



Yisheng Lv¹⁰, Editor

An Introduction to the Chair of Traffic Process Automation

EDITOR'S NOTE

Please send your proposal on profiling research activities of your or other intelligent transportation systems research groups and labs for the "ITS Research Labs" column to Yisheng Lv at yisheng.lv@ia.ac.cn.

Vision and Mission

The transport community is facing pressing challenges. Road fatalities, congestion, and emissions are jeopardizing the sustainability goals of our transport system. Moreover, transitions in transport systems are taking place at an unprecedented pace due to revolutionary technologies of communication, automation, and electrification. These challenges and technologies trigger a series of societally relevant yet scientifically fundamental questions regarding the operations of multimodal transport systems. Such questions include, What behavioral changes will emerge for users and traffic systems during the transitions? What are the impacts of disruptive technologies on traffic operations? How should we design, manage, and leverage these technologies for a sustainable transport system? Answers to these

questions are of paramount importance to our society.

The Chair of Traffic Process Automation strives to tackle the aforementioned challenges and questions by leveraging emerging concepts and technologies to optimize the operations of multimodal transport systems. We substantiate our vision with three missions:

- 1) conducting interdisciplinary research crossing transport, behavior, network, systems, and automation sciences
- 2) educating next-generation researchers and engineers
- 3) transferring knowledge and design solutions to public and private stakeholders.

To achieve our vision, we take a dynamic system approach (Figure 1) that revolves around four pillars that interact with and reinforce one another: 1) theories and models for understanding user behavior and collective traffic dynamics, 2) model-based and data-driven methods for estimating and predicting user behavior and system evolution, 3) strategies for optimizing and controlling traffic operations, and 4) procedures, metrics, and tooling for testing system performance and assessing macroscopic impact. The focal area of research of the Chair of Traffic Process Automation includes traffic dynamics modeling and simulation, multimodal traffic

management, cooperative and automated transport, and cooperative intelligent transportation system (C-ITS) services for passengers, drivers, cyclists, and pedestrians.

History

Since the founding of the College of Transport Studies (HfV), University

QUICK FACTS

Lab Name: Chair of Traffic Process Automation

Affiliation: "Friedrich List" Faculty of Transport and Traffic Sciences, TU Dresden

Website: www.tu-dresden.de/vpa

Established: 1950s

Research Focus: Multimodal traffic modeling and control, cooperative intelligent transportation systems, and autonomous vehicles

Director: Meng Wang



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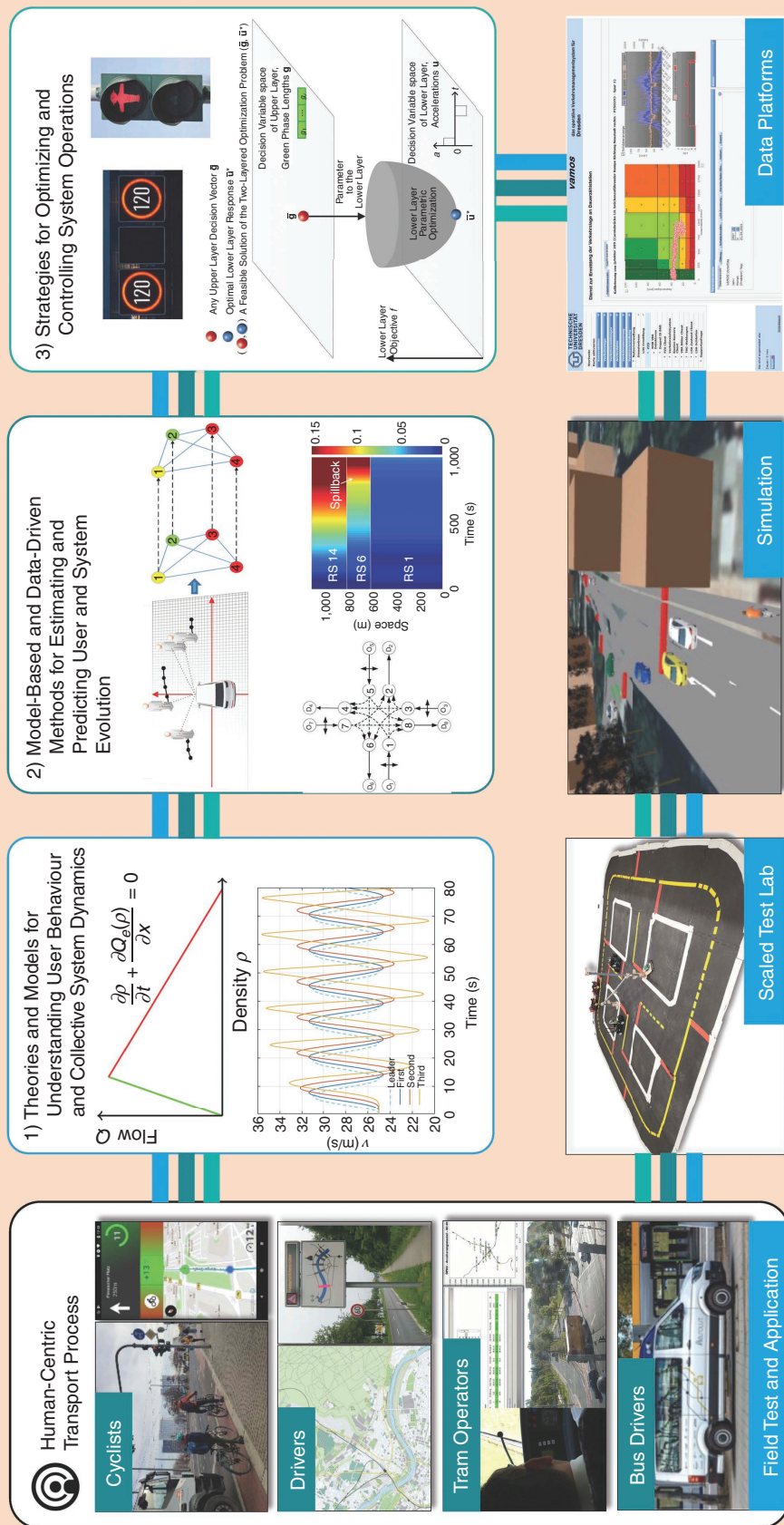


FIG 1 The dynamic system approach to address challenges in human-centric transport process: the theory/model, estimation/prediction, optimization/control, and testing/assessment.

of Transportation Dresden, in the 1950s, the Chair of Traffic Process Automation has been concerned with issues of control engineering and process automation in the application field of traffic. Under the leadership of Prof. Horst Strobel, the theory of energy-optimal train trajectories was developed. After the integration of the HFV as the “Friedrich List” Faculty of Transport and Traffic Sciences, TU Dresden, in 1992, these activities seamlessly continued. The first attempts at ITSs were developed and piloted in the 2000s under the label *das Verkehrs-, -Analyse-, -Management, und Optimierungssystem (VAMOS, or Traffic Analysis, Management, and Optimization System in English)*, the operational traffic information and dynamic route guidance system for the city of Dresden (Figure 2). Under the leadership of Prof. Jürgen Krimmling, the successive expansion of the sensors and actuators for the VAMOS system was

implemented. Driver advisory systems were developed for trains and trams along with a multicriteria traffic light control system that takes into account delays of both passenger cars and public transport. After a transition period (2019–2021) led by Dr. Birgit Jaekel, Prof. Meng Wang took the post as head of the Chair of Traffic Process Automation in 2021.

Current Activities

The Chair of Traffic Process Automation works closely with public authorities, industrial partners, and research institutions on topics of traffic monitoring and control, C-ITSs, artificial intelligence (AI) applications in transport, and automated vehicles.

VAMOS Traffic Information System

The Chair of Traffic Process Automation has been developing and maintaining the operational traffic management system for Dresden (VAMOS) since 2003.

VAMOS connects the traffic detectors available in the region and the various traffic control and guidance systems of the urban road network and the highways. The core of VAMOS is Dresden’s traffic data center. It collects data from more than 1,800 traffic sensors on urban roads in Dresden. Thanks to a successful partnership with the State Office for Road Construction and Transport, we are able to extend the data center through traffic sensors on state roads, including roadside units and Bluetooth units. The VAMOS data center has been supporting research topics on traffic flow modeling and simulation, data imputation, and traffic state estimation and prediction.

Jena 5G Vehicle-to-Everything

The project is funded by the German Federal Ministry for Digital and Transport. It aims at increasing the safety of vulnerable road users (VRUs) and optimizing traffic by taking benefits

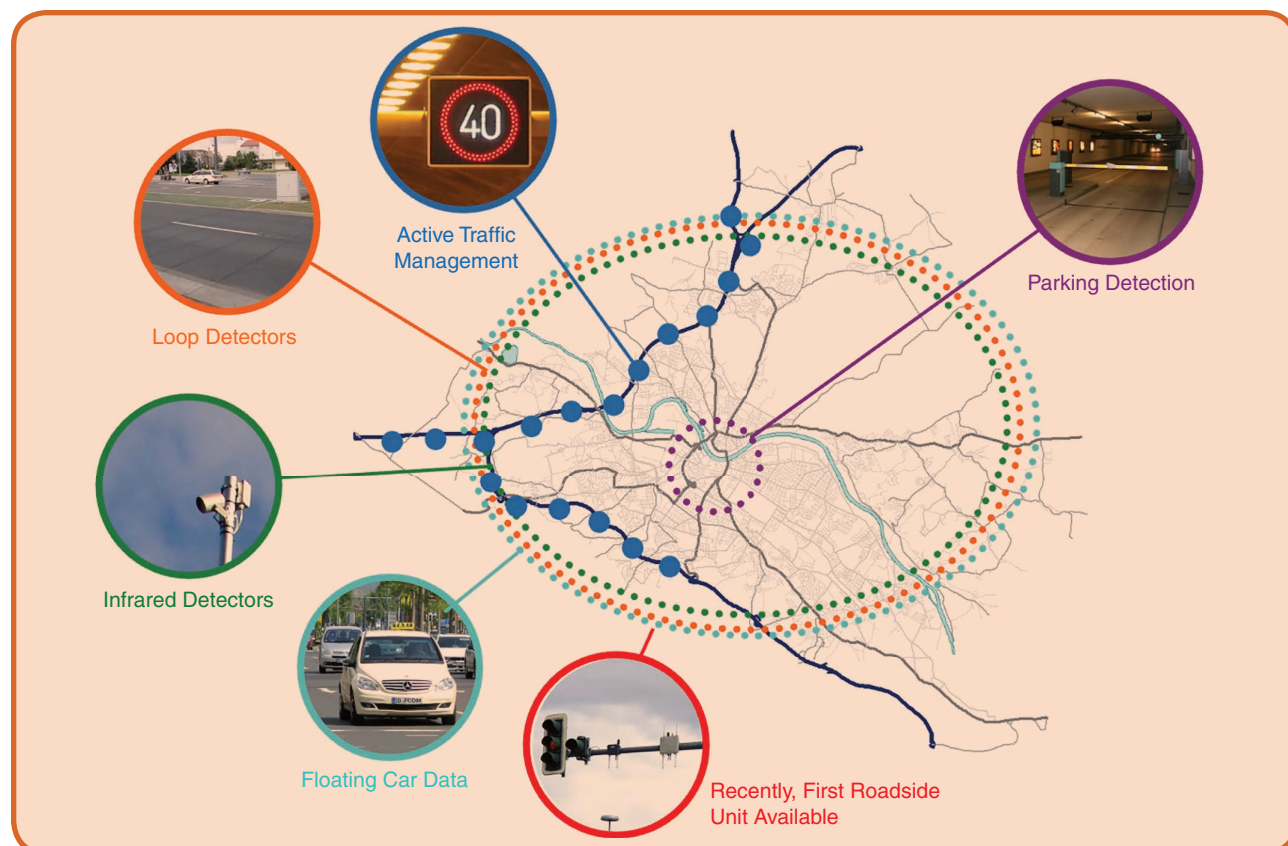


FIG 2 The VAMOS traffic information system.

Dynamic speed recommendation will enable drivers to avoid unnecessary braking and acceleration at traffic lights and hence reduce energy consumption.

for all transport modes into consideration. The project is realized in the city of Jena. One focus of the Chair of Traffic Process Automation is an intersection collision risk warning system for VRUs. Based on the evaluation of information transmitted by vehicle-to-everything (V2X) messages of traffic participants and infrastructure, future movements are predicted, associated uncertainties quantified, and collision probabilities assessed. Depending on the results of the assessment, warning strategies are applied. The second focus is the development of adaptive traffic signal control for multimodal traffic at coordinated intersections. Our approach combines the design of centralized and local control units for optimized phase selection based on information transmitted by V2X messages. The centralized unit contains a reinforcement learning-based algorithm selecting optimal phases, which are realized by the local units.

PrioBike-HH

The PrioBike-HH project (Figure 3) is funded by the German Federal Ministry for Digital and Transport and realized in the city of Hamburg. To increase the share of cycling, it is essential to promote its attractiveness. People travel by bicycle especially when they feel safe and comfortable when cycling. Both issues are addressed in the project. The project will develop a cyclist information system that gives cyclists a speed recommendation which, if followed, will allow them to arrive at the next traffic light during a clearance. An app is being developed that will provide customized speed recommendations and offer multicriteria bicycle routing. The app will simultane-

ously collect anonymized movement data of cyclists, which will then be available for analysis. Furthermore, a traffic situation-dependent multimodal optimization of the coordination of traffic signals is being developed, in which the progression speed of cyclists is considered.

Multicriteria Traffic Signal Control System and Implementation in Dresden and Leipzig

The quality-based traffic light control system aims to provide reliable and punctual public transport services to passengers by giving dynamic pri-

orities to public transport based on its timetables while balancing the delays of public transport and motor vehicle traffic. Accordingly, delayed buses and trams will be given higher priority, whereas pedestrians, cyclists, and motor vehicle traffic will benefit from longer clearance times when buses and trams run early. In addition, the driver advisory system has been integrated into the onboard units of trams in Dresden and Leipzig. The dynamic speed recommendation will enable drivers to avoid unnecessary braking and acceleration at traffic lights and hence reduce energy consumption and increase passenger comfort. The system is being rolled out in Dresden and Leipzig.

ABSOLUT

The Automatischer Busshuttle selbstorganisierend zwischen Leipzig und dem BMW-Terminal (ABSOLUT) project is funded by the German Federal Ministry for Economic Affairs and Climate Action and focused on the practical application of networked and automated shuttle buses in urban settings. To demonstrate this concept, a specialized vehicle was developed and has been in operation along a 7-km test track, running between S-Bahn station Messe and the BMW plant in Leipzig. This vehicle operates with a high level of automation, reaching speeds of up to 50 km/h on public roads. To support the project, all 12 traffic light systems on the test track have been equipped with roadside units to connect the shuttle with the surrounding infrastructure. The Chair of Traffic Process Automation is responsible for monitoring vehicle-infrastructure cooperation and ensuring efficient traffic signal control, particularly with regard to prioritizing public transport.

Education

We educate future researchers and engineers in ITSs. The teaching focuses on scientifically demanding courses, including traffic flow theory and

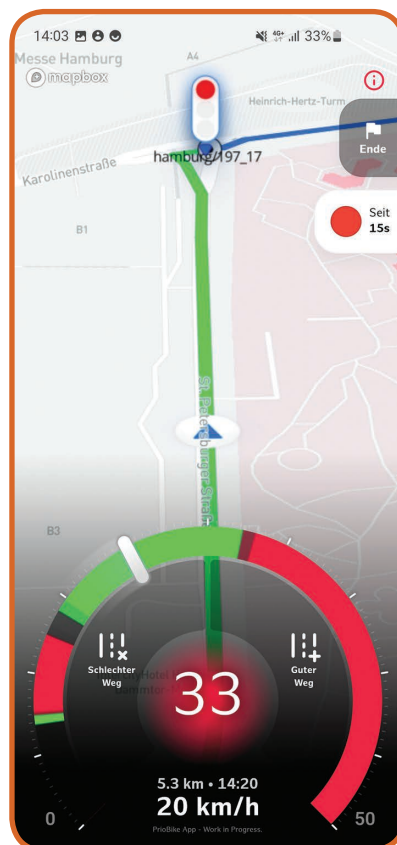


FIG 3 The PrioBike App.

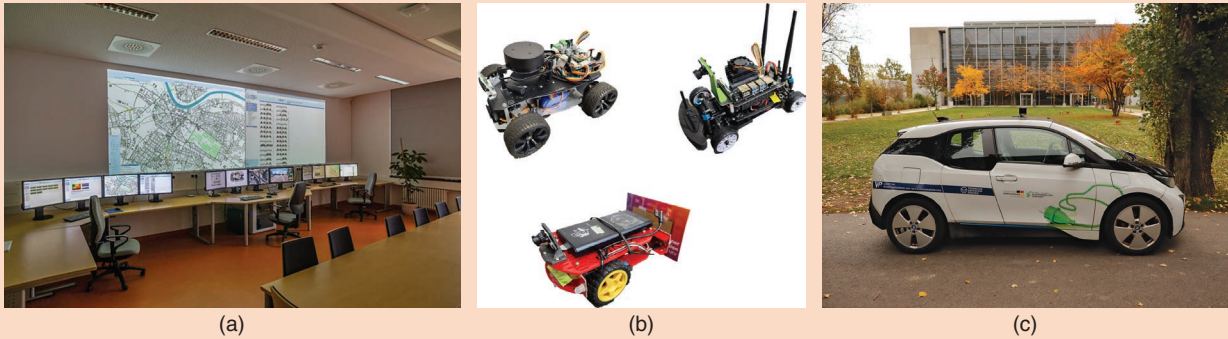


FIG 4 Research infrastructure at the Chair of Traffic Process Automation. (a) The traffic data platform. (b) Scaled autonomous vehicles. (c) An instrumented vehicle.

simulation, linear systems, optimal control, and AI, with a focus on characteristic transport problems. These are complemented by application-oriented lectures, practical courses, project work, and technical excursions. The Chair of Traffic Process Automation is leading the design of a new M.S. degree program on ITSs at TU Dresden.

Future Directions

With a track record in traffic management and process automation, the Chair of Traffic Process Automation will continuously push the boundaries of transport domain knowledge toward general behavioral, mathematical, and engineering sciences with an interdisciplinary approach. Furthermore, we aspire to respond to social changes toward sustainability and technological advancements with human-centric principles. In addition to vehicular traffic, public transport and active modes will continue to attract increasing attention in the future. These will be actively supported by several research infrastructures (Figure 4) being built at the Chair of Traffic Process Automation:

- **Traffic and environment data platform:** Building on the VAMOS traffic data center, we are enriching the data platform with public transport data and data from highway networks. In the future, we will include fine-grained data from new road-

side and onboard sensors and incorporate air quality data. The data platform will support a wide range of research topics, such as cooperative perception, network bottleneck identification, and traffic and air quality monitoring and prediction.

- **Multimodal multiscale traffic modeling and simulation lab:** The lab focuses on developing models for vehicular, bicycle, pedestrian, and rail-bound traffic at microscopic and macroscopic levels. The models will allow the investigation of network traffic management, integrated public transport and road traffic management, autonomous mobility on-demand systems, eco-traffic management, and energy-efficient driving advisory and control systems.
- **Scaled Networked and Autonomous Mobility lab:** The Scaled Networked and Autonomous Mobility lab consists of diverse robotic vehicles designed to replicate heterogeneous traffic scenarios. It serves to bridge the gap between simulation and reality so that design solutions and control algorithms can be tested in a safe and controlled environment before field implementation. It also fosters a collaborative research environment that welcomes students and researchers from diverse backgrounds to leverage our facilities and resources for collaborative work.

- **Instrumented vehicles and bicycles:** With advanced sensors equipped on our vehicles and bicycles, we can gain a deep understanding of how drivers and cyclists perceive the environment and make decisions. Data collected through our instrumented vehicles and bicycles will facilitate the modeling of driver/cyclist behavior and vehicle/cyclist/pedestrian interactions as well as the testing of driver/cyclist assistance and automated driving systems.

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