Fraunhofer
IVI

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

# INSTITUTE REPORT
# 2016

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

# INSTITUTE REPORT 2016

# EVERYTHING FLOWS

# PREFACE

It was the philosopher Hegel who already knew how to adopt the strong symbolism of water when he described the dynamics of processes in society, using the analogy that everything flows and moves forward like a wide river. To the Greek philosophers, rivers were the symbol of constant becoming and change in a tense field of contradictions. All these thoughts have formed the image of a world that nowadays seems to be going more and more awry. Migration movements, which remind us of the peoples' migrations in the early Middle Ages, terrorism motivated by religion and military conflicts, collapsing economies, increasing protectionism and radical political quarrels are threatening the consensus in society.

These developments have so far not had a significant effect on our work at the institute, and knowing that this past year was a very successful one, I wish to thank my employees for their commitment, creativity and great team spirit, which has so decisively shaped the Fraunhofer IVI during these past years.

At various levels of abstraction, flowing movements are the objective of many activities at a transport research institute. Thoughts range from macroscopic traffic flows on land and waterways, on rails or in air corridors, over commodity, cash and passenger flows, flux in vehicle structures and energy flux at high-current contacts, down to the microscopic sphere of electron and ion movements between two electrodes and the abstract space of information flow. Digital transformation processes not only revolutionize production, but they also lead to new mobility concepts, business models and vehicle technologies. Trillions of bytes are flowing through our communication networks every day. By means of highly efficient data evaluation methods and the high-performance computer technology available at the Fraunhofer IVI, online information about security-related events can be generated from the enormous data flow. The global threat level has increased dramatically, the threat of terrorism has reached Germany and many victims must be recorded. Research topics in the field of civil security have long been a part of the institute's range of services. There is now an impressive international demand for operational command and communication systems for special forces, which have proved themselves in tough police operations across several countries.

Unlimited flow is generally characterized by energy efficiency and sometimes also by high aesthetics. A delicate dance can express many different emotions in flowing movements, and by synchronizing these movements, the impression becomes many times more intensive in the Pas de deux. In the animal kingdom, the swarm behavior of birds, fish or gregarious animals shows how a multitude of individuals can move effectively and fluently in a very confined space. One of the Fraunhofer IVI's current research interests is the synchronization of highly automated traffic flows, transferring the principle of swarm movements from the sphere of nature to the field of traffic control systems in urban areas. Under the title of »Synchronized Mobility«, these ideas have generated sustainable interest in the State of Nevada.

Many locals and guests certainly enjoy the experience of baroque Dresden, where they can delight in art and culture at its highest quality, being able to enjoy art and culture at its highest quality. The collection of valuables by August the Strong is undoubtedly one of the most interesting and best-known cultural treasures in the world, and before I invite you to peruse our institute report with time and tranquility, I would like to remind you of the little bronze figure »Dresden Mercury«, which the Saxon royals received as a gift by a Medici grand duke from Tuscany at the end of the 16th century. The flying Mercury, a symbol of skill and good luck, also embodies the princely virtue to fight against an uncertain fate. I wish all of us much strength, moral fiber and assertiveness in times like these.

# CONTENTS

# FRAUNHOFER IN SAXONY

The Fraunhofer-Gesellschaft maintains nine institutes and several other research establishments in Saxony.

## INSTITUTES

- Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP, Dresden
- Fraunhofer Institute for Ceramic Technologies and Systems IKTS, Dresden
- Fraunhofer Institute for Photonic Microsystems IPMS, Dresden
- Fraunhofer Institute for Transportation and Infrastructure Systems IVI, Dresden
- Fraunhofer Institute for Material and Beam Technology IWS, Dresden
- Fraunhofer Institute for Machine Tools and Forming Technology IWU, Chemnitz and Dresden
- Fraunhofer Institute for Electronic Nano Systems ENAS, Chemnitz
- Fraunhofer Institute for Cell Therapy and Immunology IZI, Leipzig
- Fraunhofer Center for International Management and Knowledge Economy IMW, Leipzig

## FRAUNHOFER BRANCHES AND ESTABLISHMENTS

- Fraunhofer IVV, Dresden Branch Lab for Processing Machinery and Packaging Technology
- Dresden branch of the Fraunhofer IFAM Bremen
- Dresden branch of the Fraunhofer IIS Erlangen
- Technology Centre for Semiconductor Materials THM, Freiberg
- Project Group ASSID (All Silicon System Integration Dresden) of the Fraunhofer IZM
- Project Group Zittau of the Fraunhofer IWU

# FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the organization for applied research drives economic development and serves the greater societal good. Its services are solicited by customers and contract partners in the industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains 69 institutes and research units. The majority of the nearly 24,500 staff are qualified scientists and engineers who work with an annual research budget of more than 2.1 billion euros. Of this sum, more than 1.9 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and Länder governments in the form of base funding, enabling the institutes to work ahead on solutions to problems that will not become acutely relevant to industry and society for another five or ten years.

International collaboration with excellent research partners and innovative companies around the world ensure direct access to regions of the greatest importance to present and future scientific progress and economic development.

With its clearly defined mission of application-oriented research and its focus on key technologies of relevance to the future, the Fraunhofer-Gesellschaft plays a prominent role in the German and European innovation process. Applied research has a knock-on effect that extends beyond the direct benefits perceived by the customer: Through their research and development work, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region and throughout Germany and Europe as a whole. They do so by promoting innovation, strengthening the technological base, improving the acceptance of new technologies and helping to train the urgently needed future generation of scientists and engineers.

As an employer, the Fraunhofer-Gesellschaft offers its staff the opportunity to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, at universities, in industry and in society. Students who choose to work on projects at the Fraunhofer Institutes have excellent prospects of starting and developing a career in the industry by virtue of the practical training and experience they have acquired.

The Fraunhofer-Gesellschaft is a recognized non-profit organization that takes its name from Joseph von Fraunhofer (1787-1826), the illustrious Munich researcher, inventor and entrepreneur.

# FRAUNHOFER IVI

## IN THE ICT GROUP

As a part of the Fraunhofer-Gesellschaft, the Fraunhofer ICT Group is Europe's largest IT research organization.

The group has about 4,300 members who work together to provide customized, industry-specific and holistic IT solutions from a single source. They offer research and development work as well as competent technology consulting for the following business units:

- Digital media
- E-business
- E-government
- Information and communication technology
- Energy and sustainability
- Manufacturing
- Medicine
- Safety and security
- Financial services
- Automotive

Virtually all fields of information technology are addressed.


Chairman of the Group
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The group's 20 current members are the Fraunhofer Institutes for

- Algorithms and Scientific Computing SCAI
- Applied Information Technology FIT
- Applied and Integrated Security AISEC
- Communication, Information Processing and Ergonomics FKIE
- Computer Graphics Research IGD
- Digital Media Technology IDMT
- Embedded Systems and Communication Technologies ESK
- Experimental Software Engineering IESE
- Industrial Engineering IAO
- Industrial Mathematics ITWM
- Integrated Circuits IIS (Guest)
- Intelligent Analysis and Information Systems IAIS
- Medical Image Computing MEVIS
- Open Communication Systems FOKUS
- Optronics, System Technologies and Image Exploitation IOSB
- Secure Information Technology SIT
- Software and Systems Engineering ISST
- Telecommunication, Heinrich Hertz Institute HHI (Guest)
- Transportation and Infrastructure Systems IVI
- Wind Energy and Energy System Technology IWES (Guest)


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# IN ALLIANCES

**FRAUNHOFER BIG DATA ALLIANCE**

Within the Big Data Alliance, 28 institutes offer their interdisciplinary know-how and support for the efficient exploitation of large and heterogeneous sets of data.

Alliance Manager
Dr. Dirk Hecker

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**FRAUNHOFER BATTERY ALLIANCE**

Researchers from 19 Fraunhofer Institutes pool their expertise in the Fraunhofer Battery Alliance. Their aim is to design and implement technologically and economically feasible solutions for electric storage systems. Their services include topics such as materials, systems, simulation and testing.

Spokesperson of the Alliance
Prof. Dr. Jens Tübke

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**FRAUNHOFER TRAFFIC AND TRANSPORTATION ALLIANCE**

At present, 15 Fraunhofer Institutes combine their specific know-how and long-standing experience in the area of transport-related research within the alliance. Their aim is to offer complete systems solutions to public and industrial customers on an interdisciplinary technological and conceptual level.

Chairman of the Alliance
Prof. Dr. Uwe Clausen

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**FRAUNHOFER ENERGY ALLIANCE**

The Fraunhofer Energy Alliance is one of the largest energy research organizations in Europe. Its 18 member institutes provide their respective expertise in the fields of renewable energies, energy efficiency technologies, intelligent power grids, energy storage systems, as well as buildings and components.

Spokesperson of the Alliance
Prof. Dr. Hans-Martin Henning

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# PROFILE OF THE INSTITUTE

Within the past years, the Fraunhofer IVI has developed into an efficient institute that has earned national and international renown thanks to its outstanding professional expertise.

Today, over 100 employees and about 60 students work in the institute's four departments and two joint research groups with the TU Dresden and the TU Bergakademie Freiberg. In close collaboration with clients and partners as well as policy makers and funding agencies, visions have been designed and solutions presented.

The institute's research focus lies on well-established topics from vehicle and propulsion technologies, as well as on new challenges in the context of automated and connected driving. Technologies for the improvement of civil security are also becoming increasingly important. In order to respond to the rising demand of accident data collection and analysis, the research group »Vehicle and Road Safety« has been established.

Thanks to this continuous development of expertise, the institute once more managed to increase its total revenue in 2016. At 30 percent, projects funded by the German federal government and Länder constitute the biggest share. Compared to the previous year, the industrial revenues have moderately increased to 32 percent. With a share of 18 percent, projects funded within the European Framework Programme remained relatively stable.

The institute particularly invested in the extension of research infrastructure and once again provided resources for the modernization of the existing buildings. Thus not only the employees find themselves in a pleasant working environment, but also clients and project partners appreciate the inspirational atmosphere.

The positive economic situation of the Fraunhofer IVI is also reflected by the results of the employee survey. In most of the evaluated categories, the institute's results are above the Fraunhofer average. Special emphasis was put on the outstanding motivation as well as the effective and open exchange of ideas.

High satisfaction with the working conditions and one's own fields of activity add up to the positive mood and create the feeling that the Fraunhofer IVI is well-positioned to meet the challenges and opportunities that lie ahead.

# COMPETENCIES

- Autonomous utilities systems
- Digital business processes
- Electromobility
- Identification of traffic situations
- Logistics
- Mobility and travel assistance
- Multi-axle steering and guidance systems
- Operational planning and command
- Propulsion technologies
- Sensor and actuator systems
- Stationary energy storage systems
- System modeling and process control
- Ticketing and fares
- Transport planning
- Transportation ecology
- Transportation systems
- Vehicle and road safety
- Vehicle connectivity
- Vehicle technologies

## DIRECTOR

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## DEPARTMENTS

### Transportation, Energy and Environment

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Mechatronic Systems
*Richard Kratzing*

### Vehicle and Transport System Engineering

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Vehicle and Propulsion Technologies
*Dr. Frank Steinert*

Transportation Systems/Human-Machine Interaction
*Dr. Thoralf Knote*

Vehicle Control and Sensor Systems
*Dr. Sebastian Wagner*

Vehicle and Road Safety
*Dr. Christian T. Erbsmehl*

## UNIVERSITY RESEARCH GROUPS

### Locating, Information and Communication

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TECHNISCHE UNIVERSITÄT DRESDEN

## ADMINISTRATION

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# ORGANIZATION CHART

## Intelligent Transport Systems

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Mobility and Travel Assistance
*Sebastian Pretzsch*

Traffic System Data
*N. N.*

Ticketing and Fares
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Cooperative Systems
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Digital Business Processes
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# FRAUNHOFER IVI ADVISORY BOARD

**Chairman of the Advisory Board**

*Prof. Dr.-Ing. Christian Lippold,*
*Managing Director,*
*Institute of Transport Planning and Road Traffic,*
*Chair of Road Planning and Road Design,*
*»Friedrich List« Faculty of Transportation and Traffic Sciences,*
*TU Dresden*

**Members of the Advisory Board**
(as of March 2016)

*Burkhard Ehlen,*
*CEO, Verkehrsverbund Oberelbe (VVO)*

*Prof. Dr.-Ing. Viktor Grinewitschus,*
*Institute for Energy Systems and Energy Business,*
*Hochschule Ruhr West*

*MinR Hans-Peter Hiepe,*
*Head of Division,*
*Federal Ministry of Education and Research (BMBF)*

*Prof. Dr.-Ing. habil. Prof. E.h. Dr. h.c. Werner Hufenbach,*
*Director, Institute of Lightweight Engineering and Polymer Technology (ILK),*
*Faculty of Mechanical Science and Engineering, TU Dresden*

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*Managing Director,*
*Institute of Automation,*
*Chair of Automation Engineering,*
*Faculty of Electrical and Computer Engineering, TU Dresden*

*Prof. Dr. Dirk C. Meyer,*
*Director, Institute of Experimental Physics,*
*TU Bergakademie Freiberg*

*Peter G. Nothnagel,*
*CEO, Saxony Economic Development Corporation GmbH*

*Dirk Schillings,*
*Senior Director Engineering, Bombardier Transportation GmbH*

*Bernhard Schmidt,*
*Manager of Operations, Sileo GmbH*

*Nils Schmidt,*
*Director Mobility Division, Siemens AG*

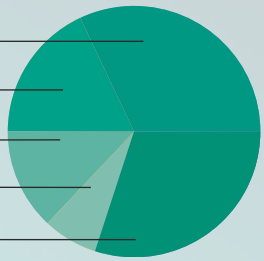
*Lars Seiffert,*
*Board of Operations and Human Resources,*
*Dresdner Verkehrsbetriebe (DVB) AG*

*Carsten Utikal,*
*Consultant – Federal-Länder-Research Institutions,*
*Saxon State Ministry of Science and the Arts (SMWK)*

# ECONOMIC DEVELOPMENT

## OPERATING BUDGET

| | |
|---|---|
| Industrial revenues | 32 % |
| EU | 18 % |
| Basic financing | 13 % |
| Miscellaneous | 7 % |
| Public sector | 30 % |

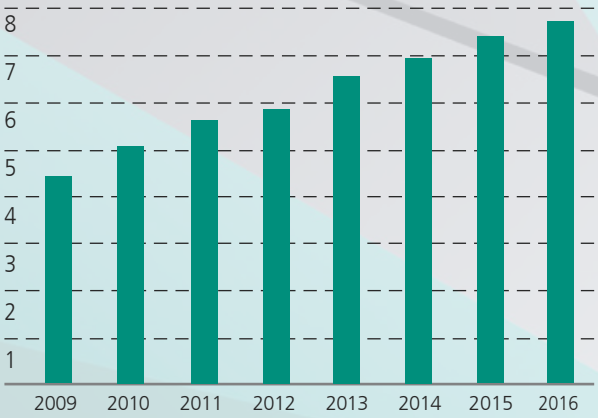


## EMPLOYEES

| | |
|---|---|
| Research fellows | 95 |
| Research assistants | 67 |
| Trainees | 4 |
| Administrative and technical staff | 15 |
| Total | 181 |

## FINANCIAL DEVELOPMENT

in € million



# PARTNERS

**International Business Relations**

In the past years, the Fraunhofer IVI has increasingly expanded its activities beyond Germany's borders. Cooperation with European partners in EU-funded projects is one of the important factors of this development. The institute is currently working on 17 EU projects from both the 7th Framework Programme and HORIZON 2020 with partners from all over Europe.

Three EU projects have been successfully completed this year: The *iCOMPOSE* project proposed a step change in the control software in fully electric vehicles for energy efficiency enhancement leading to energy savings and extended driving range, while the *IMPROVE* project focused on in-vehicle Information and Communication Technologies (ICT) innovation for commercial vehicles and aimed at a target of +20 percent range for the same battery capacity. The *EUSTO* project culminated in a Final International Conference on the protection of surface transportation infrastructures organized by the Fraunhofer IVI in Dresden in May 2016.

Regarding industry projects, the sometimes lengthy negotiations and acquisition activities undertaken in the past are finally beginning to bear fruit. Important contacts have been established and stabilized in the past years, most prominent among them relations with partners from Europe, China and North and South America. In the USA, a transatlantic cooperation on synchronized mobility is envisaged – in close cooperation with the Governor's Office of Economic Development of the state of Nevada and several partners from Saxony.

The institute is very proud to count renowned companies and institutions from all regions of the world among its partners.

**Research Organizations and Universities**

- Beijing Vocational College of Transportation
- Centro Ricerche Fiat S.C.p.A.
- CERTH-HIT Centre for Research and Technology Hellas – Hellenic Institute of Transport
- FEHRL Forum of European National Highway Research Laboratories
- Flanders Drive
- IFSTTAR French Institute of Science and Technology for Transport, Development and Networks
- LTU Luleå tekniska universitet
- Politecnico di Milano
- POLITO Politecnico di Torino
- TNO Netherlands Organisation for Applied Scientific Research
- TOI Institute of Transport Economics, Norway
- Universidad de Sevilla
- UPM Universidad Politécnica de Madrid
- UPV Universitat Politècnica de València
- VIRTUAL VEHICLE Research Center mbH
- VTI Swedish National Road and Transport Research Institute
- VTT Technical Research Centre of Finland
- Wuxi SensingNet Industrialization Research Institute

**Public Institutions**

- European Commission
- GOED Nevada Governor's Office of Economic Development
- Government of the Grand Duchy of Luxembourg, Ministry of Interior Security
- Liberec region
- UITP International Association of Public Transport
- Ústí nad Labem region


**Industry and Economy**

- Acciona S.A.
- ACEA European Automobile Manufacturers' Association
- Amadeus IT Group S.A.
- Baiyun Power Group
- Carrosserie Hess AG
- CEMOSA S.A.
- CRRC Zhuzhou Electric Locomotive Institute Co., Ltd.
- DAF Trucks N.V.
- DERAP AG
- Felbermayr Holding GmbH
- Gardner Denver, Inc.
- IES Solutions S.r.l.
- Indra Sistemas S.A.
- Irizar
- Iveco France
- Johnson Matthey Battery Systems Sp. z o.o.
- Lotus Engineering
- Magna International Inc.
- Maxwell Technologies S.A.
- NXP Semiconductors
- OLTIS Group a.s.
- OPTIMAL Ltd.
- P&G Procter & Gamble Company
- Renault S.A.
- Ricardo plc
- Samsung SDI
- Scania AB
- Škoda
- Southwall Europe GmbH
- Strukton Rail B.V.
- T-Systems International GmbH
- TB-Traxler GmbH
- Tecnalia
- Thales Communications & Security
- TLP spol. s.r.o.
- TME Toyota Motor Europe
- Van Eck Group
- Volvo Bus Corporation
- Volvo Lastvagnar AB
- Volvo Technology
- WABCO Holdings Inc.

**Transport Associations and Providers**

- Bernmobil – Städtische Verkehrsbetriebe Bern
- IP Infraestruturas de Portugal S.A.
- Network Rail Infrastructure Ltd.
- Trafikverket
- Trenitalia S.p.A.

*A list of German partners can be found in the German section of the institute report on pages 16-19.*

# FACILITIES AND LARGE EQUIPMENT

## TEST VEHICLES

- AutoTram® for the evaluation of alternative propulsion systems, lane guidance and automatic steering control
- AutoTram® Extra Grand
- Fast charging buses (12 and 18 meters)
- Mobile command vehicle equipped with a system for decision support in emergency and crisis situations
- Platform »ELENA« for the evaluation of steering strategies
- Test vehicles for driver assistance, driver information and automated driving

## LABORATORY FACILITIES

- Battery lab
- Communication and radio technology lab
- Demo lab for transport telematics
- Electronics lab
- MobiKat lab

## SOFTWARE

- ANSYS (Finite Elements Simulation)
- Apache Hadoop, HBase, HDFS, Hive, Flink, Kafka, Mahout, Map/Reduce, Spark
- ArcGIS 10.3 (geographic information system)
- CATIA V5 (design)
- COMSOL (Multiphysics Simulation)
- Dewesoft (data logging and analysis)
- DSpace Rapid Prototyping Control
- Dymola (interdisciplinary simulation of physical systems)
- Halcon (image processing)
- LabView (environment for the development of measurement, monitoring and control systems)
- Matlab/Simulink
- PC-Crash (reconstruction software)
- SIMPACK (simulation of multibody systems)

## TECHNICAL EQUIPMENT

- Calibrated infrared measurement technology
- Development control unit for mobile applications (AutoBox)
- Driving simulator for road vehicles
- Environment for the development and testing of embedded microcontroller systems of different classes
- External evaluation and data acquisition facilities for traffic applications
- Functional models and environment for the development of DC/DC converter control
- Google Glass
- HiMoNN – Highly Mobile Network Node
- Mobile camera for situational monitoring in crisis situations
- Mobile hydrogen production (HyTra) and filling station
- Mobile measurement data acquisition system (DEWETRON)
- National Instruments CompactRIO control and surveillance system with multiple IO modules
- National Instruments USRP-2920 for Software Defined Radio (50 MHz - 2.2 GHz)
- Octocopter HORUS® for photography and videography, 3D and infrared images
- PTZ camera
- Satellite-based inertial measurement unit (ADMA)
- Smartwatches (Android, iOS)
- Steering and accelerator robots
- Test stand and data acquisition systems for battery and capacitor storage units on cellular and system level
- Toolkit for EMC testing (electromagnetic compatibility)
- Universal Receiver Tester (URT): dual-channel, 250 kHz - 2.7 GHz, bandwidth 20 MHz on each channel
- Universal Receiver Tester (URT): three channels, 85 MHz - 2.7 GHz, bandwidth 50 MHz on each channel

# TECHNICAL CENTER

## LARGE-SCALE TEST STANDS

- Engine test stand for combustion engines and electrical machines
- High-performance battery simulators
- Serial hybrid powertrain and engine test field
- Test stands for
  - → auxiliary components
  - → battery cells
  - → battery modules
  - → high current contacts
  - → traction energy storage systems

## MOBILE MEASUREMENT EQUIPMENT

- DGPS measurement system Leica VIVA G15
- Long-term data acquisition in vehicles
- Measurement equipment for
  - → the analysis of traction power electronics
  - → the determination of fuel consumption
  - → vehicle dynamics
- Power and energy balances of vehicles

## HIGH FREQUENCY MEASUREMENT TECHNOLOGY

- Environment for the testing of navigation applications (GPS and INS simulation)
- Environment for the testing of radio sensor networks (ZigBee, UWB, Bluetooth LE)
- EMC shielding tent
- HF signal generation
- Interference analyses
- Interference resistance and emission
- R&S realtime spectrum analyzer FSVR 7 (10 Hz - 7 GHz)
- Wideband radio channel simulator PROPSim C2

The expansion of the institute building by a modern technical center with adjacent test track rounds off the range of services, especially in the fields of vehicle and propulsion technologies:

- **Vehicle Hall**
  - Working platform for buses and electric vehicles
  - Crane system
- **Workshop**
- **Test Track**
  - Test drives
  - Testing of new propulsion technologies
  - Testing of sensor systems and locating methods
  - Public presentations

In addition, the Fraunhofer IVI collaborates with the Institute of Electrical Engineering at the TU Bergakademie Freiberg within the high-performance center for electromobility, offering all development steps starting with

- analytical design of electrical machines, over
- numerical optimization, up to
- experimental support of test vehicles,

both as partial solutions or as a complete package.

# TRANSPORTATION, ENERGY AND ENVIRONMENT

## RANGE OF SERVICES

- Control-based multidomain modeling, simulation and implementation
- Software for passenger interchange simulation
- Automated data transfer, diagnosis and proactive monitoring of distributed process variables
- Measurement series on thermo-electrical test stand
- Robust state estimation of operation-relevant battery parameters
- Impedance spectroscopy testing
- Experimental characterization of the individual components of electrical machines, as well as integrated system testing
- Technical design, 3D visualization and 3D rapid prototyping
- Consulting on the selection of storage unit types
- Studies and expert assessments

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Our motivation in offering research and development services in a diverse spectrum ranging from mobile, traffic-related applications to stationary solutions stems primarily from the necessity to use energy resources responsibly.

The key component of many of our technological system solutions is the capacity to store large amounts of energy and release it in a needs-based way.

Will we succeed in restructuring our changing energy system so as to be both practicable and economically feasible? This question opens up a broad field of applied research options for the department's researchers and engineers.

Our scientific and economic approach to the energy storage topic comprises the following areas:

- Planning and characterization,
- Modeling and simulation,
- Implementation and optimization.

In dialog with our clients, we will find the best possible mix of energy supply, storage capacity and performance for a given energy system, whether it be a traction energy storage unit with new battery chemistry or a stationary storage unit for the autonomous supply of domestic heat and power.

# REMOTE DIAGNOSIS FOR BATTERY SYSTEMS

*Claudius Jehle*
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**Battery Ageing**

Electromobility is becoming increasingly well-established in private and commercial transportation. In this process, high-performance battery systems prove to be the decisive success factor. At the moment, however, it is still difficult for operators to evaluate the state and remaining life span of a battery.

The ageing of battery storage systems

- is invisible from the outside,
- depends heavily on the kind of use and
- requires electrochemical expertise and a complex diagnosis process incorporating chemicals, types, manufacturers and designs.

Battery ageing has an immense impact on the remaining value, amortization, availability and deployment planning, maintenance intervals, as well as safety (fire hazard).

**State Monitoring**

The remote diagnosis system developed at the Fraunhofer IVI determines relevant information about the state of the battery system and presents them to customers in a useful format.

The battery data is acquired within the vehicle using existing proprietary sources (CAN buses and others) and is therefore largely independent from the type of battery chemistry (common Li-ion technologies, lead acid). It is also possible to store and transmit additional customer-specific data, such as GPS positioning data.

The intermediate storage, pre-processing (filtering, compressing) and safe transmission of the data is realized on board the vehicle using wireless transmission processes, depending on their availability (GSM to 3G, WiFi, Bluetooth).

Thanks to a point-to-point encryption system with its own HTTPS certificate and a modern, client-based data management system, a high level of data safety is guaranteed. Efficient algorithms ensure that the data are processed on a regular basis and that the results delivered and visualized – depending on the network quality – are current to the minute.

**Customer Benefits**

With the operator's agreement and the manufacturer's support, a commercial telemetry device will be installed inside the vehicle. This device has all the certificates necessary for the private, commercial and railway transport sector and is able to record existing measurement data and transmit them securely. Modifications to the powertrain, the energy storage unit or other systems are not required.

A comprehensive diagnosis can be carried out by relying on the measurement data and state information that is also needed for the operation of the energy storage system. Combining this data with a deeper knowledge of batteries and their operation allows the execution of complex state analyses and prognoses. The recorded data is transmitted to a database server, whose software automatically evaluates it using electrochemical models and algorithms. The resulting evaluations are provided to all contractually authorized users via an API interface or web interface in a simple, comprehensible way that also allows further processing. The data volume and system functionalities can be customized by the data owners.

The system is not only suitable for vehicle operators (public transport providers, communities, logistics providers) and vehicle and battery system providers for the monitoring of ageing, maintenance and warranties. It also supports insurance agencies and lessors in the design of contracts and policies, as well as in the monitoring of amortization periods and remaining values.

# VEHICLE AND TRANSPORT SYSTEM ENGINEERING

## RANGE OF SERVICES

- Conception and design of electric powertrains for commercial and special-purpose vehicles
- Energy demand analyses; energy demand simulation for conventional, hybrid and fully electric vehicles
- Introduction concepts for electric buses
- Vehicle concepts for special purposes
- Testing and setup of powertrain components
- Fast charging concepts for electric commercial vehicles
- Innovative steering systems for extra-long road vehicles with multi-axle steering
- Development of functionally safe vehicle control systems
- Fully automated planning of maneuvers for commercial vehicles
- Analyses, surveys and developments in the fields of vehicle and road safety

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The transport sector faces the immense challenge of providing cost-efficient transportation and shipping services while increasingly utilizing renewable, climate-friendly energy sources with low or no emissions and maintaining a high degree of traffic safety at the same time.

In response to these challenges, the research areas of the Department »Vehicle and Transport System Engineering« include, among others, hybrid and fully electric propulsion systems, management of auxiliaries and storage systems for electric energy, power transmission between charging infrastructure and vehicle storage units, innovative steering systems for long road vehicles, as well as analyses and concepts for functional safety. The main focus lies on commercial and special-purpose vehicles, especially in the field of public transport.

Due to their electric energy storage systems, the range of battery buses is still limited. The department develops implementation concepts for battery buses and other types of electric buses that objectively and independently demonstrate the potential of these vehicles and propose a schedule for the implementation of this new propulsion technology. Current developments in battery technology are taken into account, as well as new concepts for charging infrastructure and energy transmission.

New approaches in the fields of vehicle and road safety complete the department's spectrum. A key focus in this area is the analysis of national accident databases. The results are used in several projects aiming at researching and developing novel simulation tools and methods for increased road safety.

# »TruckTrix®« – AUTOMATED TRAFFICABILITY ANALYSIS FOR HEAVY HAULAGES

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Anyone who has ever seen an oversized and heavy goods vehicle at a narrow road intersection has probably wondered: Is the truck really going to be able to make this turn? This question does not only occur to fascinated onlookers, but it is also important for dispatchers at shipping agents' offices. In times of increasingly large and complex transport tasks, finding the answer is becoming more and more difficult.

## Challenge

Because our transport infrastructure is generally not designed for heavy haulages, every oversized and overweight shipment must be officially approved in advance. Among others, the trafficability of critical narrows on the intended route needs to be proven in order to obtain an approval. Currently, this proof is executed manually and is based on the expert knowledge of only a few individuals. Therefore, the results are often not completely reliable. It is not uncommon for heavy duty vehicles to become wedged, causing immense costs and damages.

The automated TruckTrix® trafficability analysis will significantly facilitate the planning and execution of heavy haulages by providing safe and objective results that are comprehensible to the approving authorities and will help minimize planning risks.

## Solution Approach

The trafficability analysis relies on a graph search algorithm modified and optimized to fit the specific characteristics of oversized and overweight transports. The most important features taken into consideration are:

- Geometry and kinematics of the vehicle, including maximum steering angle, maximum articulation angle, steerable trailer axles,
- Geometry and position of the cargo, as well as a 3D collision test including ground clearance and height values.

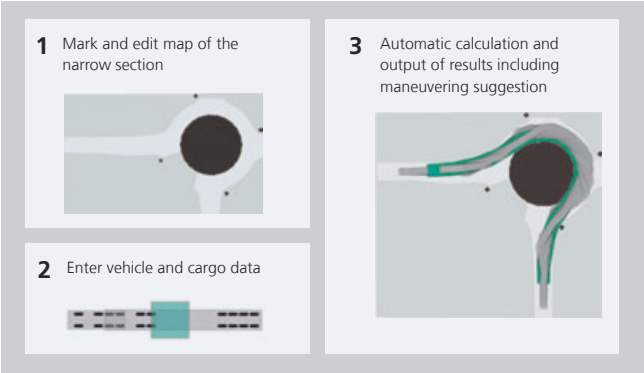
The use of a model-based approach ensures that all vehicle restrictions will be complied with. The analysis is executed on the basis of satellite images or official survey maps. The dispatcher only needs to enter information on the

- map of narrows/obstacles, vehicle and cargo, and
- starting location and destination.

The TruckTrix® web service automatically tests whether the narrow section is trafficable. If the result is positive, the system proposes a driving maneuver in the form of a video clip.

## Services

The Fraunhofer IVI carries out trafficability analyses for customers. If desired, up-to-date aerial images taken by a high-performance UAV (www.horus.mobi) can be provided. The marketing and commercialization of TruckTrix® via a Fraunhofer spin-off enterprise is currently in preparation.




1 *Objective analysis for route planning and approval procedures.*

Europäische Union
Europa fördert Sachsen
EFRE
Europäischer Fonds für regionale Entwicklung

# INTELLIGENT TRANSPORT SYSTEMS

## RANGE OF SERVICES

- Design and testing of system solutions for connected and automated driving
- Traffic detection, information and management
- Communication networks and protocols
- Information and navigation applications
- Analysis, evaluation, integration and quality control of traffic and sensor data
- Processing of large data sets (Big Data)
- Software solutions for mobile applications, both frontend and backend
- Utilization of semantic technologies for data processing and service integration
- Fare-based solutions for conventional, electronic and mobile ticketing
- Modeling and simulation of fares
- Trend and technology studies

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The level of interconnection and digitalization in complex transport systems is increasing rapidly. With the help of information and communication technologies, it is possible to organize traffic more efficiently, establish new mobility services and integrate traffic participants more actively. Key factors of this process are smartphones and wearable devices, as well as connected vehicles and automated driving.

The Department »Intelligent Transport Systems« responds to these developments and makes use of their potential. The focus is on public and private transportation – starting with a holistic view of these transport systems and ending with specialization on relevant research topics, among them information and navigation, traffic automation and management, as well as ticketing and fares. Interdisciplinary topics such as electromobility are also taken into account.

The processing of large data sets is an important aspect of all these topics. For this reason, the Fraunhofer IVI operates its own traffic and mobility data center. The institute is an associated partner of the national Big Data competence center ScaDS at the TU Dresden and contributes its expertise in the transportation sector.

The basis for the department's successful work is in-depth knowledge in the fields of information technology, mathematics, software engineering, automation technology and transportation sciences, as well as experience and know-how gained in practical project work.

# »Guide2Wear« – PUBLIC TRANSPORT NAVIGATION VIA SMARTWATCH

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Providing information for public transport passengers on smartphones has become a popular service today. A multitude of applications is available for this purpose. Most of these apps offer support on a route planned beforehand. Only a few of them also offer in-depth assistance in case of a deviation from the proposed route.

In contrast to cars, buses and trams usually do not have mountings for smartphones. In order not to lose any information, however, passengers need to keep their phones within reach or even in their hands at all times. Especially in public transport situations, this requirement has proven to be an obstacle. Passengers who are not seated or carrying luggage usually do not have their hands free.

**The Project**

This was the point of departure for *Guide2Wear*, a research project selected within in the »Traveller of the Future« call. *Guide2Wear* was successfully concluded in August 2016 after a duration of two years and its aim was to study options of using wearable devices for public transport passengers.

The project was carried out by an international and interdisciplinary team. Psychologists, geographers, traffic and transportation scientists, futurologists, economists as well as experts from the law and IT sectors worked closely together. This way, the different user groups and their specific requirements were determined as well as the expectations of public transport stakeholders and the impact of new services on the general public's mobility behavior was studied. Under the coordination of the Fraunhofer IVI, the findings have been technically implemented as an app for different smartwatches.

**The Smartwatch App**

The app developed within the project communicates all relevant travel assistance information to smartwatches, so that passengers can keep their smartphones in their pockets for large sections of the journey. The journey to and from stops is included, as well as information about available bike-sharing services at the destination. Boarding and alighting locations as well as changes are announced by the smartwatch. In case of delays, detours or missed departures, alternative routes are available. The most important information is always visible at a glance.

An additional smartphone app can be used to view further details and to enter preferences and information about the destination. This app uses a more flexible and more accurate 3D map visualization and also supports voice commands and audio responses. Both devices are considered one unit for the purposes of *Guide2Wear*. Inputs made via smartphone will be detected by the smartwatch and operating the smartwatch has effects on the smartphone.

A live demonstration of the smartwatch app was given during the final project conference in Vienna. There are adapted versions for Dresden and the San Sebastián region in Spain. It is planned to expand the app to other cities and regions, and to integrate further mobility services in the future.

Federal Ministry of Transport and Digital Infrastructure

era-net TRANSPORT


# STRATEGY AND OPTIMIZATION

## RANGE OF SERVICES

- Analyses and risk assessment in hazard prevention: planning of fire safety requirements and rescue service zones, site optimization
- Command systems for firefighters, emergency service providers, disaster management and police
- Web-based systems for data acquisition and analysis: master data and on-call duty, positioning of forces, camera surveillance, web GIS, etc.
- Robust distributed systems with analysis tools from Data Mining, Machine Learning and Natural Language Processing on the basis of Big/Smart Data
- Process restructuring on the basis of the digital transformation of SMEs, data visualization based on the Fraunhofer IVI data exploration tool AcubeS
- Decision support for operative logistics optimization: dynamic route planning, components for integrated cargo space and production planning
- Asset Management Systems for transport infrastructures: strategic, tactical and operative maintenance planning, risk assessment and predictive analysis

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In collaboration with its partners, the Department »Strategy and Optimization« develops solutions for the effective planning and control of resources. The solutions are applied in a wide range of fields:

- Security and risk prevention: firefighting and emergency services, disaster management and police
- Digital business processes: operators of digital platforms and infrastructures, OEMs, software service providers, as well as
- Logistics and infrastructure: transport service providers, infrastructure operators and contractors.

The department's key competencies are the development of new scientific models and optimization methods, as well as the conception, design and implementation of complex systems.

Within numerous research and development projects, application-oriented solutions are developed and immediately put into practice. The software systems and modules developed by the department are independently configurable and therefore flexibly operable. There are separate modules for algorithmic planning and optimization of processes, resource management, trend and scenario analysis, evaluation of uncertainty factors, infrastructure, geographical and object data integration and visualization.

Thanks to close cooperation with the end users, the systems have a high acceptance level with the main customers, who can be found among federal and state ministries, districts, communities, public offices and authorities, industry and the European Union.

# IMPRESS – DECISION SUPPORT IN LARGE-SCALE EMERGENCY SITUATIONS

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**Motivation**

In large-scale emergency situations and Mass Casualty Incidents (MCIs), response teams are faced with complex challenges: On the one hand, they need to rescue and evacuate the affected persons quickly, on the other hand, they have to deal with time constraints and limited resources. The main aim of the *IMPRESS* project, funded within the EU's 7th Framework Programme, is to increase both the efficiency and the effectivity of staff and resource deployment during large-scale emergency situations. Another objective of the project is to integrate volunteer helpers and the general public into the planned actions in an optimal way. Often, social media are used to communicate information about the current situation and about support services. The evaluation of past major incidents has revealed the problems accompanying this practice: In many cases, untested or wrong information is shared and the necessary rescue measures are obstructed as a result. Sometimes, volunteers even put themselves and others into needless danger.

**Decision Support, Communication and Situation Information**

The technological focus of *IMPRESS* lies on digital decision support for response teams in the field. The Fraunhofer IVI is developing a comprehensive system made up of servers and mobile components providing the following functions:

- Registration of injured persons, personal data and symptoms,
- eTriage – injury screening and priority setting for treatment,
- Integration of measuring data provided by wireless sensors,
- Reception of alerts from the rescue dispatch center,
- Transmission of situational information to the rescue dispatch center,
- Job management for response teams and status updates,
- Exchange of messages with the rescue dispatch center.

In addition, helpful functions for the general public and volunteers will be implemented. Among others, these are:

- Transmission of status updates and requests for help from the disaster area to the rescue dispatch center, and
- Reception of current alerts and overviews of requests for help issued by the rescue dispatch center.

**IT Architecture**

The *IMPRESS* system consists of the following components: mobile application, rescue dispatch center software, decision support algorithms, data management system and interfaces. *IMPRESS* is based on a loosely coupled architecture combined with modern web service technology, ensuring transparent data exchange. Components can be replaced or updated, new components can be added at any time. In order to facilitate the integration of external systems and data sources, *IMPRESS* is based on open standards.

The technologies developed within the *IMPRESS* project are repeatedly tested by end-users in large-scale exercises held under realistic conditions in several European countries.

**Results**

Based on the project results, end-users and experts expect that *IMPRESS* will significantly improve the management of major crises. The deployment of staff and rescue devices will be more efficient and more effective. In addition, it will be easier to exploit the support potential of volunteer helpers and the general public while minimizing risks at the same time.

# LOCATING, INFORMATION AND COMMUNICATION

TECHNISCHE UNIVERSITÄT DRESDEN

## RANGE OF SERVICES

- Design and testing of hybrid locating methods
- Development of solutions for precise track-selective locating
- Integration of wireless sensor networks
- Tests for the verification and validation of locating and communication components
- Evaluation of locating and sensor systems
- Assessment of digital traffic data services
- Signal simulation using Software Defined Radio
- Interference analyses
- Propagation and performance analyses
- Evaluation of electromagnetic compatibility (EMC)

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The acquisition of positioning information is the basis for processes of tracking and route planning executed in the field of transporting goods and passengers in traffic networks. In these situations, absolute coordinates usually do not play a predominant role. Instead, the relative distances to specific points (e. g., terminals, bus stops), curves (e. g., driving lanes or tracks) or other moving objects (e. g., nearby vehicles) are much more important. Depending on the respective application, the required precision and integrity can be very high for these locating tasks. Innovative hybrid approaches and technologies crossing all transport modes are needed to achieve the necessary standard.

In order to meet these demands, the Research Group »Locating, Information and Communication« of the Fraunhofer IVI works in close cooperation with the Chair of Transport System Information Technology, »Friedrich List« Faculty of Transportation and Traffic Sciences at the TU Dresden.

The group is specialized in the testing and analysis of components for Intelligent Transport Systems during their development, with a focus on locating and communication applications for public transport, rail freight transport and urban road traffic. Interference analysis and standards-compliant simulation of locating and communication signals on radio frequency level are some of the various methods applied in this context. Several signal generators and analyzers allow complex experiments in the laboratory, in vehicles and in the field.

# LAB-BASED TEST ROUTINES FOR COMMUNICATION SERVICES IN CONNECTED DRIVING

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The ongoing developments in automated and connected driving have created a multitude of new safety and convenience features that are based on communication and positioning. This results in an increased use of vehicle sensors and data processing requirements. In addition, vehicles will become connected to other traffic participants and to infrastructure components via upcoming radio access technologies (Car2X or Vehicle2X). Because safety-relevant driving functions are usually not tested in public areas, all tests have to be carried out under reproducible laboratory conditions and on closed test beds.

## Development of New Test Routines

The complexity of test runs grows as the number of vehicle sensors increases. The test runs demand a systematic approach that starts with the individual sensor, progresses to control devices and software interfaces, and ends with the entire vehicle. Each of the mentioned levels has specific requirements regarding the test procedures, data processing and the reduction of information from different data sources. The acquired test results are either provided for further applications or visualized within test reports. In addition, a background system for automatic problem identification qualifies and verifies the recorded measuring data to identify and analyze hidden weak spots within the vehicle.

Car2X technologies, for example, combine inertial sensors, wheel speed sensors, steering angle signals as well as navigation raw data into one single result. Especially in critical situations, the lane-sensitive positioning of vehicles must operate correctly.

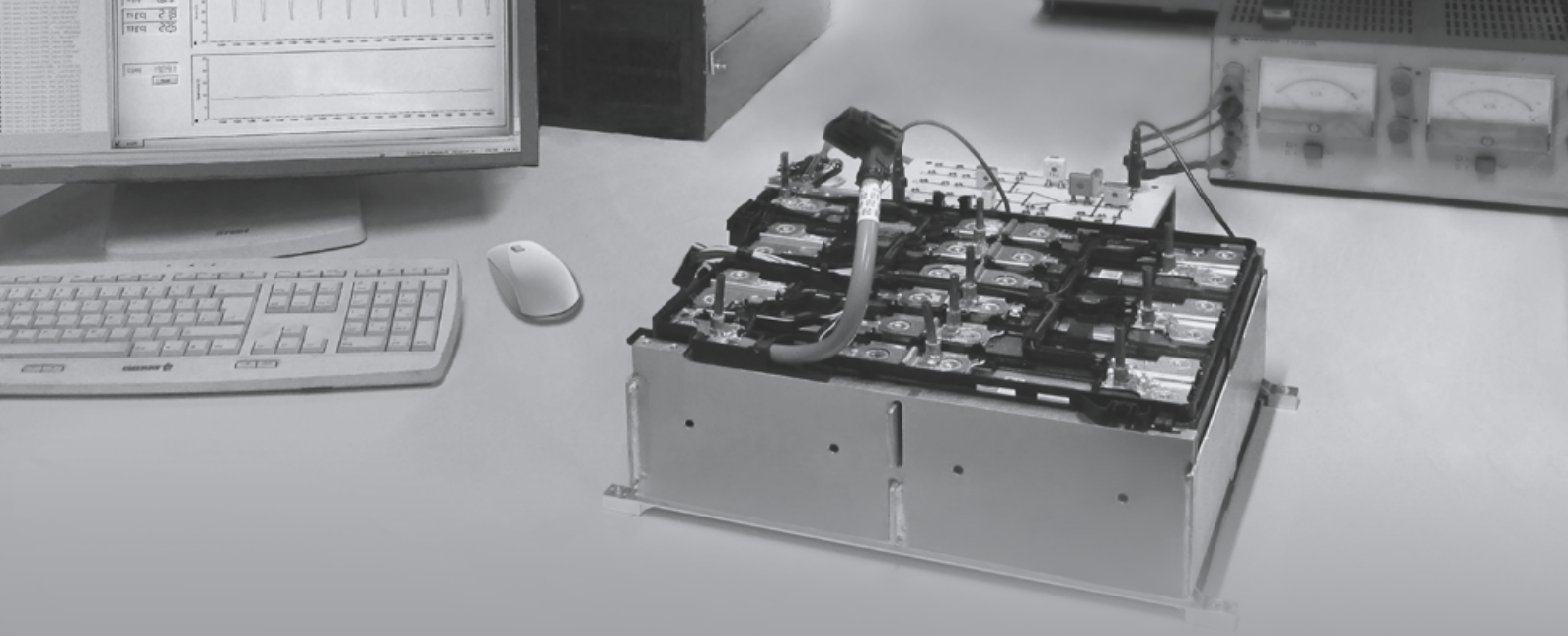
The computing power of today's software defined radio (SDR) devices can overcome the disadvantages of hardware-limited test platforms that support only a number of specific radio standards.

The term SDR describes different concepts for high frequency transmitters and receivers, in which parts of the signal processing are executed by software. With SDR, different telematics systems can be studied using only one device and in compliance with standards. In case of varying system components and requirements, it is merely necessary to adapt the test software and to specify the parameters according to the scenario (see figure 1).

## Field Tests and Future Prospects

The approach portrayed above will be implemented within the scope of the Saxon »Synchronized Mobility 2023« high tech initiative in research groups dealing with the topics »Communication and Positioning Technologies for Connected Vehicles« and »Testing and Verification«. The groups will build on first successful investigation results from previous projects on »Evaluating Car2X Modules in Urban and Suburban Areas Within the Scope of Long-Term Field Tests« and »Lab-Based Investigations of the Degradation of Reception Antennas During Data Transmission in ITS G5 Standard«.


**1** *Schematic solution approach using SDR.*



# ENERGY SYSTEM ENGINEERING

## RANGE OF SERVICES

- Analytical design of standard electrical machines and special designs with the help of our own tool chains
- Numerical calculation and optimization of electrical machines (ASM, SM, TFM)
- Thermal modeling and development of temperature sensors for spatially resolved temperature prognosis
- Control and optimization of electric traction drive systems
- Development of novel types of electrical machines (HTS motor)
- Experimental analysis of single components
- Testing of electric propulsion systems, both as individual systems and in vehicles
- Studies and expert assessments

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Since fall 2013, the Fraunhofer IVI and the Institute of Electrical Engineering at the TU Bergakademie Freiberg have been cooperating closely within a joint research group. The cooperation's aim is to exploit synergies and establish further research and development topics within the group.

The expertise of the Institute of Electrical Engineering centers on the design, calculation and thermal modeling of electric propulsion systems.

The research group's scientific profile is primarily founded on the following key topics:

- Electronic drive control,
- Design of infrastructure systems with heavily fluctuating input, and
- Energy flux control in buildings and settlements with autonomous utilities supply.

The group's long-term goal is to establish an independent research portfolio that seamlessly fits the Fraunhofer IVI's own scientific topics and that supports both teaching and research at the Institute of Electrical Engineering.

The expertise of both institutions also served as the foundation for the establishment of the shared high-performance center ELEKTROMOBILITÄT with the goal of developing electric propulsion systems that are specifically tailored to their respective applications.

# RECYCLING OF LITHIUM-ION BATTERIES: FAST, SAFE AND EFFICIENT DISCHARGING

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Due to the spread of electric propulsion systems, battery systems are being produced and operated in increasing numbers. Traction batteries are usually considered worn out if their capacity falls below 70 to 80 percent of the original capacity. Within the scope of a »second life«, these batteries can be used as stationary energy storage units for photovoltaic systems, but at the end of their life, it is necessary to recycle the cells.

The development of economic recycling processes on an industrial scale is carried out, among others, at the Institute for Mechanical Process Engineering and Treatment Technology of the TU Bergakademie Freiberg. During the recycling process, the battery modules are first disassembled, then the individual battery cells are discharged and shredded by the scissors of a granulator. The shredding causes short circuits and the release of solvents contained in the electrolytes. In order to reduce the risk of explosions and fires to an acceptable minimum, the cells must therefore be discharged completely.

**Concepts for Discharging**

Because a high throughput is required of the recycling facility, it is desirable to achieve a quick balancing of charges during the discharging of the cells. Also, for reasons of safety, temperatures and currents need to stay within specific limits, each depending on the different cell types. The method of passive discharging with the help of an ohmic load, which is often applied in simple discharge circuits, has a disadvantage: The declining cell voltage results in a declining discharging current and, in practice, in long discharging times.

Active discharging via a DC/DC boost converter, in contrast, allows a continuously high discharging current until terminal voltages of below one Volt, as well as the recuperation of the discharged energy for the grid or the facility's self-supply.

The high initial discharging current leads to a high overvoltage within the cell. As a result, the cell's terminal voltage sinks significantly below the open-circuit voltage that would occur if the discharging current were to be switched off. This means that during the final discharging phase, the terminal voltage will reach values so low that the discharging current achieved by the DC/DC converter will decline quickly even though the cell still carries a significant charge.

Therefore, active discharging through a controlled current source that causes negative terminal voltages in the final discharging phase was investigated. This approach allows the fastest discharging process that can be realized while complying with safety-relevant restrictions regarding the cell's current and temperature. The depleted state, however, cannot be determined from measured current and voltage data alone, but it has to be analyzed with the help of signal curve evaluation criteria that depend on the different respective cell types.

**Prototypical Realization**

Using a prototypical set-up of the power electronics components that includes a control and monitoring unit, it is possible to validate the concept of current-controlled discharging regarding the fast and safe discharging of a single battery cell to below a specified residual charge. In addition, this set-up is able to handle the discharging of larger battery modules consisting of series-connected single cells. Discharging larger battery modules has the advantage that the modules reach a safe state even before being disassembled, which reduces the necessary safety precautions. The discharging concept introduced above will be improved during further investigations with the aim of implementing the concept in the recycling facility located at the TU Bergakademie Freiberg.

# JUNIOR RESEARCH

## INDOOR POSITIONING ON THE BASIS OF LEAKY COAXIAL CABLES

**Motivation**

Both the introduction of customer-specific, distance-based fare systems and the optimization of schedules based on current passenger flow data require the positioning of passengers within public transport vehicles. Radio positioning presents itself as the method of choice for this task. However, multipath propagation and radio shadowed areas within vehicles often lead to inaccuracies.

Frequent causes of these disruptions are missing lines of sight (LoS) between the vehicle's built-in radio nodes and the passengers' mobile devices. Specific coaxial antennas, so-called leaky coaxial cables (LCX), with which a LoS can be established between stationary and mobile nodes at any point within the passenger compartment, can solve this problem.

Due to the radio infrastructure available in passenger compartments today, and due to the fact that modern smartphones are able to measure receive levels, the detection of passengers was executed using a level evaluation approach (received signal strength indication, RSSI) via LCX.

**Objective**

Until today, commercially available LCX have solely been used to provide radio coverage. The use of leaky coaxial cables for positioning, requires the development of a specific type of LCX that has a characteristic level curve and is resistant to environmental influences. The dissertation's aim, therefore, was to investigate how LCX can be used for locating within passenger compartments.

**Model-Based Implementation**

The characterization of the development process was realized by following a procedure model especially developed to create two LCX prototypes for a level-based positioning method. Electromagnetic field calculation was used as a tool allowing the simulative study of both the structures of leaky coaxial cables and their operation in passenger compartments. Because both of the LCX models fulfilled all predetermined conditions, it was possible to have them produced by a cable manufacturer.

**Practical Testing of Findings**

A metrological validation process conducted in a predefined passenger compartment environment confirmed the transferability of the simulation results. The application of the prototypes for indoor positioning was studied in model environments as well as in real vehicle environments, such as the Fraunhofer IVI's AutoTram® (see figure 1) and AutoTram® Extra Grand. The statistical evaluation of the acquired measuring data and the introduction of a specifically developed, zone-selective positioning approach showed that the best results were achieved with the LCX prototype 2.

Within the scope of the dissertation, a new locating approach called »zone-selective« positioning was investigated. Measurements conducted in the AutoTram® Extra Grand comprise the three vehicle zones front, middle and back that correspond to the vehicle's articulation structure. Passengers are assigned to one of the zones. The tests were executed with four different systems: standard LCX, LCX prototype 1, LCX prototype 2 and a reference system without LCX using only wireless access points.

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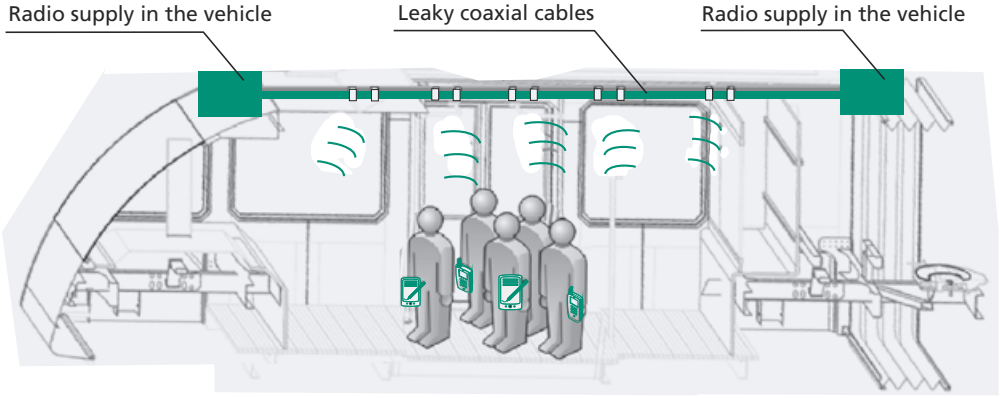
## Outlook

The use of LCX-aided positioning systems offers great advantages. System providers, for example, will be able to install cost-efficient units for passenger detection, thus creating the added value of a comfortable and accurate fare and navigation system for their customers.

In a next step, the combination of LCX with other positioning methods allowing higher positioning accuracy should be studied. One option to do this is to conduct metrological analyses in passenger compartments using the specially developed LCX prototypes in combination with commercially available positioning systems.

Furthermore, the procedure model developed within this paper also allows the investigation of possible other positioning technologies as development objectives. The emphasis of these approaches lies strongly on the advantages of leaky coaxial cables, such as the establishment of a LoS relationship between mobile devices and stationary nodes, and a reduction of the number of anchor nodes installed inside the vehicle.




**1** *Leaky coaxial cables installed in the AutoTram® for radio propagation and positioning.*

*The results were submitted as a dissertation to the »Friedrich List« Faculty of Transportation and Traffic Sciences of the TU Dresden.*

*With special thanks to my supervisors, Prof. Dr.-Ing. Oliver Michler, TU Dresden, and Prof. Dr.-Ing. Ralf Collmann, HTW Dresden.*

# DETERMINING THE IMPEDANCE OF POWER CAPACITORS

**Intention**

Capacitors are commonly used to compensate the inductive reactive power of industrial facilities. These capacitors are subject to thermal and electrical loads that are the cause for ageing processes. Eventually, the capacitors will not be able to carry out their tasks; single units may even burst or catch fire. Malfunctions of this kind create immense costs that could be avoided if a facility were to detect and prevent impending failure in a subsequent step. Before a capacitor breaks, its internal resistance (Electrical Series Resistance, $R_{ESR}$) increases significantly. This means that $R_{ESR}$ is a valuable indicator of the ageing status of the test specimen. The aim of this paper, therefore, was to develop a cost-efficient measurement method for the detection of internal resistances that is suitable for industrial use.

**Foundations**

Figure 1 shows a common equivalent circuit diagram for capacitors that can be applied in the range of nominal frequency to resonance frequency. $R_{ESR}$ is located in the range of only a few milliohms. Figure 2 demonstrates the capacitor's frequency behavior. In rated operation, $R_{ESR}$ is smaller than the capacitor's reactance by several orders of magnitude, which complicates its measurement. At resonance frequency, the impedance becomes real by assuming the absolute value of the internal resistance $R_{ESR}$. Due to ageing processes, such as self-repair or contact loss at the schoopage points, the capacity is reduced by only a few percent over time, while the internal resistance increases many times over.

**Measurement Method**

The method developed is based on undamping the capacitor by connecting negative resistances $R_{NEG}$ to it in series during a period of disconnection from the power supply. This series connection is then short circuited, which adds $R_{NEG}$ to the positive $R_{ESR}$. Mathematically, the system can be described as an oscillating circuit whose damping is proportionate to the included resistance. If $R_{NEG}$ and $R_{ESR}$ cancel each other out, there is no damping. Consequently, this means that the system performs undamped oscillations if $R_{NEG}$ and $R_{ESR}$ have the same absolute value. The undamped oscillation can be recognized by its constant amplitude.

**Measurement Circuit**

The measurement method described above was implemented in a circuit. The negative resistance was realized with the help of a negative impedance converter (NIC). The absolute value of $R_{NEG}$ can be set via control voltage. A control circuit will set $R_{NEG}$ so that the amplitude of the oscillation occuring within the capacitor and the NIC remains constant. This ensures that

$$R_{NEG} = R_{ESR}.$$

On this basis, $R_{ESR}$ can be calculated.

**Results**

The measurements conducted using capacitors of different common sizes deviated by less than 30 percent. On this basis, it is possible to reliably detect the expected multiple increase of the internal resistance. This result was achieved with the first prototype of the circuit constructed using a grid dot circuit board. It became evident that both the test object's electrical contacting and the actuator's characterization have a crucial influence on the measurement results. The same holds true for the operational amplifier used to realize the NIC.

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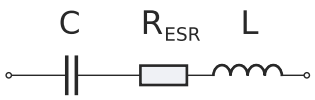
## Outlook

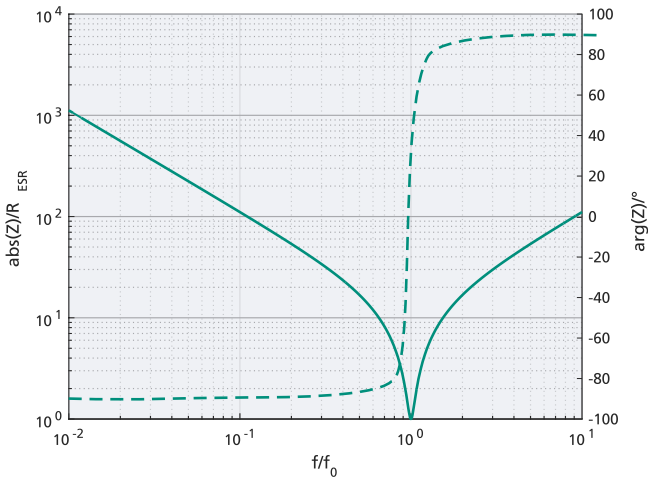
Several steps aiming to minimize the measurement deviations are planned for the future. These steps include the construction of a circuit board with an optimized layout, the integration of calibration settings reflecting the surrounding conditions, and tests with different operational amplifiers. In order to prepare the system for industrial application, a suppressor circuit is being developed. Both the expenses required for the system's installation and the space required by the measurement components can be minimized by choosing a compact and robust construction design.

## Conclusion

The measurement method developed within this paper provides a cost-efficient and reliable approach to the monitoring of capacitor ageing processes. The approach can help reduce the operating costs of industrial facilities that use capacitors and make their operation safer.




**1** *Equivalent circuit diagram for capacitors.*




**2** *Frequency response behavior of a capacitor.*

*The results were obtained within the context of a diploma thesis at the Technische Universität Dresden, Faculty of Electrical and Computer Engineering.*

*With special thanks to Dipl.-Kff. Mandy Koritz and my supervisors, Dr.-Ing. Andreas Mögel, TU Dresden, and Dipl.-Ing. Claudius Jehle, Fraunhofer IVI.*

# RECONSTRUCTION AND ANALYSIS OF TRAFFIC ACCIDENTS ON THE BASIS OF EVENT DATA RECORDERS (EDR)

**Motivation and Realization**

Road traffic safety is a core topic in many research projects. The main focus of these studies lies on the three areas of infrastructure, driver and vehicle. Regardless of which of these areas is being investigated, the analysis of traffic accidents is the basis for the development of vehicle safety. The extensive acquisition of data at the site of the accident guarantees the sufficient accuracy of its reconstruction.

The methods currently applied here mostly depend on traces which can be found on site. Due to the use of systems controlling vehicle dynamics, such as the anti-lock braking system (ABS) or the electronic stability program (ESP), hardly any traces of locking can be found at the site of the accident.

A new method for the reconstruction of traffic accidents is striving to meet this challenge. As a basis, so-called Event Data Recorders (EDR) were used, which are installed inside the vehicle and store various data on vehicle dynamics in the event of an accident.

The following list shows a selection of the information included in the EDR, which have been kindly provided by the Volkswagen AG for this study:

- Vehicle speed,
- Lateral and longitudinal acceleration,
- Position of the accelerator pedal,
- Brake operation,
- Engine speed.

**EDR Data Analysis with SAVE**

Within this diploma thesis, the software SAVE was developed. This program automatically processes and classifies the data stored on the EDR, so that information which is important for the reconstruction of the accident can be identified.

In addition to the calculation of the vehicle trajectories, SAVE is also suitable for the visualization of chronological sequences, thanks to its graphical user interface.

SAVE also offers an integrated interface for communication with the reconstruction software PC-Crash by DSD. Thus, the calculated vehicle trajectories can be displayed interactively.

The reconstruction of the accident was carried out by means of communication between both programs, SAVE and PC-Crash (see figure 1).

In addition, selected Surrogate Safety Measures were calculated using the data from the EDR. These measures help assessing the criticality of the traffic situation just before the collision. Research has also shown that EDR data can be used for investigating the avoidability of the accident.

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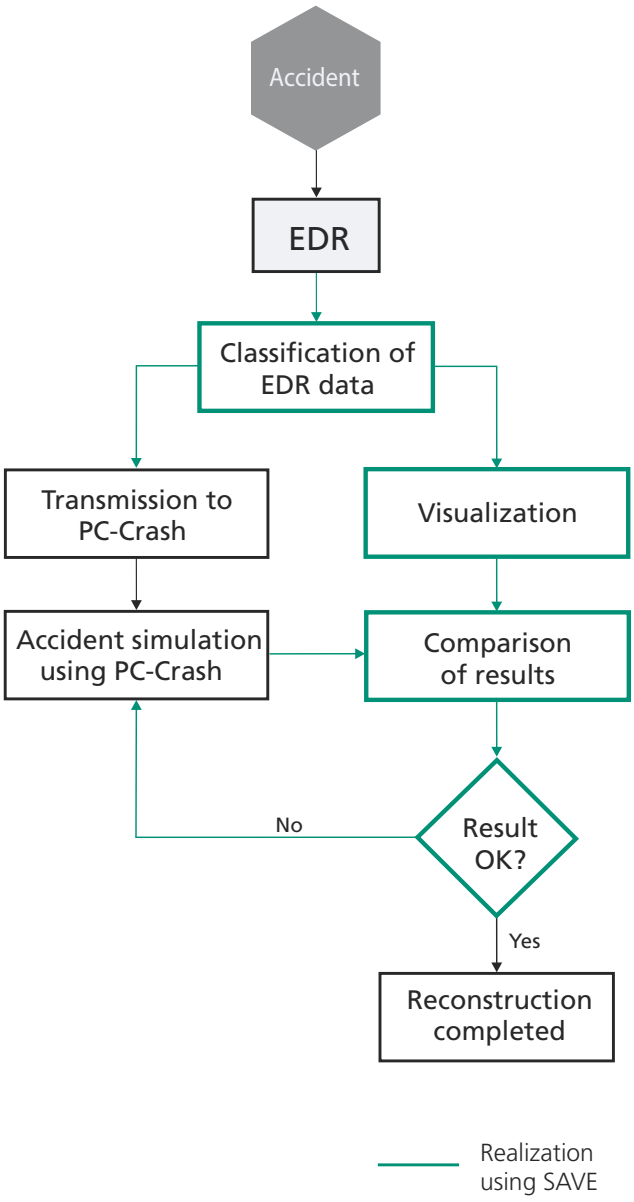


**1** *Basic sequence of the new reconstruction method.*

**Results**

EDR data are a meaningful addition to conventional traces at the site of an accident. With SAVE, a software has been developed which determines the vehicle trajectory and automates the communication with the reconstruction software PC-Crash. With this method, the missing traces of braking and locking can be replaced by means of the EDR data.

The comparison of the EDR data with the data from the crash sensors shows that the EDR speed data are subject to tolerances. The deviation from the actual value can be both positive and negative. This aspect must be taken into consideration during the accident reconstruction.

*The abovementioned results have been developed within a diploma thesis at the TU Dresden, »Friedrich List« Faculty of Transport and Traffic Sciences, Institute of Transport Planning and Road Traffic, in cooperation with Volkswagen AG.*

*I would like to express special thanks to my supervisors, Univ.-Prof. Dr.-Ing. Regine Gerike, TU Dresden and Dr.-Ing. Christian T. Erbsmehl, Dr.-Ing. Tom Landgraf, Fraunhofer IVI. I also wish to thank Prof. Dr.-Ing. Matthias Klingner, Fraunhofer IVI and Dipl.-Ing. Axel Büchner and Dipl.-Ing. Michael Stanzel, Volkswagen AG.*

# CONSTRUCTION OF AN ENERGY TRANSMISSION SYSTEM FOR THE USE IN ELECTRIC DISTRIBUTION TRANSPORT

**Impetus for the Development**

In private transport, the integration of electric propulsions in modern vehicles is constantly increasing, thereby creating a demand for the further development of fast, safe and easy-to-use recharging technologies. Also in the field of distribution transport, low-emission traction engines are often used to cover the »last mile« (daily mileage < 80 kilometers). Their recharging processes then have to be integrated into the daily routines of the provider. Currently, the energy storages of the electric distribution vehicles are being recharged overnight at charging stations, which are installed either at the loading ramps in the distribution center or in designated spaces offering the necessary infrastructure. Energy is transmitted using a conventional cable and plug connection with manual contacting. In combination with the non-automated charging process, the low charging power of this technology (≤ 22 kilowatt) implies significant restrictions for the flexibility in application.

In the *EDDA* project (Elektromobilitäts-Demonstration Docking-Anwendung, docking application for demonstration in electromobility), the Fraunhofer IVI already developed an automated fast-charging system for public transport in collaboration with several partners. This system features an aboveground interface to transmit large energy amounts with high charging power (≤ 250 kilowatt) between a wayside charging station and the vehicle energy storage, but it is specifically tailored to fulfil the needs of this particular application.

Given the background described above, this thesis focused on the development of an underfloor high-current energy transmission system, which the vehicle can drive over and which offers fully-automated recharging during loading and unloading at the ramps in distribution centers.

**System Design and Relevance for Application**

In order to make this innovative interface compatible with the traction batteries of the vehicle and the charging station, the technical parameters of the charging process must be adapted from the public transport application to meet the requirements of this new application scenario. Using an approach from construction methodology, the desired energy transmission system must be divided into the subsystems

- in-vehicle contact,
- wayside contact and
- road covering.

The interaction of these subsystems meets the predefined requirements of the overall system. By in-depth analysis of the boundary conditions, the following primary requirements have been defined:

- the space underneath the electric distribution vehicles available for installation,
- the width of the air gap which must be closed for contact and
- the positional deviations of the distribution vehicles into three spatial directions at the loading ramps in the distribution centers.

The results from these analyses are the basis for guaranteeing the desired functionality of the overall system and its implementation for the application field addressed here.

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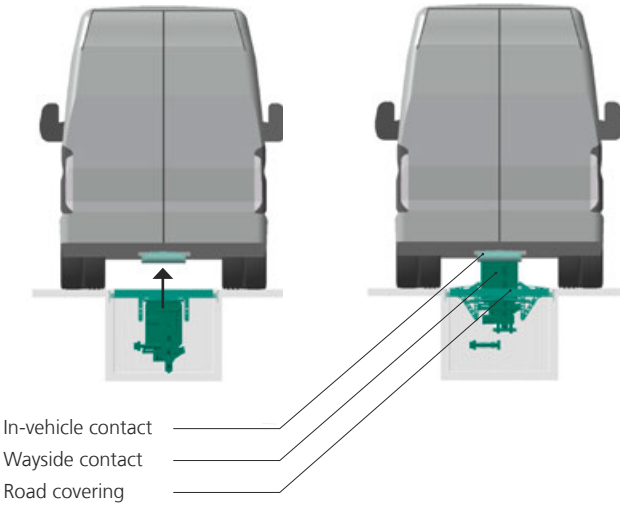
**Constructional Implementation and Functional Specifications**

The wayside contact partner serves as the underfloor base. It is installed in a permanent duct underneath the pavement und it uses a rack and pinion gear with a vertical rack for closing the air gap after positioning the vehicle. Potential errors in the installation are minimized by using a suitable stepper motor as the exclusive propulsion in the energy transmission system.

After closing the air gap, contact is established with the in-vehicle contact partner. To counterbalance positional deviations, both contact partners are of prismatic shape to enable a guided and form-fit connection between the subsystems. During the charging process, the motor is switched off and both contact partners are connected in a defined position by means of electromagnets. Once the charging process is completed, the wayside contact partner falls back into its initial position, which is caused by gravity. This movement is decelerated by a hydraulic shock absorber.

In inoperative state, the subsystem »road covering« protects the wayside mechanical system from exposures, for instance to passing vehicles and extreme weather. After the upward movement of the wayside contact partner has been initiated, a swivel mechanism opens the protection and automatically closes it when the charging process is completed.




**1** *Energy transmission system before (left) and during the charging process (right).*

**Outlook**

The results mark an important step in the development of DC fast-charging infrastructure for electric vehicles. The potential for the full automation of this system might become useful, especially with regards to the future extension of application fields and the upcoming commercialization of those vehicles – both in individually controlled as well as in driverless solutions.

With an experimental set-up at the Fraunhofer IVI, the contact system will be tested and automated.

*The results were obtained within the context of a diploma thesis at the Dresden University of Applied Sciences (HTW), Faculty of Mechanical Engineering/Process Engineering.*

*With special thanks to my supervisors, Prof. Dr.-Ing. Iris Römhild, HTW Dresden, as well as Dr.-Ing. Sven Klausner and Dipl.-Ing. (FH) Tim Vorwerk, Fraunhofer IVI.*

# DEVELOPING A CLASSIFICATION APPROACH FOR SEGMENT IDENTIFICATION IN URBAN RAIL TRANSIT

**Motivation and Objectives**

For location-based services such as navigation applications in motorized private or public transport, the Global Positioning System (GPS) serves as the state-of-the-art basis. Due to shielding and multipath caused by tunnels, underground routes or urban canyons, there is a lack of availability and accuracy with GPS, leading to research regarding the use of other surrounding information. Given the number of applications for machine learning methods and the variety of sensors included in mobile devices, the motivation came up to study regularities within the characteristics based on sensor data with a classification model which is able to identify segments. Compared with radio-based approaches such as WLAN or Bluetooth, this locating method offers the advantage that no hardware is required in the infrastructure, which would lead to further costs for installation, repair and maintenance.

**Research Setting**

The city of Nuremberg qualified as a suitable setting for data acquisition, as it features a well-developed subway network and operates a driverless line. On the subway lines U1 and U3 (see figure 2), sensor data of altogether 42 segments was collected. Hardware and software sensors were selected for the analysis, also taking into consideration other virtual sensors. To analyze the alignment of the device, three positions have been investigated – seat, pants pocket, and – randomly – coat pocket.

**Methodology**

The classification approach is a method for segment identification based on mobile sensor data and it can be divided into two systems. Based on these data, the first system is responsible for the basic classification, identifying segments within a short timeframe. This model was developed using a random forest approach, which detects and describes regularities within characteristics based on the sensor data. These regularities can for instance be caused by characteristics of the wheel/rail system or the driving behavior (breaking, accelerating).

The second system improves these basic classification results by optimizing the sequences. To achieve this, a Viterbi algorithm, based on a Hidden Markov model, was used. With this sequencing, segments can be identified over a longer period of time.

**Results**

The research initially focused on investigating the number of sensors that should be combined. The outcome being that a combination of three to five sensors is suitable for classification. The best result was achieved using the sensor combination acceleration, magnetic field, pressure, gyroscope and horizontal projection.

Looking at the five most favorable sensor combinations, it became apparent that the sensors gyroscope, pressure and magnetic field were included in all of them.

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The assumption that their influence on the classification is the most significant was confirmed by looking at the Feature Importance (FI). Using the most suitable sensor combinations, the three positions were investigated with the defined scenarios

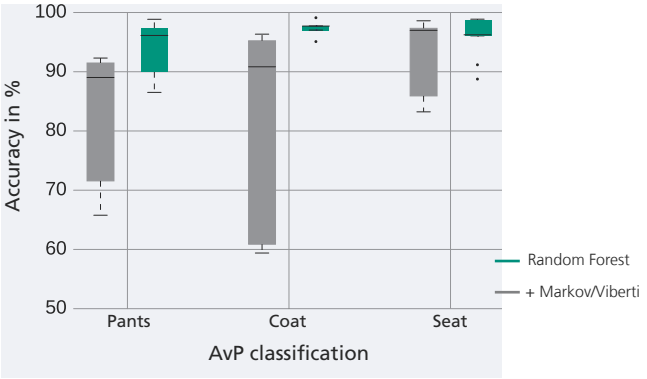
- One vs. Rest (OvR),
- One vs. Self (OvS) and
- All vs. Part (AvP),

providing insights on the rotational dependency.

Based on an AvP scenario, a generic model can be detected which delivers accuracy in classification of up to 90 percent. Using the Viterbi algorithm for sequencing optimization, the results improved for all scenarios. For the 20 segments investigated in subway line U3, accuracy went up to almost 100 percent. When looking at data from only one position (OvS), the results were much less favorable in all cases except for the »seat« position.

## Conclusion

The classification accuracy based on the collected data proves that the identification of segments is feasible. Regarding the selection of sensors, it became apparent that gyroscope, pressure and magnetic field sensors deliver the most significant contribution for the classification. It was shown that a generic model can be trained with data from various alignments, paving the way for the implementation in a real-world application scenario.




**1** *Classification results with the AvP scenario for segments of the subway line U3.*


**2** *Nuremberg subway network with the investigated lines U1 and U3.*

VAG ©

*The results were obtained within a diploma thesis at the Technische Universität Dresden, »Friedrich List« Faculty of Transport and Traffic Sciences.*

*With special thanks to my supervisors, Prof. Dr.-Ing. Oliver Michler and Dipl.-Ing. (FH) Paul Balzer, TU Dresden, as well as Dipl.-Inf. Sebastian Pretzsch, Fraunhofer IVI.*

# HIGHLIGHTS

**Fraunhofer IVI Becomes Member of *Shift2Rail* Initiative**

Following an intensive selection process, the European Commission has chosen the *Smart DeMain* consortium to become associated members of *Shift2Rail*. Within the *Shift2Rail* initiative, the consortium will be active in the »Innovation Programme 3: Cost-Efficient and Reliable High-Capacity Infrastructure«, which is going to develop new technologies for a significant improvement of railway infrastructure. The project partners will focus on designing the next generation of infrastructure components as well as a holistic concept for service and maintenance of the infrastructure. This approach is also visible in the name of the consortium, which is coordinated by Strukton Rail: *Smart DeMain* stands for »Smart Design and Maintenance for the railway of tomorrow«. In addition to the Fraunhofer IVI, members include Acciona, Cemosa and the German Aerospace Center DLR.

**Workshop on Autonomous Driving in Nevada, USA**

Since the Governor of Nevada visited the institute with a high-profile delegation in July 2015, both sides have been actively pursuing efforts to establish industry and research collaborations and exploit potential synergies. The recently initiated Saxon research program »Synchronized Mobility 2023« is especially suited to combine the innovation potentials of both Saxony and the State of Nevada. A workshop organized by the American partners, held on March 2 in the Las Vegas City Hall, was entirely focused on the topics of autonomous and connected driving. Professor Matthias Klingner and Dr. Frank Steinert presented their vision for a parallel research project in Las Vegas and Reno and discussed the steps towards its implementation in the near future. Alternating visits, for instance by Professor Alexander Paz of the University of Las Vegas and by State Secretary Dr. Hartmut Mangold document the bilateral efforts to strengthen this transatlantic cooperation.

**GHTC® Science Slam**

Through the campaign »Research in Germany«, the Federal Ministry of Education and Research (BMBF) promoted the international visibility of German research. Amongst other activities, the initiative organized the German Hightech Champion Award (GHTC®) from 2011 to 2016 to honor outstanding innovations, which were selected by a jury. The Fraunhofer IVI's technologies »AutoTram® Extra Grand« and »SMART-WAY – Mobile Public Transport Navigation« won the award and were presented to an international audience in New Delhi in 2012.

GHTC® celebrated its successful conclusion in Munich on March 4. Together with 20 other selected champions, Dr. Thoralf Knote and Sebastian Pretzsch of the Fraunhofer IVI had the opportunity to once more present their projects to a high-level audience in a Science Slam. Sebastian Pretzsch received the audience award in the »Transport« category for his presentation on *SMART-WAY*.

**Kick-off Event *iHub***

On March 7, the official launch of the *iHub* project was held at the Berlin branch of the coordinator Schenker Deutschland AG. FRAMO GmbH, a manufacturer of electric trucks, the software company PTV AG as well as the research institutes Fraunhofer IVI and the Institute for Post-Fossil Logistics PFL are jointly developing the IT-supported *iHub* system for the control of combined diesel-powered and electric truck fleets for a logistics center.

The project is funded by the Federal Ministry of Economic Affairs and Energy (BMWi) within the program »ICT for Electromobility III« and is therefore part of the »Digital Agenda 2014 to 2017«, supporting the research goals described in the government program on electromobility.

**Field Test of a Fast-Charging Plug-in Hybrid Bus in Dresden**

Supported by federal funding within the »Showcase Bavaria – Saxony ELECTRIC MOBILITY CONNECTS«, the Dresdner Verkehrsbetriebe (DVB) AG and the Fraunhofer IVI have been testing a plug-in hybrid bus in regular service on the topographically challenging route 61 in Dresden from March to September. The articulated bus was provided by the Swiss manufacturer Carrosserie Hess AG and is equipped with a high-performance battery and power electronics by the Vossloh Kiepe GmbH. Recharging was carried out at the depot in Dresden Gruna using a pantograph by the company Schunk.

The installed battery has a nominal energy content of 48 kWh and can be charged with up to 330 kW. With its usable energy amount of 38 kWh, the bus can be operated fully electrically. The bus is therefore especially well-suited for use on bus routes passing through sensitive urban areas. In addition to the fully electric driving functions and the external recharging, the research is looking into a self-learning and adaptive energy and power management for hybrid buses. This system autonomously adjusts the vehicle functions to the route and follows the objective of minimizing fuel consumption.

**Fraunhofer Visit to Colombia**

Delegates from more than ten Fraunhofer institutes visited the Latin-American country from March 31 to April 7 to investigate opportunities for cooperation and scientific exchange with companies, ministries and universities.

As head of International Business Development, Mandy Koritz represented the Fraunhofer IVI and its research topics. In addition to the AutoTram® Extra Grand and the fast-charging electric bus, the participants were especially interested in a monitoring system for ageing processes of battery cells.

**Testing of the *RMVSmart* Fare System Started**

Since April 2016, the regional transport association Rhein-Main-Verkehrsverbund (RMV) has been testing a completely new fare offer in public transport: *RMVSmart*. Initially, 20,000 users could try this offer on their smartphones. It combines performance-based prices in the rail network with package prices for buses and trams. The advantage is that greater jumps in prices, which had been criticized by passengers with regard to the current RMV fares, do not apply any longer.

In cooperation with the RMV and the WVI GmbH, the Fraunhofer IVI developed the underlying concept of the new fare offer. The institute also provided the innovative software technology used in the central fare computer of the RMV.

**Virtual autartec® Tour**

The second publicity event in the BMBF-funded project was characterized by the topic of futuristic living.

Against the backdrop of the Geierswald lake, an attractive program was offered to the numerous visitors on April 21. In addition to guest lectures on »Smart living technologies« and »Architectural design options using photovoltaics«, the autartec® partners presented and exhibited their individual technologies during an in-house exhibition.

The highlight of the event was a computer-generated, virtually accessible *FreiLichtHaus*. Dedicated to innovative technologies, the 3D model was embedded into the real surrounding of the lake using augmented reality. Tablets and smartphones of the users served as data glasses to get a realistic glimpse of the *FreiLichtHaus*.

**vbw Congress »Automated Driving – Infrastructure«**

Under the headline »Germany has a future«, a conference was held on the topic of »Automated driving – infrastructure« on May 2 in the house of the Bavarian Industry Association in Munich.

While Federal Minister of Transport and Digital Infrastructure Alexander Dobrindt explained in detail the strategies and measures of the government, Professor Matthias Klingner of the Fraunhofer IVI presented the state of the art and gave insights on the scope of research projects currently running or planned.

During the panel discussion, more than 100 interested visitors took the opportunity to address their questions to the high-profile guests.

**Novel Steering System Successfully Tested in China**

After a development phase of one year, a multi-axle steering system was successfully implemented and tested this May in a Chinese business partner's bus, which has a length of nearly 35 meters.

The tripartite vehicle has six steerable axles and can be maneuvered in two directions. Owing to the steering system developed by the Fraunhofer IVI, the vehicle's lane guidance is comparable to a tram and it can be maneuvered easily, despite its dimensions.

**Official Launch of the Electric Bus Route 89 in Leipzig**

In the presence of Leipzig's Mayor Burkhard Jung, an electric bus was officially introduced on bus route 89 of the Leipziger Verkehrsbetriebe (LVB) GmbH on May 2. The introduction was carried out within the project *EBus Batterfly*, funded by the federal government in the »Showcase Bavaria – Saxony ELECTRIC MOBILITY CONNECTS«. The vehicle used is the Fraunhofer IVI's *EDDA* bus. This bus is running in regular service between the main station and the terminus at Connewitz Kreuz, where the batteries are being recharged after each cycle within the planned turnaround time.

The LVB operates the bus. The charging station, which has been provided by the Fraunhofer IVI, is supplied via the tram power system, minimizing the effort in infrastructure.

**Demonstration of Intelligent Transport Systems in Dresden**

Within the »Synchronized Mobility 2023« initiative, a meeting was held on May 25, bringing together scientific and business partners from the consortium as well as representatives from the Saxon State Ministry of Economic Affairs, Labour and Transport (SMWA) and the German Federal Ministry of Transport and Digital Infrastructure (BMVI).

The highlight of the event was the first demonstration of highly-automated and connected driving in Dresden. Thereby, an automated vehicle by IAV GmbH drove down a nearby street, communicating with an optical signaling system which had been equipped especially for this purpose. A second vehicle was used for demonstrating aspects of connected driving.

# TRADE FAIRS

### *EUSTO* Final Conference

The *EUSTO* Final International Conference with the title »Towards Secure Transport Systems«, chaired by Dr. Ralf Hedel of the Fraunhofer IVI, was held from May 26 to 27 in the City Hall of Culture in Dresden.

The conference brought together researchers and practitioners in the field of surface transport and its protection, thus strengthening collaboration and cooperation. Speakers from several European countries and the USA addressed topics related to the protection of transport infrastructures and secure operations such as emerging threats, best practice and technological innovations. Finally, speakers and audience discussed high-priority topics for future research and development in a panel discussion.

### »Electric Freight Traffic« User's Day

Almost 70 experts from communities, trade associations, vehicle manufacturers and the logistics and applied research sectors participated in the »Electric Freight Traffic« User's Day on May 30 and 31 at the Fraunhofer IVI. Different points of view were presented and conflicts of interest were discussed – from controversial discussions about political framework conditions to the manufacturer-neutral description of technological options and the perspectives of manufacturers and users, especially shipping agents and logistics providers.

The participants were delighted by the opportunity to test various electric vehicles of different classes relevant to electric freight traffic, such as small vans, delivery pedelecs, cars and even trucks.

- **CeBIT in Hannover**
  March 14-18, 2016

  Presentation of the research project *iTESA* (intelligent Travellers Early Situation Awareness) at the booth of its funding body Federal Ministry for Economic Affairs and Energy

- **Energy Storage Europe in Düsseldorf**
  March 15-17, 2016

  Presentation of the Fraunhofer IVI's battery monitoring system at the joint booth of the Fraunhofer Energy Alliance

- **new mobility in Leipzig**
  April 12-13, 2016

  Exhibition of the fast-charging electric bus at the booth of the transport company Leipziger Verkehrsbetriebe (LVB) GmbH

- **GPEC in Leipzig**
  June 7-9, 2016

  Showcasing the latest developments in emergency response simulation and police training from the EU-funded project *TARGET* (Training Augmented Reality Generalised Environment Toolkit)

**Dresden Researchers Night**

At this year's event on June 10, almost 900 guests had the opportunity to gain fascinating insights into selected research projects of the Fraunhofer IVI. Under the motto »Staunend durch die Nacht« (Through the night in awe), the guests had the chance to make a few quiet laps on the test track – either as the drivers of an electric car or as the passengers of a plug-in hybrid bus. The virtual tour of the autartec® building, which was realized by an augmented reality app, was a highlight for the young and the old. A crafts and drawing table was provided for the youngest guests. In addition, they could participate in a treasure hunt and get to know future-oriented locating and positioning technologies.

The Fraunhofer IVI was the first stop on the special tour of Dresden's First Mayor, Dirk Hilbert. Before the official start of the event, the tour's high-profile guests, including Saxony's State Minister of Science and the Arts, Dr. Eva-Maria Stange, had the opportunity to see the many booths and take part in the activities provided by the Fraunhofer IVI as its first guests.

**Final Conference of the *Guide2Wear* Project**

The final conference of *Guide2Wear* was held in Vienna on June 13. Scientists from several countries and research areas collaborated over a duration of two years with the objective of supporting public transport passengers with the help of wearable devices. A smartwatch application, which offers public transport navigation and is able to include various modes, e. g. bike sharing, was developed under the coordination of the Fraunhofer IVI.

The app was tested live by the conference participants in Vienna's city traffic. 12 smartwatches had been provided for the test.

**Nevada Trip with State Secretary Dr. Mangold**

Following a visit by a high-profile delegation of the Governor of Nevada in 2015, both sides have been aiming for the establishment of a collaboration to build digital test beds for autonomous driving in Saxony and Nevada. Based on the model of the Saxon initiative »Synchronized Mobility 2023«, an »Open Innovation Living Laboratory Ecosystem« is being developed in Nevada.

Sebastian Pretzsch of the Fraunhofer IVI joined State Secretary Dr. Hartmut Mangold (State Ministry for Higher Education, Research and the Arts, SMWK) and his delegation on their trip to California and Nevada from July 12 to 17, where he took the opportunity to meet the Chief Strategy Officer of the Governor of Nevada, Dale Erquiaga, to present current developments in Saxony and talk about the next steps. Joint projects, the exchange of scientific staff and the formation of a bilateral working group dedicated to the framework in traffic law on ministry level have been discussed.

**Official Launch of *IN2SMART* Project**

»Intelligent Innovative Smart Maintenance of Assets by Integrated Technologies« (*IN2SMART*) is the title of the first research and innovation project launched by the *Shift2Rail* Joint Undertaking, in which the Fraunhofer IVI is participating. *IN2SMART* started on September 1, and will run for a term of three years. A consortium of 19 partners – compiled from the JU's founding and associate members and coordinated by ANSALDO STS (Italy) – are going to collaborate on topics in the field of intelligent maintenance systems and strategies.

Within *IN2SMART*, the Fraunhofer IVI is leading Work Package 9, which will lay the foundation for future asset management in railway infrastructures and offer decision support.

# TRADE FAIRS

**Kick-off Event *AutoTruck***

The research project *AutoTruck* was launched on September 8 during a meeting of the nine project partners in Lehrte.

Coordinated by the Götting KG, technologies such as

- High-precision locating and navigation,
- Safe collision avoidance,
- Car2infrastructure communication,
- Real-time maneuver planning as well as
- Fully-automated docking

will be developed until fall of 2019 for the fully-automated cooperative operation of commercial vehicles in suitable automation zones, and demonstrated in a logistics center with adjacent development roads. For trucks to also be used with drivers outside the automation zones, the additional components and processes are aiming at the suitability for licensing in road traffic and hybrid use with or without drivers.

**Press Conference at the Public Transport Expert Meeting**

Visions and challenges concerning the digitalization and interconnection within the transportation sector were the main focus of the »Intelligent Solutions for Efficient Mobility« Expert Conference held by the Sächsische Energieagentur (SAENA) on September 15. Enterprises and research institutions from Saxony presented their expertise and gave an insight into current developments, cutting-edge technologies and their practical experience. In his closing presentation titled »Synchronized Mobility in Dresden – Synchronized Mobility in Nevada«, Professor Matthias Klingner talked about ongoing international activities and cooperative projects. At the accompanying press conference, high-profile representatives from science, economy and politics answered the questions of the interested reporters.

▶ **InnoTrans in Berlin**
September 20-23, 2016

Presentation of findings regarding the saving of material, flexible manufacturing and good user comfort of railcar bodies in cooperation with the Fraunhofer IWS at the Fraunhofer joint booth

▶ **IAA Commercial Vehicles in Hannover**
September 22-29, 2016

Presentation of the novel TruckTrix® web service for the planning and simulation of heavy haulages at the booth of the Goldhofer AG

▶ **FLORIAN in Dresden**
October 6-8, 2016

Exhibition of new MobiKat components for operational command as well as data collection and analysis for fire services


**_EmiD_ Project Closing Event**

The closing event for the »EmiD – Elektromobilität in Dresden« project with its accompanying workshop for vehicle fleet managers was held on September 26 in the great plenary room of the Dresden City Hall. After the official greetings delivered by Mayor Eva Jähnigen, Councilwoman for the environment and municipal economy, and Dr. Lutz Bryja, head of department at the Saxon State Ministry for Economic Affairs, Labor and Transport (SMWA), the four project partners had the opportunity to present their results. In his presentation, Sebastian Pretzsch, group manager at the Fraunhofer IVI and official project leader, introduced a newly developed booking system for electric vehicles that includes guaranteed ranges and suggestions for recharging.

*EmiD* is one of about 40 projects from the »Showcase Bavaria – Saxony ELECTRIC MOBILITY CONNECTS« and was funded by the State of Saxony within the scope of the showcase initiative of the German Federal Government.

**Kick-off Event _Heat2Go_**

On October 19, the Fraunhofer IVI launched the research project *Heat2Go*, with the objective to develop and demonstrate a novel efficient heating system for fully-electric city buses. Thereby the project is aiming for a solution to a key problem – to achieve complete emission-free operation and further lower the barrier to using electric buses. With the companies AURORA and KONVEKTA, two experts in the field of climate control for commercial vehicles are involved, who can participate in the design of the innovation and transfer it into a viable product.

This project is receiving funding from the Federal Ministry of Transport and Digital Infrastructure (BMVI).

**_EcoTrain_ Award Ceremony**

Within the nationwide competition »Landmarks in the Land of Ideas«, highly innovative and visionary projects are honored and displayed to the public. On November 2, the DB RegioNetz Verkehrs GmbH in Annaberg-Buchholz received this certificate, signed by Federal President Joachim Gauck, for the research project *EcoTrain*.

In collaboration with the TU Dresden, the TU Chemnitz and the Fraunhofer IVI, a railcar of the Erzgebirgsbahn is being converted. With the help of the modular hybrid propulsion system, fully electrified auxiliaries and an eco-friendly $CO_2$ air conditioning system, diesel and energy consumption are being reduced, producing a train with less noise and pollutant emissions. The project »EcoTrain – Sustainable Propulsion and Energy Management« is receiving funding within the »Showcase Bavaria – Saxony ELECTRIC MOBILITY CONNECTS«.

**Toyota Delegation Visits the Fraunhofer IVI**

The institute has been successfully cooperating with Toyota Motor Europe in the field of vehicle and road safety for more than two years. As an outcome, the partners submitted a paper to the Expert Symposium on Accident Research (ESAR) in 2016. This publication describes a new method, called »Analysis and Investigation Method for all Traffic Scenarios – AIMATS«, which is used for the collection of real-world critical traffic scenarios. As a follow-up, a meeting was held at the Fraunhofer IVI on December 1, featuring high-profile representatives from Toyota branches Japan, USA and Europe.

Professor Matthias Klingner welcomed the delegation and lead the meeting together with Dr. Christian T. Erbsmehl, manager of the group »Vehicle and Road Safety«. The participants agreed to further intensify their fruitful cooperation in the field of international vehicle and road safety in the coming years.

### *TRANSFORMERS* Field Tests in Sweden

From December 5 to 23, the European research project *TRANSFORMERS* carried out field tests of a novel hybrid articulated truck in Gothenburg, Sweden. The results proved to be highly promising regarding the reduction of energy and fuel consumption.

Well-known European manufacturers of commercial vehicles, suppliers, research institutes and end users are cooperating in this project towards the optimization of the loading floors and the development of new components for road-bound freight transport. The aims are to better utilize the capacity, improve aerodynamics and to re-use breaking energy.

The Fraunhofer IVI is leading the development and integration of the electric drivetrain. Within only three years, the team managed to build a trailer carrying the novel technology which is ready for approval. When coupling the trailer with a conventional tractor unit, a fully functional hybrid propulsion is created.

### Economic Delegation from Saxony Visiting Colombia

On December 7, Federico Gutiérrez, Mayor of the Colombian city of Medellín, welcomed a European economic delegation to discuss the possibilities for application of ultra-capacity buses in the city's public transport system.

A consortium consisting of Siemens, HÜBNER, Bozankaya and the Fraunhofer IVI presented a bus concept for fast growing megacities, which is more efficient and more flexible than trams with a comparable transport capacity. The novel electronic steering system, a key technology developed by the Fraunhofer IVI, is particularly important for this concept. With this system, buses with a length of up to 36 meters can be maneuvered easily in urban areas.

### International Business Development Network Meeting

The International Business Development (IBD) network of the Fraunhofer-Gesellschaft meets twice a year. Its members include not only responsible employees from the German institutes, but also colleagues from the worldwide Representative Offices.

The Fraunhofer IVI hosted the IBD network meeting on December 7 and 8. During the workshop, topics and strategies across the institutes were discussed. Visiting the historic Christmas market »Striezelmarkt« in Dresden, the participants used the informal atmosphere to exchange experiences and ideas on current challenges in international research collaborations.

# PUBLIC BODY MEMBERSHIP AND PATENTS

## PUBLIC BODY MEMBERSHIP

**Danowski, Kamen**

- Section »Civil Protection«, Euroregion Elbe/Labe

**Engelbrecht, Julia Maria**

- IEEE Region 8: Europe, Middle East and Africa
- IEEE Intelligent Transportation Systems Society
- IEEE Vehicular Technology Society
- VDE Dresden District Association e. V.

**Erbsmehl, Christian T.**

- EVU European Association for Accident Research and Analysis e. V.

**Festag, Andreas**

- Acatech National Academy of Science and Engineering »New autoMobility«

**Grimm, Jan**

- BASt Federal Highway Research Institute, Supervisor Group »Impact of Errors on Traffic Management Systems«
- COST Action TU1305 Social Networks and Travel Behaviour
- FGSV German Road and Transportation Research Association, Working Group AG 3.2.9 »Video Detection in Traffic Management Systems«

**Gründel, Torsten**

- kontiki Working Group in Contactless Chip Card Systems for Electronic Ticketing e. V.
- CNA Center for Transportation & Logistics Neuer Adler e. V.
- ECTRI European Conference of Transport Research Institutes
- Fraunhofer Traffic and Transportation Alliance
- Network »SatNav Saxony«
- Silicon Saxony e. V., Applications Division, Working Group Cyber-Physical Systems
- UITP International Association of Public Transport

**Hedel, Ralf**

- Moderator of the ECTRI Thematic Group »Security and Risk Analysis«

**Jehle, Claudius**

- Fraunhofer Energy Alliance

**Kertzscher, Jana**

- VDE Association for Electrical, Electronic & Information Technologies e. V.

**Knote, Thoralf**

- FGSV German Road and Transportation Research Association, Working Group AG 3.10 »Theoretical Basics of Road Traffic«

Klingner, Matthias

- Dresden-concept e. V.
- Fraunhofer ICT Group
- Fraunhofer-Alumni e. V.
- International Monorail Association
- Network »Dresden – Stadt der Wissenschaften«
- Forum on Electromobility e. V.

Michler, Oliver

- Cool Silicon e. V.
- DGON German Institute of Navigation e. V., Expert Committee »Traffic Telematics«

Potthoff, Ulrich

- Fraunhofer Battery Alliance
- Development association HYPOS – Hydrogen Power Storage & Solutions East Germany e. V.

Rauschert, André

- Fraunhofer Big Data Alliance

Städel, Christian

- DIN German Institute for Standardization e. V., committee »Thermal Storage Systems for Commercial Applications«

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- Klingner, M.: **Leistungssteuereinrichtung und Verfahren zum Lastausgleich eines Netzes.** Application no.: DE 10 2011 114 344, Publication: March 21, 2013 European Application: September 20, 2012

- Wagner, S.; Zipser, S.: **Verfahren zur automatischen oder teilautomatischen spurtreuen Mehrachslenkung eines Straßenfahrzeugs und Vorrichtung zur Durchführung des Verfahrens.** Patent no.: DE 10 2006 037 588, 2011

## CERTIFICATES

- Städel, Christian: **Expert for energy-efficiency in buildings.** Registration no: 1191-16-2016

## TRADEMARKS

- **AutoTram®** DE 304 17 949, 2004

- **autartec®** DE 30 2012 021 316, 2012

- **Feldschwarm®** DE 30 2013 013 880, 2013

- **HORUS®** DE 30 2013 006 673, 2014

- **TruckTrix®** DE 30 2014 003 169, 2014

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## ARTICLES AND PRESENTATIONS

Baldi, M. M.; Tadei, R.; Heinicke, F.; Simroth, A.: **New Heuristics for the Stochastic Tactical Railway Maintenance Problem.** *In: Omega. The International Journal of Management Science, Elsevier B.V., 2016, vol. 63, pp. 94-102, ISSN 0305-0483, DOI: 10.1016/j.omega.2015.10.005*

Bartholomäus, R.; Lehmann, T.: **Enhancement of Battery Lifetime Using Model Predictive Control of Hybrid Energy Storage System.** International Symposium on Advanced Battery Power, Muenster, Germany, April 25-27, 2016, poster presentation

Bartholomäus, R.; Lehmann, T.; Jehle, C.: **Model Predictive Control of a Dual Mode Energy Storage System.** 9th Graz Symposium Virtual Vehicle, Graz, Austria, May 23-25, 2016, presentation: C. Jehle

Bartholomäus, R.; Schneider, U.; Helfer, W.: **Fast Current Control in Bidirectional Buck-Boost Converters for Electric Vehicles.** 9th Graz Symposium Virtual Vehicle, Graz, Austria, May 23-25, 2016, presentation C. Jehle

Berendes, E.; Socher, S.; Jehle, C.; Potthoff, U.: **State of Charge Estimation On Lithium-Sulfur-Batteries Using Impedance Spectroscopy.** 9th International Workshop on Impedance Spectroscopy IWIS 2016, Chemnitz, Germany, September 26-28, 2016, presentation: S. Socher

Dobrinkova, N.; Kostaridis, A.; Olunczek, A.; Heckel, M. (u. a.): **Disaster Reduction Potential of IMPRESS Platform Tools.** First IFIP Conference on Information Technology in Disaster Risk Reduction ITDRR 2016, Sofia, Bulgaria, November 16-18, 2016, Vortrag: N. Dobrinkova

Engelbrecht, J. M.; Weber, R.; Michler, O.: **Reduction of Multipath Propagation at PoA Positioning Using Uniform Circular Array Antennas. An Analysis by Measurements in Vehicular Scenarios.** 13th IEEE Workshop on Positioning, Navigation and Communication WPNC 2016, Bremen, Germany, October 19-20, 2016, poster presentation

Erbsmehl, C.: **Analysis and Investigation Method for All Traffic Scenarios (AIMATS).** Expert Symposium on Accident Research ESAR 2016, Hannover, Germany, June 9-10, 2016

Erbsmehl, C.; Landgraf, T.; Urban, M.; Laskosky, S.: **FAPS – Fraunhofer IVI Accident-Prevention-School. A New Method to Increase the Overall Traffic Safety by Using Real Accident Data and Expert Evidence.** 25th Annual Congress of the EVU, Bratislava, Slovakia, October 20-22, 2016, presentation: C. Erbsmehl

*In: Proceedings. 25th Annual Congress. Kasanický, G.; Kolla, E.; Macurová, L.; Benecová, K. (eds), Žilina, Editing Centre of University of Žilina, 2016, pp. 335-341, ISBN: 978-80-554-1260-3*

Festag, A.: **Advanced Techniques for Wireless Vehicular Communication.** 23rd World Congress on Intelligent Transport Systems and Exhibition ITS 2016, Melbourne, Australia, October 10-14, 2016, presentation: A. Festag

Festag, A.: **European V2X Standardization and Pilot Projects.** 5G V2X Workshop, Munich, Germany, October 16, 2016

Festag, A.; Kühlmorgen S.; Maslekar, N.: **Decentralized Congestion Control for Multi-Hop Vehicular Communication.** 23rd World Congress on Intelligent Transport Systems and Exhibition ITS 2016, Melbourne, Australia, October 10-14, 2016, presentation: A. Festag

# DAK

**DRESDNER AUTOMATISIERUNGS-TECHNISCHE KOLLOQUIEN**

Fichtl, H.; Beims, M.; Claus, S.; Werner, C.: **EcoTrain – der neue Hybridtriebwagen der Erzgebirgsbahn.** 43th Conference on Modern Rolling Stock, Graz, Austria, April 3-6, 2016, presentation: H. Fichtl

*In: ZEVrail. Berlin, Georg Siemens Verlag, 2016, vol. 140, special ed., pp. 73-79, ISSN: 1618-8330*

Fichtl, H.; Beims, M.; Claus, S.; Werner, C.: **EcoTrain: The Erzgebirgsbahn's New Hybrid Railway Vehicle.** *In: Transportation Research Procedia, Amsterdam [et al.], Elsevier, 2016, vol. 14, pp. 575–584, ISSN 2352-1465, DOI 10.1016/j.trpro.2016.05.296*

Fichtl, H.; Steinert, F.: **IVIsion and IVInet – Tool Chain for the Electrification of City Bus Routes**. *In: Transportation Research Procedia, Amsterdam [et al.], Elsevier, 2016, vol. 14, pp. 2554-2563, ISSN 2352-1465, DOI: 10.1016/j.trpro.2016.05.344*

Hahmann, S.; Hedel, R.; Olunczek, A.; Heckel, M.: **INCIMOB – Mobile Application for Emergency Responders.** PSC Europe Forum Conference, Joint IMPRESS-CONCORDE Workshop »Decision Support Tools for Effective Health Emergency Management«, Athens, Greece, October 23-24, 2016, presentation: S. Hahmann

Heinicke, F.: **A Multi-Depot Vehicle Routing Problem with Travel Costs and Customer Costs for Tamping Scheduling.** 28th European Conference on Operational Research EURO 2016, Poznan, Poland, July 3-6, 2016, presentation: F. Heinicke

Heinicke, F.; Simroth, A.: **From Floating Car Data to Time-Dependent Route Scheduling: A Holistic Methodology.** Annual Workshop of the EURO Working Group on Vehicle Routing and Logistics Optimization VeRoLog 2016, Nantes, France, June 6-8, 2016, presentation: F. Heinicke

- **Modellbildung und Regelung von Drei-Wege-Autoabgaskatalysatoren**

  *Dipl.-Ing. Radoy Stanchev*
  TU Darmstadt,
  Institute of Automatic Control and Mechatronics,
  April 25, 2016

- **Modellbasierte Methoden zur Berechnung von Solltrajektorien am Beispiel unteraktuierter mechanischer Systeme**

  *Dipl.-Ing. Carsten Knoll*
  TU Dresden,
  Faculty of Electrical and Computer Engineering,
  Institute of Control Theory,
  June 27, 2016

- **Formale Reglersynthese mittels konvexer Kombinationen**

  *Bastian Schürmann, M. Sc.*
  TU München,
  Department of Informatics,
  Chair of Embedded Systems and Robotics,
  October 24, 2016

- **Synthese robuster Regler für lineare Mehrgrößensysteme**

  *Dr. Tobias Zaiczek*
  Fraunhofer Institute for Integrated Circuits IIS,
  Division Engineering of Adaptive Systems EAS,
  November 21, 2016

Hobert, L.; Festag A.: **AutoNet2030 Communications: V2X for Cooperative Automated Driving.** AutoNet2030 – Final Workshop, AstaZero, Sandhult, Sweden, October 27, 2016

Holfeld, D.; Simroth, A.: **Risk Analysis for a Synchro-Modal Supply Chain Combined with Smart Steaming Concepts.** ERCIM News, Sophia Antipolis, ERCIM EEIG, 2016, issue 105, pp. 28-29, ISSN 0926-4981, online: http://ercim-news.ercim.eu/en105/special/risk-analysis-for-a-synchro-modal-supply-chain-combined-with-smart-steaming-concepts

Holfeld, D.; Simroth, A.; Tadei, R.: **Risk Analysis for a Synchro-Modal Supply Chain.** 28th European Conference on Operational Research EURO 2016, Poznan, Poland, July 3-6, 2016, presentation: D. Holfeld

Jehle, C.; Hampel, F.; Steinert, F.; Potthoff, U.: **IVIon: Ein umfassendes Batterieferndiagnose-System.** 5th Conference »Electrics/Electronics in Hybrid and Electric Vehicles and Electrical Energy Management« EEHE 2016, Wiesloch, Germany, June 8-9, 2016, presentation: C. Jehle

*In: Elektrik/Elektronik in Hybrid- und Elektrofahrzeugen und elektrisches Energiemanagement VII. Hoff, C; Sirch, O. (eds.), Renningen, expert Verlag, 2016, pp. 246-256, ISBN 978-3-8169-3346-5*

Jehle, C.; Potthoff, U.: **Batteriemonitoringsystem IVIon.** Energy Storage Europe, Duesseldorf, Germany, March 15-17, 2016, presentation: C. Jehle

Knote, T.: **Energiebilanzierung von Batteriebussen unter Beachtung von Betriebsstörungen.** 5th International E-Bus Conference »Clean and quiet – the state-of-the-art e-bus«, Berlin, Germany, May 31-June 1, 2016

Knote: T.: **Long-Term Evaluation of Trolley-Battery-Hybrid Buses and Future Plans in Eberswalde.** ELITPIC Partner Meeting, Gdynia, Poland, June 8-10, 2016

Lehmann, T.; Bartholomäus, R.; Jehle, C.: **Enhancement of Battery Lifetime Using Model Predictive Control of Hybrid Energy Storage System.** Kraftwerk Batterie 2016, Muenster, Germany, April 25-27, 2016, poster presentation

Leinmüller, T.; Spaanderman, P.; Festag, A.: **Next Steps for Multi-Channel Operation in EU V2X Systems.** 23rd World Congress on Intelligent Transport Systems and Exhibition ITS 2016, Melbourne, Australia, October 10-14, 2016, presentation: T. Leinmüller

Rauschert, A.: **Dynamic Pricing and Big Data Technologies.** Henkel Innovation Day, Duesseldorf, Germany, November 23, 2016

Socher, S.; Jehle, C.; Potthoff, U.: **Improving the Functional Safety of Automotive Batteries Using In-Situ Impedance Spectroscopy.** 6th Transport Research Arena TRA 2016, Warsaw, Poland, April 18-21, 2016, poster presentation

*In: Transportation Research Procedia, Amsterdam [et al.], Elsevier, 2016, vol. 14, pp. 3661-3666, ISSN 2352-1465, DOI: 10.1016/j.trpro.2016.05.437*

Socher, S.; Jehle, C.; Potthoff, U.: **Increased Functional Safety: Redundant Temperature Estimation of Automotive Batteries.** Kraftwerk Batterie 2016, Muenster, Germany, April 25-27, 2016, presentation: C. Jehle

Socher, S.; Jehle, C.; Potthoff, U.: **On-line State Estimation of Automotive Batteries Using In-situ Impedance Spectroscopy.** *In: Progress Reports on Impedance Spectroscopy: Measurements, Modeling, and Application. Kanoun, Olfa (eds), Berlin, de Gruyter, 2016, pp. 49-56, ISBN: 978-3-11-044983-9*

Wagner, S.; Nitzsche, G.: **Advanced Steer-by-Wire System for World's Longest Buses.** 19th IEEE Intelligent Transportation Systems Conference »Intelligent Transportation for Smarter Societies« ITSC 2016, Rio de Janeiro, Brazil, November 1-4, 2016, presentation: S. Wagner

Weber, R.; Balzer, B.; Michler, O.; Mademann, E.: **Improved RO-SLAM Using Activity Classification for Automated V2X Infrastructure Mapping.** 13th IEEE Workshop on Positioning, Navigation and Communication WPNC 2016, Bremen, Germany, October 19-20, 2016, presentation: R. Weber

Wittig, H.; Bartholomäus, R.; Lehmann, T.: **VeloCité – Development of an Energy Storage System for an E-Bike.** 6th Transport Research Arena TRA 2016, Warsaw, Poland, April 18-21, 2016, presentation H. Wittig

*In: Transportation Research Procedia, Amsterdam [et al.], Elsevier, 2016, vol. 14, pp. 3631-3640, ISSN 2352-1465, DOI: 10.1016/j.trpro.2016.05.431*

*The full list of publications can be found in the German section of the institute report on pages 54-59.*

# TEACHING ENGAGEMENTS

**Bartholomäus, Ralf**
Optimale Steuerung kontinuierlicher Prozesse.
TU Dresden,
Faculty of Electrical and Computer Engineering,
Laboratory of Control Theory, SS 2016

Robuste Regelung.
TU Dresden,
Faculty of Electrical and Computer Engineering,
Laboratory of Control Theory, SS 2016

**Festag, Andreas**
Machine-to-Machine Communication.
TU Dresden,
Faculty of Electrical and Computer Engineering,
Institute of Communication Technology (IfN), WS 2016/17

**Kertzscher, Jana**
Berechnung elektrischer Maschinen.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2016

Einführung in die Elektrotechnik.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, SS 2016,
WS 2016/17

Elektrische Energiewandler.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2016

Elektrische Maschinen und Antriebe.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

Energiespeicher.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

Energietechnik. (Lecture series)
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

Grundlagen der Elektrotechnik.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2016

Hybrid- und Elektroantriebe.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

Regelung elektrischer Antriebe I.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2016

Regelung elektrischer Antriebe II.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

Theorie elektrischer Maschinen.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

**Klingner, Matthias**
Elektroenergiesysteme.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2016

Systemtheorie in der Anwendung. (Compact seminar)
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2015/16, WS 2016/17

**Knote, Thoralf**
Straßenverkehrstechnik.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Transport Planning and Road Traffic,
WS 2015/16, SS 2016, WS 2016/17

**Michler, Oliver**
Elektrotechnische, informations- und kommunikations-technische Grundlagen. (Teil II: Grundlagen der Informations- und Kommunikationstechnik.)
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, SS 2016

Fahrzeugkommunikation und Ortung.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics,
WS 2015/16, SS 2016, WS 2016/17

Satellitenkommunikation und positionsbezogene Kommunikationssysteme.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics,
WS 2015/16, SS 2016, WS 2016/17

Technik und Verfahren digitaler, adaptiver und intelligenter Systeme.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics,
WS 2015/16, SS 2016, WS 2016/17

Theorie und Technik der Informationssysteme.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics,
WS 2015/16, SS 2016, WS 2016/17

Verkehrssensorik.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, SS 2016

**Potthoff, Ulrich**
Modellierung und Simulation in der Verkehrstelematik.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, WS 2015/16, WS 2016/17

Modellierung und Simulation 2.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, SS 2016

**Rauschert, André**
Ideen-, Innovations- und Change Management.
Gründungsmanagement.
Hochschule Mittweida (FH),
Faculty Industrial Engineering, Faculty Media Sciences
WS 2015/16, SS 2016, WS 2016/17

*A list of final theses supervised by Fraunhofer IVI employees can be found in the German section on pages 61 and 63.*


Fraunhofer
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# LIFE AT WORK AND BEYOND

On a sunny Friday in May, over 100 former employees returned to the institute to remember the old days together, but also to visit the newly renovated premises. All of them had once worked in the building, and many of them still have loyal ties to the institute, although they have found a new employer or retired a long time ago.

For 55 years now, research has been carried out in the Zeunerstrasse in Dresden. Since the move-in in 1961, the building has seen many good times and also survived through some bad times. Each decade has had its special characteristics, its personalities and scientific emphases – marked not only by technological change, but also by the changes in politics and society. What has prevailed is the wish to stay true to oneself and to always have an instinct for the right measure at the right time.

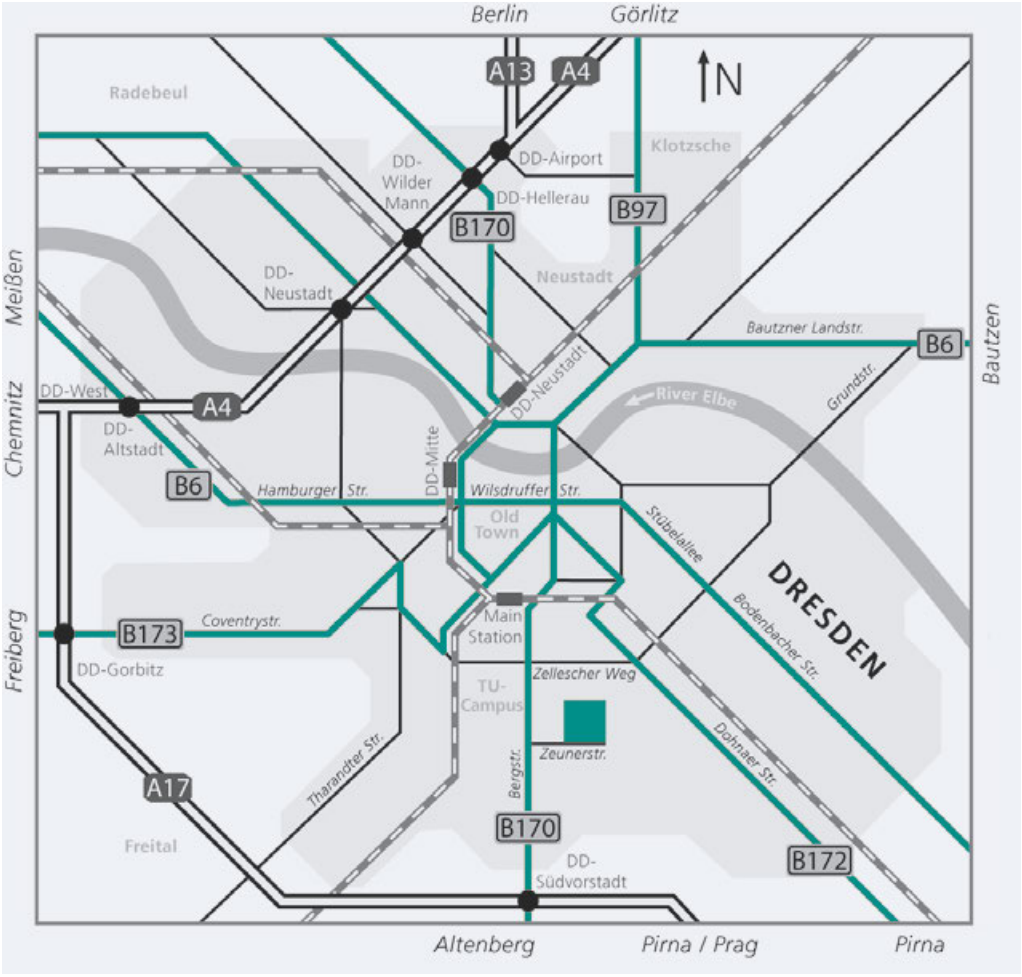
A whole number of traditions have been preserved across five decades, such as doctoral celebrations, excursions, and Christmas surprises for young and old.

Today, the focus of attention mainly lies on measures for the preservation of physical well-being. Also, the reconciliation of family and career now plays a greater role. The institute's employees gladly make use of offers such as the annual health day and in-house massages, and many participate in joint sports activities. The parent-child office, which offers sufficient space for both work and play, is also a favorite among the staff. In addition, a holiday program for the employees' children was held in 2016 for the first time. The program had the title »Traffic of Yesterday, Today and Tomorrow« and was organized in cooperation with the DLR SchoolLAB at the TU Dresden.

# HOW TO REACH US

By **public transport** from Dresden Hauptbahnhof/ Main Station, take bus 66 in the direction Technische Universität, ride three stops to »Mommsenstrasse«, 5-minute walk from there (or take a taxi from Dresden Hauptbahnhof/Main Station, ca. 2 km).

From all directions coming from **motorway junction** »Dresden-West«, change to Autobahn A17 in the direction Pirna/Prag. Take exit »Dresden-Südvorstadt«. After ca. 3 km on the B170 (Bergstrasse) in the direction Dresden, turn right into Zeunerstrasse. Information about parking facilities will be given at the reception desk.




From **Dresden Airport**, take a taxi (15 km) or the S-Bahn train via Dresden-Neustadt to Hauptbahnhof/Main Station (approx. 22 minutes).

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| | |
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| Wirtschaftsförderung Sachsen | S. 46 (2) |
| Kerstin Herold | S. 48 (2) |

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