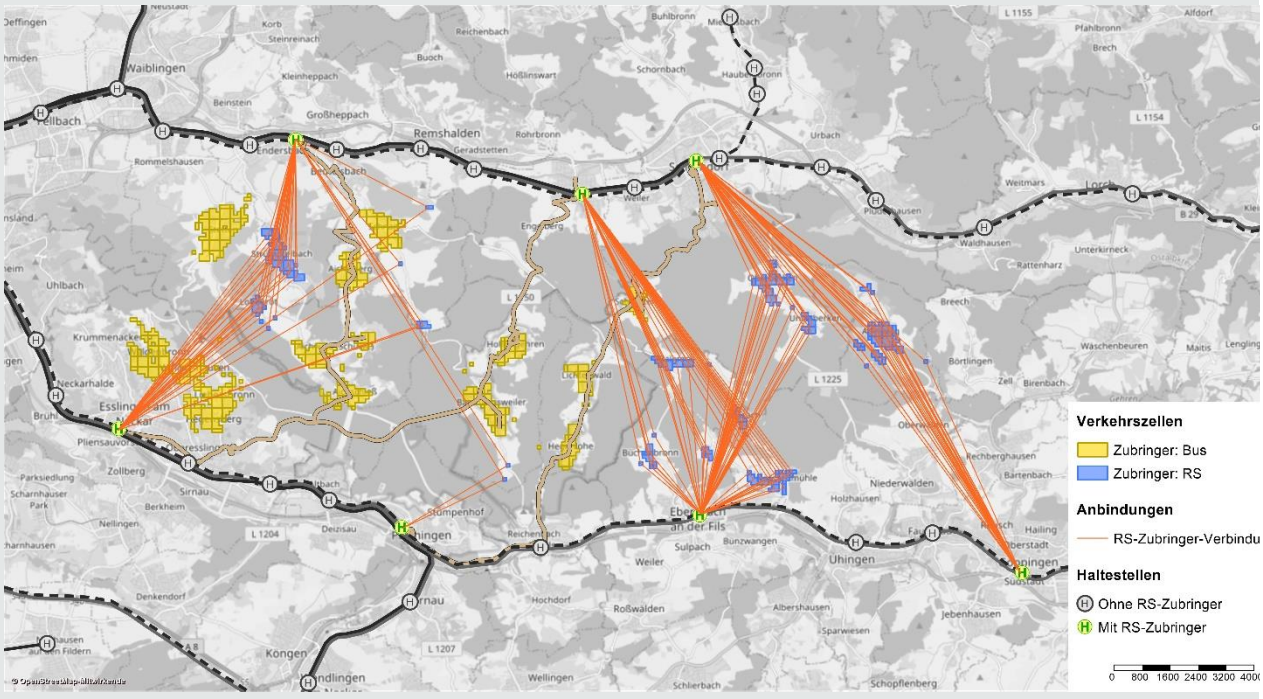

Figure 3: Simulation of scenario 3

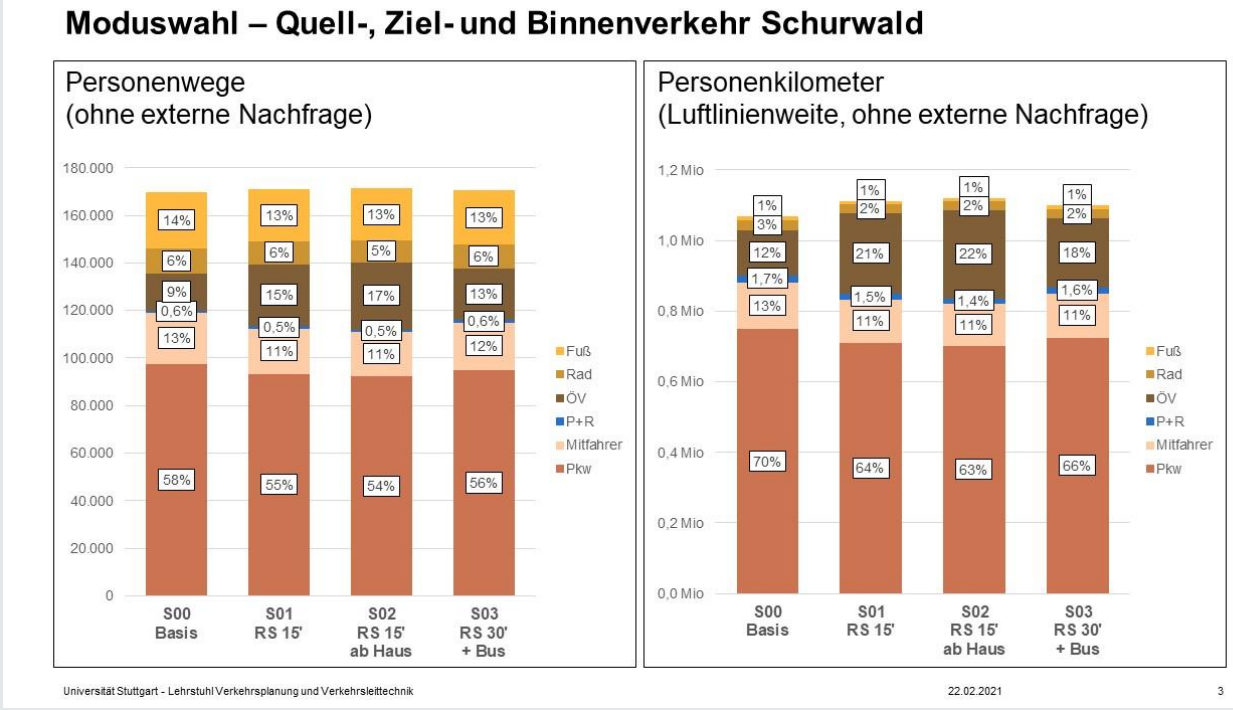

Figure 4: Modal split and kilometres per passenger compared between scenarios

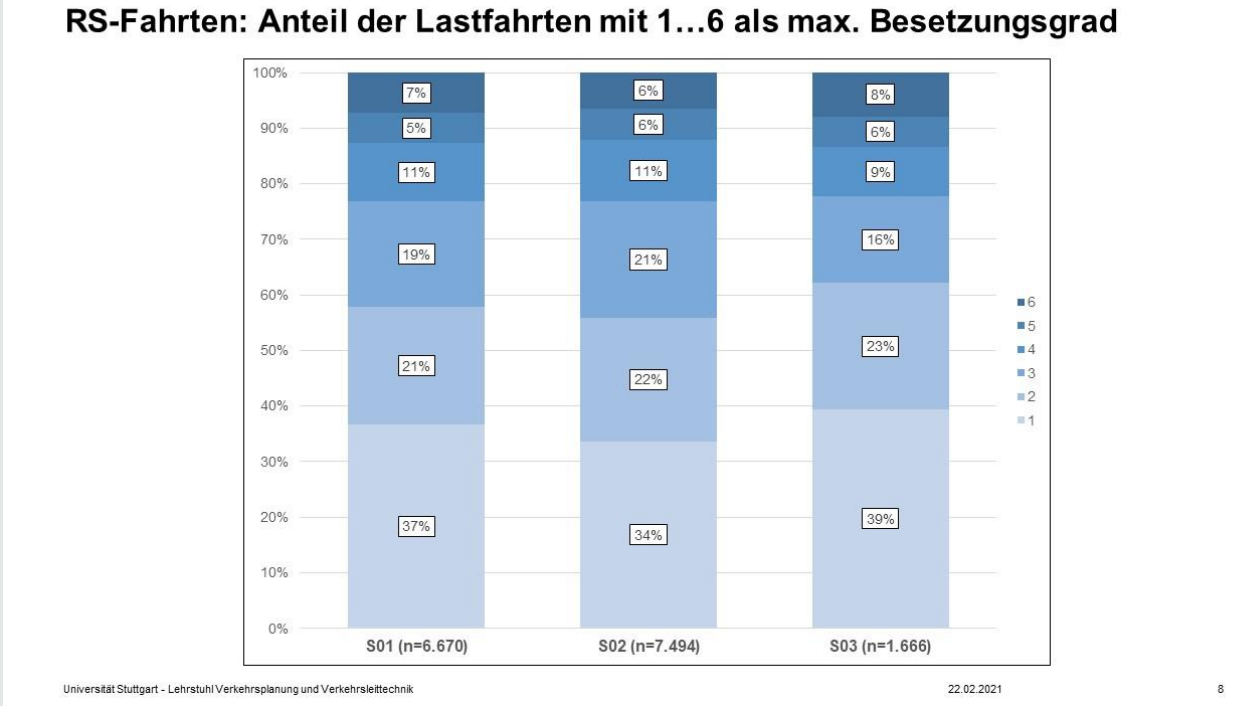

Figure 5: Occupancy rate during loaded trips compared between scenarios

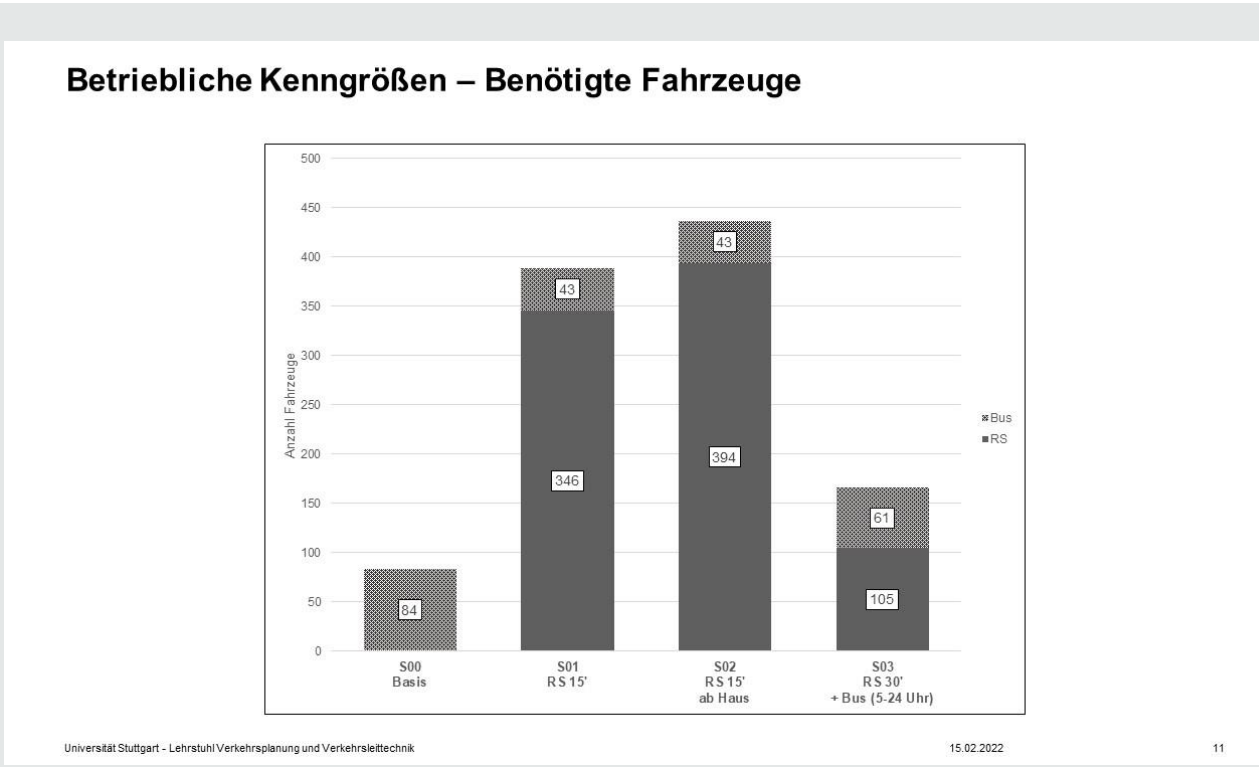

Figure 6: Required number of Ridesharing vehicles compared between scenarios

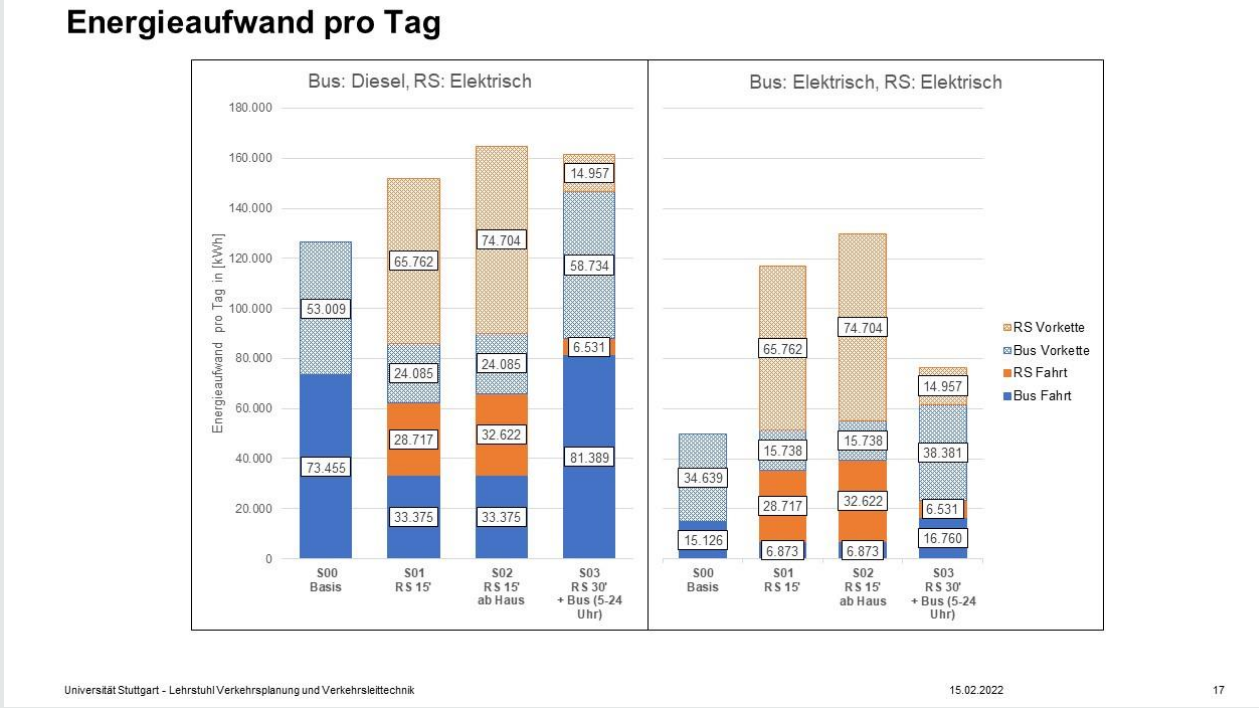

Figure 7: Energy consumption/day compared between two operation concepts

CO_2-Emissionen pro Tag

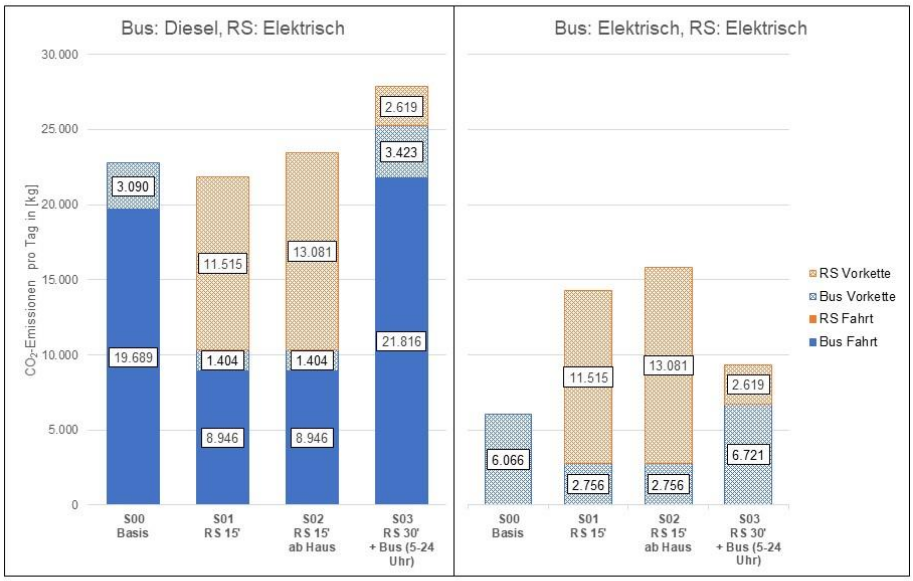

Figure 8: CO2 Emissions/day compared between two operation concepts

Kostenbetrachtung – Gesamtkosten pro Tag in €

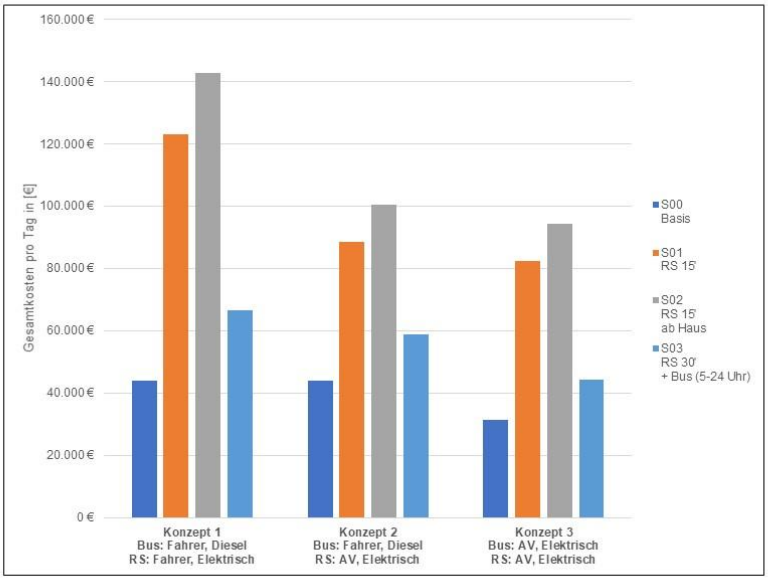

Figure 9: Costs/day [€] compared between three operation concepts