

LABORATORY PROFILE

LAMBDA - Laboratory of Applied Mathematics in Transport and Logistics

Applied mathematics for future mobility

We turn transport data into models, models into decisions, and research into practical solutions.



Faculty of Transportation Sciences, Czech Technical University in Prague

WHAT WE BRING

Mathematical modelling, simulation, AI, statistics and optimisation - applied across five connected research pillars.

EVIDENCE IN PRACTICE**Traffic control**

Deployed line control in Prague and MAVEN impact assessment.

Digital twins

A calibrated corridor demonstrator and a deployment methodology.

Demand and service design

Published behavioural, MATSim and passenger-weighted studies.

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RESEARCH MAP

Five research pillars One methodological core.

01 Cooperative & Automated Traffic Management

How can vehicles and infrastructure cooperate to improve network performance?

02 Transport Digital Twins & Data Spaces

How can live transport data support reliable prediction and operational decisions?

03 Travel Behaviour & Choice

Why do people choose a travel mode, and what makes them change?

04 Activity-Based Demand Modelling & Synthetic Populations

How can individual daily activities reveal the effects of transport policies?

05 Public Transport & Flexible Mobility

When should a corridor use a fixed route, a hybrid service or Mobility-on-Demand?

SHARED COMPETENCES

Mathematical modelling

Econometrics, discrete choice, state-space models.

AI and soft computing

Neural networks, SHAP, fuzzy and multi-agent methods.

Optimisation

Operations research, game theory and network methods.

Simulation

SUMO, MATSim, Vissim, Aimsun and multi-agent models.

Statistics and data

Survey design, estimation, data fusion and processing.

Impact assessment

KPI design, scenario evaluation and model validation.

HOW WE JUDGE THE OUTCOME

Sustainability and resilience | Explainability and human oversight
Evidence for policy and practice

PILLAR 01 / WORK AND EVIDENCE

Cooperative & Automated Traffic Management

How can vehicles and infrastructure cooperate to improve network performance?

We develop and evaluate traffic control for motorways and urban networks, combining interpretable control algorithms, connected vehicles and simulation. Our experience spans deployed line control in Prague and cooperative automation evaluated in the European MAVEN project.

CONCRETE WORK COMPLETED

- Deployed** Developed a motorway line-control system now operating on the Prague City Ring Road.
- Evaluated** In H2020 MAVEN, CTU led impact assessment of cooperative green-wave and signal-negotiation scenarios.
- Measured** Compared capacity, queues, delay and CO2 with defined simulation baselines; selected results are shown below.



MAVEN field demonstrator: automated approach to a signalised intersection. Source: MAVEN project / LAMBDA archive.

+34%

network capacity

-74%

average queue length

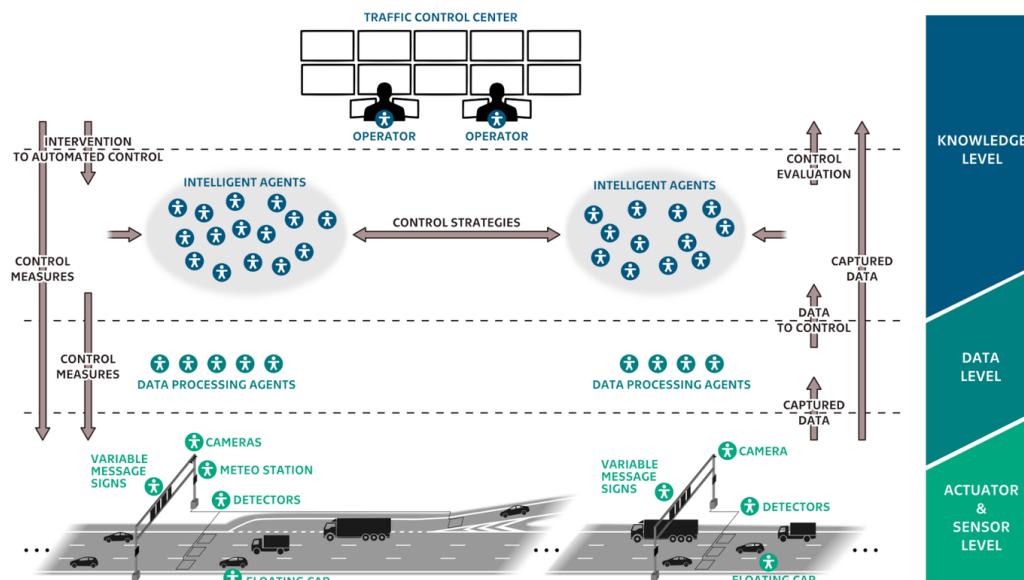
-11%

CO2 emissions

MAVEN integrated green-wave impact-assessment simulations with speed and lane advice, relative to the project baseline. Scenario-specific results; field demonstrations tested functionality.

PILLAR 01 / METHOD, EVIDENCE AND COLLABORATION

Cooperative & Automated Traffic Management



Three-level multi-agent traffic management architecture. Source: LAMBDA research archive.

PROVEN RESULT

A motorway line-control system developed under TA ČR ALFA was deployed on the Prague City Ring Road. In MAVEN, CTU led impact assessment and evaluation and contributed to city engagement.

RESEARCH FRONTIER

Cooperating signals and vehicles, per-vehicle prioritisation and transferability between Prague and Taipei. The Taiwan Tech research line is in development; substantive results are expected from 2027.

WHAT WE CAN DELIVER WITH A PARTNER

With traffic management centres, ITS suppliers and CCAM demonstrators: define scenarios, develop control algorithms and lead independent simulation-based evaluation.

SELECTED PUBLICATIONS AND OUTPUTS

Příbyl, Blokpoel & Matowicki (2020). Addressing EU climate targets: Reducing CO2 emissions using cooperative and automated vehicles. Transportation Research Part D, 86, 102437.

[doi:10.1016/j.trd.2020.102437](https://doi.org/10.1016/j.trd.2020.102437)

Kuklová & Příbyl (2017). Changeover from decision tree approach to fuzzy logic approach within highway management. Neural Network World, 27, 181-196.

[doi:10.14311/NNW.2017.27.008](https://doi.org/10.14311/NNW.2017.27.008)

PILLAR 02 / WORK AND EVIDENCE

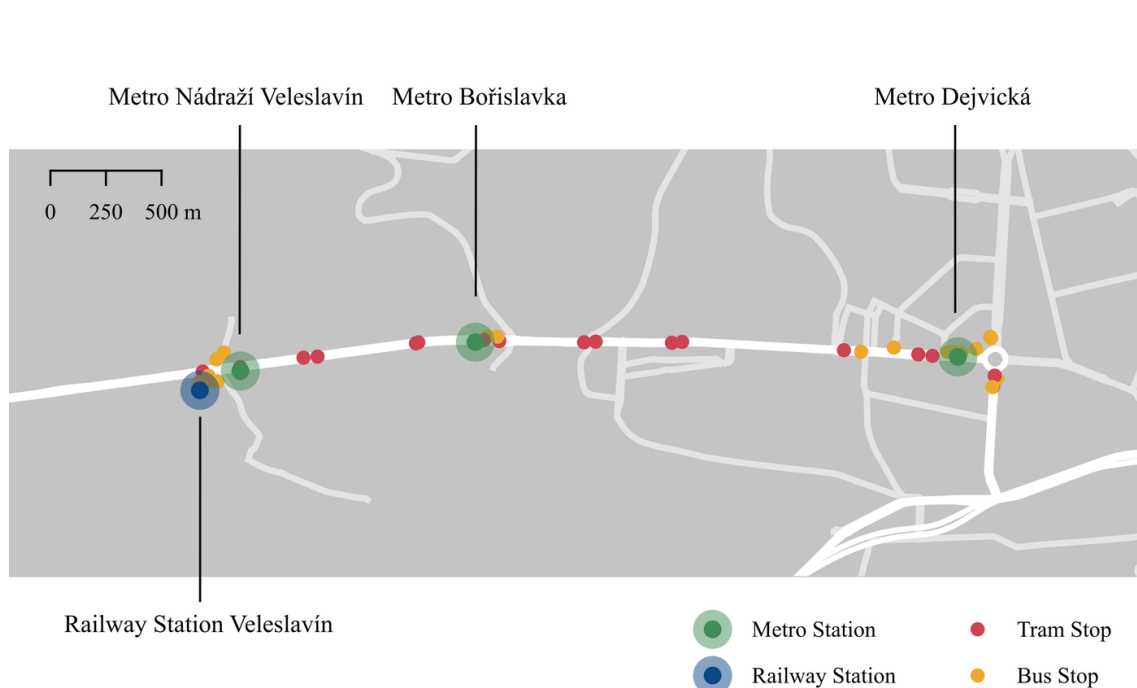
Transport Digital Twins & Data Spaces

How can live transport data support reliable prediction and operational decisions?

We connect heterogeneous city data to continuously calibrated transport models. The Evropská corridor demonstrator provides an evidence base for data integration, short-term forecasting and the design of human-in-the-loop decision support on road and rail networks.

CONCRETE WORK COMPLETED

- Integrated** Combined detector, vehicle and public-transport data from five provider organisations in the D3E corridor demonstrator.
- Calibrated** Continuously adapted a SUMO model to observed flows while enforcing physically consistent junction and screenline flows.
- Forecast** Ran 5-, 10- and 15-minute predictions; the 5-minute simulator forecast reduced RMSE by 45.5% against persistence.



D3E study corridor on Evropská, Prague: road traffic, public transport and signalised intersections. Source: D3E / LAMBDA.

GEH < 5

six evaluated detectors

45.5%

lower 5-min forecast RMSE

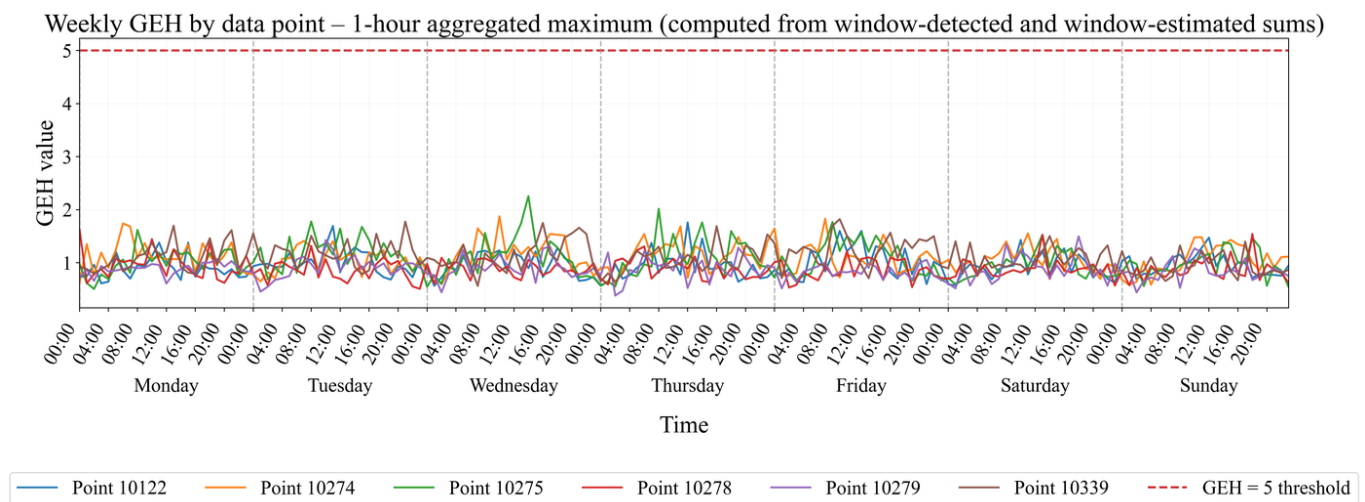
5

data-provider organisations

LAMBDA project evaluation: 3-9 November 2025. Simulator RMSE 120.88 vs persistence 221.89 vehicles/hour at 5 minutes; reduction calculated as $1 - 120.88/221.89$. Results apply to this evaluation.

PILLAR 02 / METHOD, EVIDENCE AND COLLABORATION

Transport Digital Twins & Data Spaces



GEH validation over the evaluation week; threshold shown at 5. Source: D3E / LAMBDA project evaluation.

PROVEN RESULT

D3E delivered a structured database, an offline model, a functional demonstrator and a Ministry of Transport-endorsed deployment methodology. The data concentrator and calibrated forecasting workflow are demonstrated assets.

RESEARCH FRONTIER

A railway reference architecture couples asset health, operations and resilience. Human-in-the-loop operator studies and empirical validation of the railway architecture remain research tasks. European rail consortia are a collaboration target.

WHAT WE CAN DELIVER WITH A PARTNER

With cities, twin-platform developers and infrastructure managers: specify data interfaces, calibrate models, validate forecasts and design an operator-approved decision loop.

SELECTED PUBLICATIONS AND OUTPUTS

Lom & Přibyl (2021). Smart city model based on systems theory. International Journal of Information Management, 56, 102092.

[doi:10.1016/j.ijinfomgt.2020.102092](https://doi.org/10.1016/j.ijinfomgt.2020.102092)

Přibyl, Přibyl & Svátek (2021). Interdisciplinary Urban Tunnel Control within Smart Cities. Applied Sciences, 11, 10950.

[doi:10.3390/app112210950](https://doi.org/10.3390/app112210950)

PILLAR 03 / WORK AND EVIDENCE

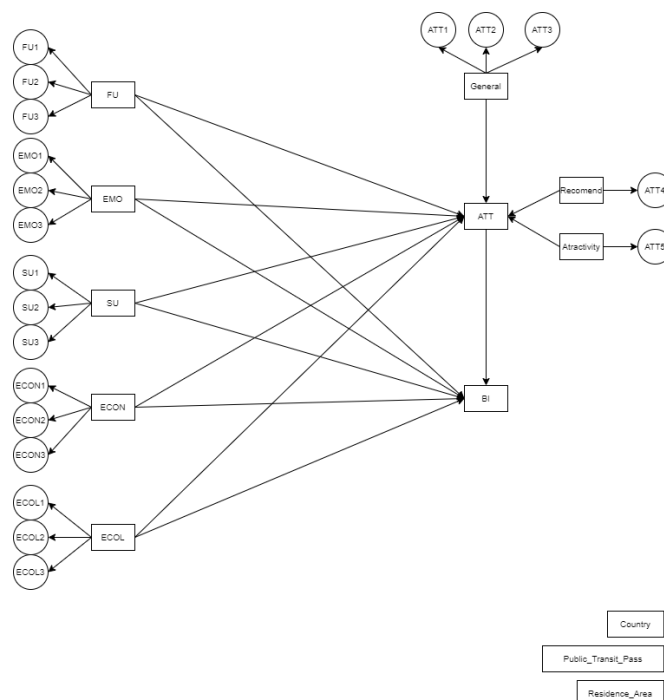
Travel Behaviour & Choice

Why do people choose a travel mode, and what makes them change?

We combine behavioural theory, survey research, econometrics and explainable machine learning. Our studies address mode choice, MaaS adoption, habitual car use and the gap between stated intentions and feasible changes in everyday travel.

CONCRETE WORK COMPLETED

- Collected** Surveyed 6,405 urban daily commuters in Germany, Czechia, Poland and the United Kingdom.
- Estimated** Published a mixed-choice model of MaaS preferences and service sensitivities in Transportation.
- Explained** Applied a deep neural network and SHAP to identify variables associated with predicted mode choice; this is not a causal model.



Structural model of the intention-behaviour gap, estimated from the SMART and MaaS survey programme. Source: LAMBDA.

6,405

urban daily commuters

4

European countries

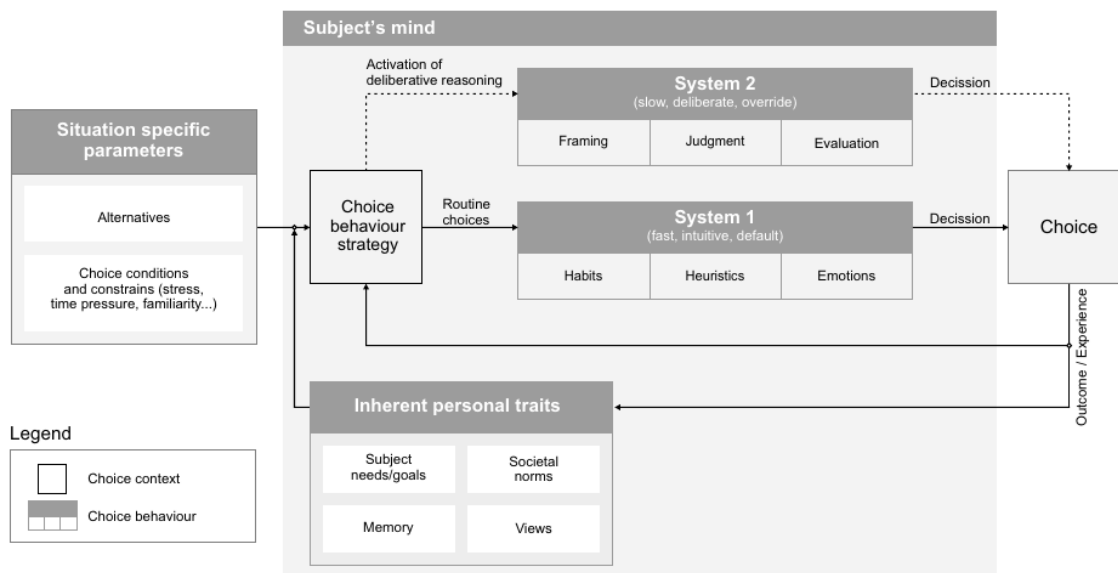
2026

Transportation issue publication

MaaS choice study: Germany, Czechia, Poland and the United Kingdom; Matowicki et al., Transportation 53, 399-432 (online 2024). Survey evidence concerns preferences and potential adoption.

PILLAR 03 / METHOD, EVIDENCE AND COLLABORATION

Travel Behaviour & Choice



SPARC dual-process framework: a research direction linking habits, heuristics and deliberation to model structures. Source: LAMBDA; under development.

PROVEN RESULT

Published mixed-choice modelling compares potential MaaS users across four countries. Further studies examine carsharing purposes, habitual car users and DNN/SHAP mode-choice interpretation.

RESEARCH FRONTIER

SPARC maps psychological mechanisms to mathematical model structures. Current work seeks testable formulations of habit, deliberation and adaptation, and links behavioural learning to demand models.

WHAT WE CAN DELIVER WITH A PARTNER

With cities, mobility providers and behavioural researchers: design a focused survey, estimate service sensitivities and assess how proposed services could complement public transport.

SELECTED PUBLICATIONS AND OUTPUTS

Matowicki et al. (2026). Complementing or competing with public transit? Evaluating the parameter sensitivity of potential MaaS urban users in Germany, the Czech Republic, Poland, and the United Kingdom with a mixed choice model. *Transportation*, 53, 399-432.

[doi:10.1007/s11116-024-10501-9](https://doi.org/10.1007/s11116-024-10501-9)

Çevik, Přebyl & Samandar (2024). Understanding travel behavior: a deep neural network and SHAP approach to mode choice determinants. *Neural Network World*, 34, 219-241.

[doi:10.14311/NNW.2024.34.012](https://doi.org/10.14311/NNW.2024.34.012)

PILLAR 04 / WORK AND EVIDENCE

Activity-Based Demand Modelling & Synthetic Populations

How can individual daily activities reveal the effects of transport policies?

We generate synthetic populations, construct daily activity plans and simulate travel with MATSim. The published Ústí nad Labem pipeline connects population synthesis to policy analysis; current work extends demand modelling and its links to operational simulation.

CONCRETE WORK COMPLETED

- Built** Created a synthetic population for the Ústí nad Labem region from census and micro-survey inputs.
- Generated** Assigned each synthetic agent a 24-hour activity schedule and simulated route, mode and timing adaptation in MATSim.
- Applied** Used the resulting agent-based model in a published regional transport-policy analysis in Transportation.

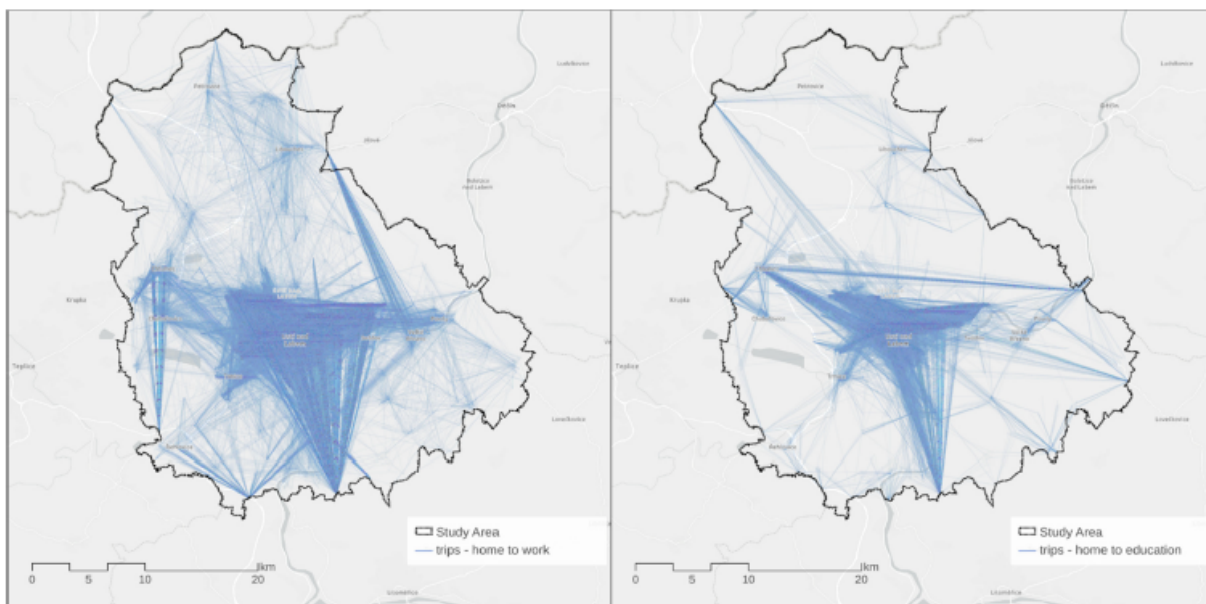


Figure 9. Origin–destination (OD) pairs of the primary activity trips (from home to work location (left) and from home to education location (right)).

Generated home-work and home-education OD pairs, Ústí nad Labem. Maia Pereira et al. (2022), Applied Sciences, Fig. 9, CC BY.

24 h

daily agent activity plans

2022

published synthesis pipeline

2025

published policy application

Regional implementation and policy analysis documented in Applied Sciences (2022) and Transportation (2025). National-scale synthesis is a RESISTRANS research objective.

PILLAR 04 / METHOD, EVIDENCE AND COLLABORATION

Activity-Based Demand Modelling & Synthetic Populations

1. Census + surveys

2. Synthetic agents

3. Daily activities

4. MATSim plans

5. Policy scenarios

6. Impact appraisal

Research workflow: population and behaviour assumptions remain traceable through to scenario outcomes. Synthesis based on the published LAMBDA pipeline.

PROVEN RESULT

A published regional pipeline creates agents and daily schedules for MATSim. A subsequent Transportation article applies the agent-based model to transport-policy analysis in Ústí nad Labem.

RESEARCH FRONTIER

National-scale synthetic populations, demand under disruption and coupling between slow behavioural adaptation and fast operational models. Transferability requires calibration and validation in each new region.

WHAT WE CAN DELIVER WITH A PARTNER

With planning agencies, MATSim teams and crisis-mobility researchers: build a regional population, validate travel demand and compare a defined set of pricing, service or disruption scenarios.

SELECTED PUBLICATIONS AND OUTPUTS

Maia Pereira et al. (2022). An Advanced Travel Demand Synthesis Process for Creating a MATSim Activity Model: The Case of Ústí nad Labem. Applied Sciences, 12, 10032.

[doi:10.3390/app121910032](https://doi.org/10.3390/app121910032)

Dingil et al. (2025). Evidence-based transport policy analysis driven by agent-based simulation: the case of mobility in Ústí nad Labem. Transportation, 52, 1191-1219.

[doi:10.1007/s11116-023-10453-6](https://doi.org/10.1007/s11116-023-10453-6)

PILLAR 05 / WORK AND EVIDENCE

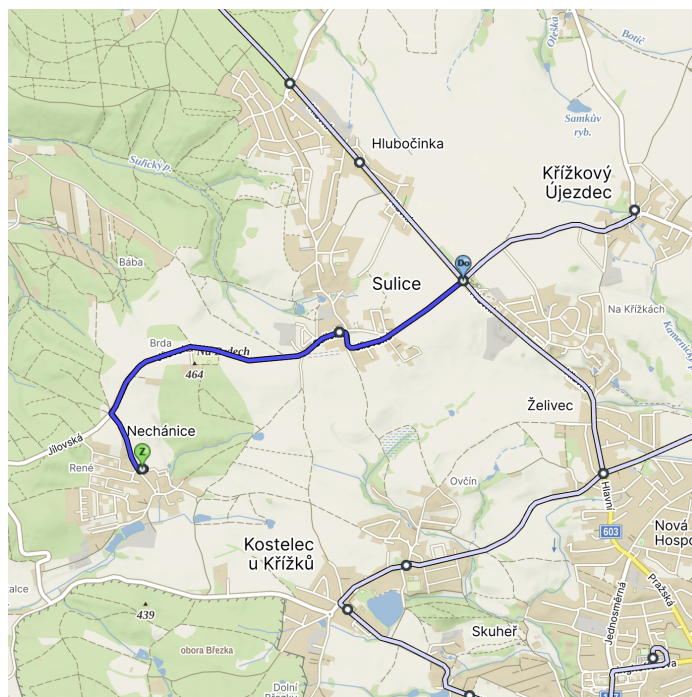
Public Transport & Flexible Mobility

When should a corridor use a fixed route, a hybrid service or Mobility-on-Demand?

We evaluate public transport from the passenger's perspective. Route-deviation indicators connect accessibility and directness to who actually benefits. This empirical work supports a broader research direction on the suitability of fixed and flexible services.

CONCRETE WORK COMPLETED

- Rebuilt** Reconstructed full-year 2025 operational records for Prague suburban routes 335, 337 and 339 at inter-stop-section level.
- Linked** Connected GTFS trips, automatic passenger counts and OSRM reference paths, including branch and deviation structures.
- Published** Introduced the Passenger-Weighted Route Deviation Ratio to quantify whether a detour benefits the passengers using it.



A deviation in the Prague suburban network: local access improves while through passengers travel farther. Source: LAMBDA PT research.

PWRDR

published indicator, 2025

3 routes

335, 337 and 339

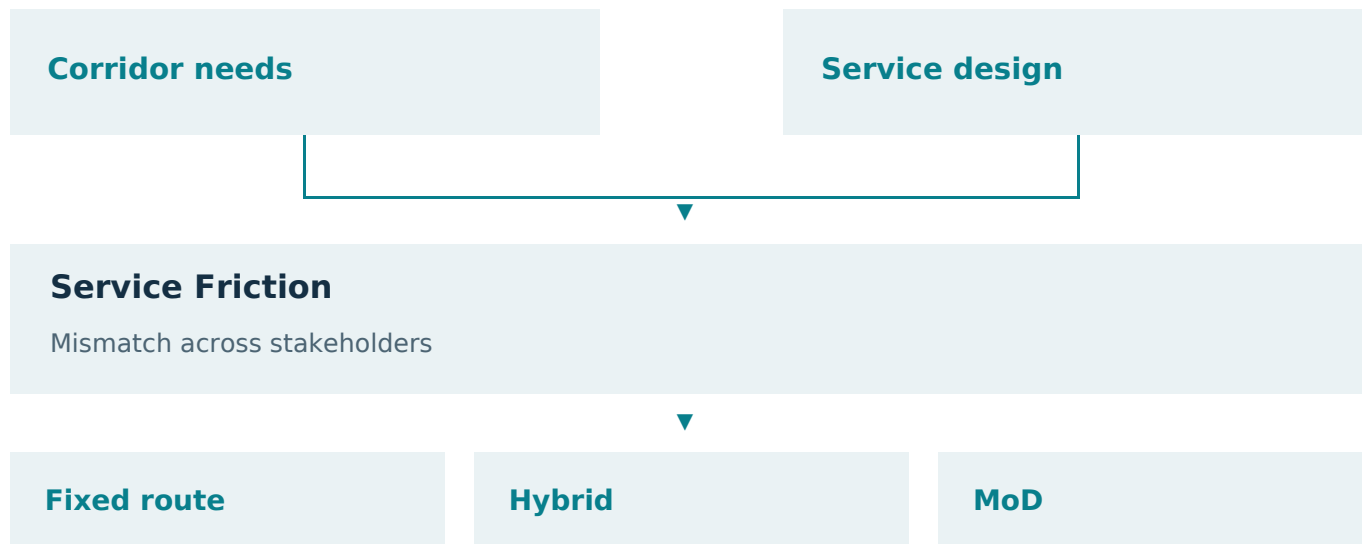
2025

operational-data coverage

Case-study scope: full-year 2025 operational records and APC observations September 2025-February 2026. Service-effect estimates are under development.

PILLAR 05 / METHOD, EVIDENCE AND COLLABORATION

Public Transport & Flexible Mobility



Service Friction research: simplified conceptual overview adapted from LAMBDA. Empirical transition boundaries remain under development.

PROVEN RESULT

The Passenger-Weighted Route Deviation Ratio is published in Transactions on Transport Sciences. The data workflow links observed operations and passenger counts to route structure in Prague suburban services.

RESEARCH FRONTIER

Net Passenger-Time Balance and the Theory of Service Friction are under development. The aim is to identify when access gains justify detours and when a different service configuration becomes preferable.

WHAT WE CAN DELIVER WITH A PARTNER

With transport authorities and MoD operators: diagnose one corridor, quantify access and in-vehicle-time trade-offs, and compare fixed, hybrid and flexible service scenarios using observed demand.

SELECTED PUBLICATIONS AND OUTPUTS

Horažďovský & Příbyl (2025). Passenger-Weighted Route Deviation Ratio (PWRDR) as a Parameter of Public Transport Quality. Transactions on Transport Sciences, 16 (SI SCSP), 32-36.

[doi:10.5507/tots.2025.008](https://doi.org/10.5507/tots.2025.008)

Jirmanová, Horažďovský & Příbyl (2026). From Metrics to Decisions: Interpreting Route Deviation and Service Quality Indices in Public Transport Planning. Smart Cities Symposium Prague.

[doi:10.1109/SCSP69985.2026.11548643](https://doi.org/10.1109/SCSP69985.2026.11548643)

PLATFORMS AND RESEARCH ENVIRONMENT

Research with a route to real-world use

RESISTRANS | NATIONAL RESEARCH PLATFORM

A six-year centre for smart and resilient mobility, coordinated by CTU and led by Ondřej Přibyl. It connects transport research, industry and public-sector needs.

2026-2031

research programme

13

consortium participants

273.6m

CZK, total eligible cost

TA ČR SIGMA TQ28000041. Figures refer to the whole consortium. Source: supplied Dossier V2, section 10.1.

Evropská living lab

A multimodal Prague corridor, municipal data integration and a calibrated model support technology evaluation and transfer to another city.

Industry and operator links

Cooperation includes SmartPlan in urban modelling and AŽD Praha in railway automation. CzeCCAM connects the work to the Czech automated-mobility community.

International research experience

MAVEN, nuMIDAS, STORM and PLIADES provide EU project experience. Taiwan Tech cooperation supports comparative traffic-control research.

Engagement with decision makers

The RESISTRANS external board includes the Ministry of Transport, Správa železnic, ŘSD, the State Fund for Transport Infrastructure, the Ministry of Defence and the Police of the Czech Republic.

Collaboration can combine a defined research task, an operational study site and validation against a shared set of performance measures.

WORK WITH LAMBDA

Start with a decision that needs evidence.

A useful first project has a specific operational question, accessible data and an outcome that a partner can act on.

A CITY OR TRAFFIC OPERATOR**Evaluate a control or digital-twin intervention.**

Site model, baseline, candidate measures and impact evaluation.

A TRANSPORT AUTHORITY OR MOD PROVIDER**Choose an appropriate service for one corridor.**

Passenger-time diagnosis and fixed, hybrid or flexible scenarios.

AN INFRASTRUCTURE OR RAIL PARTNER**Connect asset and operational knowledge.**

Data requirements, model architecture and a validation plan.

A RESEARCH CONSORTIUM**Add a defined modelling and evaluation contribution.**

Behavioural studies, demand simulation or evaluation leadership.

TO SCOPE A JOINT TASK, BRING

One question to resolve; the study area or system; available data; and the decision or deliverable the work must support.

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Research Highlights 2026 | Prepared from Dossier V2 and the LAMBDA research archive.