FRANKFURT UNIVERSITY OF APPLIED SCIENCES

ReLUT - Research Lab for Urban Transport
NEWSLETTER 01/2022

ReLUT RESEARCH LAB FOR URBAN TRANSPORT FRANKFURT UAS

Welcome!

The Research Lab for Urban Transport is an interdisciplinary team of researchers in Frankfurt, Germany working on current and future challenges of mobility. Our research focuses on the development of economic and ecological solutions for new mobility models. In addition to the disciplines of transport planning and logistics, ReLUT combines a wide range of competencies: urban planning, social science, data science (Big Data), computer science (AI), geoinformation, law, automotive engineering, and economics.

In this issue, we highlight a few of the projects that we completed in the past six months. In November 2021, we wrapped up the P+R Aktuell research project focused on improving park and ride facilities. The SimCityNet project, focusing on the impact and logistics of implementing low-emission and emission-free buses and municipal vehicles in urban settings, finalized its results with city simulation plan of Hanau, Germany. And the ParkRight study, which was completed in May 2022, gathered and analyzed data on how parking violations impact safety, in particularly for cyclists and pedestrians. The results of the study should improve safety in high-risk areas.

Although three of our projects have come to completion, we are always moving forward with new ideas and research projects. We hope you enjoy reading about all the projects our team has been working on. We are always looking for areas of collaboration! Please reach out to us if any of our projects are of interest to you.

Best wishes,

Petra Schaefer

Kai-Oliver Schocke

Tobias Hagen

P+R Aktuell

Gefördert durch:
Bundesministerium für Digitales und Verkehr
aufgrund eines Beschlusses des Deutschen Bundestages

P+R-Aktuell

The research project P+R Aktuell focuses on accurately evaluating solutions and services for park and ride facilities. The project started in December, 2020, in collaboration with the partners of [ui!] Urban Mobility Innovations (B2M Software GmbH), the Smart City Systems Parking Solutions GmbH, and the Society for Integrated Traffic and Mobility Management (Gesellschaft für Integriertes Verkehrs- und Mobilitätsmanagement - ivm GmbH). The project ended at the end of November, 2021. ReLUT, as a scientific partner, was mainly responsible for the accompanying scientific research.

The aim of the project was to record the utilization of P+R facilities in real time and to forecast parking options with the help of artificial intelligence. For this purpose, the municipalities of Eschborn and Eppstein made their seven P+R facilities available to the project consortium, where the forecasting could be tested.

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As part of the project, all P+R facilities investigated were equipped with a total of more than 700 ground sensors, which use magnetic field and radar sensors to record available and occupied parking spaces in real time. The data collected from the sensors was used in two ways: to provide data for the forecast model and to make the information available via an app for private users to view parking occupancy in real time, allowing users to see where parking spaces are available before they start their journey.

P+R facilities are currently an important element to enabling intermodal transport behavior. The probability of a free parking space is an important factor for the users‘ decision to travel to a specific facility or area. If users are able to assess parking availability before they start their journey, access to intermodal mobility behavior may be facilitated.

Based on the sensor occupancy data and vehicle movement data, so-called floating car data (FCD), a model was created that forecasts the future occupancy of the respective facility. It was found that the model forecast provided reliable results even with a reduced number of installed ground sensors provided that the sensor-based data was supplemented by floating car data. Furthermore, an anonymous survey was conducted at the seven P+R facilities in which the usage behavior of the facility users was examined. In addition, the following topics were examined: source and destination of the respondents, degree of occupancy of the vehicle used as well as traffic behavior and choice of means of transport along the entire route. In order to ensure the transferability of the project results to other P+R facilities, structural and use-specific criteria were developed to typify the P+R facilities. For example, the criteria took into consideration the location, surroundings, size, and number of parking spaces. In order to ensure the accuracy of the sensor data at the P+R facilities, supplementary manual counts were carried out at each of the facilities to record the current condition and collect data.

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In the future, the model can be further developed so that more specific individual data, such as weather, scheduled events, or parking patterns at individual P+R facilities, can be included in the forecast of the occupancy rate, making the parking occupancy forecast even more accurate and relevant.

Zoë Winkler
Research Assistant

Faculties 1 & 3
ReLUT

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ParkRight: Systematized recording and understanding of parking violations

Gefördert durch:
Bundesministerium für Digitales und Verkehr
aufgrund eines Beschlusses des Deutschen Bundestages
ParkRight
mFUND

Parking violations cause numerous problems affecting daily mobility. Safety problems for cyclists and pedestrians are of particular concern. Municipalities are trying to reduce parking violations by issuing parking tickets to penalize parking violators. However, there are no extensive and official statistics on illegal parking in Germany. In order to reduce parking violations, it is important to understand the causes. Empirical models of illegal parking can be used to predict parking violations. These predictions can help to optimize the use of control personnel, to reduce administrative costs of municipalities, and to implement measures to reduce parking violations.

As part of the research project ParkRight, we collected data on parking violations based on video footage taken from windshields of driving vehicles. Nearly 7,000 videos with an average length of 70 seconds were recorded in 2019. With this data, we manually identified about 10,000 parking violations with the help of a labelling tool. In addition, we identified infrastructural characteristics like street categories (e.g. main shopping street) and vehicle types. The street attributes (e.g. maximum speed) and spatial data (e.g. number of Points of Interest (POI) such as shops and offices within a certain distance) were incorporated from OpenStreetMap.

We compared maps with the collected data and found that 49% of parking violations occur in areas where parking is absolutely prohibited, followed by other violations (16%), parking violations in restricted stopping zones (15%), and double parking (11%). Approximately 80% of the vehicles that committed the parking violations were private vehicles. The remaining 20% can be allocated to commercial traffic.

In the statistical analysis, a count data regression was used to model parking violations. The most intuitive way

to present the results seems to be predictions of parking violations per kilometer for different settings. We found parking violations per km to be highest in main shopping areas. In addition, availability of free parking spaces reduces illegal parking while the number of POI increases illegal parking.

This study implemented an innovative method of data collection. Recent studies mainly use parking ticket data to assess parking violations. This approach induces a selection bias since drivers may avoid areas with a high level of parking enforcement. The data collection of parking violations in our study is based on video footage taken from driving vehicles. This anonymous data collection avoids selection bias. Another benefit to this method of data collection is the ability to transfer recording devices to other vehicles, for example to municipal services like waste collection.

Although the data collection process provides several benefits, it also has some limitations. GPS data underlies errors that can be caused by signal barriers, e.g., tall buildings or trees, and inconsistencies in the labelling approach can lead to inaccuracies. To minimize errors, employee training is important and comparing results between different people ensures the quality of the data.

This research project, funded through the promotion program mFUND of the Federal Ministry for Digital and Transport, has been running since January 2021 and ended with a closing ceremony in May 2022. For more information visit: https://parkright.bliq.ai/

M. Sc.
Nicole Reinfeld
Research Assistant

Simulation of fleet management with electric buses

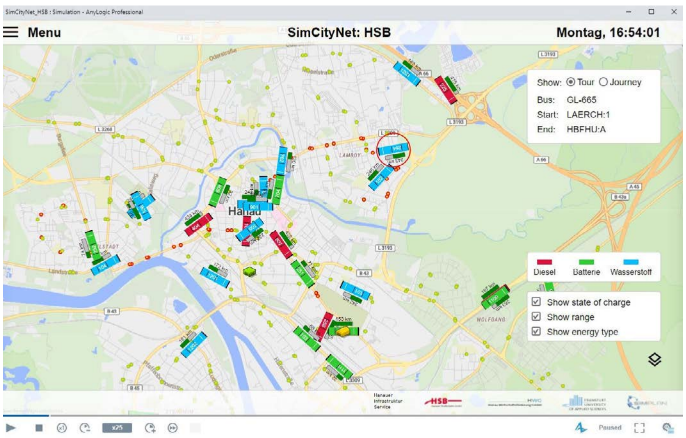
The Clean Vehicles Directive prescribes targeted measures for the procurement of corresponding low-emission and emission-free vehicles in municipal fleets and puts pressure on all local transport companies nationwide. Many transport companies have already tested the first electric buses in pilot projects and successfully integrated them into their operations. However, the conversion of larger parts of the vehicle fleet or the entire fleet is uncertain and associated with a high financial risk. The SimCityNet research project addresses this research question and provides solutions for the sustainable integration of electric buses into local public transport. In a digital model („digital twin"), the complete road network of a municipality, the city of Hanau in this case, can be mapped. On a virtual road network, various operating concepts with different drive and vehicle models, charging strategies, and fleet constellations can be simulated and evaluated.

A virtual traffic modelling simulation was developed within the SimCityNet project. Thanks to funding by the Hessen Agentur GmbH and in collaboration with the simulation service provider SimPlan AG, a digital traffic model was developed for the Hanau street cars (Hanauer Straßenbahn GmbH - HSB) and the Hanau Infrastructure Service (HIS). The simulation model was used to analyse the operational processes of local public transport (HSB) and waste collection with refuse collection vehicles (HIS) in Hanau. In the digital twin model, short-, medium- and long-term fleet planning was carried out for both battery electric vehicles and fuel cell vehicles, as well as for a possible mixed fleet.

The results for HSB show that for battery-electric buses with the typical range of 170 - 200 kilometres, a significant additional demand of 40% more buses would be needed in Hanau. If battery-electric buses with a range of 300 - 350 km were integrated, the additional demand for vehicles would be reduced by 20%. High ranges of fuel cell buses and comparatively short refuelling times have the potential to operate the circulation planning, compared to the current situation, without additional vehicles. On the other hand, there is a considerable additional financial outlay for vehicle investments and hydrogen operating costs.

In order to reduce the additional demand for vehicles in a battery-electric fleet and at the same time to keep the high investment costs for fuel cell vehicles low, the mix of both drive technologies shows great potential. The fleet mix with 70% battery electric vehicles and 30% fuel cell vehicles leads to an additional demand of 13 vehicles with ranges of 170-200 km for battery electric vehicles. With the same mix and a range of 300 km, operation can be carried out with the same number of vehicles as today. In addition to the fleet-specific effects, the economic aspects also provide an important decision-making basis for the operational strategy measures. Even considering hydrogen, which is still highly priced today, a mixed fleet of battery electric and fuel cell vehicles would reduce operating costs by 22 %.

An increase in fleet size is not operationally possible for HIS, as the tour planning of the different waste types must be maintained. The simulation results have shown



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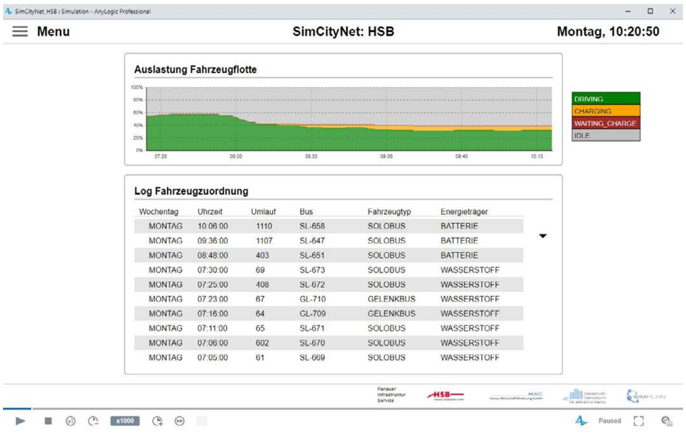

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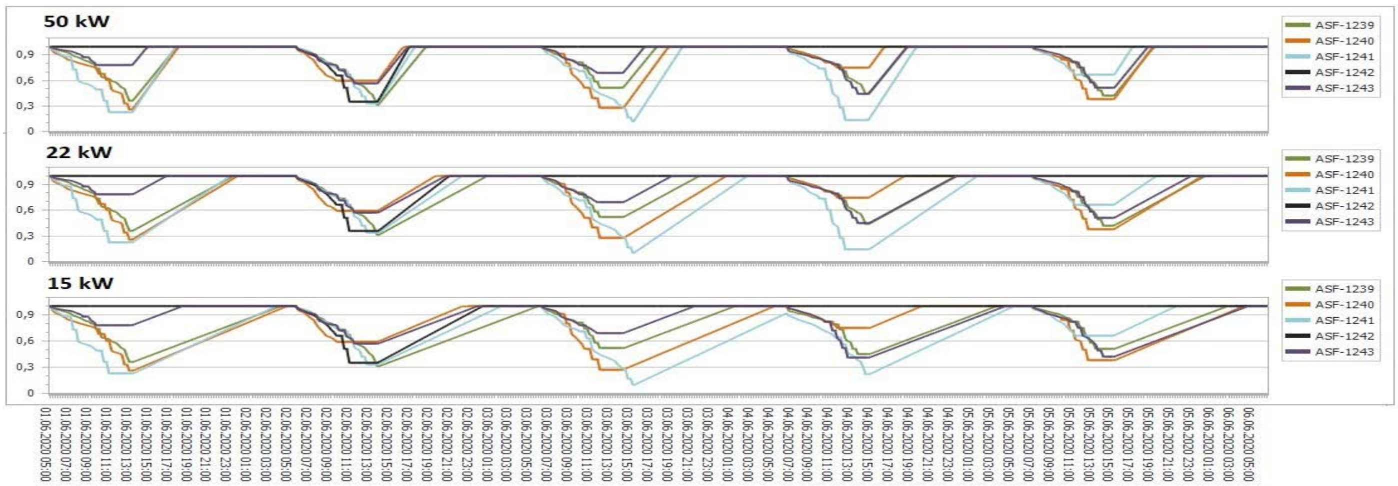
that fuel cell vehicles can operate all tours in Hanau. Because Hanau has residual waste collection points and paper/cardboard collections located far outside the city borders, battery electric vehicles can primarily be used for routes collecting organic waste and light packaging. Half of the vehicle fleet could be operated by battery electric vehicles. The combination of both drive technologies has the advantage of reducing energy requirements. The disadvantage of a longer charging time for battery electric vehicles is not a problem for a waste collection operation. The operating hours of the HIS, from 6:00 a.m. to about 2:00 p.m., provide sufficient time after the collection process to charge the refuse collection vehicles and avoid high charging peaks. The adjacent graph shows the state of charge (SoC) of each individual battery electric vehicle in different colours for a scenario with five battery electric vehicles in the mix. The state of charge of the vehicles is shown for an entire week in the winter scenario. By using different charging powers (50 kW, 22 kW and 15 kW), the effects on the charging behaviour can be compared. At the start of operation (6:00 a.m.), the state of charge drops and is recharged to 100 % SoC at the end of the tour (approx. 2:00 p.m.). With a charge of 15 kW, the vehicles only reach a SoC of 100% shortly before moving out or, as seen in the blue line, sometimes start operation with an SOC lower than 100%.

The diverse simulation scenarios also provide various insights regarding suitable charging strategies and management for Hanau. The results are a helpful basis for the planning and operation of public transport and waste management in Hanau as well as for the dimensioning of the required infrastructure in the depot.

The final report is available on our homepage.

M. Eng.
Gerome Löw
Research Assistant



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Requirements of cargo bikes for the infrastructure: Completion of the project-mo.de research project

HESSEN Hessisches Ministerium für Wirtschaft, Energie, Verkehr und Wohnen

project–mo.de

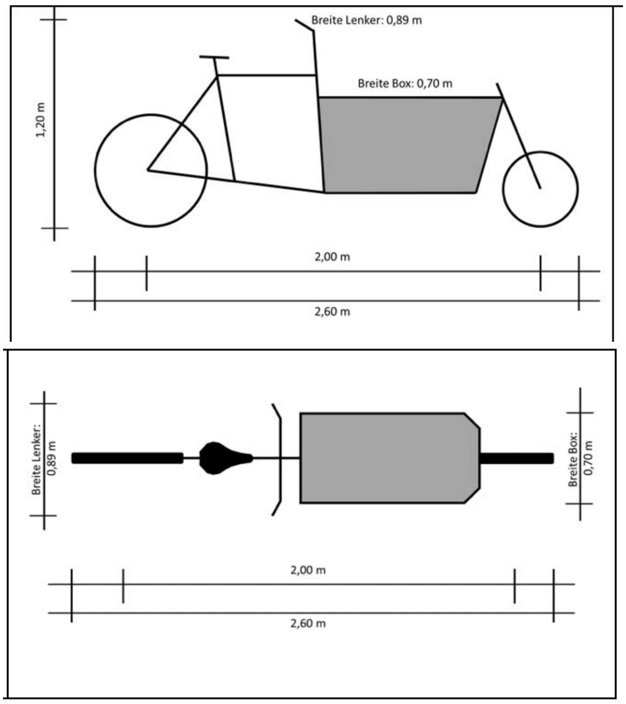
LOEWE Exzellente Forschung für Hessens Zukunft

In December 2021, the project-mo.de research project from the LOEWE focus „Infrastructure - Design - Society" was successfully completed with the work package „Requirements of cargo bikes on the infrastructure." The overall project involved three sub-projects: obtaining expert opinions on cargo bike dimensions and traffic planning, collecting experiences from cargo bike riders, and evaluating real data on cargo bikes to create a dimensioning vehicle for traffic planning. The final report describes these data points in detail and recommendations for action were derived from them.

Overall, it was found that many measures are already being carried out and implemented in the cargo bike sector. Efforts are primarily aimed at making the use and procurement of the bikes low-threshold and, if possible, making them available to people of all income levels. In addition, high-profile measures are being used to try to make cycling a common practice. In cities and mid-sized towns, the use and deployment of cargo bikes is predominantly seen as positive and advantageous, especially because it can replace inner-city trips with zero emissions. However, limitations were also noted. The bike lane infrastructure was most prominently criticized and with obstructions in the bike lane being the most frequently mentioned complaint in the interviews.

Experienced cargo bike riders who were interviewed confirmed the poor bike lane infrastructure described above. These riders reported that the bike lanes are too narrow and generally have poor surface conditions. Additionally, they reported that the traffic islands are too small for cargo bikes, and that structural requirements such as bollards, circulation barriers, and grated curbs are missing. The lack of public transport options and suitable parking facilities are additional major obstacles for trips with cargo bikes.

The description of the numerous obstacles make it evident that the bicycle infrastructure must consider sufficient sizing and scaling in the future. One approach could be the use of a dimensional vehicle for cargo bikes in transportation planning. By collecting data and conducting an internet search of over 100 cargo bike dimensions, a dimensional vehicle was created as part of the project.



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The research resulted in a realistically proportioned cargo bike that is 2.60 meters long, has a wheelbase of exactly 2 meters, is 1.20 meters high, and has a 70 centimeter wide transport box and 89 centimeter wide handlebars. The use of such a dimensioning vehicle is to be applied, for example, in streetscape design. A future addition of minimum turning curves or curve radii to the concept should still be worked out. The final report can be found on the ReLUT homepage.

M. Sc.
Lukas Fassnacht
Research Assistant

ClusterMobil: tessellation and spatial analysis

City segmentation, or in general the discretization of spatial space (called tessellation) is a key component in many spatial analyses. In the framework of our project, ClusterMobil, we compared different methods to tessellate space. In addition to regular methods, such as squares and hexagons, irregular methods were also studied. Irregular methods, such as Voronoi-Polygons and city blocks consider not only the spatial space but also additional data, such as Points of Interest and street segments. Using additional data allows the discretization to be more realistic and adapt to the natural structure of the underlying area. All considered methods are published as a python package called TessPy.

The tessellation units, called tiles, are paired with additional data such as count variables and GPS data. As a result, each tile consists not only spatial data but also non-spatial data. These units are called Local Geographic Units. The LGUs are used in clustering algorithms. The discretization of the underlying area into interpretable units representing a certain group (cluster), where each cluster is characterised by the considered data, allows an even better understanding of the structure of the area. For the interpretation different statistical measures and methods are used. Detailed results can be found in this working paper.

This research project, funded by the state of Hessen through the promotion program, “Innovation in logistics and mobility,” has been running since May 2021 and is planned to continue until the end of December 2022.

M. Eng.
Siavash Saki
Research Assistant

M. Sc.
Jonas Hamann
Research Assistant

Kombinom project will be continued

From October 2020 to September 2021, ReLUT teamed with Hannover University of Applied Sciences and Arts to carry out data modelling for the use of autonomous buses in rural areas for combined passenger and freight transport in the Kombinom project. The aim was to compile existing data to analyse the concept‘s potential in a simulation study.

This combined approach is now being further developed in Kombinom_2. The project consortium consists of ReLUT, Hannover University of Applied Sciences and Arts, SimPlan AG, Senozon AG and tbw Research GesmbH. The aim of Kombinom_2 is the conceptual development of a simulation application for a decision support system regarding the combined, autonomous transportation of goods and passengers. The first step is to design area-specific passenger mobility and logistics models with autonomous vehicles. For this purpose, mobility-specific and logistical requirements for combined mobility and logistics concepts are collected and classified by means of a market analysis of existing autonomous vehicles. The data should be transferred to the entire German, Austrian and Swiss (D-A-CH) region.

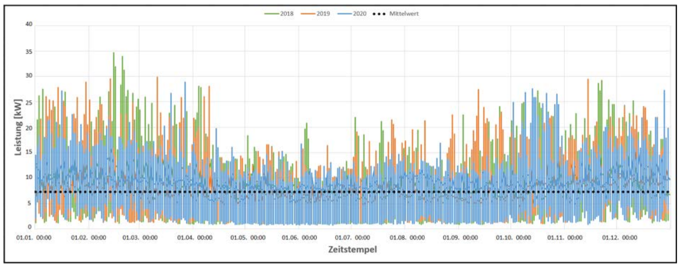
The simulation application offers the possibility to develop and virtually test combined transport models and concepts in order to evaluate economic, ecological, and social added value as well as increments in the quality of life in rural areas. The decision support system serves as a basis for potential implementation projects and facilitates the rapid implementation of pilot applications.

The project is funded by the Federal Ministry for Digital and Transport (BMDV) and the Modernity Fund (mFUND).

M. Eng.
Gerome Löw
Research Assistant

eCARe – Interim Report

The eCARe project is a process-based charging management concept for e-car logistics that began in 2021. Until now, research for electromobility has focused on component development or the creation of charging infrastructure for end customers. However, with increasing sales of e-vehicles and global production, there is a need for optimized logistics that take into account the specific characteristics of battery or fuel cell vehicles. Using data that our group collected on the development of electromobility, we were able to plan a charging infrastructure for the project partner‘s use. To do so, the technical data (battery capacity, charging capability, and range) of various electric car models were collected. The pool of electric cars described vehicles exclusively from the manufacturer Daimler as these vehicles represent the majority of vehicles at the project partner‘s site which was initially considered. It became apparent that all vehicles can be charged with a Type 2 charging cable and a charging power of up to 22 kW (AC). When analyzing the load profiles of 2018, 2019, and 2020 models to determine the available power at this location, the average power was about 7.3 kW and the maximum power was about 34.62 kW.



Load profile of the active power 2018/2019/2020 © ReLUT

On the procedural and logistical side, the consideration and theories of future scenarios of electric mobility were backed up with concrete figures. The result is a tool that allows a wide range of variables to be selected and the parameters to be combined with one another. The aim of the tool is to be able to determine both the total charging processes to be carried out and the total electricity consumption per year for the scenarios in specific years to be selected. This data is then to be used by automotive logistics service providers so that they can generate a benchmark for the fleet that passes through the logistics center each year and thus adapts logistics and charging structures to future electrification. The year 2020 shows the initial values of the simulation. This year and the following years are calculated with 250 working days. Taking into account electrification ratios, fleet size, and a potential breakdown of e-car weight classes, the calculations result in an exemplary baseline of 4,700 charging operations for the year 2020 with an annual consumption of 17,000 kWh. In this way, other scenarios and years can also be calculated and estimated. Looking at the best-case scenario for 2035, a significant increase to 21,500 charging processes and an electrical consumption of 134,000 kWh can be seen. However, this assumes the optimal steering of emission targets on the part of politicians and the simultaneous implementation of the producing companies.

M. Sc.
Lukas Fassnacht
Research Assistant

Last Mile City Logistics Event
June 29 - 30, 2022
Berlin, Germany

ReLUT will be represented by Zoe Winkler, Siavash Saki, Gérôme Löw, and Steffen Henninger who will be presenting the projects iLaPark, start2park, Kombinom2, and LieferradDA.
For more information about the congress, click here.
Tickets at 50% discount are available on our home page. See you in Berlin!

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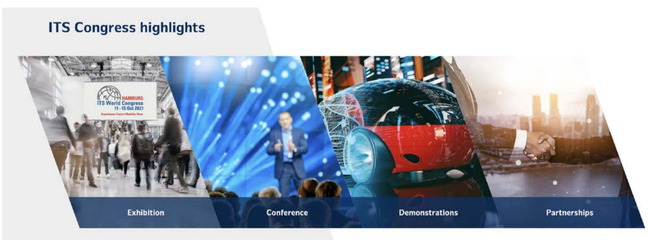
ITS World Congress in Hamburg

The ITS World Congress took place from October 11-15, 2021 in Hamburg, Germany. It is one of the world‘s largest events focusing on smart mobility and the digitalization of transportation. The event takes place every year in a different world region. The Congress included a convention for professionals, an accompanying trade fair exhibition, and technology demonstrations. The goal was to raise awareness of smart mobility solutions among policy makers, experts, and the general public.

At the congress in Hamburg, ReLUT's Dennis Knese participated on two panels organized by DB Connect covering the visions of tomorrow‘s mobility. In the panel, „Strengthening public transport through integrated alternatives to private car ownership,“ he pointed out the importance of a user-centered redesign of mobility that is more oriented towards people‘s needs, e.g. a more seamless, integrated and comfortable travel chain, especially with regard to the combination of bicycles and trains. The panel, „New mobility on the way from niche to mainstream: the Hamburg way,“ focused on the efforts in Hamburg, the second largest city in Germany, toward making mobility more sustainable. He discussed the pros and cons along with practical examples with representatives from politics and business.

Not only was the convention itself successful, there were numerous fruitful discussions with national and international representatives, as well as interested individuals from the mobility and logistics industry, took place around the exhibition stands. Visit the ITS World Congress website for a full overview of the event.



European Transport Conference 2022

September 7 - 9, 2022
Milan, Italy

The following papers from the ReLUT team have been accepted for presentations at the 2022 European Transport Conference (ETC):

„ClusterMobil – Discretization of Urban Areas using POI-based Tessellations“ -Jonas Hamann

„Analyzing the determinants of cruising for parking: When does the parking search begin?“ -Siavash Saki

„Modelling of Parking Violations Using Zero-Inflated Negative Binomial Regression – A Case Study for Berlin“ -Nicole Reinfeld

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