SCSP 2025

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Proceedings of Abstracts

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Conference topics and objectives

The focus of SCSP 2025 will be mainly on research in the field of strengthening the resilience of smart cities. We will discuss also the changes due to energy crisis. We encourage researchers with different background to participate and share their findings. The Symposium aims to be a multidisciplinary forum for exchanging ideas and best practices in the field of Smart Cities not limited to theory but also including real world applications.

The Smart Cities Symposium Prague 2025 covers the following key areas:

- Cooperative Cities
- System approach to Smart and Climate-Neutral
- Cities transformation
- Livable cities
- Smart Cities Modeling
- City resiliencyg

Accepted papers will be submitted for inclusion into IEEE Xplore subject to meeting IEEE Xplore's scope.

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Communication Platform for Rail Traffic Management and Control System

Roman Štěrba, Přemysl Šrámek, Daniel Kalášek

Railway; Traffic; Management; OPTIMA; Shift2Rail; Demonstrator; Integration

The article deals with the Shift2Rail OPTIMA project, which stands for communication platform for traffic management demonstrator. The aim of this project was to create an integration layer into which information from different information systems would be distributed, further processed and used to optimize traffic management processes.

Leveraging FRAME Methodology for EU-Wide Harmonization of National Access Points

Petr Bureš, Zuzana Bělinová, Benjamin Witsch

EU-wide harmonization, Interoperability, ITS Architecture, FRAME, NAP, NAPCORE, National Access Point

The FRAME (FRamework Architecture Made for Europe) methodology enables consistent deployment of Intelligent Transportation Systems (ITS) services across various transport domains, cities and networks in Europe. This paper details the development and enhancement of a comprehensive National Access Point Reference Architecture (NRA) using the FRAME methodology. The reference architecture serves as a blueprint for new NAP implementations and identifies standards for existing NAPs, fostering secure and private data exchange, trust, and interoperability. The NRA, developed in the NAPCORE project, in the dedicated task led and contributed to by the authors of this paper, consist of motivational, functional, physical, organizational, and communication views created in the Enterprise Architect software. The NRA defines the architecture for two NAP types, significantly improves each view by addressing earlier limitations and by adding new features such as definition of interfaces and related standards, broader definition of agreements between actors. Additionally, the paper discusses the challenges encountered during the development process and underscores the significance of common terminology and harmonized interfaces in enhancing NAP utilization across Europe.

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Determining the factors influencing car use in Hungary

Bálint Csonka

Car use behavior, Questionnaire survey, Willingness to use cars, Statistical analysis

More and more cities are committed to traffic calming, but such measures often face social resistance by car users. Therefore, it is essential to understand the causes that affect car use. This study investigates the factors influencing passenger car use including access to public transportation, household size, commuting, parking availability, bikeability, status symbol, and income. For testing, an online questionnaire was conducted in Hungary, and the Pearson Chi-square (χ^2) test was applied. It was found that the most influential factors were the access to high-quality public transportation, parking availability at home, and the income. Moreover, people who drive their children to school commute less frequently to work by car. Accordingly, encouraging individual transport of students through school streets and bike bus programs, and the support of public transportation were the identified practical measures.

Enhancing Bulk KPI Evaluation Efficiency in Smart Cities Using Parallel Computing

Ondřej Šulc, Petr John, Jiří Hynek, Michal Valný, Tomáš Hruška

Key Performance Indicators, Smart Cities, FaaS, AWS, Cost Efficiency

"The rapid proliferation of Internet of Things (IoT) devices, projected to reach over 16 billion in 2023, has significantly transformed sectors like Smart City management. This growth introduces challenges related to the volume, velocity, and variety of sensor data, necessitating efficient monitoring and management solutions. While existing tools and frameworks simplify data ingestion and storage, they often lack analytical capabilities, placing a greater burden on users for decisionmaking. Key Performance Indicators (KPIs) offer a promising approach to addressing this gap, enabling automated performance assessment across various dimensions such as sustainability and efficiency. This paper focuses on optimizing KPI evaluation routines within IoT management platforms, using the Logimic's smart city solution ACADA as a case study. The model and KPI evaluation code were first optimized to improve overall efficiency. This optimization alone resulted in a 13x speedup, reducing the evaluation time from 50 seconds to just 3.6 seconds. Subsequently, by leveraging multi--core architectures, performance was further enhanced. Utilizing four cores, a significant 27x speedup was achieved, ultimately bringing the evaluation time down to just 1.8 seconds. These results highlight.the potential of such optimizations to enhance platform efficiency, reduce computational costs, and improve the scalability of IoT solutions for Smart Cities. However, it also emphasizes the importance of model and code quality, which is essential for efficient parallel computing."

Spatial risk assessment model for the transport of dangerous goods by road

Pavel Hluska, Pavel Hrubeš

Transportation of dangerous goods, D-R routing model, Risk analysis, Geographic Information Systems (GIS), Traffic accidents, Predictive models, Dynamic risk assessment, Optimization

In today's globalized society, the transportation of hazardous goods plays an important role in economic processes. With this growing trend, the transportation of hazardous materials brings a new challenge in terms of responsibility for ensuring safety and minimizing risks during transportation. The theoretical part of this scientific article describes the model by Ebrahimi and Tadic, which examines accident rates on a given edge of a graph, and how this research further develops by adding necessary variables. In the practical part, fleet data obtained from the real operations of transportation companies will be presented, providing a comprehensive overview of the movements of transport units. These data are analyzed in the study in relation to accidents involving transport units with a weight exceeding 7.5 tons in the Czech Republic. This data allows for the investigation not only of the probability of accidents involving units with a weight over 7.5 tons but also the impact and severity of these accidents. Additionally, a modified D-R routing model will be introduced.

Where to change from public transportation to car-sharing? Developing a transfer point optimization method

Márton Korompay, Dávid Földes

multimodal transportation model; car-sharing; public transportation; transfer points; TOPSIS method

"The combined use of public transportation and car-sharing in the urban environment can provide a competitive alternative to private transportation. Public transportation, particularly the rapid rail network, provides quick access to the downtown while car-sharing services offer flexibility and convenience in the outer districts. Combined journeys can combine the benefits of both transportation modes, especially if transfers between them can be managed smoothly. We defined the Travel Chain Indicator to evaluate travel chains in terms of travel time and cost. To select the optimal transfer point, we used the TOPSIS method, which allows for ranking the evaluated indicators and choosing the best alternative. The method developed was tested in a case study in Budapest, considering a metro line and seven destination points in an outer district further from the metro line that can be reached by car-sharing use. The results showed that combined modes offer the best solution when time and cost criteria are defined with similar weights. The method developed can be used for route optimization and service area development for car-sharing operators, identifying the areas where multimodal travel is a competitive alternative."

Emergency Call Centres in Smart Cities using Artificial Intelligence

Leon Rothkrantz

Automated speech technology, dialogue management, emergency calls, hybrid system, Multimodal Eliza, Chat GPT

In the Netherlands, the National Control Room (NCR) located in the smart city of Apeldoorn, handles about 400 dispatches reporting emergency situations every day. But regularly in case of terroristic attacks, explosions and bombing alarms NCR is overloaded. In this paper we discuss a new hybrid emergency center, including new AI technologies as Chat GPT to increase the capacity of NCR. The NCR used scenario modelling for efficient response. The NCR is strongly linked with the Traffic Information Centers (TICS) in the cities but is also connected to Burgernet, a communication network between Police, City Government and civilians. Via GIS, remote sensing systems and special Apps data will be collected and processed. A special telephone number 112 has been created to report about traffic incidents. The calls maybe executed by a caller using a smart phone or automatically by an Emergency (eCall) system in the car. The calls are preprocessed in a special emergency centers.

Personality trait-based model to study the acceptance of electric scooter-sharing

Gabriella Tanai, Dávid Földes

scooter-sharing, micromobility, technology acceptance, personality traits, Big Five

"Electric scooter-sharing services are available in several cities. However, thei perception is divisive, and their share in the total modal split is low. To improve the modal share and the acceptance level of shared scooters, understanding the users is necessary. We aimed to explore users' expectations, fears, and doubts. The methodology of the Technology Acceptance Model was applied and expanded with electric scooter-sharing service-specific variables. As a novelty, the so-called Big Five personality traits were added to the model to reveal their influence on the intention to use. To investigate the connections between the model variables, a comprehensive questionnaire survey was carried out as a case study in Budapest, Hungary. The main finding of our research is that the users of electric scooter-sharing services are more extroverted, sociable, assertive, and enthusiastic. Moreover, we found that social influence and travel awareness have a positive impact on perceived usefulness. Our results can be used in service enhancements and user-centered service planning."

Micro delivery hub design and placement in Prague 2

Kateria Jilkova, Katerina Zizalova, Tomas Horak, Miroslav Svitek

micro hubs, effective delivery, last-mile, resilient urbanism

"Scientific article explores the strategic placement of micro hubs of Prague 2 and describes pivotal function of them. Data sets obtained from a logistic delivery company were used for the analysis and processed in python to convert them into the usable form. Afterwards, the application QGIS was needed to select the potential places of placement the micro hubs. By setting the predefined distance of service area, the location of micro hubs of Prague 2 was possible to find and describe in more detail."

"Time-saving potential of biometrical technologies at Vaclav Havel Airport Prague from check-in to boarding"

Matyas Mori, Ondrej Rychtera, Tomas Horak, Miroslav Svitek

Airport Prague, biometric technologies, boarding, Boeing 737-MAX 8, Smartwings

"Biometric technologies have emerged as crucial tools in optimizing airport security processes. This article explores the integration and impact of biometric technologies at airports, with a specific focus on their implementation to enhance existing procedures. The practical aspect of the study involved the collection and analysis of boarding data from Smartwings flights at Prague Airport. This data will be systematically compared to evaluate the efficiency gains achieved through the incorporation of biometric technologies in the boarding process. The study aims to quantify the temporal benefits brought about by the adoption of biometric solutions."

Evaluation of Machine Learning Models for Discretionary Lane Changing Decisions

Saima Zaheen, Ehsan Yahyazadeh, Ruey Long Cheu

Lane Changing, Fuzzy Inference System, Support Vector Machines, Artificial Neural Networks

"This study presents the evaluation of selected machine learning models in predicting discretionary lane changing decisions in German and California highways. Fuzzy inference system, support vector machine and artificial neural network models were analyzed. First, these models were trained, and their decisions evaluated with the observed driver's behavior in the highD vehicle trajectory data collected in German highways. Then, the predictions made by two fuzzy inference system models with the highD data set from Germany and the NGSIM data set from California were compared. The results indicated that none of the models tested were superior than the others, and these models may need to incorporate one or more input variables to make better lane changing decisions in different driving conditions."

Enhancing the pedestrian crossing modeling with priority regulations in Vissim traffic simulation software

Szilárd Szigeti, Gábor Pauer, Dávid Földes

Traffic Simulation, Pedestrian Crossing, Crossing Decision Modeling, Control Logic, Priority Regulation

This study investigates the performance of the traffic simulation software Vissim in the context of pedestrian crossings. The primary aim was to analyze the functioning principles and limitations of priority regulation methods, compare their performance, and propose potential improvement options. Vissim provides two core methods for managing priority—conflict zones and priority rules. However, these approaches do not fully address real-word factors, such as noncompliance with priority rules and pedestrian's crossing decisions based on vehicle proximity. To overcome these limitations, we introduced an innovative methodology utilizing loop detectors placed at 10-meter intervals to monitor vehicle positions. This was combined with signal logic to simulate pedestrians' distance-dependent crossing decisions. The integration of real-world pedestrian decision-making processes into the simulation was validated through modifications to the software, and their impacts on key performance indicators - such as execution time and accuracy - were evaluated. The proposed approach provides a more realistic representation of pedestrian-vehicle interactions, significantly improving the accuracy and reliability of traffic simulations.

Developing a Geometric Logistics Network for Efficient Goods Distribution in Prague

Nikhil Tetali, Stefan Popa, Tomas Horak, Miroslav Svitek

"This paper presents a geometric logistics network model for Prague, Czech Republic, aimed at optimizing urban goods distribution. It evaluates the city's urban structure and demographics to strategically position logistics hubs. The efficiency of the road networks between these hubs is analyzed to minimize travel time and reduce costs. The proposed model integrates Just-In-Time Logistics to optimize order processing, inventory management, and transportation. The paper visually and descriptively illustrates the logistics framework, emphasizing the efficiency of road connections between hubs. This approach offers a unique interpretation of city logistics tailored to Prague's urban layout. The paper concludes by exploring how this model can improve Prague's logistics and serve as a model for other cities to implement smarter urban logistics solutions."

Factors influencing Car Ownership: An Example from the Prague Metropolitan Area

Milan Kříž, Vít Janoš

Car Ownership, Distance-Decay Function, Individual Transport, Logit Model, Mobility Tool, Mode Choice, Prague Metropolitan Area, Public Transport, Transport Modeling

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Shared Mobility Service Usage Patterns – Results of a Representative Rurvey in Budapest

Dávid Földes, Ráchel Surányi, Bálint Csonka,Borbála Simonovits, Csaba Csiszár

shared mobility, bike-sharing, scooter-sharing, car-sharing, usage habits, questionnaire survey

"To increase the share of shared mobility, understanding the general characteristics of active users and, moreover, the characteristics of non-users is essential. In this paper, we aimed to reveal the correlation between travel habits, general personal characteristics, and the use of shared mobility services, such as scooter-sharing, bike-sharing, and car-sharing. The data from a representative online survey were used; the respondents are citizens of Budapest, Hungary, and have a driver's license. We found that the active users are mainly from the younger generation with higher educational levels and higher incomes. Most users have subscriptions for more than one shared mobility service type. Furthermore, the service availability in the neighborhood and the car ownership influence car-sharing use. These findings contribute to the limited knowledge of the choice between different shared mobility types. The results can be used by operators to improve shared mobility services; the target groups of a campaign can be identified by the results."

Optimization of recycling bin placement using OpenStreetMap data

Alena Rybičková, Oleg Mazur, Petra Skolilová

waste management, facility location problem, p-median

"This study presents an optimization approach for improving the placement of recycling bins in the town of Plasy using a graph-theoretic model. The problem is formulated as a p-median acility location problem, using OpenStreetMap data to analyze urban infrastructure. Two optimization criteria are considered: the first minimizes the total distance from residential buildings to the nearest recycling bin, while the second incorporates population-weighted distances based on the number of apartments per building. Several variants are evaluated, ranging from redistributing existing bins to adding new collection points. The results demonstrate that optimized placement can reduce average walking distances by up to 18% without excessive infrastructure expansion. The findings provide a cost-effective methodology for municipalities seeking to enhance waste collection accessibility while balancing operational effciency and infrastructure investments."

Towards Street-Level Traffic Analysis Using Waze Crowdsourced Data

Magdaléna Ondrušková, Jiří Hynek, Radek Burget

Waze, Waze for Cities, Traffic analysis, Data processing, Route planning

"Traffic congestion represents a global challenge, significantly impacting the quality of life for urban residents. As a result, one of the main goals for traffic engineers is to optimize urban traffic flow. Advances in technology have introduced new diverse sources of traffic data, such as IoT-based sensors, mobile network operators, and crowdsourced platforms like Waze and Google Maps. This paper uses crowdsourced data from the Waze navigation application, obtained through the Waze for Cities program, to associate traffic congestions and incidents with specific street segments. The methodology is demonstrated through a usage scenario in Brno, employing two Waze datasets—Traffic Congestion and Traffic Incidents—alongside a municipal street network dataset. The proposed approach systematically maps traffic events to street segments, offering a detailed and citywide perspective on traffic conditions. To illustrate the application of this method, traffic events, and congestion levels are visualized along a computed route between two distinct locations. The route is generated using an optimized A* algorithm, modified to enhance calculation speed and efficiency."

Placement of Battery Electric Bus Charging Points considering Urban Land Prices

Péter Ákos Szilassy, Antal Joós, György Ágoston

Charging infrastructure, electric buses, land price analysis, covering method, cost optimization

"As electric vehicles become more widespread, the adoption of electric buses in public transportation systems is also increasing. This growing adoption has led to an increased demand for charging infrastructure, necessitating large, dedicated areas where buses can park for extended periods during charging. This study applies a mathematical approach, specifically the covering method, to determine the optimal placement of electric bus charging stations in a general urban environment. The analysis considers key factors such as land prices, spatial distribution, and the travel distance required for buses to access charging facilities. A cost-based evaluation is conducted to compare different charging location strategies, including terminal-based and centralized depot charging. By incorporating economic and operational constraints, the study aims to identify cost-effective solutions for long-term infrastructure planning. The findings offer practical insights for urban planners and transit authorities seeking to optimize the deployment of electric bus charging infrastructure while reducing overall system costs."

Service-Level Choice Modeling in Suburban Railway Transport

Rudolf Vávra, Vít Janoš

Journey Time, Public Transport, Service Frequency, Service-Level Choice, Timetabling, Suburban Railway Transport, Transport planning, Transport Model

This paper focuses on modeling passengers' choices of service levels in suburban railway public transport, where multiple service levels are available. The aim is to analyze cases where the exact timetable is unknown, but journey times and service frequencies for each service level on a given route are available. The paper first introduces the hierarchy and segmentation of passenger transport, along with the transport supply parameters that influence system--split. This is followed by a description of the mathematical model and the method used for its calibration. The results of the model calibration for selected suburban railway routes in the Prague metropolitan area are then presented. Finally, the findings are discussed in terms of how journey time and service frequency affect passengers' average travel times on specific routes served by multiple service levels of public transport.

The port of Rotterdam: A smart region connected to the Randstad

Tim Nootenboom, Wout Schaerlaecken, Tomas Horak, Miroslav Svitek

Multimodal hubs, Port of Rotterdam, public transport, rail network, smart mobility

"The Port of Rotterdam is Europe's largest port and a major supplier of the entire continent. Almost 200 000 people work in this area, yet it has no public transport network whatsoever. This report focuses on possible public transport solutions for this region, keeping in mind the geological challenges of the area. With the use of a python script, a flexible train network was designed. This network is capable of transporting over 50% of the total employees of the port to their workplace within 3 hours. When commuters reach the port, they can make use of the multimodal hubs to use their preferred mode of transportation to travel the last kilometres of their trip. This will all neatly be integrated in the existing Dutch public transportation network, allowing the use of the OV-chipkaart when taking any of the available modes of transport. This solution provides a much cleaner and environmentally friendly way of transporting commuters around the port area."

Machine Learning-Based Travel Mode Prediction: A Comparative Methodological Approach

Nilesh Bhosle, Jayant Jagtap, Miroslav Svitek

Mobility as a Service (MaaS), Smart cities, Travel behavior, Travel mode prediction, Travel pattern, Travel tracking

"Since the last few years, cities are continuously expanding because of urbanization. This urbanization has increased the need of effective management of resources such as public transportation, private vehicles, roadways, and several other things. Forecasting and study of travel mode selection provide insights into the factors influencing individuals' selection of transportation modes for their trips. This analysis plays a significant role in promoting sustainable transportation in smart cities. Hence, in this work, prediction, and evaluation of travel mode selection is carried out using different machine learning algorithms. The comparative analysis of ten different machine learning is carried out using the DLR Urban Traffic dataset. The experimental results indicate that the Random Forest classifier surpasses the performance of other classifiers. The random forest classifier achieved an overall accuracy of 99.30% in predicting individuals' travel modes. The evaluation of the proposed system is carried out using different metrics such as precision, recall, accuracy, and AUC curve. This demonstrates that the proposed

Sustainable Lifecycle Management of Urban Infrastructure Technological Assets Using Information Modeling for Maintenance Planning

Tomáš Tichý, Jiří Brož, Jiří Růžička, Eva Hajčiarová, Kristýna Navrátilová, Pavel Mašinda, Lukáš Kacar, Zuzana Bělinová, Pavol Kuchár, Petr Procházka

technological equipment, diagnostics, urban infrastructure, information modeling, transport system, smart technology, life cycle, BIM, tunnel system, maintenance planning

The sustainable development of urban technological and technical systems is closely linked to the acquisition of relevant data and information. Such information is crucial not only for the effective management and administration of these systems but also for identifying critical risk points and monitoring the life cycle of infrastructure. A key element is the use of information modeling and predictive approaches that facilitate continuous monitoring throughout the entire operational phase, thereby ensuring effective maintenance planning. This paper synthesizes various methods and technologies employed in the information modeling of technological systems and explores their application in the modeling and simulation of external factors affecting transport infrastructure. Particular emphasis is placed on the predictive maintenance of technological equipment, with tunnel technology analyzed as a case study a key component of urban transport and technological infrastructure. The primary objective is to demonstrate the potential for extending the life cycle of technological equipment or, at the very least, reducing the financial demands associated with maintaining its operational state through the use of information modeling.

Defining Railway Traffic Conflicts and Optimising Their Resolution: A Machine Learning Perspective

Michal Matowicki, Jakub Mlynczak, Piotr Golebiowski, Jan Přikryl

Machine Learning, identification and classification of conflicts.
conflict resolution, railway traffic management, global optimisation

"This paper reports on the initial phase of research into automated traffic conflict resolution for suburban railway operations. It defines railway traffic conflicts, categorising types such as catch-up, crossing, and proximity, and establishes optimisation criteria focused on punctuality, efficiency, safety, and passenger satisfaction. Promising machine learning approaches are reviewed, including supervised learning for conflict prediction, reinforcement learning for adaptive resolution, and unsupervised methods for identifying conflict-prone scenarios. The study concludes by proposing a simulation framework for empirical evaluation, providing a foundation for AI-driven advancements in railway traffic management."

Intersection User Class Detection Using UAV Images and YOLO-Based Algorithms in Smart Cities

Erdem Doğan, Enes Ayan, Ersin Korkmaz, Ali Payıdar Akgüngör, Onur Çaydere, Hakan Yıldırım

Intelligent transportation Systems, Object detection, YOLO, Deep learning

"The growing population, increasing transport demand and the resulting challenges require the development of advanced intelligent traffic management systems for smart cities. Modern intelligent traffic management requires the integration of advanced deep learning technologies for critical tasks such as monitoring and assessment. Although high-quality data sets are required to train deep learning-based systems, the available data sets in this area are still limited. This study aims to develop a data set and models for traffic analysis using Unmanned Aerial Vehicle (UAV) images and YOLO-based algorithms. For this purpose, a comprehensive data set was created with 17,876 annotated images of intersections with different geometric configurations and of road users. This data set was used to train and test various YOLO (You Only Look Once) models for object recognition. The test results underline both the quality of the data set and the potential of YOLO models in traffic analysis and serve as a valuable reference for future research."

Solving parking problems in densely built-up housing estates – case study in Liberec

Jiří Růžička, Martin Langr, Eva Hajčiarová, Jiří Brož, Tomáš Tichý, Kristýna Navrátilová

parking, parking space, capacity, occupancy, ELABORATOR project

"In times of increasing automobile use, cities often face parking problems. In addition to city centers, places with dense buildings and populations also appear to be very problematic in terms of parking – typically areas around housing estates. A complete solution to these problems is often not possible due to infrastructure conditions. Within the Smart City concept, we often look for solutions that help to partially solve these problems.

This paper deals with a case study of the Liberec-Rochlice urban district. The city is actively trying to find measures and solutions that would contribute to sustainable mobility for all road users and local residents. Based on the preliminary proposed measures in the city, the authors set hypotheses for research, which were subsequently tested in the form of a short-term local survey. Thus, it was examined how problematic the available parking capacity, parked vehicles over 5.5 m, lack of parking spaces for short-term parking at the entrances to apartment buildings and reserved parking spaces for a specific license plate appear to be in the area. Based on the results of the local survey, these hypotheses are evaluated and solutions for future monitoring of parking spaces in the area are specified."

Approaches to the Data Governance in Transportation Domain - Data Quality Rules Design and an Example of Traffic Data Inspection

Martin Langr, Pavel Hrubeš

data governance, data quality, data quality rules, traffic data quality check

"The paper focuses on the practical application of procedures for the design and creation of a complex system of data quality rules in transportation domain. The aim of the research was to verify the feasibility of implementing all relevant practices of the data governance concept for the specific needs of transportation data and to present possible ways of quality evaluation of these data. The paper describes the proposed requirements, tools and methodology for developing a complex approach to data governance and data quality evaluations. The functionality and benefits of the proposed procedures and their real implementation have been verified by applying the procedures on real data from selected profiles of the D11 motorway in the Czech Republic from the year 2023. The discussed results demonstrate the functionality of the proposed solution and allow for future largescale application of the verified procedure across the full geographic coverage of the data. It is also possible to apply the procedures and rules to other data sources or data from other types of roads including urban traffic."

Influence of Accessibility on Passenger Demand in Suburban Rail Transport

David Juřík, Vít Janoš

Land use, Railway, Regression model, Station, Transport demand, Transportation

"Transport planning is an important part of Smart City and Smart Region planning. For efficient transport it is needed to know the numbers of passengers at individual stops. When deciding about placing a new stop the information about the number of people using it is missing. Therefore, it is useful to be able to estimate the frequency of passengers. This paper is focused on determining the importance of different factors influencing frequencies of passengers at train stops. Data about frequencies and demographical characteristics in Ústí nad Labem Region, Czech Republic are used. The importance of factors is tested using correlation analysis, and a multinomial linear regression based on existing train stops is estimated."

Evaluation of Network Manager B2B Flight Data Accuracy

Vít Fábera, Marián Pánis

accuracy, airplane position, analysis, flight data, NM B2B

The Network Manager business-to-business services (NM B2B), a EUROCONTROL company in Europe specifically, collect flight data in European area and allow other companies to use their data in their own systems. The emphasis is focused specifically to the NM B2B Flight data, which obtains information about the predicted flight trajectories. The paper analyses the NM B2B Flight data accuracy in three different geographical areas of Europe while using multiple surveillance information sources for the comparison and complex evaluation. The areas with the highest accuracy were identified, as well as the disparities between individual sectors. The results of the work provide important insights into the behavior of NM B2B Flight data, which are crucial for further utilization. The study also presents the software module, which is capable of storing the data and evaluating it in real time. This feature enables the users to observe how the trajectory and the data precision evolve throughout the flight. Overall, the combination of the software solution and the accuracy analysis offers the benefits of utilizing the NM B2B data.

Transferability of ML Time Series Prediction for Energy Forecasting in Smart Homes

Filip Štolfa, Petr John, Jiří Hynek, Tomáš Hruška

Electricity Consumption Prediction, IoT, TCN, TCN-LSTM, Smart Grid

"This work explores the use of machine learning models (ML) in the context of Internet of Things-enabled smart energy management systems, particularly focusing on home energy management systems (HEMS). With the growing adoption of such devices, these systems have the potential to improve energy efficiency and reduce costs. This paper examines the feasibility of using time series prediction models for energy consumption forecasting, replacing traditional methods like Auto-Regressive Moving Average (ARMA) with deep learning approaches, namely Time Convolutional Network (TCN) and Temporal Convolutional Network – Long Short-Term Memory (TCN-LSTM) architectures. Using two smart home datasets, NIST and IHEPC, the paper evaluates the transferability and accuracy of the models. Results indicate that while the models perform well within a single dataset, they struggle to transfer reliably between datasets, likely due to the limited feature set used. Despite this, the models can be deployed on low-power devices with artificial intelligence (AI) chips, though their realworld application may require significant investment in sensors or reliance on third-party Application Programming Interfaces. The findings highlight the potential of machine learning in smart energy systems, while also addressing challenges related to model transferability and practical deployment. These findings contribute to Smart Cities Modeling by highlighting the role of machine learning in optimizing energy use for sustainable urban systems."

Validity of Speed-Based Congestion Detection in Traffic Data

Zuzana Purkrábková, Pavel Hrubeš

traffic data, floating car data, data quality, data analysis, correlation, congestion detection

In the Czech Republic, floating car data currently serve as a supplementary source of information on traffic conditions. This data source may become advantageous in the future, particularly due to its availability and independence from fixed infrastructure. Although this data includes several parameters related to congestion, its validity has not been sufficiently documented. This article focuses on analyzing the relationship between vehicle speed, travel time, and congestion detection to verify the quality and reliability of this data. Through statistical analyses, consistent correlations between speed parameters and travel time were identified, confirming their suitability for further traffic modeling. On the other hand, parameters related to congestion detection exhibit significant variability, indicating the need for more in-depth analysis and the application of more sophisticated modeling methods.

Diffusion of Innovation: A Systematic Literature Review of 3D Printing in Construction

Andrea Palazzo, Ulrike Michel-Schneider

3D printing in construction, additive manufacturing in construction, construction automation, diffusion of innovation

"This study assesses the adoption of 3D printing technologies in construction, focusing on materials, printer types, and broader trends. It examines key barriers and drivers influencing industry adoption.

Relevant studies from academic databases and industry sources were selected based on technological and economic aspects, including journal articles, conference papers, and industry reports resulting in the analysis of technology and material use, adoption trends, as well as barriers such as cost, regulatory challenges, and technical limitations, alongside drivers like sustainability demand and automation advancements. Findings show the adoption of the technology remains in the early stages, with uneven implementation across markets and different target markets. The study evaluates the pace of adoption and recommends strategies to accelerate the integration of 3D printing in construction. These include workforce re-skilling, enhanced government incentives, and cost-reduction initiatives. The study concludes that while 3D printing technologies hold immense potential to revolutionize construction, further effort is required to overcome technical, regulatory, economic, and social barriers for widespread implementation."

Enhance of License Plate Matching Procedure Quality Using Augmented Probability Matrix Method

Eva Hajčiarová, Kristýna Navrátilová, Jiří Růžička, Tomáš Tichý

license plate, license plate matching, LPR, ANPR, traffic data, quality, probability

"The issue of traffic data quality is an important part of the Smart City concept. Accurate and high quality traffic data serves cities not only for detailed traffic insights, online and offline traffic management, but also for future decision making on the im-plementation of strategic traffic measures. This paper focuses specifically on the processing and evaluation of data from constantly developing license plate recognition (LPR) systems and aims to develop a method that allows comparing text strings of license plate characters from different vehicle records and, without knowing the real (correct) shape of the license plate, determine whether the compared records belong to the same vehi-cle or not – in other words, whether they should be matched.

The paper builds on previous research and a quality improve-ment method based on a probabilistic model for two measurement profiles. This paper focuses on the application, actualization and extension of the mentioned method to LPR systems with arbitrary number of measurement profiles. The proposed tool has been tested on real traffic survey data and is shown to be fully applicable for application to areas with arbitrary number of measurement profiles."

Transparency in Czech Regions: Evaluation of Open Data Availability for Public Awareness

Kristýna Zaklová, Petr John, Adam Janošík, Jiří Hynek, Tomáš Hruška

Open Government Data, Smart City Sustainability, Regional Council, Government Transparency

"Innovations in information technology have created opportunities to improve living conditions for citizens and residents. One key development is the smart city concept, which offers benefits like ambient-assisted living. However, residents need to express their needs and evaluate whether legislators take meaningful steps to address them. Effective monitoring of policy decisions is necessary not only at the city level, but also for larger administrative units such as regions or the entire state. Effective monitoring requires leveraging open government data with appropriate tools to prevent misinformation and empty political promises. Assessing the availability and quality of these data is the key to achieving these objectives. The regional elections in autumn 2024 were an impulse for us to assess the transparency of Czech regional councils—specifically, how easily citizens can access and understand information about policy decisions that affect them. In addition to analysis of the available data and assessment of the transparency of the regions, our results include a process to achieve this goal, applicable to other OGDs, and unified datasets and visualizations confirming the universality of the tools we have developed."

A Spatial Algorithm for Dataset Integration Applied to Cycling Data

Radoslav Eliáš, Juraj Lazúr, Jiří Hynek, Tomáš Hruška

Data transformation, Data handling, Geospatial data, Data models, Cycling transport, Open Street Map

One of the main problems of modern Smart Cities is the constant increase in traffic volume and travel times. City governments are trying to address these problems by promoting alternative modes of transport, including cycling. The infrastructure of modern Smart Cities is planned on the basis of analyses obtained from various data sources. In the case of cycling, suitable data comes from e.g. automated counters, manual counts or training applications. The first step in the effective use of data is typically to assign the data to the corresponding physical infrastructure elements in real space. Thus, the geographic component of datasets plays an important role in linking them. However, different data sources describe the same infrastructure elements differently, which makes it impossible to link the datasets in a straightforward way. The city of Brno had to deal with such a problem when trying to use the available data sources to improve the quality of cycling infrastructure. The purpose of this paper was to propose a method for transforming the different input datasets describing cycling transport into a common dataset that will serve as a basic data source for the analyses. The result is an integration algorithm that links the data describing the same infrastructure elements. The output of the algorithm is a model mapping the individual datasets into one common mapping network. This mapping can then be applied to both existing and future data. The implemented solution was tested in cooperation with the Brno City Council, where the integration of 5 different datasets was tested. The use of the integrated data was subsequently tested within two implemented dashboards.

Passenger-Weighted Route Deviation Ratio (PWRDR) as a Parameter of Public Transport Quality

Patrik Horažďovský, Ondřej Přibyl

Public transport, Public transport Quality, Travel Time, Transport planning, Route Deviation

"Designing efficient and competitive public transport services in urban areas requires a balance between service quality, accessibility, and operational efficiency. While traditional planning methods primarily optimize for travel time and coverage, this paper introduces the Passenger-Weighted Route Deviation Ratio (PWRDR) as a novel parameter to evaluate the quality of transit routes. The PWRDR quantifies the extent to which a public transport line deviates from its direct path to serve additional areas, balancing accessibility and efficiency. This parameter considers the relationship between deviation length, travel time impact, population served, and the functional purpose of the route. We present a mathematical formulation and a methodological framework for integrating PWRDR into public transport planning. By incorporating this metric, planners can better assess the trade-off between directness and service coverage, leading to more effective and user-centered transit network designs."

Urban Parking Dynamics: One-Day Surveys for Long -Term Unused Vehicles – Part 2

Roman Dostál, Aneta Dostálová, Josef Kocourek

Adaptive policies, Data-driven planning, Long-term data, Parking surveys, Unused vehicles, Utilization rates, Vehicle turnover

Following up on previous research into parking survey methodologies, this study deals with the question of whether single-day surveys can reliably reflect long-term parking behavior. Utilizing an extensive 2024 dataset from a medium-sized Czech municipality, we compare short-term (1-day) and extended (4-day) survey results across diverse urban environments—including high-density, low-density, and mixed-use areas. The research aims to (i) reassess the prevalence of unused cars over different time spans, (ii) explore correlations between short-term parking data and factors such as population density and urban typology, and (iii) evaluate the ratio of unused cars in other environments, overall evaluating the potential for a simplified, cost-effective survey approach that remains methodologically robust. By integrating AI-assisted data collection with rigorous statistical analyses, our findings refine and extend earlier studies, establishing new connections between short-term observations and long-term parking dynamics.

Advancing Urban Mobility Through Design Research: A Case Study on Applying Adaptive Curbside Management in a Space-Constrained Street Environment

Markus Holzmair

Curbside Management, Autonomous, Dynamic, Modular, Virtual Reality, Eye Tracking, User Acceptability, Adaptive Architecture, Digital Twin, Smart Cities

Dynamic and Adaptive Curbside Management (ADCM) [1] advances traditional urban planning principles by enabling more flexible and responsive use of public space. While previous research has explored ADCM through autonomous robotic systems and modular elements, this study focuses on it's application in spatially constrained urban streets where full real-time adaptability is not feasible. Using Fraunhoferstraße in Munich as a case study - an arterial road with fixed tram infrastructure, high multimodal demand, and recent controversial design interventions - this research develops a practical, non-robotic design solution that integrates key elements of ADCM within the realm of existing regulations. The study applies design research, digital twin simulations, and stakeholder analysis to propose targeted urban interventions that improve functionality, safety, and urban livability. Currently; the conditions on Fraunhoferstraße are not favorable because of frequent traffic congestion, lack of shading, a lack of parking and loading zones, and a total absence of vegetation, leading to overall public disagreement with the current situation. This paper presents a strategy to improve the street's functionality through adaptive curb elements, improved space allocation, and urban design refinements that address the needs of all stakeholders - cyclists, pedestrians, public transit users, local businesses, and motorists. By showcasing a scalable and code-compliant approach, this research provides a model for integrating ADCM principles into historically significant and spatially-constrained urban environments.

Conceptual Approach to a Smart Way of Attracting Passengers to Trains through the Train Interior

Daniel Drnec, Michal Drábek

passenger preferences, perceived comfort, rolling stock interior, train interior

"Rail transport is a perspective transport mode of the future due to its low environmental impact. Various push and pull measures can be used to increase the modal share of rail. Given the restrictive nature of push measures, it is smart to make maximum use of pull measures. One of the pull measures is the user-friendly interior of rail vehicles, which is the aim of this paper. First, a review of existing studies and methods used to obtain user preferences is conducted. Based on the findings, a conceptual approach for obtaining user preferences and designing an optimal rolling stock interior concept was subsequently defined. The main idea of the proposed approach is to consider the passenger's stay in the vehicle as a dynamic process - the passenger does not only sit in a seat, but also moves during the journey (e.g. goes to the toilet, takes things out of carry-on luggage etc.). Another important part is to take into account external influences such as frequency of connections or journey times."

Virtual Reality as a Training Tool for Utility Vehicle Operators in Smart Cities

Petr Bouchner , Michal Cenkner, Naďa Tylová

Virtual reality, utility vehicle operator, design evaluation, ergonomics

The increasing complexity of urban mobility and infrastructure maintenance in smart cities necessitates the development of enhanced training methodologies for utility vehicle operators. This paper analyzes contemporary simulation techniques used in operator training, emphasizing the role of virtual reality (VR) in improving design evaluation, ergonomic assessment, and operator performance. We introduce a framework for integrating VR into the design evaluation process for next-generation utility vehicles within an immersive simulation environment. The presented approach incorporates objective metrics such as head and hand tracking and motion analysis, with subjective questionnaire-based feedback.

Spatio-Temporal Variability Estimations of Street Lighting Places using Night-Time Lights

František Kekula, Bernard Kosovec, Pavel Hrubeš

night-time light radiance, street-lighting places, earth observing data, planar point patterns, spatial descriptive measures, spatial density-based methods

Quantitative assessments of spatial and temporal distributions of street lighting across larger areas are difficult to make and express in such a form that would be appropriate as model inputs. This paper examines the density of street lighting places based on Earth Observing (EO) data in four urban areas of the Czech Republic. Previously processed GIS data of the night-time lights and planar point patterns of street lighting places were utilised. First, spatial measures of central tendency and dispersion were used to investigate the centrality and directionality of the point patterns. Second, density-based methods were conducted to assess the local and global densities of the patterns and measure the tendency to depart from Complete Spatial Randomness (CSR). Finally, the dependence of the point densities on the night-time light radiance was investigated by quadrat counting. The results of the spatial measures confirm strong directional patterns in smaller areas with sparse street lighting networks. Conditional Monte Carlo tests confirm that the point patterns deviate from CRS. Lastly, the density estimations based on night-time light radiance revealed that the higher density of points is accompanied by higher values of the radiance.

Issues of safety of autonomous railway operation at the GoA3 and GoA4 level

Martin Leso, Lukáš Kacar

Automatic train operation (ATO), Grade of automation (GoA), rail transport

This contribution discusses the issue of approaching safety issues for newly introduced autonomous rail vehicle operation systems with the GoA3/GoA4 automation level. In particular, the paper discusses the issue of normative requirements for establishing and demonstrating safety requirements that are in place today for railway systems. The paper seeks to define the minimum criteria or processes that should be met and demonstrated in order for autonomous train operation to be accepted as sufficiently safe for commercial operation.

Research highlights

FACULTY OF TRANSPORTATION SCIENCES CTU IN PRAGUE

LAMbDA

LAMbDA is a competence centre that solves problems of transport and logistics using appropriate mathematical methods and algorithms. The main knowledge of the laboratory includes mathematical modelling, statistical data processing, operational research and traffic simulations.

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We offer

We offer collaboration for PhD students in their dissertation topics as well as in scientific and commercial projects. We are particularly interested in the correct application of appropriate analytical tools in the following areas:

Mathematical modelling

- Econometric methods, logistic regression, hypothesis testing
- Models based on soft computing (FIS, ANN, ANFIS, GA, MAS, etc.)

Statistical processing of data from traffic detectors and traffic surveys

- Support for the preparation of surveys (including sociological surveys) and their evaluation

Operational research

- Linear programming tasks and applications
- Game theory
- Network optimization, graph theory

Our goal is to connect modern transportation and logistics problems with applied mathematics, assign appropriate approaches and solutions to specific topics to create better science.

Impact assessment of the impact of different measures (policies) (e.g. new vehicles, autonomous mobility, sharing economy, etc.)

- Traffic simulation tools to verify the impact of projects (in particular microscopic traffic simulation in SUMO, VISSIM and others), simulation using multi-agent tools (AnyLogic)
- Statistical processing of results

Application domains include:

- **Integration of automated and cooperative vehicles into traffic management**
  - **European project MAVEN** (Managing Automated Vehicles Enhances Network) (www.maven-its.eu) defined developed various use cases integrating cooperative vehicles into traffic management and provided impact assessment.
  - **TA ČR project AMCEMA** (Automated management center for minibuses as autonomous MoD) model of optimal routing algorithm regarding negociation of customer and provider goals
- **Automated train control using expert system**
  - **TA ČR project VEXA** (Development of an expert system for autonomous train) (https://vexa.fd.cvut.cz) tested automated train operation and its safety implications.
- **Quantification of congestions impact**
  - **TA ČR project GLOMODO** (Global transport model in Prague) developed among others a method for establishing cost of congestions.
- **Modelling of decision-making process in transportation and study of travel behaviour**
  - **European project Maas Together** uses various discrete choice models to understand main aspects affecting transport mode choice.
  - **OP VVV project SMART** (Smart City – Smart Region – Smart Community) used multiagent activity-based model MATSim to analyse impact of policies.
- **Highway management using soft computing methods (Fuzzy systems, Multi-agent systems)**
  - **National project TA ČR SIRID** (Development of a new generation of a highway management system) developed new concepts of highway management.
- **Smart City modelling and digital twins**
  - **NCK TAČR Smart Evropská** (digital polygon of the city of Prague) (https://gatetoeurope.eu/) integrated different domain-specific simulation tools to model policy impact.

CzeCCAM

CZECCAM

About CzeCCAM

The Czech Association for Autonomous and Cooperative Mobility (CzeCCAM) was founded at the beginning of 2023 with the goal of promoting an interdisciplinary and holistic approach to cooperative and automated transport.

It brings together key stakeholders in the fields of science and development in the Czech Republic with a long-term view of growing in relevant supporting areas such as law, the environment, and humanities. Its aim is to create a truly holistic design of new connected, cooperative, and automated mobility built on human and societal needs.

Research

The applied research in the field of autonomous transport and related new mobility systems is highly interdisciplinary. This implies that the problems at hand cannot be solved by small, distributed groups or start-ups. It requires the close cooperation of researchers, municipality representatives, and industry experts.

At the same time, it is not possible for a relatively small country such as the Czech Republic to have such a large number of cutting-edge teams at its disposal to afford competition in research. Involvement and cooperation of different stakeholders is a key assumption in achieving relevant outcomes within an acceptable time frame.

CzeCCAM is a **cooperative environment for all stakeholders in the area**. It offers a common space for aligning visions of future mobility systems and services, cooperation on mutual R&D projects and to promote conceptual think-tank like outcomes to relevant governmental institutions.

Focus of CzeCCAM

"Cooperative enviroment, not just vehicles"

The focus on **holistic research, design, and development of connected, cooperative, and automated human-centric mobility is crucial**:

- The control algorithms for cooperative traffic management should be distributed from the traffic management centers through traffic controllers to particular vehicles.
- The communication technology used for V2X (vehicle-to-anything communication) should be shared with other purposes, such as mobile communications, to reduce overall energy demands.
- At the same time, technology should be developed technology for including all (road) transport users in a connected environment.

For this purpose we will establish a **common**, however **distributed, R&D laboratory** to further investigate the interactions between all cooperative and also non-connected entities in road transport. These "United Labs" will follow the same low energy demanding approach and further support cooperation in CCAM topics.

CzeCCAM

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CZECCAM

FACULTY OF TRANSPORTATION SCIENCES CTU IN PRAGUE

Reliability and Safety in Aviation and Space

OUR SCOPE OF AVIATION AND SPACE RESEARCH

- Maintenance planning and planning optimization
- **Reliability and safety – tools based on knowledge modelling**
  - **Our solutions are based on own conceptualization and proper semantics:**
    - **Conceptualization of safety methods**
    - **Domain models of aircraft systems, failures, operational procedures etc.**
- Unmanned aircraft systems – HW and SW up to integration into airspace
- Human factor performance evaluation – through psychophysiological state
- Aircraft operation optimization
- Airport simulations
- CNS systems analysis and modelling

RESEARCH SCOPE IN RELIABILITY AND SAFETY

- Designing safe systems, Safety management, Investigation
- All types of aviation organizations, including regulators and the military
- Applying modern safety engineering, system safety approach, Safety-II
- Knowledge-driven SW tools, studies / development of safety methods

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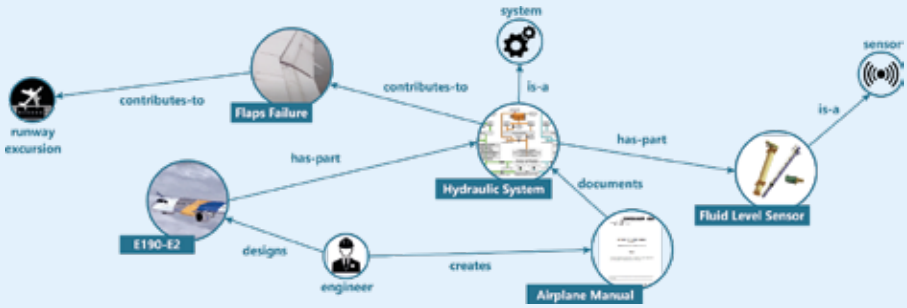
Conceptual Models

Our solutions are based on our own conceptualization and proper semantics.

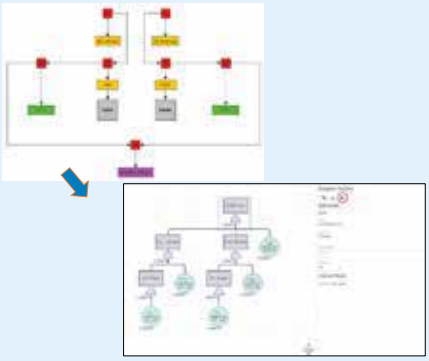
- Conceptualization of safety methods
- Domain models of aircraft systems, failures, operational procedures etc.



Reliability and Safety Tools

FTA/FMEA tool

- e.g. Automatic generation of FTA/FMEA analyses from product schemas



STAMP-based Investigation Tool

- Semi-automated of accidents and incidents, by meansinvestigation of process documentation (BPMN diagrams) and STAMP accident causality model.

FACULTY OF TRANSPORTATION SCIENCES CTU IN PRAGUE

TRESSA – Traffic-Related Environmental, Economic and Societal Sustainability Assessment

A tool evaluating the impact of transport on society and environment.

Supports data-driven decision-making on the implementation of various transport measures (policies).

Key Highlights

- **Critical Insights:** Unravel the complex effects of traffic congestion on environment, health, and societal costs (ESG).
- **Integrated Approach:** Comprehensive system view covering all transport modes and different data sources.
- **Data-Driven Decision Support:** Tools to aid data driven policy-making for transport measures based on merged heterogenous data sources.
- **Impact Assessment:** Quantifies congestion effects on fuel consumption, air quality, and ESG (Environmental, Social & Governance) factors.
- **Uniqueness and complexity:** First-of-its-kind approach reflecting Czech Republic's specific conditions in numerous aspects.
- **Validation:** Tested on real traffic data; adaptable for diverse urban settings, including assessment of impact on Václav Havel Airport operation.

Key Questions Answered

- How does traffic congestion affect our environment, health, and society?
- What is the monetary impact of various city policies and traffic organisation decisions?
- What are the societal costs of transportation delays?
- How traffic quality correlates across city?
- How to quantify impact of traffic resulting from decisions, urban planning, special events and more.

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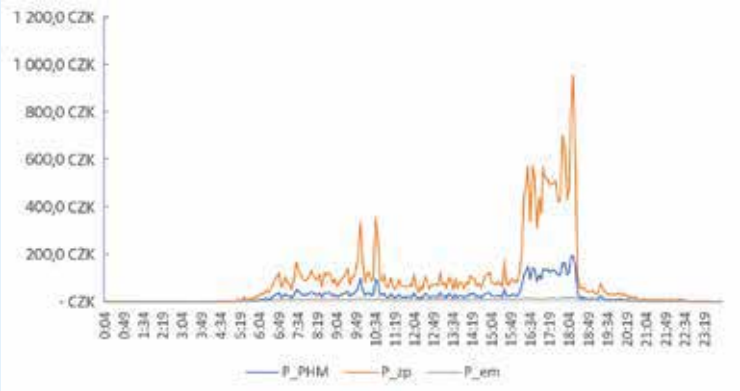
Project Outcome

↘ A validated, knowledge-based assessment tool empowering data-driven decisions, specifically calibrated for the Czech Republic's unique traffic and environmental conditions.



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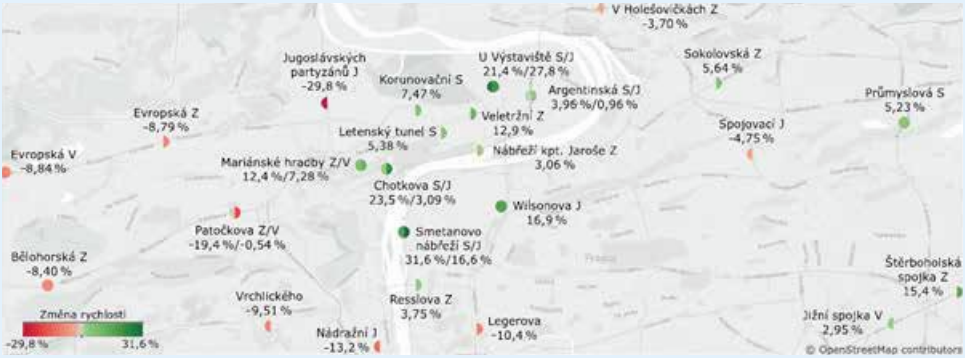
Ilustration of the cost of congestions during a day

P_PHM
Cost of increased fuel consumption

P_zp
Cost of lost time

P_em
Cost of increased production of emissions



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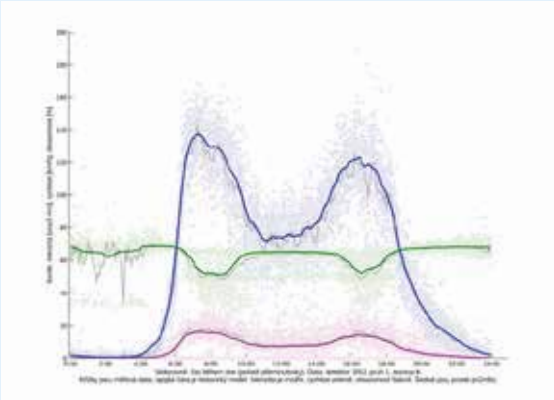
Change in the average speed on various strategic traffic detectors in Prague before (left)/after (right) opening tunnel complex Blanka



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Selected smoothed characteristics of a traffic flow on a selected sensor in Prague

More on
https://akce.fd.cvut.cz/en/scsp2025

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