Fraunhofer
IVI

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

INSTITUTE REPORT 2017

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2017

SHAPING A SECURE FUTURE

PREFACE

On New Year's Eve, the ringing of the church bells is almost drowned by the loud racket in the cities and on the countryside. The sound of the bells, which has proclaimed joy, sorrow and hope to the people for centuries, offers something calming these days, while so much seems to be in doubt. The ringing on New Year's Day marks the end of a very successful year for our Fraunhofer Institute in Dresden, and full of confidence we can look forward to what the next year will bring. Overflowing order books promise a lot of highly creative work. I believe that the community of all institute employees will perform these tasks as cooperatively as they always have. After excellent annual accounts in 2017, we are – for the very first time – heading into a year in which the entire institute budget, including the industrial revenues, is already contractually secured. Everyone has contributed to this in his or her field of responsibility and therefore I want to express my deepest gratitude to all employees, students, as well as interns.

We are looking forward to exciting challenges and interesting encounters in large-scale international projects. Transatlantic research collaborations with the universities of Las Vegas and Reno are taking definite shape. In the face of the tense global security situation, the importance of international cooperation cannot be emphasized enough. The ringing of the bells, which in the past had warned the people about the dangers of fire and war, also reminds us thereof. In this light, the topic of the annual report appears ambiguous like a late medieval picture puzzle, confusing the senses and protecting the critical artist from being prosecuted by the authorities. Our own authorities seem to be much concerned with themselves these days, which makes us want to repeat the words from the religious motet by Saxon court conductor Heinrich Schütz: »Give our rulers and all lawgivers peace and good government, that under them we might lead a quiet and peaceful life…«.

Nobody wants to evade the responsibility of creating a secure future for the generations to come. Still, a feeling of general uncertainty has spread within large parts of society. In spite of the booming economy, the risks of Europe's financial crisis remain present. Conflicts between religions, nations and ethnic groups are increasing again. It is evident that unlimited freedom does not set any limits at all. Terrorism, crime, no-go areas, natural disasters, pandemic diseases, mass-casualty incidents – the list could go on and on. Globalization has brought forward a new hazard potential, overshadowing in its effect much that had been felt a threat only a few years ago. More than ever, personal integrity proves a precious commodity, which needs to be defended. High-tech developments at the institute thus contribute to the improvement of domestic security by effectively supporting responders in their life-threatening duty.

Not only artists, but also well-known psychologists have looked into the phenomenon of illusion. In today's heated political debates about the divided nation, one might refer to our fooled senses occasionally. After all, picture puzzles teach us not to follow the first impression, but to go looking for what is hidden. Once we have found it, we again become aware of the ambiguity of the hidden pictures. The reason for dealing with human perception so intensively nowadays is the goal to enable autonomous systems in detecting unknown situations and consequently generating decisions. We are still far from guaranteeing the safety of autonomous systems, but it has already become apparent that machine learning and artificial intelligence offer scientific methods to meet this great technological challenge in the future. Allow yourself to be inspired by the range of interesting topics, with the help of which the Fraunhofer IVI wants to make our world a little more secure.

CONTENTS

FRAUNHOFER IN DRESDEN

Five institutes and five additional research institutions with altogether 2000 employees and an annual turnover of more than 167 million euros represent the Fraunhofer-Gesellschaft in Dresden.

INSTITUTES

- Fraunhofer Institute for Ceramic Technologies and Systems IKTS
- Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP
- Fraunhofer Institute for Material and Beam Technology IWS
- Fraunhofer Institute for Photonic Microsystems IPMS
- Fraunhofer Institute for Transportation and Infrastructure Systems IVI, Dresden

FRAUNHOFER BRANCHES AND RESEARCH INSTITUTIONS

- Dresden branch of the Fraunhofer Institute for Integrated Circuits IIS, Erlangen
- Dresden branch of the Fraunhofer Institute for Machine Tools and Forming Technology IWU, Chemnitz
- Dresden branch of the Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM, Bremen
- Dresden branch of the Fraunhofer Institute for Process Engineering and Packaging IVV, Freising
- Project Group ASSID (All Silicon System Integration Dresden) of the Fraunhofer IZM, Berlin

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 72 institutes and research units. The majority of the nearly 25,000 staff are qualified scientists and engineers who work with an annual research budget of more than 2.3 billion euros. Of this sum, more than 2 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 4500 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 consulting for the following technology fields:

- Numerical software and simulation
- Usability and human-computer interaction
- Reliable cyber physical systems
- IT security and safety
- Digital networks and the Internet
- Graphics and media technology
- Image acquisition and evaluation
- Big Data management and analytics
- Automation technology and engineering

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The group's 21 members (as of 2017) are the Fraunhofer Institutes for

- Algorithms and Scientific Computing SCAI
- Applied and Integrated Security AISEC
- Applied Information Technology FIT
- 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 (Guest)
- Industrial Mathematics ITWM
- Integrated Circuits IIS (Guest)
- Intelligent Analysis and Information Systems IAIS
- Mechatronic Systems Design IEM (Guest)
- 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 Fraunhofer Big Data Alliance, 30 institutes offer their interdisciplinary know-how and support for the efficient exploitation of large and heterogeneous sets of data. Under the coordination of the Fraunhofer IVI, a major project was launched. In addition, a study on »Artificial Intelligence as a Future Market« has been carried out in cooperation with two further institutes on behalf of the Fraunhofer Executive Board.

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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. The Fraunhofer IVI is one of the four members of the Steering Committee.

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.

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PROFILE OF THE INSTITUTE

Constant growth, a balanced budget and solid economic returns provide an excellent basis for the ongoing prosperous development of the Fraunhofer IVI. The comfortable financial situation of the institute is emphasized by well-filled order books for the coming years.

Problems and challenges in securing the medium-term and long-term competitiveness characterize the update of the strategy process, which has started in 2017. This also includes the critical analysis and systematic development of new topic areas. Considerable effort is directed towards the cooperation with universities to increase the scientific input and output.

Research projects in the fields of automated and connected driving as well as electromobility in logistics and heavy vehicle traffic are becoming increasingly important. Given current and future technological and societal changes, the institute keeps focusing on security topics. This extends to aspects of civil protection and the functional safety of technologies in synchronized mobility.

With the recently launched »Innovative Regional Growth Core« project Feldschwarm®, funded by the German Federal Ministry of Education and Research BMBF, a completely new market has been entered – building on the existing competencies in electrification and digitization. In collaboration with regional partners, the Fraunhofer IVI will help shape the transformation towards a highly automated and sustainable agriculture until 2020.

Research projects funded by the federal government and Länder constitute a share of altogether 40 percent. Industrial revenues have remained stable at over 30 percent since 2011. Projects within the European research program HORIZON 2020 have reached a share of 17 percent.

The Fraunhofer IVI is constantly investing in improving its infrastructure and modernizing its premises in order to offer an attractive workplace for excellence in research. The east wing of the building was redecorated this past year using the institute's own resources.

The institute has about 120 employees and 70 student assistants working in four departments, and collaborates closely with the TU Dresden and the TU Bergakademie Freiberg. Particular attention is currently paid to the recruitment of new scientists for various research fields.

COMPETENCIES

- Autonomous utilities systems
- Digital business processes
- Electromobility
- Identification of traffic situations
- Intelligent Transport Systems
- 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
- Vehicle and road safety
- Vehicle connectivity
- Vehicle technologies

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Vehicle Control and Sensor Systems
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Vehicle and Road Safety
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Chair of Road Planning and Road Design,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
TU Dresden

Members of the Advisory Board

Burkhard Ehlen,
CEO, Verkehrsverbund Oberelbe (VVO)

Prof. Dr.-Ing. Viktor Grinewitschus,
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MinR Hans-Peter Hiepe,
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Commanding Officer of the Special Task Force Saxony,
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Faculty of Electrical and Computer Engineering, TU Dresden

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Bernhard Schmidt,
Manager of Operations, Sileo GmbH

Nils Schmidt,
Director Mobility Division, Siemens AG

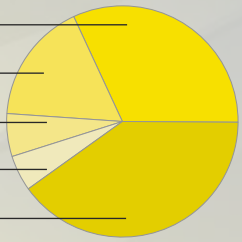
Lars Seiffert,
Board of Operations and Human Resources,
Dresdner Verkehrsbetriebe (DVB) AG

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

ECONOMIC DEVELOPMENT

OPERATING BUDGET

Industrial revenues	32 %
EU	17 %
Basic financing	6 %
Miscellaneous	5 %
Public sector	40 %

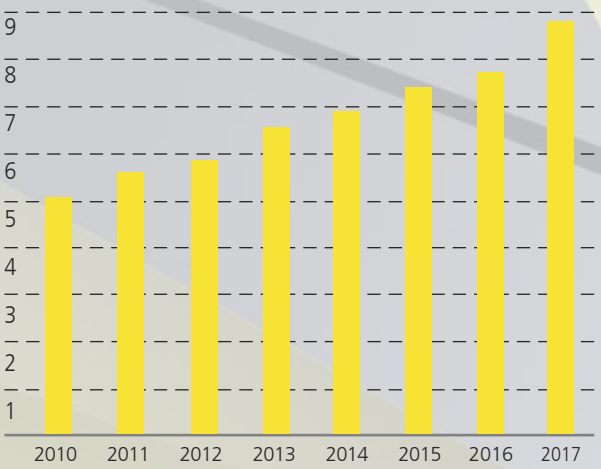


EMPLOYEES

Research fellows	100
Research assistants	75
Trainees	5
Administrative and technical staff	17
Total	197

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 16 EU projects from both the 7th Framework Programme and HORIZON 2020.

Two EU projects were successfully completed this year: The IMPRESS project has improved the efficiency of decision making in emergency health operations by providing a modular Incident Management & Decision Support System that can effectively manage diverse response teams and medical resources as well as prepare and coordinate response activities, using data from multiple heterogeneous sources. Since summer 2016, the vehicles from the TRANSFORMERS project have been driving on roads across Europe. The project's innovations include a trailer mounted, »Hybrid on Demand« electric driveline and various innovative measures to optimize the aerodynamics of the complete vehicle.

Looking at international collaboration, the institute is proud to count renowned companies and institutions from all regions of the world among its partners. Even with industry projects, the sometimes lengthy negotiations and acquisition activities undertaken in the past are bearing fruit. Important contacts have been established and stabilized in the past years, most prominent among them relations with partners from all over Europe, China, Japan, India and North and South America. In the USA, a transatlantic cooperation agreement has been signed with the Governor's Office of Economic Development of the state of Nevada and several partners from Saxony, striving for joint research projects and academic training in the field of synchronized mobility.

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.
- Chengdu Xinzhu Road & Bridge Machinery Co., Ltd.
- 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.

1 *Demonstration of modular bus concepts with the AutoTram® Extra Grand on the Fraunhofer IVI test track.*

FACILITIES AND LARGE EQUIPMENT

TEST VEHICLES

- AutoTram® and AutoTram® Extra Grand
- AutoTruck with electric drivetrain for highly and fully automated driving in depots and logistics centers
- Fast charging buses (12 and 18 meters)
- Mobile command vehicle equipped with a system for decision support in emergency and crisis situations
- Test vehicles for driver assistance, driver information and automated driving

LABORATORY FACILITIES

- Battery lab
- Lab for communications systems and positioning
- 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®/Python®
- PC-Crash (reconstruction software)
- SIMPACK (simulation of multibody systems)

TECHNICAL EQUIPMENT

- Calibrated infrared measurement technology
- Car2X communication (on-board and roadside unit)
- 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
- GNSS signal generators, base station and rover
- 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
- Toolkit for EMC testing (electromagnetic compatibility)

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
  - → remote battery monitoring
  - → the analysis of traction power electronics
  - → the determination of energy and 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
- R&S realtime spectrum analyzer FSVR 7 (10 Hz - 7 GHz)

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
- 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
- Consulting on the selection of storage unit types
- Experimental characterization of the individual components of electrical machines, as well as integrated system testing
- Heat storage concepts for electric vehicles
- Technical design, 3D visualization and 3D rapid prototyping
- Studies and expert assessments

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Deriving from the necessity to use energy resources responsibly, the department offers research and development services in a diverse spectrum ranging from mobile, traffic-related applications to stationary solutions.

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

Is it possible to restructure the 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.

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

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

In dialogue with the clients, the experts 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.

»HEAT2GO« – FAST-CHARGING LATENT HEAT STORAGE SYSTEM FOR FULLY ELECTRIC CITY BUSES

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Following the resolutions of the United Nations Climate Change Conference in Paris, the German transport sector is facing the objective to reduce CO_2 emissions by 40 percent, compared to 1990, until the year 2030. In public transport, changing from diesel buses to zero-emission vehicles can make a significant contribution to this development. The market launch of zero-emission electric buses is delayed for instance by the lack of a suitable heating concept which is technically, ecologically and economically feasible.

The *HEAT2GO* Project

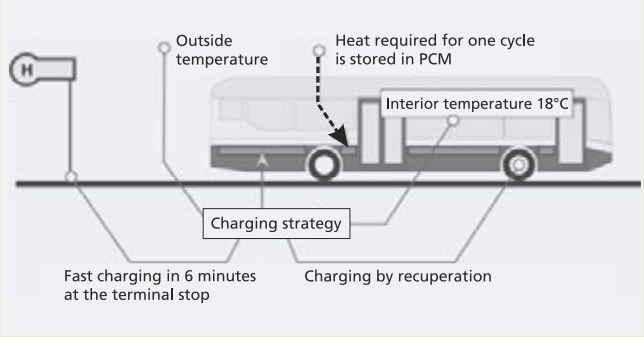
In the light of these challenges, the *HEAT2GO* project, part of the research initiative »Electromobility« funded by the Federal Ministry for Transport and Digital Infrastructure, has been developing a fast-charging latent heat storage system since October 2016 under the coordination of the Fraunhofer IVI and with participation of the heating system manufacturers AURORA Konrad G. Schulz GmbH & Co. KG and Konvekta AG. The system is designed for application in electric buses that operate by the principle of opportunity charging: The vehicles, equipped with low-capacity batteries, are recharged at terminal stops for a few minutes several times a day. As shown in figure 1, the latent heat storage system takes up this principle to enable the charging of the heat storage in parallel and guarantees the heat supply until the next charging opportunity. With this technology, the heating system can be operated without causing any emissions and without straining the battery.

The project develops fast-charging latent heat storage systems in two system versions. While the storage modules of one of the heating systems supply the stored thermal energy directly into the air in the passenger compartment, the discharging of the indirect system is carried out using an interposed water circuit. In addition to the system design, the Fraunhofer IVI is responsible for comprehensive heat demand simulations and route analyses.

The determination of the State of Charge, the wayside energy supply, contributions to functional safety and the optimization of the vehicle's operational and energy management are also in the focus of development.

Prototypical Implementation

The first prototype of the storage module in a scale of 1:15 has already been completed by the Konvekta AG. With 2500 cycles and a supply voltage of 720 VDC, the operational principle and the necessary fast-charging capacity have been successfully demonstrated, achieving an effective energy density of 30 Wh/kg. Further on into the project, the heating system will be fully realized and integrated into a 12 m bus for demonstration. It is planned to evaluate the performance both in the climate chamber and in regular operation.



1 *Operational principle of a fast-charging latent heat storage system.*

Federal Ministry of Transport and Digital Infrastructure

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 introduction 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.

Novel 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.

DATA COLLECTION FOR THE ASSESSMENT OF VEHICLE SAFETY FUNCTIONS

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An increasing number of safety-relevant and automated driving functions will have a significant influence on traffic in the near future. For analyzing the effectiveness of current electronic assistance systems such as ESC, airbags or ABS, real-life tests are the method of choice. However, the rising number and special characteristics of advanced safety systems require the model simulation of some parts of the assessment, development and verification. Until now, there has been a widespread lack of comprehensive input data. The AIMATS method has been developed to close this gap by offering a system to acquire missing data for simulating driving functions related to safety and automation.

AIMATS (Analysis and Investigation Method for All Traffic Scenarios)

The first step of an AIMATS data collection is the targeted analysis of exhaustive accident statistics from the database available at the Fraunhofer IVI. This analysis looks into issues such as the behavior of animals and motorized road users in critical and non-critical encounters. The analysis of 2.5 million data sets then provides a map of POIs (Points of Interest) with accident black spots.

At these POIs, an autonomous measuring device, developed and constructed by the Fraunhofer IVI, is installed for the observation of traffic scenarios by means of far range infrared. The resulting data material (framerate of up to 28 frames per second) is analyzed graphically in the next step. For the final evaluation, various image processing methods such as optical flow, background estimation and object identification strategies are key elements. These calculations deliver trajectories describing the movement of main objects – individual road users and animals – on a path. With trajectories, it is possible to integrate different data sets from reality into the simulation software, from standard and critical driving situations to traffic accidents.

Examples from Practice

AIMATS was used in practice for the first time in 2016. In this initial investigation project, so far unknown movements of vehicles and animals in animal crossings in both normal as well as critical situations have been recorded and evaluated. AIMATS was able to record

- more than 150,000 animal crossings,
- approx. 30,000 encounters between wild animals and cars and
- more than 10,000 critical situations between wild animals and cars.

In addition, four traffic accidents in connection with wild animals have been registered. These results far exceeded the customer's expectations (2500 deer crossings, 250 encounters, 125 critical situations).

The findings from this wildlife observation study, including for example speed, species and behavior of animals as well as the minimal distance in critical situations, are comparable to the results from »Naturalistic Driving Studies« (NDS), which collected and analyzed data from on-board records.

In 2017, AIMATS was used to record junction scenarios with different road users, providing this data as a basis for the evaluation of vehicle safety features. In the context of these new requirements, AIMATS was refined to extend its application range.

AIMATS offers a cost-effective solution for the infrastructure-based collection of all types of critical traffic scenarios. Owing to its extensive data material, the AIMATS method is fully scalable and can be used in many parts of Germany.

INTELLIGENT TRANSPORT SYSTEMS

RANGE OF SERVICES

- Design and testing of system solutions for connected and automated driving
- Traffic detection, information and management
- V2X 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, V2X communication, 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.

»ITS FACILITIES« – COMMUNICATION FOR AUTOMATED DRIVING

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Intelligent Transport Systems (ITS) contribute significantly to the improvement of safety and efficiency in transport. Automated and autonomous driving take a key role in this context and require connected vehicles and transport infrastructure. In this sector, ITS-G5 has evolved as a communication technology which is expected to be introduced throughout Europe within the next years.

The ITS-G5 system offers a multitude of functions from wireless transmission and network protocols to data security. In order to simplify the development and implementation of services and applications, »ITS Facilities«, a middleware with communication protocols, is used.

Software Framework for »ITS Facilities«

The ITS-G5 was designed for application in the field of vehicle safety and transport efficiency. The current state of the art mainly covers driver information and warnings and focusses on motorized private transport. Examples are the electronic brake light, information about the signal status of traffic lights as well as warnings regarding construction sites. To extend the range of applications, further advancements will support automated driving and involve other road users (pedestrians and cyclists) as well as public transport.

The Fraunhofer IVI is working on a software framework for »ITS Facilities« which initially supports the standardized version of ITS-G5, and which will be developed over time while integrating latest results from ongoing projects.

This applies especially to functions of automated and autonomous driving, for example cooperative perception. Objects in the vehicle environment are detected by sensors and transmitted to other vehicles and the transport infrastructure to create a dynamic and high-precision map for the coordination of driving maneuvers.

This field also includes the exchange of maneuver intentions between vehicles as well as the transmission of driving suggestions (speed, lane etc.) by the infrastructure.

Applications and Outlook

The framework is widely used within the initiative »Synchronized Mobility 2023 – Intelligent Transport Systems in Saxony« and its related R&D projects. It is being tested in the laboratory, integrated into vehicles and the transport infrastructure (Road Side Units) as well as validated on a test field. In addition, this framework is a crucial enabler for further Fraunhofer IVI projects in the fields of communication-based control and automation in transport.

Possible scenarios include

- Traffic flow optimization of automated vehicles (e. g. platooning)
- Autonomous driving in automation zones (e. g. electric vehicles in the area of charging stations)
- Automated driving of agricultural machinery (e. g. »2D Precision Farming«).

Future field studies will illustrate the enormous potential of ITS communication for the realization of automated and autonomous driving in various fields of application.

STRATEGY AND OPTIMIZATION

RANGE OF SERVICES

- Systems for operative and tactical command for firefighters, emergency service providers, disaster management and police
- Analyses and risk assessment in hazard prevention: planning of rescue service zones, site optimization
- 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 for 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, which are applied for the effective planning and control of resources in a wide range of fields:

- Security and risk prevention,
- 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 R&D projects, the team develops application-oriented solutions, which are immediately put into practice. These software systems and modules 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.

VEHICLE ROUTE PLANNING WITH DAYTIME DEPENDENT ROUTING INFORMATION

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Vehicle route planning is a central task of operational logistics. This includes the scheduling of vehicle routes according to transport assignments. Therefore, precise routing information – routes and driving time – in between the individual assignments is required.

Due to alternating traffic volume, this information and the related ideal routes are subject to variation. Delays, detours as well as arrivals ahead of time arise if daytime dependency is not taken into account during the planning process. These aspects lead to waiting periods, penalty charges for non-delivery and necessary additional deliveries as well as increased driving costs for the transport service provider.

The *TOTARI* Project

Within the research project, a concept was developed to enable vehicle route planning under consideration of daytime dependent information. Floating car data (FCD) are analyzed at different times of the day, deriving speed profiles that are used for the determination of ideal routes. On this basis, a daytime dependent routing is carried out by following the steps described below.

(1) Data Analysis
Floating car data – recorded by GPS devices – are the source for actual driven routes. The deviation from the expected driving time according to the routing can be calculated using time stamps. The measured data were organized, cleansed and clustered to exploit the calculated speed attributes. Each routing graph edge (road section) is matched to a particular speed profile, which is defined as the vector of the daytime dependent deviation from the expected speed. As a result, the storage effort is reduced and routing is simplified.

(2) Routing
Two different approaches have been compared: Sequential calculation of routing information at different times of the day and simultaneous calculation of routing information of all times of the day. Even though the latter strategy is faster in theory, it exceeds storage possibilities in practice. Therefore, the well-known A* search algorithm was enhanced by daytime dependencies.

(3) Vehicle Route Planning
In order to reduce computing time, the project examined between which delivery destinations daytime depending routing information is required: Looking at the ideal vehicle route planning, assignments in sequence are located in close proximity to each other. Therefore, daytime dependent routing is only necessary in between close destinations. Experiments based on real routes demonstrated that a radius of 25 kilometers is a favorable compromise between saving computing time and deviations in planning.

Results

The concept was implemented and integrated into the transport management software of the project partner OPTITOOL. Within the project, a pilot operation was carried out with two transport service providers: the waste disposal service Meindl and a beverage delivery service. The quality of the vehicle route planning was evaluated by analyzing the deviations between planned and actual driven routes. It was demonstrated that accuracy can be improved significantly when taking daytime dependencies into consideration. Thus, results in planning will become more reliable.

ENERGY SYSTEM ENGINEERING

RANGE OF SERVICES

- Analytical design of standard electrical machines and special designs with the help of the institute's 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.

AGING DIAGNOSTICS FOR TRACTION BATTERIES

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Application-Oriented Diagnosis Problem

In the field of energy storage systems, the lithium-ion technology offers great advantages regarding the key parameters of energy and power density, safety as well as lifespan. Experts consider this technology the most suitable for use in electric and hybrid vehicles in the medium term until 2030. High demands on the vehicle performance and reliability result in major challenges in monitoring the battery state. Relevant parameters for the battery management system, such as State of Charge and State of Health, can only be determined precisely if their complex connection to highly dynamic operational conditions is taken into account.

Model-Based and Data-Based Analysis Method

The capability of a lithium-ion cell to store energy and supply power decreases during its life span. The intensity of various aging mechanisms depends on the cell's conditions of use and storage. Particularly, the temperature ϑ, the amount of load current I, the mean State of Charge SoC and the Depth of Discharge DoD influence the battery's service life.

In contrast, there is very little knowledge about the specific aging behavior of an energy storage unit used in a traction application. Often, the cell manufacturer specifies only the possible number of full cycles z^{ref}. This refers to the number of complete charge/discharge cycles with constant charge and discharge current conducted under a defined temperature up to a loss of 20 percent of the initially available capacity Q_0. However, the resulting charge conversion turns out to be an insufficient measure for the State of Health, as the described reference conditions differ substantially from the load profiles in the vehicle. These gaps need to be taken into consideration appropriately in the aging prognosis.

The model approach is based on the assumption that the capacity loss depends exponentially on the number of cycles z. The aging-related progress of capacity is given by

$$Q(z)=Q_0\,(1-\sqrt{(a^{ref}*a^{bel}(I,\vartheta,SoC,DoD))^2*z})$$

in which the aging under reference conditions is depicted by a^{ref} and the influence of operating conditions is depicted by a^{bel} (I, ϑ, SoC, DoD). By means of the operational conditions I, ϑ, SoC, DoD, it is possible to calculate the stress factor a^{bel} at any time during measurement but also over an extended period. With this factor a^{bel} and a given load profile, the attainable number of cycles z can be compared to the number of reference cycle z^{ref} by

$$\frac{z}{z^{ref}}=\left(\frac{1}{a^{bel}}\right)^2.$$

In addition, the shares of the individual operational conditions in the entire aging process can be determined.

Practical Application in the Vehicle

In practice, the calculation of the stress factor is combined with the estimation of the present capacity $Q(z)$. This way, the initial parameterization of the function a^{bel} (I, ϑ, SoC, DoD), referring to the cell chemistry, can be adapted to the particular aging behavior of the cells over the course of vehicle use.

This diagnosis method is a considerable advantage for operators in the emerging hybrid and electric vehicle market. They still lack the option of assessing the state of their vehicles and most importantly, that of the batteries. With the web interface IVImon, the Fraunhofer IVI offers a visualization solution to determine and compare the aging parameters of an entire fleet of electric vehicles, providing the basis for a number of new business models to suit various user groups.

JUNIOR RESEARCH

STATE OF CHARGE ESTIMATION OF LITHIUM-SULFUR CELLS

Motivation

Lithium-sulfur batteries (Li-S) are regarded as a promising successor technology to Lithium-ion batteries (LIB), especially due to their theoretical energy density, which is five times higher. Before Li-S cells can be applied in practice to substitute LIB, the chemical stability must increase and reliable algorithms for the state estimation need to be developed.

Established State of Charge (SoC) estimation methods based on Open Circuit Voltage (OCV) are not applicable to Li-S, as the voltage behavior differs fundamentally from LIB. During LIB operation, Li-ions intercalate without significant changes in the chemical structures of the electrodes. In contrast, Li-ions in Li-S cells chemically react with the sulfur cathode, leading to polysulfide formation. Changing the chemical composition also affects the battery impedance that serves as basis for developing an SoC estimation model within this thesis.

Measurement Method

Electrochemical impedance spectroscopy is a proven method to determine battery characteristics, but it often requires time-consuming measurements over a broad frequency range. Therefore, the battery should be in equilibrium state beforehand, which implies the necessity to interrupt operation for several hours. This fact and the high measuring equipment costs disqualify this method for direct SoC estimation in practice. A significant reduction of measurement time and hardware costs can be achieved by identifying and tracking only a set of frequencies in which the impedance shows a significant sensitivity to SoC.

In addition to frequency (f) and State of Charge (SoC), battery impedance (Z) depends on temperature (T), State of Health (SoH), relaxation time (t_r) and current (I). For a realistic extraction of the SoC, knowledge about the impact of these additional dependencies is required.

Development of the Impedance Model

After defining the reference conditions, the relation between impedance and SoC was determined experimentally (Z(f, SoC)). In order to quantify further dependencies (T, SoH, t_r, I), investigations were carried out in separate cycles. Subsequently, the model reference frequency f_m, at which the impedance was most sensitive towards the SoC and slightly sensitive towards further variables, was determined.

The pre-measured reference relation $SoC_{ref}(f_m, Z_{ref})$ is the starting point for determining the SoC based on the impedance measurement at f_m. Impedance measurements under realistic conditions are corrected to reference conditions by empirical correction functions for T, SoH, t_r, as well as I, which improves the accuracy of the SoC algorithm (figure 1). By using correction functions, the method also becomes independent from the batteries' equilibrium state. An additional current integration guarantees continuous model SoC estimation (coulomb counting). Thus, the initial SoC is initiated by impedance measurement.

Results of the Model Validation

For validation reasons, the Li-S cells were discharged several times with a dynamic power profile following the New European Driving Cycle (NEDC). Additionally, temperature was varied in the range of 10 and 40°C and the discharging process was interrupted for a relaxation time of five hours. During the cells' operation, the model determined the state of charge with a maximum deviation of 10 percent. Compared to this, errors up to 50 percent can be expected for voltage-based SoC estimations due to the voltage plateau. The results of this analysis illustrate that the impedance-based SoC estimation describes a promising method for future Li-S batteries.

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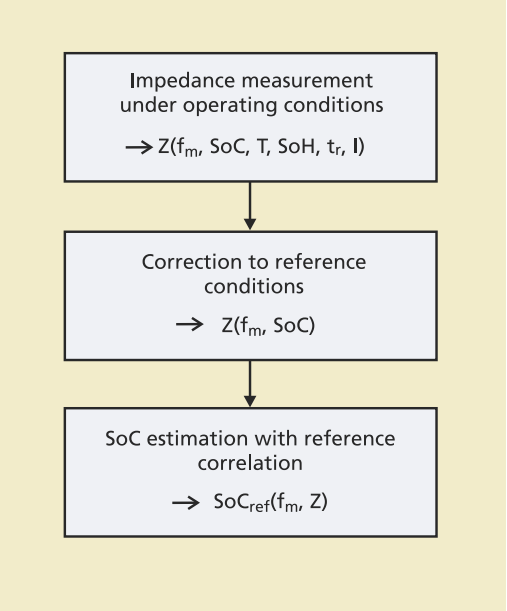
Outlook

The model has so far been parameterized only for the discharging process. It still has to be adapted under consideration of the charging process. Further analyses are necessary to investigate the impact of battery aging on the impedance. As Li-S cells are not fully available for commercial use yet, it was not possible to carry out a validation across different suppliers. To refine the method, a suitable measuring circuit for the integration in battery management systems has to be developed in a next step.



1 *State of Charge estimation based on battery impedance.*

With special thanks to my supervisors Dr.-Ing. Julia Kowal (TU Berlin) and Dipl.-Phys. Sebastian Socher (Fraunhofer IVI) and Fraunhofer IWS for the supply of Li-S cells and scientific exchange.

HIGHLIGHTS

Chinese Delegation Visits the Fraunhofer IVI

On January 13, representatives of the Xinzhu Corperation – Chengdu Xinzhu Road & Bridge Machinery Co., LTD – visited the Fraunhofer IVI in Dresden together with Professor Peter Mnich (Modern Railways) for exploratory talks towards a cooperation in the field of vehicle and propulsion technologies.

Eight months later, in September 2017, the contract for a large-scale project in Chengdu was signed.

Official Launch of the Northern Nevada Living Lab in January 2017

Since the Governor of Nevada's first visit to the Fraunhofer IVI in July 2015, both sides have been actively pursuing efforts to collaborate in building digital test beds for autonomous driving in Saxony and Nevada. As a result, the establishment of a Living Lab in northern Nevada is under way, aiming to explore solutions for safe, clean and efficient transportation. Building on the expertise of the University of Nevada, public transportation is the primary research focus.

In addition to the regional transport provider Proterra, the Governor's Office for Economic Development, the cities of Reno, Sparks and Carson City and other regional companies and institutions, and the Fraunhofer IVI joined as project partners. The institute connects intelligent mobility to Living Lab developments being explored in Germany. »As a result of collaboration with Fraunhofer, this takes on global importance and elevates the work we are doing to an international stage,« Steve Hill, director of the Governor's Office of Economic Development, said.

***IVS-KOM* Kick-off Meeting**

The kick-off meeting for the *IVS-KOM* research project was held on February 24 at the Fraunhofer IVI. This project receives funding by the state of Saxony within the high-tech initiative »Synchronized Mobility 2023 – Intelligent Transport Systems in Saxony«, and collaborates closely with other projects from the network, for instance *REMAS* and *SYNCAR*.

With partners from industry and research, the project will develop various platforms for on-board units in vehicles, roadside units and traffic signal systems. These platforms will be tested in real-life public transport environments and also validated for applications in vehicle automation. Furthermore, recommendations for the use of communication technologies and networks in the overall ITS context will be given.

First Feasibility Studies in the *ELIPTIC* Project Completed

In March 2017, the first feasibility studies in the *ELIPTIC* project were completed with interesting results. This European initiative unites 33 partners, analyzing 21 concepts for electric public transport in 11 cities with the aim of supporting the further cost-efficient take-up of electric vehicles by using existing electric transport infrastructure.

In addition to promising use cases in the cities of Brussels and Bremen, studies were carried out in Leipzig and Eberswalde, both in collaboration with the Fraunhofer IVI. Investigations include the use of existing tram infrastructure as a charging concept for battery buses, as well as the introduction of trolley-hybrids to replace a diesel bus line.

HarmonizeDD Project Receives Approval in Berlin

A consortium of industrial companies and scientific institutions initiated the Saxon research initiative »Synchronized Mobility 2023« to face the challenges of digitalization and interconnection in the field of transportation. The Federal Ministry of Transport and Digital Infrastructure supports this state initiative by officially appointing Dresden as one of six cities to become urban digital test fields for autonomous driving. This development is supported by federal funding.

The Fraunhofer IVI takes the lead in numerous research projects of the »Synchronized Mobility 2023« initiative. Federal Minister Alexander Dobrindt granted further funding within the »Funding guideline automated and connected driving on digital test fields in Germany« (Förderrichtlinie automatisiertes und vernetztes Fahren auf digitalen Testfeldern in Deutschland). Parliamentary State Secretary Dorothee Bär handed over the notifications of approval to the project partners on March 30.

Workshop with the Universities of Reno and Nevada

Following an initial high-level workshop in Nevada in 2016, the second event was held on April 4 in Dresden. Objectives included discussions on the project tasks as well as the coordination of conditions for a mutual PhD exchange program. Four more Fraunhofer institutes (IIS/EAS, FHR, ENAS and IOSB) introduced themselves to the university representatives from Reno and Las Vegas and highlighted their competencies to be included in the joint research project. On the following day, regional industry partners joined the event to present their activities in the field of autonomous and connected driving.

Visit from a Norwegian Delegation

On April 27, the Fraunhofer IVI welcomed 30 delegates from the Troms county municipality and its local transport association. The meeting, which had been organized by the Saxon energy agency SAENA, was held to introduce each other and to exchange ideas on future mobility concepts.

Saxon Entrepreneur Trip to China

A delegation of entrepreneurs, led by Saxony's State Minister for the Environment and Agriculture, went on a business trip to China from May 6 to 13. The aim of this trip was to establish contacts with local companies and public institutions in the fields of environmental and agricultural engineering and the food industry. International Business Development expert Mandy Koritz presented the Fraunhofer IVI's focus areas to initiate a scientific dialogue with Chinese research institutes.

Kick-off Event *HarmonizeDD*

The *HarmonizeDD* research and development project was officially launched with a kick-off meeting on May 11-12 in Dresden. To support connected vehicles, the project will develop an innovative cloud-based transport system. The focus will be on the interaction of conventional and future highly automated vehicles in mixed urban traffic as well as transport infrastructure in urban scenarios. The Fraunhofer IVI coordinates this project, which is closely linked to the initiative »Synchronized Mobility 2023«. The results will be evaluated on the urban digital test field for autonomous driving in Dresden. The two-year project is funded by the German Federal Ministry for Economic Affairs and Energy (BMWi) with resources from the »Funding guideline automated and connected driving on digital test fields in Germany«.

Fraunhofer Annual Conference

For 25 years now, Fraunhofer has been an established engine of progress in the new federal states of Germany. This anniversary was celebrated at the end of May with special events in Dresden – one of the research organization's largest sites. In addition to a public event in the city center, visitors could see an interactive exhibition in the Congress Center showcasing recent research highlights.

In an open round of talks at the Albertinum, Professor Matthias Klingner, Lars Seiffert (Director, Operations and HR of the Dresdner Verkehrsbetriebe AG) and Dr. Frank Dressel, a representative of the »Zukunftsstadt«, got together to discuss mobility topics, including also the Saxon initiative »Synchronized Mobility 2023«.

2nd »Electric Freight Traffic« Users' Day

On June 14, more than 50 experts from innovative logistics companies, electric vehicle manufacturers and related research institutions met during the industry-specific user's day to discuss current challenges in electric freight traffic. The event was held in the city of Essen, for the first time in cooperation with the Haus der Technik e. V. In addition to this year's main topics of financing and procurement, the participants debated vividly on new technological developments: »Introduction barriers – such as battery prices, which are still too high – can be implemented in an economically feasible way by using suitable technical measures like aging diagnosis«, Claudius Jehle said. He is manager of the Fraunhofer IVI's Group on Storage Systems and Converters. With its remote battery monitoring system, the institute is well equipped for the future requirements of electric logistics.

15th Dresden Science Night

Under the motto »a night creating knowledge«, many research-related institutions opened their doors to welcome visitors on Dresden's Science Night for the 15th time. The Fraunhofer IVI also participated in the event by once more offering a diverse program. In addition to a display on the history of computer engineering, which invited visitors to dive into the world of abacuses and analog IT, the institute also presented the current Big Data trend in more detail. As an example, the *iSand* project demonstrated how information from social media sources can be processed for the use in disaster management. Another highlight for the visitors was the autartec® house. The house came to life by means of augmented reality, turning from a simple 2D print into a tangible, real object on the tablet screen. The *Guide2Wear* project sparked the audience's interest by showing the potential of wearable devices in public transport navigation. The evening program was rounded off with a kids' station offering little handicrafts projects and the opportunity to try the computer games of the parent generation.

Project *SePIA* Launched on June, 15

The future technologies of automated and connected driving and Intelligent Transport Systems are making progress all around the world. Vehicles with automated driving functions have to achieve at least the level of the driving skills of an attentive human driver. To improve the functional safety of these technologies in the future, the project *SePIA* (Scenario-Based Platform for the Inspection of Automated Driving Functions) will develop and analyze a complex validation platform for electronic subsystems and the overall vehicle under the coordination of the FSD GmbH. *SePIA* is funded by the EU through the European Regional Development Fund and the State of Saxony. The Fraunhofer IVI will provide accident data, process and detect the criticality of accidents and report data, and analyze the critical scenarios yet missing.

Presentation of Modular Bus Concepts

Based on results of the European research project »European Bus System of the Future (*EBSF*)«, the follow-up project *EBSF 2* started in May 2015. More than 40 partners pool their expertise to develop and test technologies for the bus transport of tomorrow. The Fraunhofer IVI contributes to two larger research topics. One of them is concerned with the needs-based adaption of the length of city buses during regular operation. It proposes to split a multi-unit bus so that the trailer can be detached at the articulation joint and the remaining segment can be used independently. The implementation was carried out in cooperation with Hübner GmbH, the world's leading manufacturer of articulation systems.

The innovative solution was officially demonstrated on June 21, using the AutoTram® Extra Grand. Numerous international guests came to visit the Fraunhofer IVI to follow this presentation.

The project is funded within the European Research Framework Programme HORIZON 2020 and coordinated by UITP.

Visit by a Delegation from Singapore

Together with the Saxon State Ministry for Higher Education, Research and the Arts and the TU Dresden, a Singaporean delegation – including, for instance, the company ST Engineering – visited the Fraunhofer IVI on June 23.

The meeting was held to introduce each other and explore the options of cooperation in the field of electromobility.

AWARDS

- **EBUS Award 2017**
  Category »Consulting and Monitoring Companies«
  Berlin, March 6, 2017

  Award for excellent achievements in the introduction of electric buses

- **Student idea competition of the CLEANTECH Initiative Eastern Germany**
  Category »Energy Technology«
  Spremberg, April 3, 2017

  1st prize together with GEDES e. V. for the design and optimization of a latent-heat storage system in the context of energy-autonomous buildings

- **German Mobility Award 2017**
  Berlin, June 29, 2017

  Research project »FAPS – Fraunhofer IVI Accident Prevention School« as an innovative solution for safe mobility of teenagers based on real accident data

- **eMove360° Award for Electric Mobility & Autonomous Driving**
  Finalist in the category »Charging Infrastructure«
  Munich, October 16, 2017

  Development of an automated underfloor fast-charging system

***TRANSFORMERS* Final Conference**

On June 29, the Final Conference of the European research project *TRANSFORMERS* »Configurable and Adaptable Trucks and Trailers for Optimal Transport Efficiency« was held at the Volvo Trucks Experience Center in Gothenburg, Sweden.

The consortium, which included 13 renowned European partners, presented as their project results four innovations to increase the transport efficiency for semi-trailers:

- Hybridization of the overall vehicle by installation of an electric drivetrain into the semi-trailer
- Development of a novel double loading floor to improve the loading efficiency
- Measures in aerodynamics to reduce air resistance
- Adaptability of all measures to specific transport tasks

More than 100 guests, including well-known European commercial vehicle manufacturers, suppliers, research institutes, public authorities and end users had the opportunity to convince themselves that a CO_2 reduction of 25 percent (measured in g/(t*km)) is possible due to a clever combination of all project innovations.

Launch of the *Feldschwarm*® Research Project

Digitalization, electrification, autonomous and self-organized work in the fields – even in the seemingly archaic field of agriculture, extensive transformation processes are currently underway and ready to meet the challenges of the next industrial revolution. The research project *Feldschwarm*® (field swarm), funded by the German Federal Ministry of Education and Research (BMBF) as an innovative regional growth core with a total of 8 million €, will contribute to these developments.

After several years of thorough preparations, the project has finally been kicked off as the grant notifications were handed over in Dresden's »Die Gläserne Manufaktur« (Transparent Factory) on July 5.

In collaboration with the international market leader John Deere, Saxon SMEs, research institutes of the TU Dresden and the Fraunhofer-Gesellschaft will develop highly flexible and automated agricultural machinery that protect the soil and build upon renewable propulsion technologies. With a total budget of 12 million €, the project is one of the most voluminous R&D projects in Saxon agricultural engineering.

Workshop »Value Creation through Smart Farming & Forestry in Saxony«

On behalf of the Saxon State Office for the Environment, Agriculture and Geology (LfULG), the Fraunhofer institutes IVI and IKTS have carried out a study with the objective to analyze the value creation potential in Saxony's agriculture and forestry within the context of current high-tech developments. The study presents action scenarios and specific measures to increase this potential under consideration of sustainability aspects.

During an initial workshop on August 8, experts in the fields of »digital village and digital services«, »agriculture and forestry 4.0« and »rural value creation, business models and direct marketing« came together for discussions. This meeting was followed by a second workshop in October, which was also hosted by the Fraunhofer IVI.

TRADE FAIRS

Cartox² Kick-off

On August 17, the Fraunhofer IVI hosted the *Cartox²* kick-off meeting. *Cartox²* is a service platform for generic services of connected and automated driving, which will be developed within a 3-year research project.

In addition to the coordinator Fraunhofer IVI, the TU Dresden and several software companies (CETECOM GmbH, hrd.consulting, Software AG, MechLab Engineering UG) are members of the consortium.

Potential users of *Cartox²* include car manufacturers, suppliers, telecommunications providers, municipalities and authorities as well as providers of digital mobility services. The project will run until June 2020, supported with funding from the Federal Ministry of Transport and Digital Infrastructure within the mFUND research initiative.

Fraunhofer Delegation Trip to India

Organized by the Fraunhofer Representative Office India, led by Ms. Anandi Iyer, the Fraunhofer institutes IFAM and IVI joined the delegation »Electro Mobility in India« and travelled to New Delhi from September 4 to 8. Dr. Thoralf Knote, Head of the Department »Vehicle and Transport System Engineering«, and Mandy Koritz, International Business Development expert, represented the Fraunhofer IVI.

In various meetings with the Ministry of New and Renewable Energy (MNRE), Government of India; the National Thermal Power Corporation Ltd. – Energy Technology Research Alliance (NETRA); Ernst & Young and the National Thermal Power Corporation Ltd., introduction concepts for electric vehicles and charging infrastructure were discussed.

- **Energy Storage Europe in Düsseldorf**
  International conference and trade fair for energy storage
  March 14-16, 2017

  Exhibition of a cloud-based battery SoH monitoring technology at the joint booth of the Fraunhofer Energy Alliance

- **EXPO REAL in Munich**
  International trade fair for property and investment
  October 4-6, 2017

  Virtual presentation of the autartec® house at the booth of the State of Saxony

- **FLORIAN in Dresden**
  Trade fair for fire brigades, civil protection and disaster control
  October 5-7, 2017

  Presentation of solutions in the field of civil protection and security together with the partners TÜV Rheinland, SiKonA and KL FORMAT

- **International Heavy-Duty Days in Hohenroda, Germany**
  Conference and trade fair in the field of heavy haulages
  October 6-7, 2017

  Demonstration of the automated trafficability analysis TruckTrix® in cooperation with Codequare GmbH & Co. KG

Business Trip to Toyota's Headquarter in Japan

By invitation of Toyota, Dr. Christian T. Erbsmehl, group manager, and Dr. Tom Landgraf of the Fraunhofer IVI visited the department »Active and Passive Vehicle Safety« at the Japanese corporation from September 18 to 24.

Besides visiting the Toyota driving simulator and the crash center as well as watching a live test of active safety systems, the colleagues presented current research results from projects with Toyota Motor Europe.

Dr. Landgraf proved himself with his presentation at the FAST-zero conference and established numerous contacts with experts from research and the automotive industry. Dr. Erbsmehl was invited by Prof. Furakawa to become a session chair and scientific co-organizer of the next FAST-zero conference held at Virginia Tech, USA.

Through meetings in Toyota's research and development center in the City of Mishima on the foothills of Mount Fuji, the business relations between the Fraunhofer IVI and Toyota Japan have been intensified. Several joint projects are planned for the future.

Virtual Launch of the autartec® House

Making future technology suitable for everyday use – this was the motto of the scientific colloquium Virtual Launch »autartec® – from Realization to Test Run«. The third public event of the project was held on September 20 on the premises of the associate partner ifn Anwenderzentrum GmbH in Lauchhammer. Inspiring presentations and tangible exhibits fascinated more than 90 participants.

New thermally optimized building materials, structurally integrated electric storage devices as well as long-term thermal energy storage units based on zeolites will prove their practicality within this research project. Many supply technologies will be applied in the future floating *house* on Lake Bergheide. Next year, the house will be set afloat against the impressive backdrop of the F60 exhibition mine in Lichterfeld-Schacksdorf.

The project is funded by the German Federal Ministry of Education and Research.

Japanese Delegation Visits the Fraunhofer IVI

A delegation of high-ranking representatives from Japanese companies and research institutions, led by Professor Shimizu, visited the Fraunhofer IVI on October 23. The institute Director, Professor Matthias Klingner, presented business figures and explained current research and development projects and future topics to the group. He focused on the latest efforts and results in autonomous driving within the context of »Synchronized Mobility«. Furthermore, challenges, possible applications and opportunities for cooperation in the field of battery storage were part of a lively discussion as Japan is considered the birthplace of the lithium-ion technology.

TRADE FAIRS

Entrepreneur Trip to China

A high-profile delegation from politics, industry and science, led by the Saxon Minister-President Stanislaw Tillich, travelled to China from November 14 to 23.

Mandy Koritz presented the Fraunhofer IVI to local companies and universities. The participants were especially interested in developments from the areas of vehicle engineering and propulsion technologies for public transport and heavy haulages.

Competencies in the fields of electrification and automation open up opportunities for the institute to support China in tackling its environmental challenges in agriculture. Highlights of the travel program included a concert of the Sächsische Staatskapelle Dresden in the Qintai Concert Hall in Wuhan and a boat trip to the Three Gorges Dam.

ASAM International Conference 2017

Organized by ASAM, the Association for Standardization of Automation and Measuring Systems, and the Saxon State Ministry of Economic Affairs, Labour and Transport (SMWA), experts met at the international conference »Autonomous Driving – Big Testing and Big Data as the Next Challenge« on December 6 and 7 in Dresden.

The Fraunhofer IVI not only contributed two presentations. The institute also supported the event preparation phase and introduced the Saxon initiative »Synchrone Mobilität 2023« together with partners from industry and science during the accompanying poster exhibition.

- **eMove360° Europe in Munich, Germany**
  International trade fair for mobility 4.0 – electric – connected – autonomous
  October 17-19, 2017

  Presentation of an automated underfloor fast-charging system

- **Busworld Europe in Kortrijk, Belgium**
  Bus and coach exhibition
  October 20-25, 2017

  Presentation of a technology guide for the development of very long buses at the booth of Hübner GmbH & Co. KG

  Project presentation of eBus Cluster at the booth of AURORA Konrad G. Schulz GmbH & Co. KG

- **Hypermotion**
  Trade fair on the digital transformation in transportation
  November 20-22, 2017

  Presentation of the *Cartox²* project at the joint booth of the Fraunhofer Transport Alliance

PUBLIC BODY MEMBERSHIP AND PATENTS

PUBLIC BODY MEMBERSHIP

Danowski, Kamen

- Section »Civil Protection«, Euroregion Elbe/Labe

Engelbrecht, Julia Maria

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

Erbsmehl, Christian T.

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

Festag, Andreas

- 5G Automotive Associaton e. V.
- Acatech National Academy of Science and Engineering »New autoMobility«
- ETSI European Telecommunications Standards Institute

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 Groups AG 3.2.9 »Video Detection in TMS (Traffic Management Systems)« and AG 3.2.10, »Quality Management of TMS«

Gründel, Torsten

- CNA Center for Transportation & Logistics Neuer Adler e. V.
- ECTRI European Conference of Transport Research Institutes
- Fraunhofer Traffic and Transportation Alliance
- kontiki Working Group in Contactless Chip Card Systems for Electronic Ticketing e. V.
- 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 Alumni e. V.
- Fraunhofer ICT Group
- Forum on Electromobility e. V.
- International Monorail Association
- Network »Dresden – Stadt der Wissenschaften«

Michler, Oliver

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

Potthoff, Ulrich

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

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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- Klausner, S.; Gamsizlar, Ö.: **Elektrische Kontaktanordnung.** Patent no.: DE 10 2009 023 072, 2012

- Klausner, S.; Vorwerk, T.; Seiler, C.: **Unterflur-Kontaktsystem.** Application no.: DE 10 2017 218 226.1, 2017 Application no.: DE 10 2017 204 608.2, 2017

- Klingner, M.: **Leistungssteuereinrichtung und Verfahren zum Lastausgleich eines Netzes.** Application no.: DE 10 2011 114 344, 2011

- 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

Auerswald, R.: **Test Procedure of Automated-Connected Driving Functions on Public Urban Testbeds.** ASAM International Conference 2017, Dresden, Germany, December 6-7, 2017

Bartholomäus, R.; Lehmann, T.; Schneider, U.: **Model Predictive Control of Highly Efficient Dual Mode Energy Storage Systems Including DC/DC Converter.** In: Comprehensive Energy Management – Safe Adaptation, Predictive Control and Thermal Management. Watzenig, D.; Brandstätter, B.(eds), Cham, Springer, 2017, SpringerBriefs in Applied Sciences and Technology, pp 33-46, ISBN 978-3-319-57445-5

Chen, J.; Ludwig, M.; Ma, Y.; Walther, D.: **Zooming in on Ontologies – Minimal Modules and Best Excerpts.** 16th International Semantic Web Conference ISWC 2017, Vienna, Austria, October 21-25, 2017, presentation: D. Walther

Danidou, Y.; Dimopoulos, C.; Heckel, M.; Olunczek, A. et al.: **Implementation of the IMPRESS Project Platform in Real Test Case Scenarios.** 5th Annual Conference »Interagency Interaction in Crisis Management and Disaster Response« CMDR COE 2017, Sofia, Bulgaria, June 1-2, 2017, presentation: N. Dobrinkova

Dobrinkova, N.; Kostaridis, A.; Olunczek, A.; Heckel, M. et al.: **Disaster Reduction Potential of IMPRESS Platform Tools.** *In: Information Technology in Disaster Risk Reduction. Murayama, Y.; Velev, D.; Zlateva, P.; Gonzalez, J. J. (eds.), Cham, Springer International Publishing, 2017, IFIP Advances in Information and Communication Technology, vol. 501, pp. 225-239, ISBN 978-3-319-68485-7*

Engelbrecht, J.; Weber, R.; Michler, O.: **Reduction of Multipath Propagation at PoA Positioning Using Uniform Circular Array Antennas.** *In: Proceedings 13th Workshop on Positioning, Navigation and Communications WPNC 2016. IEEE, 2017, DOI: 10.1109/WPNC.2016.7822859*

Erbsmehl, C.; Landgraf, T.; Yuasa, H.: **Animal Street Crossing Behavior.** 25th International Technical Conference on Enhanced Safety of Vehicles ESV 2017, Detroit, USA, June 5-8, 2017, presentation: C. Erbsmehl

In: Proceedings. Online: https://www-nrd.nhtsa.dot.gov/departments/esv/25th/

Erbsmehl, C.; Lubbe, N.; Ferson N.; Landgraf, T.; Urban, M. et al.: **Analysis and Investigation Method for All Traffic Scenarios (AIMATS).** *In: Reports on the ESAR-Conference 2016 at Hannover Medical School. Bundesanstalt für Straßenwesen (eds.), Bremen, Fachverlag NW, 2017, Berichte der Bundesanstalt für Straßenwesen, subseries Fahrzeugtechnik, issue F 117, ISSN 0943-9307*

Gkotsis, I.; Eftychidis, G.; Hedel, R.; Olunczek, A.; Hahmann, S. et al.: **IMPRESS – Medical Location-Aware Decision Making During Emergencies.** 5th International Conference on Remote Sensing and Geoinformation of the Environment RSCy 2017, Paphos, Cyprus, March 20-23, 2017, presentation: I. Gkotsis

In: Proceedings. Spie, 2017, vol. 10444, DOI: 10.1117/12.2279138

González, A.; Kühlmorgen, S.; Festag, A.; Fettweis, G.: **Resource Allocation for Block-Based Multi-Carrier Systems Considering QoS Requirements.** IEEE Globecom 2017, Singapore, December 4-8, 2017, presentation: A. González

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Gründel, T.: **Synchronized Mobility.** ASAM International Conference 2017, Dresden, December 6-7, 2017

Hahmann, S.; Miksch, J.; Resch, B. et al.: **Routing Through Open Spaces – a Performance Comparison of Algorithms.** *In: Geo-spatial Information Science, 2017, November 24, DOI: 10.1080/10095020.2017.1399675*

Hedel, R.; Hahmann, S.; Brausewetter, P. et al.: **Optimal Resilience Planning for Interconnected Critical Infrastructures – Developments of the EU-CIRCLE Project.** 5th Annual Conference »Interagency Interaction in Crisis Management and Disaster Response« CMDR COE 2017, Sofia, Bulgaria, June 1-2, 2017, presentation: R. Hedel

Holfeld, D.: **Learning from the Past – Risk Profiler for Intermodal Route Planning in SYNCHRO-NET.** International Conference on Operations Research »Decision Analytics for the Digital Economy« OR 2017, Berlin, Germany September 6-8, 2017

Holfeld, J.; Süveg, M.: **BaseStation Simulator for NB IoT and Cellular Product Validation.** RF & Wireless Technology Day »Trends, Challenges, and Solutions«, National Instruments and NOFFZ Technologies, Düsseldorf, Germany, July 11, 2017, presentation: J. Holfeld

Hung, S.-C.; Zhang, X.; Festag, A.; Chen, K.-C.; Fettweis, G.: **Virtual Cells and Virtual Networks Enable Low-Latency Vehicle-to-Vehicle Communication.** IEEE Globecom 2017, Singapore, 4-8 December, 2017, presentation: S.-C. Hung

▶ Regelung nicht-resonanter Mikrospiegel mit elektrostatischem Kammantrieb

Dipl.-Ing. Richard Schroedter
Fraunhofer Institute for
Photonic Microsystems IPMS

May 15, 2017

▶ Nichtlineare Lenkregelung für Sattelzüge

Dipl.-Ing. Gunter Nitzsche
Fraunhofer Institute for Transportation
and Infrastructure Systems IVI

July 3, 2017

▶ Regionale prädiktive Regelung – MPC als stückweise affine Verallgemeinerung des linearen Riccati-Reglers

Kai König, M. Sc.
Ruhr-Universität Bochum,
Department of Mechanical Engineering,
Automatic Control and Systems Theory

November 6, 2017

Jiménez-Redondo, N.; Calle-Cordón, A.; Kandler, U.; Simroth, A. et al.: **Improving Linear Transport Infrastructure Efficiency by Automated Learning and Optimised Predictive Maintenance Techniques (INFRALERT).** Building up Efficient and Sustainable Transport Infrastructure BESTInfra 2017, Prague, Czech Republic, September 21-22, 2017, presentation: N. Jiménez-Redondo

In: IOP Conference Series »Materials Science and Engineering«, 2017, vol. 236, DOI: 10.1088/1757-899X/236/1/012105

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Llatser, I.; Jornod, G.; Festag, A. et al.: **Simulation of Cooperative Automated Driving by Bidirectional Coupling of Vehicle and Network Simulators.** IEEE Intelligent Vehicles Symposium IV 2017, Redondo Beach, USA, June 11-14, 2017, presentation: I. Llatser

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Nitzsche, G.; Wagner, S.; Engel, M.: **Electric Drivelines in Semi-Trailers: TRANSFORMERS – an Additional Way to Hybridisation.** *In: 14th International Conference Commercial Vehicles »Truck, Bus, Van, Trailer«. VDI (eds.), 2017, VDI Berichte 2298, pp. 167-178, ISBN 978-3-18-092298-0*

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Reichelt, B.; Ußler, H.; Michler, O.; Holfeld, J. et al.: **Model-Based Generation and Validation of Different Sensor Information Contributing to a Fusion Algorithm in Connected Vehicles.** 5th IEEE International Conference on Models and Technologies for Intelligent Transportation Systems MT-ITS 2017, Napoli, Italy, June 26-28, 2017, presentation: B. Reichelt

In: Proceedings. IEEE, 2017, DOI: 10.1109/MTITS.2017.8005691

Schwetlick, H.; Kandler, U.: **Block Newton Method and Block Rayleigh Quotient Iteration for Computing Invariant Subspaces of General Complex Matrices.** *In: Linear Algebra and its Applications, 2017, vol. 526, pp. 60-94, ISSN 0024-3795, DOI: https://doi.org/10.1016/j.laa.2017.03.025*

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Urban, M.; Erbsmehl, C.: **Generating and Validating Multibody Simulation Models of E-Bikes for PC-Crash.** 26th Annual Congress of the EVU, Haarlem, Netherlands, October 19-21, 2017, presentation: M. Urban

Wagner, S.: **Autonomous Trucks Applications in Logistics and Automation Zones.** International VDI Conference Autonomous Trucks 2017 »Technology, Connectivity, Digitized Use Cases, Infrastructure & Safety«, Düsseldorf, Germany, March 28-29, 2017

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The full list of publications can be found in the German section of the institute report on pages 44-49.

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Optimale Steuerung kontinuierlicher Prozesse.
TU Dresden,
Faculty of Electrical and Computer Engineering,
Laboratory of Control Theory, SS 2017

Robuste Regelung.
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Faculty of Electrical and Computer Engineering,
Laboratory of Control Theory, SS 2017

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

Fichtl, Holger
Propulsion Technology and Alternative Propulsion Systems.
Dresden International University,
Certificate course: Vehicle Safety and Traffic Accident Research,
Academic year 2017

Kertzscher, Jana
Berechnung elektrischer Maschinen.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2017

Elektrische Energiewandler.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2017

Einführung in die Elektrotechnik.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering,
WS 2016/17, WS 2017/18

Elektrische Maschinen und Antriebe.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Energiespeicher.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Energietechnik.(Lecture series)
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2017/18, WS 2017/18

Grundlagen der Elektrotechnik.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2017

Hybrid- und Elektroantriebe.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Regelung elektrischer Antriebe I.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2017

Regelung elektrischer Antriebe II.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Theorie elektrischer Maschinen.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Klingner, Matthias
Elektroenergiesysteme.
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, SS 2017

Systemtheorie in der Anwendung. (Compact seminar)
TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2016/17, WS 2017/18

Knote, Thoralf
Straßenverkehrstechnik.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Transport Planning and Road Traffic,
WS 2016/17, SS 2017, WS 2017/18

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

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

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

Potthoff, Ulrich
Modellierung und Simulation in der Verkehrstelematik.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, WS 2016/17, WS 2017/18

Modellierung und Simulation 2.
TU Dresden,
»Friedrich List« Faculty of Transportation and Traffic Sciences,
Institute of Traffic Telematics, SS 2017

Rauschert, André
Ideen-, Innovations- und Change Management.
Gründungsmanagement.
Hochschule Mittweida (FH),
Faculty Industrial Engineering, Faculty Media Sciences,
WS 2016/17, SS 2017, WS 2017/18

Steinert, Frank
Automatisierung in der Landtechnik.
TU Dresden,
Faculty of Mechanical Science and Engineering,
Institute of Natural Materials Technology, SS 2017

A list of final theses supervised by Fraunhofer IVI employees can be found in the German section on pages 51 and 53.


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X5965
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M5960
X5963

LIFE AT WORK AND BEYOND

A balanced and healthy lifestyle has become an integral part of work life. For many years now, the institute has supported its employees' physical well-being, offering for instance in-house massages and a fitness center. In the institute library, the staff can find specialized literature on how to avoid neck ache and back pain. The focus of this year's health day was put on the sensitive issue of »burn-out prevention«.

Teams are built as employees jointly participate in local sports events, such as the Dresden city run or the dragon boat race. A major highlight was the visit of the forest high rope park, where overcoming, coordination and physical strength were required for the climbing tasks.

The rising fitness trend is vividly demonstrated by the institute's bicycle rack. During the summer months, nearly every spot is occupied. More and more employees can be seen using fitness trackers. That is why one can hear a hum here and see a satisfied nod there when people are happy that their daily step target has been reached.

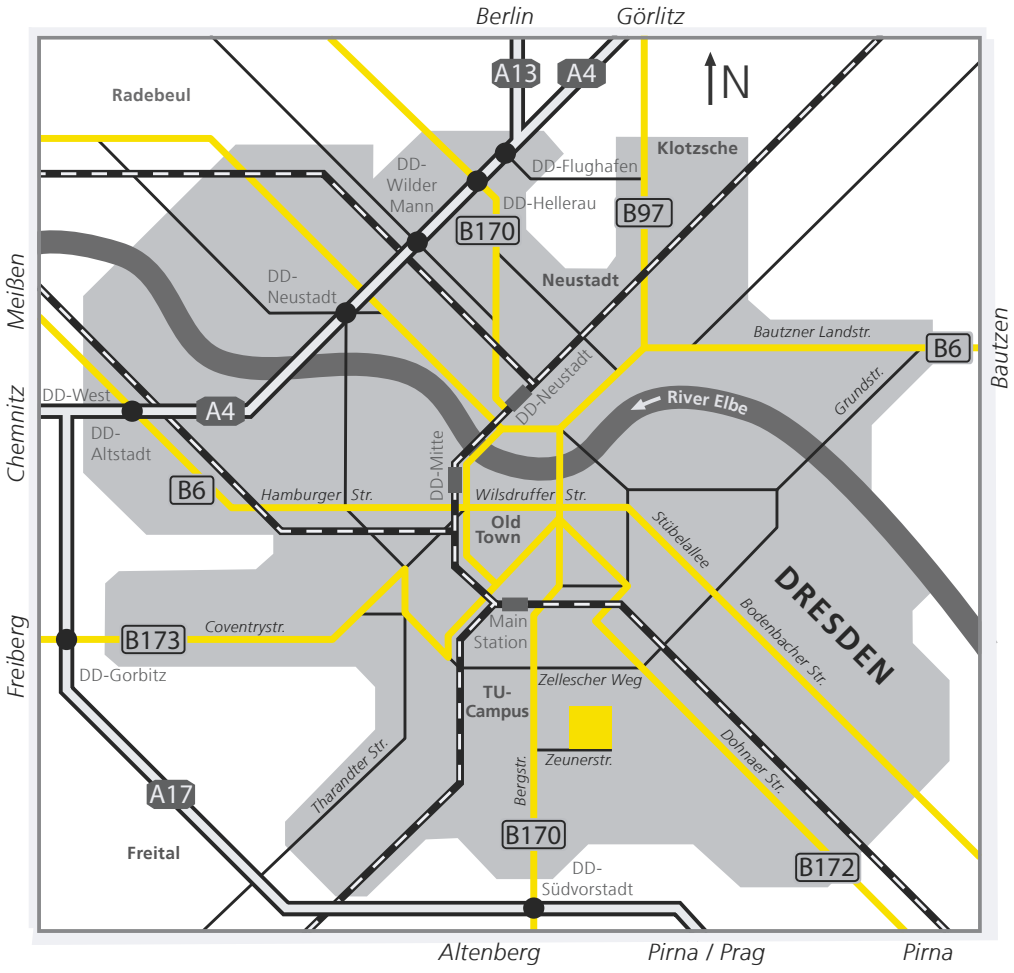
In terms of healthy eating, the institute's own beehive, which produces a small quantity but high quality of honey, is not the only asset of interest. In addition, the staff can purchase fresh vegetables from a local greengrocer.

To improve the quality of break times, a new outdoor seating area was built. Renovation works in the building have been completed after modernizing the work space in the attic and redesigning the bathroom facilities on the ground floor.

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, approx. 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 approx. 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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PHOTO ACKNOWLEDGEMENTS

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Fraunhofer IVI pp. 24, 38, 40, 41

PRINTED BY

SDV Direct World GmbH

www.sdv.de