Fraunhofer
IVI

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

INSTITUTE REPORT
2012
2013

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Fraunhofer Institute for
Transportation and Infrastructure Systems IVI

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PERSPECTIVES

The fate of a Fraunhofer Institute rarely evolves as straight and coherently as the way in which Renaissance painters transferred natural perspectives to their canvases using a thread and grid. Nevertheless, the term perspective (which, in German, can mean something that is expected, and which, in its Latin origins, meant a »view through« something that is able to project the depth of space onto a flat surface using a geometric three-dimensional construction) is ideally suited as a guiding principle along which to conceptualize an institute report.

Attempting to reduce the diversity of all the things that happen at a research institute within the course of a year to a few dimensions is not always justified. As complex as life presents itself to us, it is often the small things – but sometimes also the big events – that mark a well-balanced day-to-day work life. In 2013, the great collegial team spirit and creative commitment of every one of us helped open up perspectives that were almost unimaginable even a few years ago. For this, I would like to sincerely thank all the employees at the Fraunhofer IVI.

In terms of their significance, the everyday actions of a Fraunhofer Institute are organized around three central coordinates: scientific excellence, economic success and social cohesion.

The Fraunhofer-Gesellschaft's self-conception calls for scientific achievement on an internationally acclaimed level. This self-conception is put into practice within diverse types of collaboration with universities, national and international research organizations, through the personal commitment of leading Fraunhofer employees in teaching and training, by organizing scientific events or through the publication of research papers. Regarding this scientific profile, the Fraunhofer IVI made considerable progress in 2013. In addition to the TU Dresden, the TU Bergakademie Freiberg, one of Saxony's most well-known universities with an extraordinary history, will be a second cornerstone of the Fraunhofer IVI's academic ties. Founded in 1765 as the »Kurfürstlich-Sächsische Bergakademie[1]« and responsible for the education and training of miners, the TU Bergakademie Freiberg today is among the oldest educational institutions in the field of technology, surpassed only by the École des Ponts et Chaussées in Paris.

Scientific excellence, as it is understood and practiced at the Fraunhofer IVI, goes beyond teaching and working within the research groups at two Saxon universities. In addition to a great number of Bachelor, Master's, and Diploma theses as well as dissertations that have been supervised by institute employees, the institute's positive scholarly development in recent years is documented by a considerable number of articles published in renowned journals, by papers presented at international congresses and by different guest lecturer invitations from foreign universities.

(1) Mining academy of Electoral Saxony

From the perspective of economic viability and stability, the institute was able to once more present an outstanding annual balance in 2013, which complies with all requirements of the Fraunhofer financing model. If we recall in this context the image of 3D construction, the research and development tasks directly commissioned by industrial partners are the focal points for all Fraunhofer Institutes. At the Fraunhofer IVI, the rate of these revenues rose again in 2013 and is now at well over 30 percent. Moreover, the acquisition of research funds from the European Union and increased revenue from world-wide projects – for example in South America, Russia, China and Switzerland – underline the institute's growing international reputation. Only a few years ago, the internationalization of research collaborations used to be an area in which the benefits rarely justified the costs. Now, on the other hand, interesting prospects lie in the institute's future. All in all, the financial year of 2013 was concluded with a positive balance, and well-filled order books promise that the institute's finances will be equally balanced in 2014.

In 2013, the Fraunhofer IVI completed its first cycle within the process of strategy development. This continuous external evaluation can be viewed, in a figurative sense, as a kind of guiding line equal to that which the medieval mine surveyor used along with his plumb-line, quadrant scale and suspended compass in order to determine the direction of underground tunnels. The strategy development process evaluates the institute's performance potential in detail, provides points of reference and gives advice concerning the future development of research areas. As surveyors of these analyses, the members of the Fraunhofer IVI Advisory Board have shown great commitment and have substantially contributed to the strategy development process.

The positive recommendations made by the Advisory Board at the close of the strategy development process, the balanced annual accounts of the past years, stable industrial revenues and scientific capability in a variety of fields (including academic ties) – all of these were prerequisites that impelled both the Fraunhofer Executive Board and the Fraunhofer Senate to officially declare the Fraunhofer IVI an independent Fraunhofer Institute in the fall of 2013. With this, a long-cherished intention of the Fraunhofer IVI since its founding in 1999 has been realized.

In this context, I express my gratitude to all members of the Fraunhofer IVI Advisory Board, to Prof. Neugebauer, President of the Fraunhofer-Gesellschaft, who has emphatically supported this decision, and especially to Dr. Beck and Dr. Zimmermann, Heads of Division with the Saxon Ministry for Higher Education, Research and the Arts, who have also supported us in our pursuit of independence for many years.

The guidelines for the institute's future development have been fixed, our successes are irrefutable, and the work life at the institute also had a multitude of pleasant and eventful experiences in 2013. Our institute report, to whose perusal I cordially invite you, is an attempt at conveying all of this to you.

We thereby hope that you will be fascinated by the different impressions and perspectives of a camera that attentively accompanied us on our course through a good year.

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FRAUNHOFER-GESELLSCHAFT

Prof. Dr. Reimund Neugebauer, President of the Fraunhofer-Gesellschaft since 2012.

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 67 institutes and research units. The majority of the more than 23,000 staff members are qualified scientists and engineers who work with an annual research budget of 2 billion euros. Of this sum, more than 1.7 billion euros are 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 collaborations 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.

Fraunhofer-Haus Hansastrasse 27c, 80686 München.

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 TRAFFIC AND TRANSPORTATION ALLIANCE

At present, 16 Fraunhofer Institutes are combining their specific know-how, research infrastructure and long-standing experience within the area of transport-related research in order to offer complete systems solutions to public and industrial customers.

In June 2013, the alliance celebrated its 10th anniversary. Together with guests from politics and industry, the members of the alliance looked back on an eventful start-up period, the establishment of its five working groups Automotive, Aviation, Mobility, Rail and Waterborne, as well as their participation in countless trade fairs, workshops, discussion forums both in Germany and abroad, as well as in collaborative research projects. Among these projects, »GNSS Galileo«, to which the Fraunhofer IVI made a considerable contribution, was highly successful.

As an institute for traffic research, the Fraunhofer IVI contributes to the work of the alliance, bringing in numerous competencies, in particular in the areas of traffic information systems, traffic management and innovative traffic and propulsion systems.

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Prof. Dr. Uwe Clausen

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FRAUNHOFER LIGHTWEIGHT CONSTRUCTION ALLIANCE

»From concept to product« is the motto of the Fraunhofer Lightweight Construction Alliance, in which 15 institutes have established a joint platform to take on challenging projects that deal with lightweight construction and cover the entire development process from material through to design, simulation and production and up to the prototype. Key aspects of activity are:

- new materials and material composites,
- manufacturing and joining technologies relevant to lightweight construction,
- functional integration,
- design and configuration,
- non-destructive and destructive test methods,
- prototypical realization.

For the Fraunhofer IVI, lightweight construction in vehicles is constantly gaining in significance.

Areas such as body work, chassis and the interior offer weight reduction potentials that have positive effects on the design of innovative propulsion configurations and accordingly contribute to fuel and emission reductions with conventional propulsion technologies.

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THE FRAUNHOFER IVI IN ALLIANCES

FRAUNHOFER WATER SYSTEMS ALLIANCE (SYSWASSER)

Even today, access to clean drinking water is not a given in many regions of the world. Developing and threshold countries often lack the necessary infrastructure, but even modern industrialized countries are dealing with water supplies and wastewater treatment systems that are in need of renewal. Due to present-day demographic changes, flexible and at the same time economically viable solutions are needed.

Twelve Fraunhofer Institutes are combining their expertise and competencies in researching and developing new water system technologies in the Water Systems Alliance (SysWasser) in order to make a sustainable contribution to the efficient and environmentally friendly use of the vital resource of water.

The department of infrastructure systems, which is traditionally an integral part of the Fraunhofer IVI, looks back on long-standing experience in control engineering within the areas of wastewater treatment and system control as well as optimization. The department was significantly involved in a pilot project funded by the Saxon State Ministry of the Environment and Agriculture.

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Dr. Harald Hiessl

Managing Director
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FRAUNHOFER BATTERY ALLIANCE

Of the 15 institutes participating in the Fraunhofer Battery Alliance, four have joined forces within a Fraunhofer-internal preliminary research program (MAVO) in order to develop sulfur-based cyclically stable and intrinsically safe high-power energy storages with an energy density of over 400 Wh/kg and superior application potential. The guiding principle »(Sich) abheben mit Lithium-Schwefel« (»taking off with lithium sulfur«) is relevant for the project LiScell in two ways, figuratively referring to success in competitive international research as well as quite literally to the application in the Fraunhofer IVI's flying sensor platform HORUS.

The Fraunhofer IVI has a test stand for high-power energy storages, lithium-ion batteries and double-layer capacitors for:

- the testing of energy storages/power electronics,
- long-term tests of durability and malfunction,
- simulation of different ambient conditions, as well as
- research into energy management strategies.

The institute looks back on many years of experience from its own battery research and practical tests on the AutoTram®.

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20 YEARS OF FRAUNHOFER IN DRESDEN

To mark the 20th year of its presence in Dresden, Fraunhofer invited guests from science, economy and politics, long-standing supporters, advisory board members, industrial and research partners as well as employees from local institutes to celebrate a ball at the Dresden airport in March of 2012. High-profile speakers attended the event to honor the anniversary, including Saxony's Prime Minister Stanislaw Tillich, the Rector of the TU Dresden, Prof. Hans Müller-Steinhagen, the Deputy Mayor of Dresden, Dirk Hilbert and, as Fraunhofer representatives, Prof. Hans-Jörg Bullinger, at the time President of the Fraunhofer-Gesellschaft, as well as Dr. Alexander Imbusch, who today is the chairman of the Fraunhofer-Zukunftsstiftung (Fraunhofer Future Foundation) and who was actively involved in the establishment of Dresden's research landscape in the early 1990s.

Fraunhofer research came to Dresden after the Academy of Sciences of the German Democratic Republic was disbanded in 1991. The research society seized the opportunity to expand their scientific profile, gain highly skilled and motivated staff and open up new locations for their institutes.

In 1992, the Fraunhofer research institutions for

- Electron Beam and Plasma Technology FEP,
- Ceramic Technologies and Systems IKTS,
- Photonic Microsystems IPMS as well as
- Material and Beam Technology IWS

were integrated into the Fraunhofer-Gesellschaft. In the following years, other Fraunhofer Institutes founded branches in Dresden. The Fraunhofer IVI started as branch for Process Control of the Fraunhofer IITB in Karlsruhe, with 25 employees at the time. By now, there is no other location with as many Fraunhofer Institutes as Dresden. Prof. Bullinger thus proudly invited the responsible directors to join him on stage for a short statement and a big thank-you.

After the official part of the event, the 1800 guests continued with the celebrations and enjoyed great food followed by both modern and traditional dance music on several floors until the early morning hours. Due to the remarkable success of this first Fraunhofer ball, the committee decided to have another large-scale event to mark the 25th anniversary of Fraunhofer in Dresden in 2017.

Director
Prof. Dr. Matthias Klingner

Head of administration
Kornelia Brüggert

Founded in 1999, the Fraunhofer IVI in Dresden employs more than 80 research fellows and has four departments as well as two research groups in cooperation with the TU Dresden and the TU Bergakademie Freiberg. It originated in the former branch for Process Control of the Fraunhofer IITB in Karlsruhe.

The institute operates in a wide array of transport-related research and development topics, ranging from the fields of electromobility, traffic planning and traffic ecology, traffic information, vehicle propulsion and sensor technologies, but also incorporates traffic telematics, the information and communication sectors as well as disposition and logistics.

Memberships of the institute include the Fraunhofer ICT Group and the Fraunhofer Alliances Traffic and Transportation, Battery, Lightweight Construction, Big Data and Water Systems. The staff is also actively involved in the Fraunhofer Networks Sustainability, International Business Development, EU, Social Media and PR.

The Fraunhofer IVI has become well-known for its solutions in electronic ticketing, the mobile public transport navigation system SMART-WAY and a system for cross-border disaster management. Lately, the AutoTram® Extra Grand with its length of 30.7 meters, equipped with hybrid propulsion technologies and an electronic multi-axle steering system, has been the center of attention.

Facilities and large equipment include high-performance laboratories, innovative test platforms and vehicles as well as modern hardware and software. In 2013, the Fraunhofer IVI's research infrastructure was expanded by a new technical center that includes a vehicle hall and an adjacent test track.

PROFILE OF THE INSTITUTE

Transportation, Energy and Environment
Dr. Ulrich Potthoff

- System Models and Process Control
  Dr. Ralf Bartholomäus
- Energy Storage and Converter Technologies
  Richard Kratzing

Intelligent Transport Systems
Dr. Torsten Gründel

- Mobility and Travel Assistance
  Dr. Sunna Torge
- Ticketing and Fares
  Dr. Torsten Gründel

Strategy and Optimization
Dr. Kamen Danowski

- Disposition
  Dr. Kamen Danowski
- Business Processes
  André Rauschert
- Logistics
  Axel Simroth

Vehicle and Transport System Engineering
Dr. Thoralf Knote

- Propulsion Technologies
  Dr. Frank Steinert
- Transportation Systems/Human-Machine Interaction
  Dr. Thoralf Knote
- Sensor and Actuator Systems
  Dr. Stephan Zipser
- Vehicle Technologies
  Dr. Holger Fichtl

Research Group of TU Dresden
Prof. Dr. Oliver Michler

- Locating, Information, Communication
  Dr. Georg Förster

Research Group of TU Bergakademie Freiberg
Prof. Dr. Jana Kertzscher

- Energy System Engineering
  Prof. Dr. Jana Kertzscher

The Fraunhofer IVI Advisory Board meeting on March 20th, 2013, was held against the background of the institute's first cycle within the strategy development process, which had begun in the fall of 2012. The strategy development process does not only include detailed analyses, regular workshops and the drafting of a strategy paper, but also an audit conducted by external consultants. In coordination with the Senior Vice President of the Fraunhofer-Gesellschaft, the recently appointed Fraunhofer IVI Advisory Board members agreed to take over this responsibility.

Accordingly, the main emphasis during the event lay on the presentation of the results of the strategy development process. As an integral part of the strategy audit, Professor Klingner presented the institute's »both lived and living« overall strategy to the auditors. This strategy is based on the analysis of strengths and experiences under consideration of external market requirements, and it derives core competencies and business units as logical consequences of these analyses.

After an open and constructive discussion panel, the auditors summarized their evaluations and gave their advice. However different their individual assessments might have been, there was general agreement on one aspect: over the past few years, the Fraunhofer IVI has gone through a remarkable phase of development and is regarded as a reliable and competent partner in its business sector. Trends are being detected at the right time and research topics are being placed accordingly.

Professor Lippold, Advisory Board Chairman and director of the audit, emphasized in his closing statement in front of all auditors that »in light of its impressive figures and its remarkable growth curve, granting the institute a status of independence is to be supported without reserve«. Thus, it was finally possible to set the course for a submittal to the Fraunhofer Executive Board, who decided that the Fraunhofer IVI would act as an independent institute as of January 1st, 2014.

ADVISORY BOARD

Chairman of the Advisory Board

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

Members of the Advisory Board

Dr. Annerose Beck,
Head of Division, Saxon State Ministry for Higher Education, Research and the Arts (SMWK)

Burkhard Ehlen,
CEO, Verkehrsverbund Oberelbe (VVO)

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

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

Prof. Dr. techn. Klaus Janschek,
Managing Director, Institute of Automation,
Chair of Automation Engineering,
Faculty of Electrical and Computer Engineering,
TU Dresden

Dr. Siegfried Meuresch,
Head of Division,
Federal Ministry of Economics and Energy (BMWi)

Prof. Dr. Dirk C. Meyer,
Prorector, Structural Development,
TU Bergakademie Freiberg

Peter G. Nothnagel,
CEO, Saxony Economic Development Corporation Wirtschaftsförderung Sachsen GmbH

Dirk Schillings,
Senior Director Engineering, Bombardier Transportation GmbH

Bernhard Schmidt,
CEO, Göppel Bus GmbH

Reiner Zieschank,
Chief Financial Officer and Dean of Technology,
Dresdner Verkehrsbetriebe AG

On October 17th, 2013, the Senate of the Fraunhofer-Gesellschaft decided that the Fraunhofer IVI – a former branch of the Fraunhofer IOSB in Karlsruhe – may act as an independent institute. The institute's balanced scientific orientation, the sustainable structure in personnel and the collaboration with universities might have been crucial for this decision, but above all, the positive economic development in recent years has contributed to this process.

The annual increase in project revenue has been continued. Research projects financed by the public sector make up a share of 49 percent. Due to the transition from the 7th Framework Programme to Horizon 2020, the share of EU revenues decreased to 9 percent as compared to 17 percent in 2012. Industrial revenues rose from 30.5 percent in 2012 to 31.1 percent in 2013.

The number of employees has increased accordingly, as part of the staff moved into new offices in the technical center. The installation of new laboratories has also been completed. Due to the formation of a research group with the TU Bergakademie Freiberg, an ongoing expansion of staff and identification of new research fields is to be expected.

Based on sound financing and a well-developed and future-oriented infrastructure, the highly motivated and skilled employees of the Fraunhofer IVI will be able to put forward innovative solutions in collaboration with companies and research partners to further enter foreign markets.

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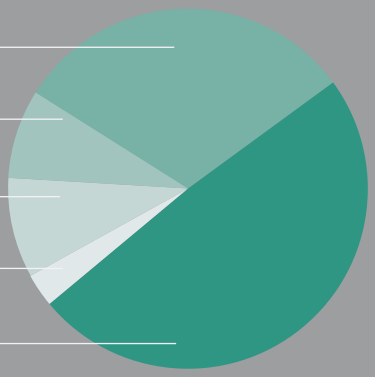
ECONOMIC DEVELOPMENT

OPERATING BUDGET 2013

Industrial revenues	31 %
Basic financing	8 %
EU	9 %
Miscellaneous	3 %
Public sector	49 %



EMPLOYEES 2013

Research fellows	84
Research assistants	58
Trainees	5
Administrative and technical staff	14
Total	161

FINANCIAL DEVELOPMENT

in € million

1

TRANSPORTATION, ENERGY AND ENVIRONMENT

- Electrochemical, electromechanical and thermo-electrical energy storages and converters
- In-situ procedures for fault detection and state-of-health diagnosis of high-power energy storages
- Model-based SOC and SOH determination of lithium-ion batteries under uncertainty
- Observer-based battery management systems
- Liquid and air-cooled high-power lithium-ion traction batteries
- Multimodal analysis and optimization of electrical cell contacts
- Operational strategies and design of dual storage systems (combined supercaps and lithium-ion batteries)
- Charge controllers for traction energy storage systems
- Model-based simulation and design of advanced cooling systems
- Hybrid power packs for buses and trams
- Model-based error analysis for fuel cell systems
- Predictive energy management for hybrid road and rail vehicles
- Latent-heat storage systems for peak load shaping
- Predictive load-synchronous thermal management
- Feasibility studies on innovative vehicle air conditioning concepts
- Assessment of energy efficiency in bus air conditioning
- Model-based screening of environmental data
- Prediction and reduction potential of PM10 emissions
- Impact analysis for low emission zones
- Grid integration of charging processes for EV fleets
- Intelligent system management and grid connection of renewable energy systems
- Design studies on technically functional vehicle interior parts
- Innovative surface coating of vehicle interior elements
- Energy efficiency analysis of wastewater treatment plants

VEHICLE AND TRANSPORT SYSTEM ENGINEERING

- Concepts for buses and intermediate vehicles
- Electrical and hybrid propulsion technologies
- Fuel and energy efficiency analyses for hybrid vehicles, incl. measurements
- Concepts for introducing electric buses in public transport companies
- Ergonomic evaluation of control and display concepts in automotive engineering
- Engineering of multi-axle steering systems (model-based design, simulation and test drives, steer-by-wire systems)
- Driver assistance systems for commercial vehicles
- Life cycle cost analysis and cost-benefit analysis of new transportation technologies in public transport
- Simulation of traffic situations in the driving simulator
- Fast charging of electric energy storages in urban transit buses
- Electronic and optical lane detection systems for conventional and special vehicles
- Camera-based measurement and testing systems for technical processes and health research
- Infrared and video measurement technologies
- Steering-based dynamic stabilization of commercial vehicles
- Optimized route and path planning for heavy-duty transport
- Lightweight construction optimization and structural calculations for buses and rail vehicles
- Octocopter HORUS (HOvering Remote controlled Ultra-light Sensor platform) for thermal imaging, photo and video flights, stereo photography, photogrammetry, measurements and surveillance
- Fraunhofer System Research for Electromobility II

COMPETENCIES AND PROJECTS

INTELLIGENT TRANSPORT SYSTEMS

- Intermodal information systems for public transport and cities
- SMART-WAY – Galileo Based Navigation in Public Transport Systems with Passenger Interaction
- Electronic fare management based on Be-In/Be-Out technologies
- »HandyTicket Deutschland« – supra-regional mobile ticketing system for public transport and parking
- PKM – fare modules in public transport
- PED – editor for public transport tariffs
- TKV – tariff simulation tool
- Traffic IQ – pilot project on information quality in traffic
- CLOSER – Connecting Long and Short Distance Networks for Efficient Transport
- STAR-TRANS – Strategic Risk Assessment and Contingency Planning in Interconnected Transportation Networks
- SMS services for schedule and city information
- NADINE – public transport navigation with modular service platform
- Geocoded database system for use in traffic and transportation
- WEATHER – Weather Extremes: Impacts on Transport Systems and Hazards for European Regions
- GeMo – shared use of e-mobility: vehicles, data and infrastructure

STRATEGY AND OPTIMIZATION

- MobiKat – Technology for strategic planning and operative-tactical command in emergency response
- MobiKat MBD – GIS module for ammunition disposal services
- IDIRA – Interoperability of Data and Procedures in Large-Scale Multinational Disaster Response Actions
- COSMOD – Cross-Border System for Management and Optimization of Disaster Control and Crisis Management
- Dynamic vehicle routing for transportation companies
- Maintenance management for infrastructure operators
- CATO – CBRN Crisis Management: Architecture, Technologies and Operational Procedures
- PrimAIR – concepts for airborne primary rescue in sparsely populated areas
- EZOLAT – real-time optimization of intra-corporate storage and transportation processes
- OptiCap – optimized synchronization of production and logistics capacities
- PLUSS – operational production planning under uncertainties
- Analysis of market trends
- Concepts for linking transportation and services

LOCATING, INFORMATION AND COMMUNICATION

- Simulation of radio signals based on recorded and generated samples (GPS, Glonass, Galileo, SBAS, GBAS, DAB, DVB-T, RDS/TMC, TPEG etc.)
- Comparative IT-supported evaluation of telematics components (e. g., antennas, receivers, navigation systems)
- Vehicle locating in railway and road traffic systems based on global navigation satellite systems, multi-sensor data fusion, map matching and ground-based wireless sensor networks
- Lane and track-sensitive vehicle locating
- Radio-based, wired and hybrid vehicle and infrastructure communication
- Multivariate methods and filter techniques for state estimation, data analysis and data fusion

1 *Field test of MobiKat technologies.*

FACILITIES AND LARGE EQUIPMENT

TEST VEHICLES

- AutoTram®, test vehicle for the evaluation of alternative propulsion systems, lane guidance technologies and automatic steering control
- Test vehicles for driver assistance, driver information and automatic driving
- Mobile command vehicle equipped with system for decision support in emergency and crisis situations
- Platform »ELENA« for evaluation of steering strategies
- Urban transit bus with serial hybrid propulsion system

SOFTWARE EQUIPMENT

- Matlab/Simulink
- DSpace Rapid Prototyping Control
- CATIA V5 (design)
- ANSYS (finite element simulation)
- COMSOL (Multiphysics simulation)
- Dymola (interdisciplinary simulation of physical systems)
- SIMPACK (simulation of multibody systems)
- LabView (environment for the development of measurement, monitoring and control systems)
- Dewesoft (data logging and analysis)
- Halcon (image processing)
- ArcGIS 10.1 (geographic information system)
- Apache Hadoop, Map/Reduce, HDFS, HBase, Hive, Mahout

LABORATORY FACILITIES

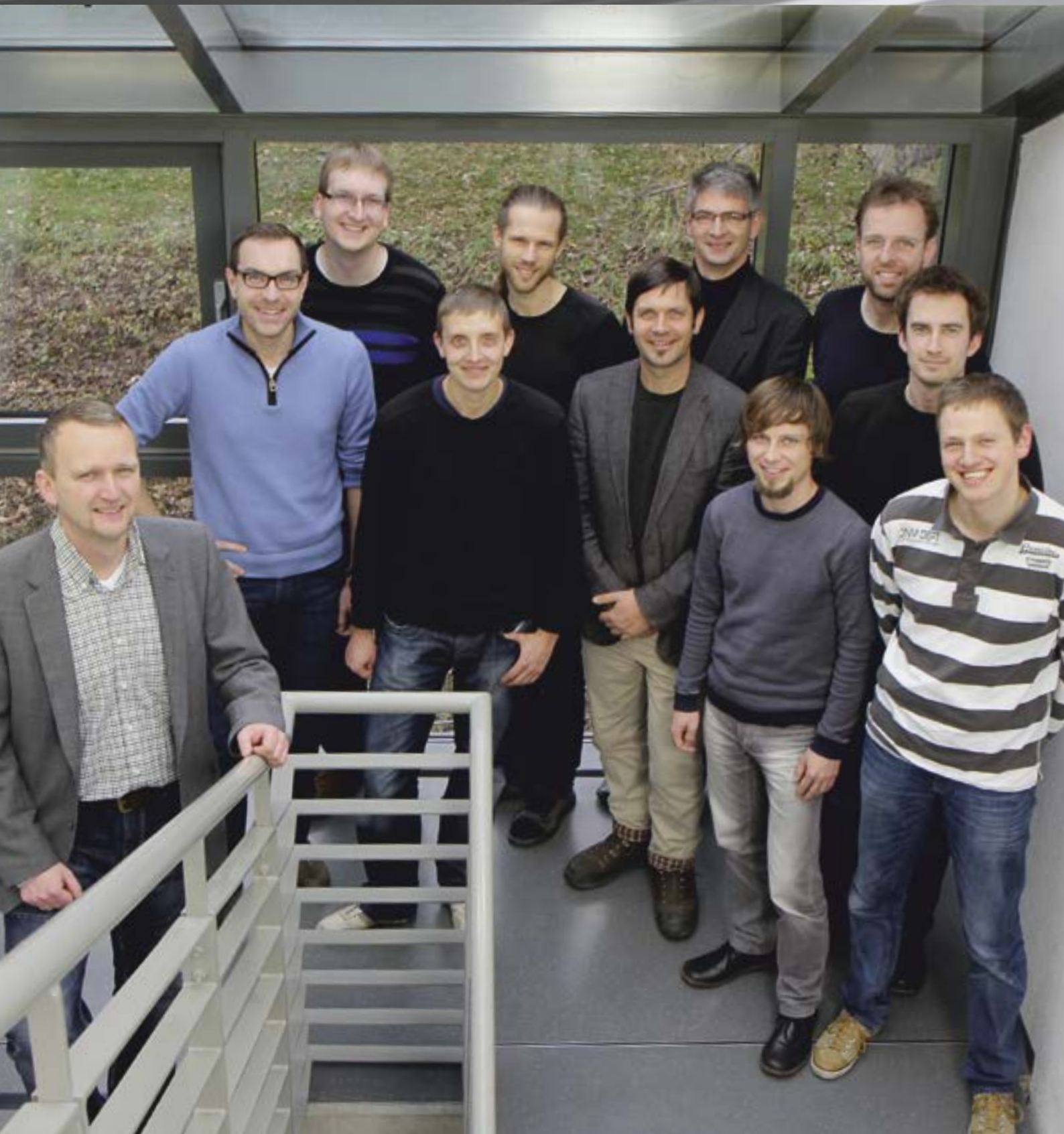
- Sensor technology and image processing
- Communication and radio technologies
- Demo lab for transport telematics
- Battery lab
- Electronics lab

TECHNICAL EQUIPMENT

- Vehicle hall with crane system and test track
- Engine test stand
- Test stand for auxiliary components
- Test stand for high current contacts
- Driving simulator for road vehicles
- Environment for development and testing of sensor, actuator and processing systems
- External evaluation and data acquisition facilities for traffic applications
- Mobile hydrogen production (HyTra) and filling station
- Test stand and data acquisition systems for battery and capacitor storage on the cellular and system levels
- Test stand and data acquisition system for measurement of small electrical contact resistances
- Environment for development and testing of embedded microcontroller systems of different classes
- Functional models and work bench for control development of DC/DC converters
- Inertial measurement unit (ADMA)
- Mobile measuring data acquisition system (DEWETRON)
- Development control unit for mobile applications (AutoBox)
- Steering and accelerator robots
- Universal Receiver Tester (URT) with two channels (250 kHz - 2.7 GHz) with bandwidth 20 MHz
- Universal Receiver Tester (URT) with three channels (85 MHz - 2.7 GHz) with bandwidth 50 MHz
- National Instruments USRP-2920 for Software Defined Radio (50 MHz - 2.2 GHz)
- National Instruments CompactRIO control and monitoring systems with IO modules
- Toolkit for testing electromagnetic compatibility (EMC)
- Octocopter HORUS for photography, videography and thermal photography
- Calibrated infrared measurement technology
- Mobile camera for monitoring in crisis situations

1 *Fraunhofer IVI technical center.*

TRANSPORTATION, ENERGY AND ENVIRONMENT



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Research in the fields of transportation and the environment is often subject to contrary demands, for instance current mobility requirements and the associated use of resources. The efficient handling of energy is of great importance in this respect. The department »Transportation, Energy and Environment« operates in a versatile field of activity, which demands the scientific evaluation of this conflict by means of evidence-based methods as well as the enhancement of the research field with novel technical solutions. The systematic chain of energy production, energy transmission, energy conversion and energy storage reflects the core competencies of the department's working groups: »Energy Storage and Converter Technologies« focuses on mobile and stationary applications and designs energy efficiency concepts and innovative solutions. »System Models and Process Control« abstracts systemic principles and develops targeted measures.

Today's challenges in research are generally of an interdisciplinary nature. The department is thus actively networking with other organizations on several levels: in Fraunhofer Alliances, Fraunhofer Networks or in preliminary research programs. In these groups, the scientists and engineers discuss current issues of battery security and battery reliability modeling, aspects of sustainability and the handling of scarce resources.

The combination of well-theorized solutions and feasible realization concepts attract the interest of industrial customers. Successfully implemented project results, for example, from battery system development or energy efficiency evaluation for HVAC systems by order of several well-known European bus manufacturers, show the constant demand for the development services of the Fraunhofer scientists.

The researchers are convinced that novel methods must be mostly interdisciplinary. Principles of systems theory draw on basic thermal, electrical and mechanical coherences and thus become the key for systems solutions both in mobile and stationary applications.

Energy Storage and Converter Technologies

Key areas of activity are innovative solutions in the field of energy generation, energy conversion and storage, including universal issues such as the global challenge of integrating energy from renewable sources into the grid and the evaluation of grid and energy regulations as well as novel approaches to load balancing and balancing energy as services in the grid.

Energy storage is still the key technology of electromobility – its capacity and capability considerably influence the appeal of electric vehicles. The working group deals with the development and integration of intelligent energy storage solutions. These systems are modular, compact and highly integrated, equipped with novel low-maintenance measurement and control software.

Another core area of interest is the development of holistic heating and cooling concepts for hybrid and electric vehicles that include new components and significantly reduce overall energy requirements. For the control of energy flows, a model predictive thermal management is used. The influence of this thermal management on energy consumption and CO_2 emissions can be determined with the help of simulation tools and validated by the test vehicle AutoTram®.

The working group also deals with concepts for local self-sustaining energy supply in the building sector. Energy components are designed, simulated and validated according to thermal, electrical and water management specifications. Data-based feasibility analyses give insight into environmental issues.

System Models and Process Control

The working group's main area of activity is the application of modern methods of control engineering, primarily in the vehicle engineering sector. Research work focuses on predictive energy management in electric and hybrid propulsions, as well as the modeling and control of electrical energy storages for high systems efficiency and life span.

The working group realizes their R&D efforts in national and international projects. The engineers contribute their energy-related expertise and skills to numerous research undertakings all throughout the institute. Examples are novel energy storages on a lithium-sulfur basis and the development of special components for autarkic energy and utilities supply.

Owing to the development of new concepts for both the online state-of-charge/state-of-health determination of lithium-ion energy storages and the control of electrical energy converters in dynamic applications, products can reach a higher quality, even when combined with the conventional system hardware.

CEO of Göppel Bus GmbH with partners and employees on company premises.

PARTNERS

- AIB Architekten Ingenieure Bautzen GmbH
- Bombardier Transportation GmbH
- BMVBS Federal Ministry of Transport, Building and Urban Development
- BBSR Federal Institute for Research on Building, Urban Affairs and Spatial Development
- B & O Gebäudetechnik GmbH & Co. KG
- Carmeq GmbH
- CWA Constructions SA/Corp
- DEKRA Automobil GmbH
- DREWAG Stadtwerke Dresden GmbH
- DREWAG NETZ GmbH
- driveXpert GmbH
- DVB Dresdner Verkehrsbetriebe AG
- ElringKlinger AG
- EKF – Robotic Systems
- ENSO Energie Sachsen Ost AG
- Euracom GmbH
- EvoBus GmbH
- Göppel Bus GmbH
- GEA Bock GmbH
- Heliatek GmbH
- Hochschule Lausitz
- Hochschule Mittweida
- HTW Hochschule für Technik und Wirtschaft Dresden
- IAV GmbH, Ingenieurgesellschaft Auto und Verkehr
- ifN-group
- Infineon Technologies
- INNIUS DÖ GmbH
- Iveco France
- JTI Jenaer Technologie- und Innovationsberatung
- Kirsch GmbH
- Li-Tec Battery GmbH & Co. KG
- LZS Leichtbau-Zentrum Sachsen GmbH
- MAN Bus & Truck AG
- Maxwell Technologies SA
- Neue WMS Flocktechnik GmbH
- Pneumatik Berlin GmbH
- SAENA Sächsische Energieagentur GmbH
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- Volvo Bus Corporation
- Wilde Metallbau GmbH
- WSB Neue Energien GmbH
- ZeoSys GmbH Zeolithsysteme
- 50Hertz Transmission GmbH

AGENT-BASED MODELING AND SIMULATION OF PASSENGER INTERCHANGE

Problem

The time needed for the boarding and alighting of passengers represents a significant portion of the total driving time of buses and trains, especially at periods of high demand. Which type of technical vehicle interior design is suitable for achieving ***optimal passenger interchange times***? In order to answer this question, a research and development project gave insight into

- whether physical impact factors of passenger interchange can be determined,
- which values and parameters bear a significant influence on the boarding and alighting time,
- whether a dynamic model is able to depict the real-life situation with sufficient precision, and
- in how far practical conclusions can be derived by simulation from the model.

Approach

It is plausible that parameters such as the number of passengers and geometrical structures, for example door width or a comfortable arrangement of seats and handrails, have an influence on the passenger interchange time. With this in mind, a flexibly ***configurable simulation tool*** for the determination of passenger interchange times was developed in collaboration with an industrial partner. Within given geometric dimensions, with known starting positions of the persons involved, and under consideration of other framework conditions, a highly reliable model-based estimation of the time required for passenger interchange can be made.

The Fraunhofer IVI developed a ***heuristic, agent-based model*** that dynamically maps the movements of several persons involved in a passenger interchange situation.

Procedure

This model is especially suited for the analysis of connections between a system – such as, for example, a tram system – and the behavior of the agents, or passengers. In order to generate plausible movement patterns, the individual behavior of each passenger needs to be classified and reproduced as precisely as possible: each agent is assigned with a destination, either on the inside of the tram if the agent is boarding, or outside of the tram if the agent is alighting. Their seating depends on which and how many places are already occupied. Seats are preferred over standing places, and – if possible – natural minimum distances between persons are observed. In the calculation of the path $P: \mathbb{R} \rightarrow \mathbb{R}^2$, mathematical and physical methods of optimal planning under constraints are used: based on the two-dimensional velocity field v and the comfort range g, ***time-optimized motion planning*** avoiding low-comfort zones is performed. The potential field ϕ results from this as a weighted sum containing a time component, a distance component and a comfort component:

$$\phi = \alpha \int 1 \, dt + \beta \int \frac{1}{v(P(t))} dt + \gamma \int g(P(t)) \, dt \rightarrow min$$

Resulting from the demand of the agents to reach their respective destinations within the shortest possible time and using the shortest possible path, their unimpeded movement will occur in a direction perpendicular to the curves of equal potential. Due to ***interaction with other passengers***, however, movement restrictions occur. At this point, it is no longer possible to come to an analytical solution, and only the use of stochastic simulations proves to be an expedient method. Figure 2 shows the fundamental modeling of these interactions with the help of overlapping interaction fields with the potential ϕ. The unimpeded movements (orange arrows 1) are superimposed by evasive movements (blue arrows 2). These evasive movements depend on the distance to and the movements of the other agents. The red arrow 3 illustrates the resulting movement within the potential field.

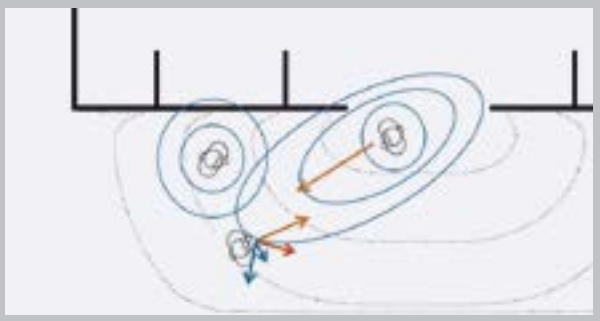
Especially ***movements of persons within the tram*** prove to be a significant factor of the total time required for passenger interchange. Because of limited interior space, more severe interactions between agent and system as well as between the agents occur. This may lead to situations of conflict, which in turn can lead to a major increase in passenger interchange time. Outside of a tram, in contrast, relatively unimpeded movement is possible in most cases. In addition, various special cases and social conventions have to be taken into consideration:

- Persons carrying luggage or pushing baby strollers require more space and are less mobile.
- Groups of people traveling together act differently regarding seat choice and interaction with each other than passengers traveling alone.
- Alighting passengers are usually given priority before boarding passengers.

Results

The simulation program allows an in-depth analysis of various factors that influence passenger interchange time. Figure 2, for example, illustrates the relation of passenger interchange time and the number of passengers in an exemplary case: at 75 persons or less, the total interchange time increases only linearly, the increase depending mainly on the number and width of doors.

At over 75 persons, however, the passengers significantly impede each other. This leads to an additional, disproportional increase in interchange time. Changes to the technical design of the vehicle interior may be a suitable remedy: such modifications can be performed with the model-based simulation tool, which thus evolves into an indispensable development tool for the next generation of vehicles.



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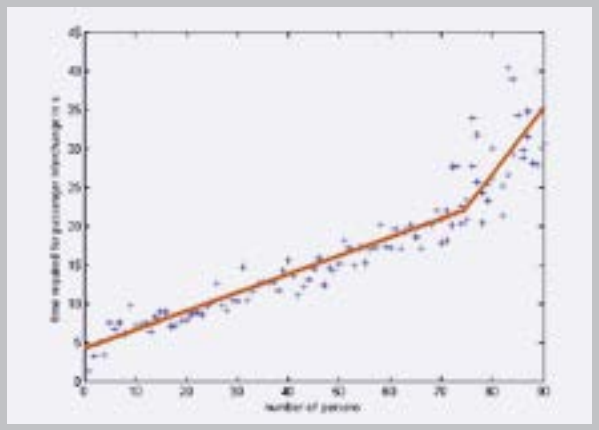

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1 *Two-dimensional comfort field used for the modeling of interaction between passengers.*

2 *Stochastic simulation: correlation of passenger interchange time and passenger numbers, disproportional increase for P > 75.*

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INTELLIGENT TRANSPORT SYSTEMS

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The department »Intelligent Transport Systems« has successfully operated at the market for more than a decade. Having emerged from the Working Group »Intermodal Information and Control Systems« of the Fraunhofer Research Institution for Process Control, the department has significantly shaped the Fraunhofer IVI's research profile in transportation and traffic engineering.

The two Working Groups »Mobility and Travel Assistance« and »Ticketing and Fares« successfully realize projects in a large variety of research topics, acting in interdisciplinary teams with a broad range of skills. The staff includes computer scientists, information engineers, transportation engineers as well as automation technicians.

Research and development projects are carried out by order of ministries, local authorities, transport companies, industry and the European Union.

The core competency of the Working Group »Mobility and Travel Assistance« are information systems based on novel communication and navigation technologies. Application-oriented research is also carried out in the fields of traffic state estimation as well as traffic planning and coordination in large urban areas. Navigation is becoming increasingly important as a research topic for the department. Together with the application of innovative technologies in location-based services and car sharing or carpooling solutions, the field of traffic information reveals a considerable development potential as an area of expertise in national and international contexts.

The focus of the Working Group »Ticketing and Fares« is electronic fare management and mobile ticketing, including the development of high-performance ticket servers. Another area of research are concepts and software systems for fare modeling and the automatic computation of fares, which can be applied to background and embedded systems as well as to simulation environments.

In the fields of electronic ticketing and traffic management, the department's highly complex information and management systems have been in daily use with our customers for many years. Thus, the maintenance, updating and further development of these systems are an important field of activity for the department.

Mobility and Travel Assistance

In addition to the key research field of information in public transport, research activities of the working group comprise traffic management, traffic planning and infrastructure identification, including socio-economic aspects as well as navigation and traffic monitoring.

The main research focus is navigation in public transport networks, integrating a number of neighboring disciplines. Navigation technologies are not only relevant for mobile location-based services developed at the institute, but also for car sharing and carpooling solutions in the context of electromobility and other third-party applications.

In the field of traffic planning and analysis, the scientists are conducting research into existing traffic flows and future mobility demands of regions in both passenger and freight transport. In motorized private transport, various data, such as traffic volume, speed, traffic tailback or spatial occupancy rate (e. g. in parking lots) can be acquired.

Ticketing and Fares

Extensive know-how and long-standing experience in electronic and mobile ticketing combined with outstanding competence in software technologies form the basis of the group's research work.

Developments include flexible ticket servers, background systems of electronic fare management as well as software for the design of complex price calculation algorithms and highly optimized, XML-based fare modules for embedded systems in public transport. Cross-cutting issues, such as the integration of regional fare databases and information systems right up to the development of attractive web applications and interactive maps are complementing the core competencies.

The team is looking into various aspects of automatic fare calculation for public transport – from the study of innovative fare models to the development of specially designed software for fare simulation under consideration of large amounts of data.

Demonstration of mobile apps at the GeMo meeting in Dresden.

PARTNERS

- bodo Bodensee-Oberschwaben Verkehrsverbundgesellschaft mbh
- CERTH-HIT Centre for Research & Technology Hellas
- DB Deutsche Bahn AG
- DLR German Aerospace Center
- DVB Dresdner Verkehrsbetriebe AG
- GTT Gruppo Torinese Trasporti
- HanseCom
- IFSTTAR French Institute of Science and Technology for Transport, Development and Networks
- Landeshauptstadt Dresden
- momatec GmbH
- NVBW Nahverkehrsgesellschaft Baden-Württemberg mbH
- Politecnico di Torino
- RVD Regionalverkehr Dresden GmbH
- RMV Rhein-Main-Verkehrsverbund GmbH
- Siemens AG
- TAF mobile GmbH
- TU Dresden, Faculty of Transportation and Traffic Sciences
- TÜV Rheinland Industrie Service GmbH
- UPM Universidad Politécnica de Madrid
- VBB Verkehrsverbund Berlin-Brandenburg GmbH
- VDV eTicket Service GmbH & Co. KG
- VDV Association of German Transport Companies
- VMT Verkehrsgemeinschaft Mittelthüringen GmbH
- VON Verkehrsverbund Oberlausitz-Niederschlesien GmbH
- VRR Verkehrsverbund Rhein-Ruhr AöR
- VRS Verkehrsverbund Rhein-Sieg GmbH
- VTI Swedish National Road and Transport Research Institute
- VTT Technical Research Centre of Finland
- VVO Verkehrsverbund Oberelbe GmbH
- VVS Verkehrs- und Tarifverbund Stuttgart GmbH
- VVV Verkehrsverbund Vogtland GmbH
- WVI Prof. Dr. Wermuth Verkehrsforschung und Infrastrukturplanung GmbH

NADINE – A SINGLE APP FOR NAVIGATION AND TICKETS IN PUBLIC TRANSPORT

With the increasing spread of smartphones and mobile internet, passenger information services in the field of public transport are gaining more and more significance. A wide variety of mobile applications (apps) is already offering passenger support in the individual parts of the travel chain (trip planning, finding stops, buying tickets etc.). However, users today expect continuous guidance and door-to-door support, just as they know from private car navigation solutions. It is not desirable for passengers to need a separate app for each of their transport-related tasks. Instead, they should be able to trust their mobile travel companion to master all difficulties and questions that arise during the journey, thereby effectively lowering the access barriers to public transport. The following methods and innovations developed within the NADINE project, funded until 2015 by the Federal Ministry for Economic Affairs and Energy (BMWi), aim to meet those demands.

The overall goal of the research project NADINE is the realization of a fare-sensitive door-to-door navigation application for public transport, which is adaptable both to new cities and to new content. In addition to the public transport network, the app covers access and exit points to stops in the form of pedestrian routes, as well as interchange directions at complex nodes. Thus, it offers functionalities similar to established solutions in the automotive sector. Its innovative, open service architecture for mobile devices allows for fully transparent use by third-party applications such as city information services, which can thus be easily expanded to include navigation functionalities. The desired use by public transport is additionally supported by an integrated mobile ticketing system. With the help of hybrid localization and intuitive navigation, the availability and usability of existing systems can be improved significantly. Pilot tests conducted together with two public transport operators and in collaboration with mobile ticketing and information services will show the high practicability and transferability of the approach.

Project Objectives

Continuous navigation realized as modular service architecture

Many past attempts at creating a universal application capable of integrating all available data and services have failed. In order to avoid failure, NADINE's door-to-door navigation will be offered in the form of several separate services that can be transparently integrated into other applications via defined open interfaces.

Fare-sensitive navigation

NADINE will combine technologies to create a continuous »authentic door-to-door navigation application in public transport as a native implementation for mobile platforms in connection with mobile ticketing«, using the VDV core application as a basis. Users will be able to move freely through the public transport network, just like they are used to from pedestrian or car navigation. In this context, »continuous« refers to navigation covering the entire scope of the public transport travel chain:

- from the front door to the departure stop, when walking from one stop to another, as well as from the destination stop back to the front door via pedestrian navigation,
- at the stop to the designated vehicle, from one vehicle to another while changing and from the destination stop back to the pedestrian network via the junction navigation described below and
- within the network of public transport stops and lines.

In addition, the navigation service will be integrated into a smartphone solution for the purchase of tickets that match the proposed navigation routes.

Intuitive navigation at complex public transport nodes

In addition to a visualization of the route network, passengers receive object-oriented navigation directions, for example: »Leave the subway station in the direction of travel, then turn left«, »Use the main entrance, walk in the direction of the information terminal, and then on to platform 7« etc. This approach requires a novel method for modeling transport nodes (generally easy to develop and maintain), which is designed in such a way that passengers will not constantly have to keep an eye on their smartphones.

Continuous hybrid localization

A hybrid procedure combining several different localization methods is applied:

- GNSS-based (e. g., GPS, Galileo),
- via WLAN (in shadowed surroundings above ground or indoor/surroundings below ground),
- ITCS-based in vehicles, as well as
- via inertial sensors.

The expansion of localization by context recognition (e. g., »walking«, »inside a vehicle«, »inside a building«) as well as point-of-interest identification (e. g., »close to the cash machine«) guarantees a more precise positioning. In addition, Car2x approaches, which are currently undergoing standardization within the project IP-KOM-ÖV, can be used to determine a passenger's position in direct interaction with vehicles.

Realization and Outlook

Following the implementation of the described navigation components, the individual segments will be integrated and built into a complete system. During a comprehensive trial and piloting period, the solution will be tested in several steps in the cities of Nuremberg and Erfurt, and will be calibrated for its transfer into permanent operation.

Due to the open service concept approach, other app providers will be able to integrate NADINE's fare-sensitive navigation into their own developments, applications and services. It can thus be expected that the solution will be widely distributed throughout Germany and beyond.

The easy integration of NADINE's services into existing systems creates completely new application opportunities. By combining navigation solutions from both the private and the public transport sector, a true intermodal navigation system can be offered for the first time.

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STRATEGY AND OPTIMIZATION

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The department, which is divided into three working groups, offers a wide array of services in the research areas of security, business process analysis, logistics planning and infrastructure management. The interdisciplinary team includes computer scientists, geoscientists as well as mathematicians with both professional expertise and practical knowledge.

Application-oriented research and development projects are focused on decision support for an optimized planning and control of resources. The core competencies of the department comprise the development of novel optimization processes and algorithms as well as the conception and implementation of complex systems.

An integral part of the design of holistic approaches are flexible modules, developed and transferred into practice, designed for algorithmic planning and the optimization of processes, resource management, scenario and trend analysis, the assessment of uncertainty factors, the integration of infrastructure, geodata, technical data and visualization. Customers include federal and *Länder* ministries, county administrations, administrative bodies and authorities, companies and the European Union.

The solutions developed in the department have gained wide acceptance among customers. A specific field of responsibility is the extensive support, including the update to and enhancement of systems, leading to long-term customer retention and satisfaction.

Disposition

The main focus of the working group is the development of solutions for optimized scheduling and control of human and technical resources. The scientists work in close cooperation with end-users in the field of security, developing and implementing novel risk analysis and risk assessment, strategic planning and operational command processes, which are used in practice by fire departments, civil protection, rescue services and police. Regular public demonstrations of the solutions in operation guarantee a trusting cooperation and a close connection between research and praxis.

Logistics

The core competency of the working group is the design of planning concepts for the operational optimization of logistics processes and their implementation in decision support systems. These novel concepts and systems are based on models and methods of Operations Research. Special emphasis within research and development is put on logistics planning in scenarios with conditions of uncertainty and constantly changing information. Thereby, planning processes and algorithms that enable a real-time, capable and robust adjustment of existing solutions are needed.

Fields of application include classic logistics and transportation tasks such as vehicle routing and storage management, but also production planning and manufacturing control in connection with logistics requirements and the maintenance management of infrastructure systems. Customers and partners of the working group are mainly systems houses and service providers from the field of logistics as well as end-users.

Business Processes

The core field of activity in this working group is the modeling of strategic measures for process design. The objective is to achieve a holistic approach: from the identification of sustainable new business areas to the assessment of options for action and implementation.

Especially in steadily changing areas such as economic and settlement strategies, donation management and market options related to demographic change, in particular Ambient Assisted Living (AAL) as well as financial issues, robust forecast models are important for identifying feasible options within the development scenarios and thus for the reliable support of decision-making.

Based on this analysis, options for action can be defined and evaluated. The main objective is to identify and develop new business areas and business models, for instance, by horizontal integration.

In order to guarantee sustainability, the group also works with institutions and businesses.

In accordance with a constantly improving system, the results are in turn used for prediction and gradually facilitate a more accurate analysis.

Fire-fighting forces activating a mobile camera.

PARTNERS

- Akademie o.p.s. Brno
- antwortING GmbH
- apromace data systems GmbH
- ASSMANN Büromöbel GmbH & Co. KG
- CEMOSA S.A.
- Chemnitz Police Headquarters
- DACHSER GmbH & Co. KG
- DB Schenker Logistics
- DMA S.r.l.
- Dresden Informatik GmbH
- DRK German Red Cross
- DUALIS IT Solutions GmbH
- Friedrich Schiller University Jena
- Geofabrik GmbH
- HTW Dresden, University of Applied Sciences
- IPM GmbH
- KIT Karlsruhe Institute of Technology
- Landeshauptstadt Dresden
- Landkreis Bautzen
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- MBD Mecklenburg-Vorpommern
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- TU Dresden
- TECNALIA
- TLP spol. s.r.o.
- TÜV Rheinland Industrie Service GmbH
- Universidad de Sevilla
- Vector Command Ltd.
- WANKO Informationslogistik GmbH

REAL-TIME OPTIMIZATION OF INTRALOGISTICAL TRANSPORTATION AND STORAGE PROCESSES

Optimization of Intralogistical Processes

Logistical processes in industrial manufacturing can only function smoothly when they are carefully planned and controlled. On the operative level of day-to-day business, complex tasks that continuously enable short-term decision-making regarding the optimal use of resources must be solved. In this context, diverse parameters such as capacities, compatibilities and urgency need to be observed, and partly contrary objectives such as cost efficiency, high utilization or compliance with deadlines need to be met.

Due to the increasing complexity of processes in manufacturing and logistics as well as the far-reaching effects of associated decisions, the demand for supporting IT systems used for the planning and control of all fields of operative logistics is growing.

Initial Situation

At the outset of a research project initiated by the Fraunhofer IVI, a manufacturer of household appliances was faced with challenges similar to those typical to operative logistics:

An extension of product range and production volume made it necessary to adapt parts of the company's intralogistics and to find an entirely new conception for the other parts. Among others, a new storage concept had to be developed so that the expected larger quantities could be processed in a higher throughput and in spite of restricted space for reserve and storage areas. The company's storage system, which had previously stored products separated by type, had to be replaced by the so-called chaotic block storage system in which mixed product types can be stored in the storage lanes. However, this storage system complicates the management and handling of storage processes. Above all, it is necessary to minimize efforts for the relocation of stored goods.

In addition, transport to and from the warehouse is controlled by inbound and outbound manufacturing processes. The order of these processes is planned beforehand, but they are also subject to production-related variations and disturbances. Thus, they can only uncertainly be considered as input quantity for storage planning.

Requirements

In the context of the collaborative research project, a system for automatized decision support that would control all intralogistical processes connected to the new block storage warehouse was to be designed and implemented.

Among the essential tasks of this system is the permanent calculation of each product type's optimal storage and retrieval processes within the new block storage system in accordance with the sequence of the previous and subsequent manufacturing steps. Achieving an optimal utilization of the available space with fast access times and a minimum of relocations is the great challenge for the determination of storage locations. This challenge has to be met so that chaotic block storage systems can guarantee a punctual allocation of the requested outgoing goods in spite of mixed product types in the storage lanes. Additionally, existing transport resources used for storage operations and the material flow between different manufacturing areas need to be factored into the optimal planning of storage processes.

Real-time capability is another important requirement for the decision support system, as it has to flexibly react at all times to unexpected changes in the manufacturing process by adapting the storage and retrieval sequence of certain product types.

Method and Procedure

The underlying task – like many other planning tasks in operative logistics – can be mathematically described as a difficult combinatorial optimization problem under uncertainty. The basis of the solution that was found is mathematical modeling with a stochastic component, integrating individual steps in the manufacturing sequence as uncertainties with the help of historical data concerning storage access and retrieval.

In the design of algorithms, a methodology is used that has been developed especially for similar problem types with stochastic or dynamic uncertainty: the Monte Carlo Rollout method, in which combinatorial tree search methods are extended by Monte Carlo simulations in order to generate robust and anticipatory planning results.

The implementation of the solution algorithms by means of software libraries expanding existing IT planning systems helps to transfer research results into practical application. By additionally integrating RFID technologies into intralogistic processes, it is possible to attain a realistic image of the storage and manufacturing situation at any time and to plan accordingly in real-time.

Results

As a first result, simulation studies gave proof that, in the course of extending a product range, the storage that was previously separated according to product types would have to be given up in favor of chaotic block storage.

It was shown both in computer experiments and the demonstration phase that the implementation of chaotic storage yields good results. If the various product types are thoroughly mixed, however, novel controlling strategies based on the Monte Carlo Rollout method are necessary. Only their application can ensure an optimal use of the restricted space. Furthermore, the necessary time and resource requirements for warehouse management are distinctly lower than under application of conventional storage concepts. Especially the rate of relocations can be drastically reduced if the retrieval output sequences and their fluctuations are taken into account.

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VEHICLE AND TRANSPORT SYSTEM ENGINEERING

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Technologies for novel commercial vehicle concepts are the main area of research in the department »Vehicle and Transport System Engineering«. Core competencies include innovative vehicle solutions and key enabling technologies in the areas of road-bound and rail-bound public transport, including vehicle design, solutions for individual parts construction, innovative propulsion technologies, methods for energy-efficient vehicle operation regarding propulsion and auxiliaries as well as steering control and driver assistance systems. Many of the developed solutions have been applied in the AutoTram® Extra Grand.

Along with the developments, the department also carries out studies of operational concepts in public transport. Since 2012, special emphasis has been placed on the development of concepts for the introduction of battery buses in cooperation with several German transport companies. The findings of vehicle and operational concepts in public transport are also transferred to other commercial vehicle sectors, for instance, agricultural applications or heavy goods transportation.

Project work is carried out using up-to-date hardware and software. Especially for construction tasks, a high-performance computer lab with work stations is available for engineering purposes. The operation of many solutions is tested in advance using simulation tools developed by the department. These tools include applications for individual components, vehicle models as well as models for the mapping of complete catenary systems.

Several test vehicles are available for the practical analysis and application of the developed solutions, including the AutoTram® Extra Grand, a serial hybrid bus, a vehicle for the testing of steering algorithms, a test stand for conventional, electric and hybrid drivetrains including auxiliaries as well as various labs. The technical equipment of the department is complemented by measurement equipment, used, for example, for detailed local assessment of energy consumption in vehicles and a driving simulator for application in cars and buses.

Vehicle Technologies

Increased environmental awareness, ongoing urbanization and changing mobility needs require new vehicle solutions. Based on these findings, the working group is developing new concepts for public transport systems, both in road-bound and in rail-bound areas. Research activities also include intermediate vehicles and monorails as well as the analysis of hybrid buses in regular service. Solutions covering a considerable part of the development chain are created in close cooperation with well-known manufacturers of public transport vehicles and suppliers in this sector. Tasks include design studies, packaging studies for the integration of assemblies, CAD-supported modeling and calculation of structural mechanics as well as durability testing and visualizations for the complete vehicle or its individual components. The working group's competencies in vehicle technology are substantiated by the successful development and implementation of the AutoTram® Extra Grand.

Transportation Systems/Human-Machine Interaction

The core competencies of the working group are the development of concepts for the introduction of all-electric buses in public transport, the planning of public transport operational concepts as well as analyses of life-cycle costs of conventional and innovative vehicle systems for public transport.

Another area of research is the energy efficiency of public transport vehicles. The group thereby compares different propulsion and energy supply concepts. A modern driving simulator is used for the development and validation of operational and display concepts as well as driver assistance systems. It also offers the option of testing the planning and design of future workplaces for bus drivers.

Propulsion Technologies

Research and development activities of the working group include the design of drivetrain concepts for cars and commercial vehicles, the dimensioning of drivetrain components as well as the prototypical realization and testing on the institute's test stands and in test vehicles. The corresponding operational strategies and energy management are developed and optimized with a view to efficiency, durability of components and the minimization of primary energy use. Auxiliaries are also taken into consideration in the process. The working group is developing innovative concepts for the hybridization and electrification of agricultural implements and communal vehicles with the objective of increasing both the degree of automation and the efficiency of these systems.

Sensor and Actuator Systems

One focal point in vehicle engineering is the model-based design and testing of multi-axle steering systems. For the AutoTram® Extra Grand, a steer-by-wire system was conceptualized and successfully implemented with industrial partners. Essential contributions are simulation studies, evaluation in test vehicles (Rapid Prototyping) as well as commissioning. By means of optimized path planning, software-based methods are developed to ensure a collision-free passing of narrows by multi-axle steered commercial vehicles and trucks.

In addition to the metrological monitoring of test drives, specific measurement and testing concepts for scientific and industrial application are developed, e. g. precise temperature measurement for animals (referenced infrared thermography and image processing) as well as testing systems for the manufacturing of security paper.

Cathleen Klötzing, project supervisor for electromobility, Saxon Energy Agency – SAENA.

PARTNERS

- Adam Opel AG
- AgResearch Limited
- Alcatel-Lucent Deutschland AG
- Barnimer Busgesellschaft mbH
- Baiyun Power Group
- Bombardier Transportation GmbH
- Carbo Fibretech GmbH
- Carrosserie Hess AG
- Continental Safety Engineering GmbH
- DAF Trucks N.V.
- Daimler AG
- DAL dairy automation Ltd.
- DB RegioNetz Verkehrs GmbH
- DEKRA Automobil GmbH, Klettwitz
- DERAP AG
- DVB Dresdner Verkehrsbetriebe AG
- EURABUS
- Fachhochschule Aschaffenburg
- FSD Fahrzeugsystemdaten GmbH
- FEHRL
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- Götting KG
- Hochschule Anhalt, University of Applied Sciences
- HTW Dresden, University of Applied Sciences
- HTWK Leipzig, University of Applied Sciences
- Hübner GmbH
- IABG Industrieanlagen-Betriebsgesellschaft mbH, Lathen
- IRIZAR
- IRU Projects ASBL
- Jenaer Nahverkehr GmbH
- KIT Karlsruhe Institute of Technology
- Kölner Verkehrs-Betriebe AG
- KVG KreisVerkehrsGesellschaft Main-Kinzig mbH
- LVB Leipziger Verkehrsbetriebe GmbH
- Li-Tec Battery GmbH & Co. KG
- Max Bögl
- MDV Mitteldeutscher Verkehrsverbund
- M&P Motion Control and Power Electronics GmbH
- Mobil Elektronik GmbH
- MVG Münchner Verkehrsgesellschaft
- Neue WMS Flocktechnik GmbH
- NVV Nordhessischer VerkehrsVerbund
- ObjectFab GmbH, Dresden
- OMT GmbH Oberflächen und Materialtechnologie
- Ortloff Technologie GmbH
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- Stadtwerke Bonn GmbH
- STW Sensor Technik Wiedemann GmbH
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- TU Dresden
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- üstra Hannoversche Verkehrsbetriebe AG
- Van Eck B.V.
- VCDB VerkehrsConsult Dresden-Berlin GmbH
- VDV Verband Deutscher Verkehrsunternehmen
- VHH Verkehrsbetriebe Hamburg-Holstein AG
- Verkehrsunfallforschung an der TU Dresden GmbH
- Virtual Vehicle
- Voith Engineering Services GmbH
- Volkswagen AG
- Volvo Lastvagnar AB
- Vossloh Kiepe GmbH
- WITTUR Electric Drives GmbH

OCTOCOPTER HORUS – ADAPTABLE SENSOR PLATFORM FOR MULTIPLE APPLICATIONS

Motivation

In order to gather measurement data and images in areas that are difficult to access, a small and agile technology carrier, which can be easily equipped with a variety of different camera modules, sensors or measuring devices, is needed. Depending on the field of application, such an autonomous aircraft can even be an affordable alternative to manned flight operations. Based on this motivation, the octocopter HORUS was developed at the Fraunhofer IVI in collaboration with Airclip and the Institute of Lightweight Engineering and Polymer Technology (ILK) of the TU Dresden.

The idea of developing a hovering sensor platform emerged from a private quadrocopter project in which valuable experience was gained with regards to various motor-propeller combinations, mechanical superstructures and the vibration decoupling of propellers, frame and electronic components.

For the assembly of the electronics, MikroKopter technology was taken as a reference. Based on tested components, which are discussed within a chat forum and a wiki, the details of this technology are available to all users and could therefore also be applied in the development of HORUS. After a few system adjustments, calibration of the sensors, and parameterization of the control algorithms, numerous test flights demonstrated highly safe and trustworthy flight characteristics.

Variability

A reliable flight performance, eight rotors ensuring fail-safe operation and its increased payload capacity are the foundation of the octocopter's most important characteristic – its variability regarding fields of application. Due to the custom-designed carbon fiber composite frame, the copter can carry devices weighing up to 3.5 kilograms to otherwise inaccessible locations while offering a maximum space of 90 liters. As a multipurpose frame for different kinds of devices, HORUS can be configured to customers' specifications in a very short time. It is possible to mount and exchange a diversity of container modules within a matter of minutes using a simple clip mechanism. The following section describes the various fields of application in more detail.

3D Modeling

At the Fraunhofer IVI, HORUS is used to generate 3D models of buildings and landscapes. The sensor platform is able to autonomously circle around the object to be modeled in order to gather the required data. After landing, these data are transformed into a 3D model of the object within a few minutes. The resulting model contains both the object's three-dimensional structure and its surface texture. By converting the model into different output formats, the data can be further processed with a variety of design, construction and display programs.

Video and Photography

One of HORUS's typical application areas is aerial photography. Aerial photos can be used, for example, in the:

- maintenance of structures (dams, wind turbines),
- observation of areas that are difficult to access and/or dangerous (slopes with danger of falling rocks, buildings in danger of collapsing),
- animal observation (observation of nests, cliff breeders),
- traffic flow surveillance and accident detection,
- observation of water flow after liming, surveillance of water flow in the renaturation of former open cast mines,
- documentation of natural events, e. g., the Elbe River flood of 2013,
- detection and documentation of progress in the construction process of buildings for the improvement of planning.

High-resolution images and full HD videos in 2D and 3D are possible. All optical modules can be swiveled at 180 degrees without parts of HORUS becoming visible and interfering with the picture.

Infrared Images

Equipped with a calibrated infrared camera, HORUS is able to record data otherwise invisible to the human eye. Thus, it is possible to quickly and easily detect and measure thermal bridges in roofs, smoldering fires in forest areas, defective cells in large photovoltaic installations or the hot water contamination of rivers.

Technology Carrier

Due to its high payload capacity, the octocopter can be individually adapted to a great variety of scenarios. Depending on the respective requirements, the corresponding technology can be mounted on specially developed module plates. In this way, instruments such as localization devices, laser scanners, gas sensors, temperature sensors, pollen traps, air velocity or humidity sensors, particulate matter measuring devices and microphones used for sound model counseling can be freely positioned in three-dimensional space and repeatedly and accurately moved on fixed trajectories.

Potential

Because of its modularly exchangeable concept, high technical variability and low costs, HORUS is a serious alternative to both manned and unmanned flying objects that are already in operation and used for scientific measuring campaigns. At the Fraunhofer IVI, a wide array of software tools and specialized know-how is available for the evaluation of the collected data.

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LOCATING, INFORMATION AND COMMUNICATION

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TECHNISCHE UNIVERSITÄT DRESDEN

The Working Group »Locating, Information and Communication«, which has been conceptualized as a research collaboration with the chair of »Transport Systems Information Technology«, is an essential component of the strategic cooperation between the TU Dresden and the Fraunhofer IVI. This chair is part of the Institute of Traffic Telematics at the Faculty of Transportation and Traffic Sciences »Friedrich List« and it is led by Professor Oliver Michler. Six scientists currently work in the group, three of whom are preparing their PhD theses.

With regard to content, the group's focus is mainly on topics relating to both radio-based and line-bound data transmission. Software Defined Radio, hybrid locating methods, energy-efficient sensor positioning networks and interference analysis make up the main emphasis. Numerous projects result from specific issues of technology-oriented small and medium-sized enterprises. With its profile in traffic telematics and communication technologies, the working group also supports other departments in the application of up-to-date locating and communication methods.

In close cooperation with the TU Dresden, the working group can draw on extensive laboratory equipment in communications technology. In addition to highly efficient signal generators and analyzers, this includes systems for multi-channel recording, reproduction and simulation of radio-frequency signals compliant to standardized protocols. For instance, laboratory-based studies in the context of traffic telematics radio systems such as RDS/TMS traffic information and DAB/DAB+ are carried out.

Locating

Modern applications in traffic telematics are increasingly based on linking factual information with their corresponding location. This evolution can be observed in road, rail, air and waterborne transportation systems. Depending on their purpose, specific requirements concerning availability, accuracy, energy consumption and integrability as well as other qualitative characteristics determine the type and technology of the applied locating method.

Problems in lane and track-sensitive locating, together with radio-based indoor and outdoor locating and research into and validation of respective methods for multi-sensor data fusion are within the focus of the working group. In cooperation with the Institute of Traffic Telematics at the TU Dresden, extensive laboratory equipment is available for the simulation of mobile GNSS (Global Navigation Satellite Systems) signals. The equipment is used for the laboratory-based evaluation of GNSS receiver systems and the testing of navigation and tracking devices.

Information

Methods and systems that can influence the behavior of travelers or technical components of traffic processes in the form of surveillance, protection, control or optimization by obtaining, transmitting and analyzing information are part of traffic telematics.

Thus, a main emphasis of the working group is to completely map the signal processing chain from source to destination for applications in traffic telematics and, additionally, to identify potential problems in planning and optimization relevant for future research.

Digital traffic information services using various transmission technologies (broadcasting, mobile communications, RFID etc.) are important in this respect, as well as multivariate statistical methods for the analysis of large amounts of data. A particular focus lies in the standards-compliant generation of RF signals for data services within broadcasting systems, such as RDS/TMC or TPEG. The group's customized laboratory equipment is continually being adjusted and developed in the course of the research.

Communication

In traffic telematics, stationary infrastructure (e. g., sensors, actuators, display elements) and mobile objects (e. g., vehicles) have to communicate with each other via information technology. Depending on the specific use case and the technical conditions, either conducted, optical or radio-based communication technologies can be applied.

The working group therefore focuses on linking their competencies in traffic engineering, traffic telematics and telecommunications engineering and is closely interconnected within the institute itself, with other Fraunhofer Institutes and university institutions. Their given topics relate to the fields of data transmission, digital signal processing including source encoding, and also problems associated with the planning of radio networks. With regards to this, radio-based sensor networks, which simultaneously enable energy-efficient locating and data transmission on the same hardware basis, are increasingly important for the research and development activities of the working group.

Installation of locating components in the AutoTram® Extra Grand.

PARTNERS

- ADAC e. V.
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- Delimon GmbH
- Dresden Elektronik Ingenieurtechnik GmbH
- ECD Electronic Components Dresden GmbH
- FSD Fahrzeugsystemdaten GmbH
- ibes AG
- IRK-Dresden
- KOMMZEPT Ingenieurbüro Hausmann
- Landesbetrieb Mobilität Rheinland-Pfalz
- National Instruments Germany GmbH
- NOFFZ ComputerTechnik GmbH
- TCAC GmbH
- TU Dresden
- Thomas Werner Industrielle Elektronik e. Kfm.
- ZAFT e. V.
- ZIGPOS GmbH

RECORD-PLAYBACK SYSTEMS FOR APPLICATIONS IN LF AND RF

Specific Tasks in Traffic Telematics

The number of electronic components used in vehicle technology and transport system engineering is steadily increasing. To various extents, this is true for all transport modes (road-bound, rail-bound, waterborne, airborne). These traffic telematics components carry out functions relating to:

- safety (e. g., emergency brake assistance),
- comfort (e. g., entertainment), or
- vehicle operation (e. g., optimization of resources).

Usually, all such components are part of a complex chain consisting of data collection, locating, communication and information processing.

This process chain needs to be protected from both accidental and deliberate interference. In this context, tests conducted in the lab as well as in the field are used to verify and validate the desired functionalities and interference robustness.

Laboratory-based test configurations have an advantage over field tests, largely because concrete scenarios can be precisely reproduced and because they can be embedded into automated production processes. In lab tests, however, it is necessary to simulate all relevant surrounding signals that would have an impact on the components if tested in the field. Next to electromagnetic effects, especially low-frequency (LF) signals such as mechanical vibrations, accelerations and rotations are of importance, as well as radio-frequency (RF) signals, such as radio-based positioning and radio data transmissions. It is crucial yet difficult to simulate these signals in a laboratory environment.

The Record-Playback Concept

The record-playback concept is an approach in which all relevant surrounding signals are measured and recorded during one or more field campaigns. The signals are digitized and saved as so-called I/Q data on disk arrays so that they can be repeatedly and synchronously reproduced in the lab with the help of suitable signal generators or other actuators. The system under test is then subjected to the generated signals in order to assess its functionality and fault tolerance. This approach is suitable for all signals affecting the test system that do not induce bidirectional communication. In general, these include inertial sensor signals and broadcasting-based radio signals (e. g., digital and analog sound broadcasting, satellite positioning). It is additionally possible to digitize and save surrounding signals that are part of the bidirectional communication of other systems (e. g., wireless networks, mobile communication).

Technical Realization

Together with the Chair of Transport Systems Information Technology of the TU Dresden, the Fraunhofer IVI maintains a record-playback system as well as complementary analyzers, generators and actuators for surrounding signals in both the LF and RF ranges which may occur in traffic telematics messaging systems. The core of the RF device configuration is a Universal Receiver Tester (URT) produced by Averna/National Instruments with three channels (85 MHz to 2.7 GHz) at a bandwidth of 50 MHz as recorder, connected with a 40 TB disk array and an equivalent three-channel generator. The synchronously connected LF system consists of a stepper motor mounted on a turntable used to generate rotatory inertial signals and various LF channels for audio, video, vehicle bus protocols (e. g., CAN) as well as analog and digital signals (e. g., door signal).

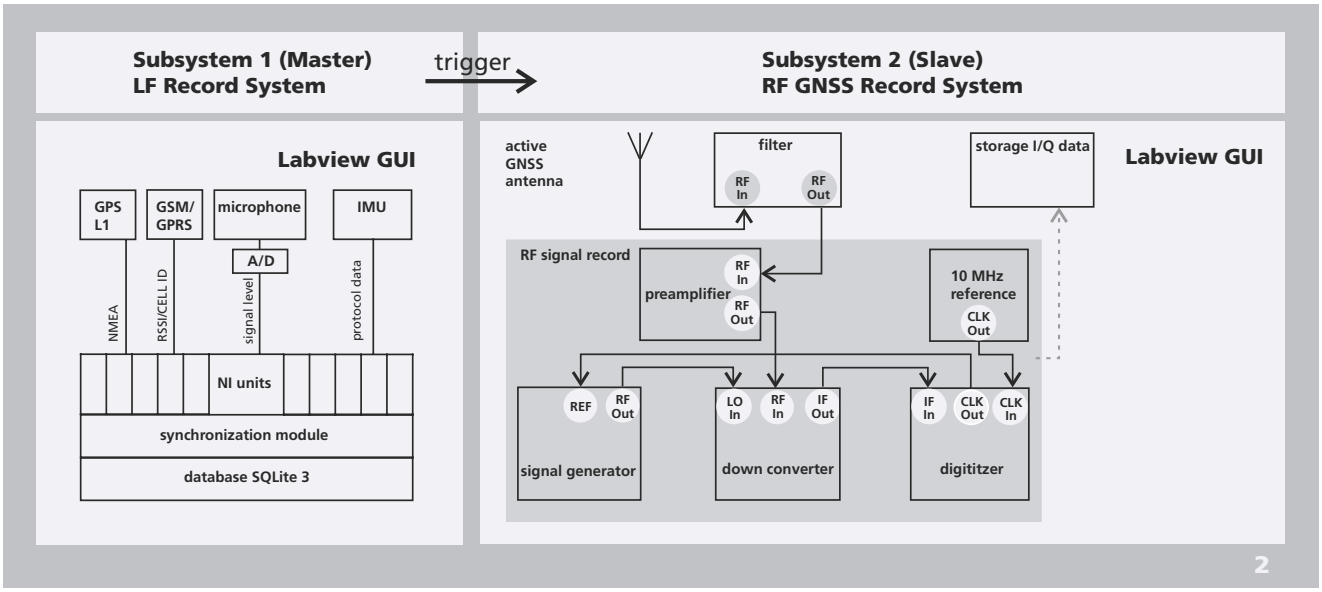
1

Practical Application

The system architecture illustrated in Fig. 2 is used for the mobile recording of LF and RF surrounding signals. The LF system on the left records acoustic signals via two microphones and inertial sensor data via a corresponding device (IMU – inertial measurement unit). Two locating modules (GPS and mobile communication) are used for positioning and synchronization.

The synchronized RF system is illustrated on the right. Due to the 50 MHz bandwidth of each of its three channels, it is possible to detect and save different signals such as GPS, GLONASS and Galileo simultaneously in the respective bands (L1, L2, L5).

Detailed analyses concerning the reproducibility of satellite locating signals have been conducted. In the course of these analyses, the general suitability of the approach has been shown. During the past months, an extensive collection of surrounding signal constellations related to satellite locating has been compiled. At the moment, several different scenarios are available for railway lines (among others: high mountain ranges with arcades/tunnels or urban areas with pronounced street canyons), for road traffic (driving through intersections, lane selection) and for inland shipping (channels and ship locks). With their help, the elaborate field testing of traffic telematics components related to satellite locating can be substituted by lab testing.



2

1 *Signal generator (right) with disk array (left).*

2 *System architecture for mobile recording of LF and RF surrounding signals.*

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ENERGY SYSTEM ENGINEERING

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For a Fraunhofer Institute working in the fields of mobility as well as environmental and energy technology, it was of almost symbolic significance to establish a research group at the renowned TU Bergakademie Freiberg in 2013 and to teach courses there in the field of applied systems theory. Almost three hundred years ago to the day, Freiberg's mining administrator Hans Carl von Carlowitz had established his principle of the sustainable management of natural resources in his book »Sylvicultura oeconomica«. This principle, which in the past was restricted to Saxon mining, metallurgy and forestry, has long since proven to be an issue of global generational responsibility. Radical changes in energy supply, lack of drinking water in developing countries, demographic change – many societal as well as economic issues suggest a revival of the Fraunhofer IVI's dominant research competencies of the 1990s, comprising the simulation and control of supraregional electricity supply systems, load control, decentralized water treatment, or modeling of dynamic storage and transport operations in gas pipelines. As the »university of resources«, the TU Bergakademie Freiberg offers an ideal framework for these research activities.

The Fraunhofer IVI has already started to recruit staff within the Institute of Electrical Engineering, led by Director Prof. Kertzscher, in order to establish a research group with core themes in the fields of energy technology and power electronics.

The predominant scientific competencies of the Institute of Electrical Engineering are the dimensioning, electromagnetic calculation and thermal modeling of electric machines, the observation of energy flows in stationary energy infrastructure as well as the development of power electronics components. The aim of the collaboration between the Fraunhofer IVI and the Institute of Electrical Engineering is to generate subject-specific synergies. In its start-up phase, the scientific orientation of the joint research group will be determined by three research foci: electric drive control, dimensioning of infrastructure systems with heavily fluctuating input and the control of energy flow in self-sustaining buildings or settlements. The group's long-term goal is the development of an independent research portfolio that will seamlessly fit with the other subjects at the Fraunhofer IVI and that will support both teaching and research at the Institute of Electrical Engineering.

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Motivation

In the past, most developments regarding the fuel consumption optimization of conventional commercial vehicles were focused primarily on the reduction of energy requirements of the traction task. Another less frequently considered option to reduce fuel consumption is offered by the optimization of the energy requirements of auxiliary components. Using the examples of typical 12 meter and 18 meter city buses, the operating strategies of different auxiliaries were optimized. The following constraints had to be taken into consideration:

- realization of the proposed measures as part of a model revision or a retrofit,
- reduction of technical modifications of the vehicle to a minimum,
- avoidance of a hybrid approach with modified drivetrain with additional motors or generators inside the drivetrain.

Optimization

The basis of all optimization tasks was a multi-domain vehicle model within a combination of the conventional drivetrain and all relevant auxiliary systems. In addition, the according conventional vehicle and auxiliary control strategies were implemented. The vehicle model incorporates the systems:

- drivetrain with combustion engine, converter/couplings, gear unit, differential, wheels, chassis,
- electrical on-board power supply with starter, generators, battery, consumers,
- pneumatic system with compressor, storage, valves, door cylinders, suspension, brakes,
- steering system with power steering pump, hydraulic steering process model,
- cooling system with coolant pump, hydraulic fan pump, viscous coupling, hydraulic fan, thermal engine model.

Based on the measured and simulated real motion profiles, the vehicle model delivers the temporal sequences of the operating points of the combustion engine and of the various auxiliary systems during the drive cycle. Subsequently, an optimization process that uses the Dynamic Programming in a Bellmann algorithm to calculate the optimal control sequences for the auxiliary systems was developed. This algorithm defines the optimal switching times and operating points of the compressor, the alternators and the main fan system of the vehicle. As has been mathematically proven, the resulting control sequences deliver the absolute best fuel consumption result for the defined auxiliary process. The fuel consumption reached could not be reduced any further.

Because of the very high computational effort, the described algorithm could not be implemented into actual vehicle controllers. Therefore, heuristic rules have been derived from the optimized system behavior and have been evaluated and improved in order to use the optimal result as a benchmark. The heuristic control strategy achieved over 90 percent of the maximum possible fuel consumption reduction potential.

With this approach, various auxiliary optimization measures have been developed and tested:

- intelligent management of the air compressor as a standalone solution and the additional integration of a clutch,
- improved control of the main engine fan with usage of the thermal capacity of the engine block,
- installation of a vario drive gear including a control algorithm for the power steering pump,
- installation of an innovative Ultra Cap system as a controllable source/sink inside the electrical system of the vehicle as a standalone solution and the additional integration of a clutch between generators and ICE.

JUNIOR RESEARCH

OPTIMIZATION OF AUXILIARY MANAGEMENT IN CONVENTIONAL COMMERCIAL VEHICLES

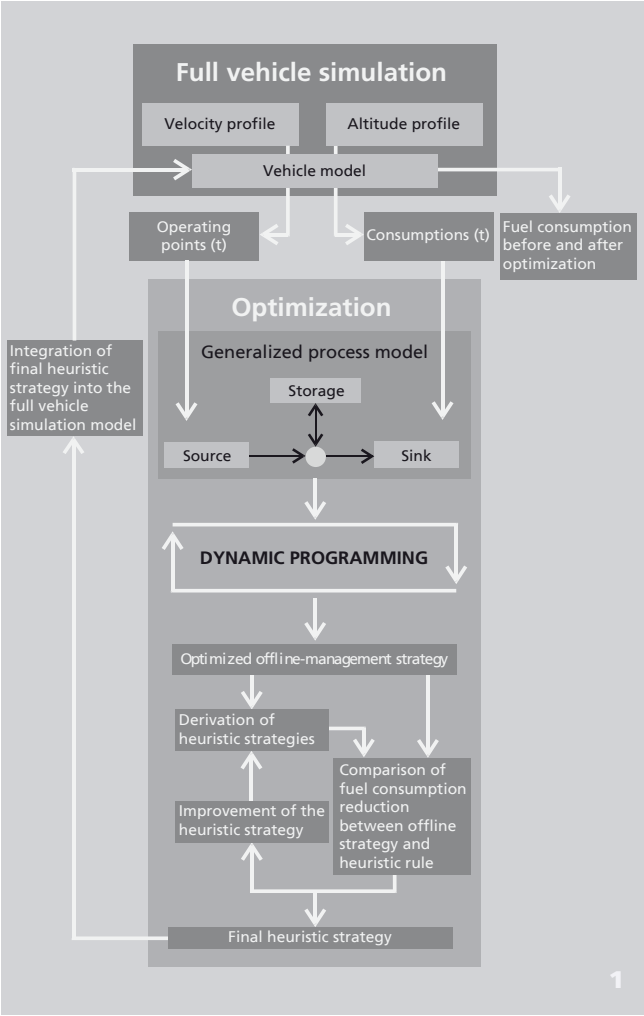
Results

The vehicle model with the implemented standard strategies for auxiliary control has been validated by comparison with real, measured city buses and the according vehicle model on typical SORT 1, 2 and 3 cycles. Simulations and measurements have shown a very good correlation regarding fuel consumption. The model-based realization of individual proposed optimization measures including tests and evaluation was separately performed in a first step and subsequently combined.

For individual measures, relevant savings of up to 3 percent have been reached. A combination of all measures reached a typical improvement of approx. 11 percent for 12 meter city buses and approximately 9 percent for 18 meter city buses on various drive cycles. The complete fuel consumption reduction, which is higher than the added saving of each single measure, can be explained by three main effects:

- The improved control more intensively uses the kinetic energy of the vehicle for auxiliary power, which is generally exempt from charges. This energy does not have to be additionally delivered by the propulsion engine during the normal driving and accelerating phases.
- The losses of unused auxiliary drives are reduced to a minimum by the usage of clutches. This leads to better and more efficient operating points of the engine.
- The fuel consumption decreases, and with it, the necessity to generate the according cooling power of the fan system.

The implementation of the optimized auxiliary management will prove easy due to the fact that all measures can also be integrated into existing vehicles as retrofit solutions.



1 *Process for deriving heuristic operational strategies.*

The studies were carried out in the context of a PhD thesis at the TU Dresden, Chair of Construction Machines and Conveying Technology.

The author would like to thank Prof. Dr. Günter Kunze.

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Motivation

Modern livestock farming is following a trend to higher efficiency. This is leading to more automation and an increasing number of animals per farm. In addition, stricter legal requirements for animal health and welfare enforce a demand of systems for an automatic animal monitoring. This article discusses new infrared thermography-based developments for animal monitoring applied on dairy cows.

The monitoring of dairy cows and calves still contains numerous elements of manual observation. In the case of large herds, several hundred animals per farm are not unusual; here, the manual monitoring is very time-consuming, tedious and potentially fault-prone.

Infrared thermography (IRT) is a promising approach to automatic animal monitoring. IRT provides the advantages of a contactless, nonreactive and very fast measurement of the body temperature as an important indicator of health.

Since the significant improvements in the IR camera technology in the 1960s (better handling, resolution and robustness), numerous studies have been conducted and attribute a high diagnostic potential to the IRT. Nevertheless, the veterinary applications are limited to racehorses and zoo animals.

IRT-based veterinary applications have two main drawbacks:

- time-consuming manual image analysis,
- relatively low measurement accuracy regarding absolute temperature values.

The manual analysis restricts the application of IRT screening to a few animals per day. The desired daily mass screening of large herds would suggest a necessity for a complete automated image analysis using image processing algorithms. The latter fact is not obvious and therefore often neglected. However, the typical sensor drift of IRT cameras prevents – if no additional technical measurements are performed – a sound time series analysis.

Precise Veterinary Infrared Thermography

To increase measurement accuracy, the measurements were analysed following the Guide to the Expression of Uncertainty in Measurement (GUM). For conventional veterinary IRT measurements under field conditions, the absolute measurement accuracy is about ±2.2 Kelvin. The analysis further showed that the combination of a referencing and an optimized measuring configuration with a model-based temperature correction provides a measurement uncertainty of less than ±0.5 Kelvin.

This provides a more precise time series analysis and will enable new diagnostic approaches.

Automatic Image Processing

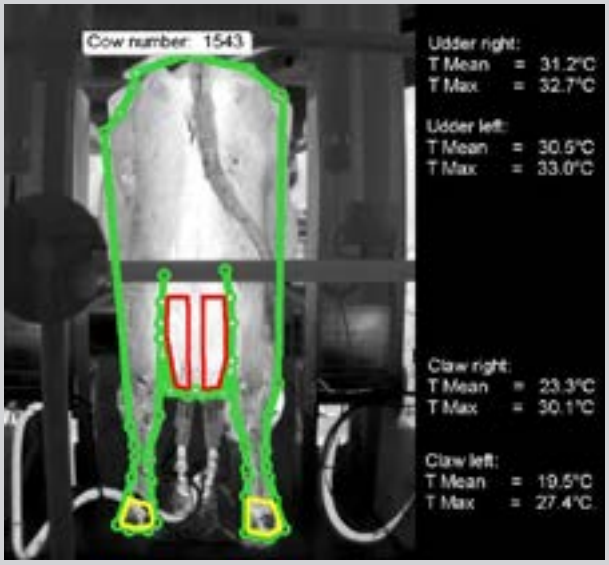
The automation of veterinary IRT requires a robust and precise automatic image processing comprising the segmentation of anatomically related image areas and the calculation of temperature data of diagnostically relevant body parts. Due to animal movements and individual body shapes, this task turns out to be rather challenging.

The newly developed image processing meets this challenge by providing fast and accurate image analysis. It is based on active shape models and level sets adapted to IRT. The body parts of interest, for example, the udder and claws, were automatically detected (see Fig. 1). The algorithms developed have been proven in large field studies.

AUTOMATION OF VETERINARY INFRARED THERMOGRAPHY

Summary

The new developments of the precise infrared-based temperature measurement and the automatic image processing represent two important technical steps toward the realization of automated animal monitoring systems. The suggested approaches provide an efficient technology to IRT mass screening, which is essential for the further development of statistically secured diagnosis algorithms.



1

1 *Infrared image of a dairy cow at the milking carousel; automatically detected regions of interest (udder, claws) have been marked.*

The studies were carried out within the scope of the project VIONA (FKZ 03WKP04B), funded by the German Federal Ministry of Education and Research. The results will be submitted as doctoral thesis at the TU Dresden, Faculty of Electrical and Computer Engineering.

The author thanks Prof. Dr. habil. Gerald Gerlach of the TU Dresden, Prof. Dr. agr. Steffi Geidel of the HTW Dresden as well as Prof. Dr. Matthias Klingner and Dr. Stephan Zipser of the Fraunhofer IVI.

EUROPEAN COOPERATION

The 2012 European Research Ranking once again identified Fraunhofer as a top institution among German participants in the EU research funding programs.[1] Accordingly, the Fraunhofer IVI looks back on their highly successful participation in the 7th Framework Programme of the EC with a total of 15 collaborative projects completed or running, 3 of which have been coordinated by the institute.

During the planning of proposals for research projects, the scientists took a broad position regarding fields of interest – starting from transport-related calls to collaboration in security projects and up to selected topics in information and communication technologies. Not only do these projects foster the development of existing competencies, but they also help to open up new research areas, initiate important partnerships and establish networks on a European scale. In addition to the »conventional« projects in FP7's cooperation sector, the Fraunhofer IVI together with Czech partners also developed a cross-border information platform for large-scale disaster management within the regional funding program »Ziel 3/Cíl 3«.

The Commission's new research framework program, HORIZON 2020, will again provide numerous opportunities for the institute to participate in a wide array of subject areas. Research in international consortia will remain the most important branch for the Fraunhofer IVI, but new funding instruments might also play a role in the future, for instance, when it comes to closer cooperation with small and medium-sized enterprises. Drawing on valuable experience and reliable partners from past years, a sound basis has been established for helping to tackle Europe's societal and industrial challenges.

[1] European Research Ranking provides estimates on the funding and networking performance of European research institutions [www.researchranking.org].

1 *British Ambassador Simon McDonald visiting the Fraunhofer IVI.*

IMPROVE – Integration and Management of Performance and Road Efficiency of Electric Vehicle Electronics
2013 - 2016

IMPROVE develops novel information and communication technologies for commercial, fleet-operated vehicles. By integrating cloud-based information sources, predictive algorithms and optimized vehicle communication structures as well as information flows,

- a target of +20 percent range for the same battery capacity will be added,
- battery life will increase,
- fleets will be optimally utilized and
- the cost of key components will be reduced.

All these performance enhancements will be achieved while maintaining safety and increasing the comfort and wellbeing of drivers. The Fraunhofer IVI is developing a battery monitoring system in the project, which by means of in-situ impedance measurement provides precise SOH and SOC as well as optimized control and utilization of the traction battery. Model-based predictive control algorithms, which access cloud-based information sources and fleet data via mobile network and internet, guarantee the energy-efficient planning of trajectories.

By using a highly integrated, separately excited electric motor, the weight and complexity of components can be reduced. In addition, the avoidance of permanent magnets based on expensive rare earths offers economic advantages.

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iCOMPOSE – Integrated Control of Multiple-Motor and Multiple-Storage Fully Electric Vehicles
2013 - 2016

To improve the energy efficiency of fully electric vehicles (FEV), iCOMPOSE proposes a step change in the control software architecture with a particular focus on comprehensive energy management. This will lead to an extended driving range, with additional benefits of improved safety and comfort. The key objectives are:

- the integration of the energy and thermal management, driveability and vehicle dynamics control into a single supervisory controller with failsafe control functions, using control allocation and model-predictive techniques,
- a demonstration of the compatibility of the integrated control software with the actual computational power of novel multi-core automotive control units and
- the integration of a dual-mode energy storage (DMES) to increase driving comfort, battery lifetime and system efficiency.

The results will be assessed on highly versatile FEV demonstrators with different drivetrains and energy storage systems comprising batteries and supercapacitors. The Fraunhofer IVI is responsible for the DMES development and implementation. Model-based energy and thermal management algorithms will be part of this task, as will the development of a highly efficient bidirectional DC/DC converter in hardware and software.

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IDIRA – Interoperability of Data and Procedures in Large-Scale Multinational Disaster Response Actions
2011 - 2015

Imagine a large-scale disaster situation where relief units and resources from abroad are available – but cannot be effectively used due to a lack of coordination. The IDIRA project with 18 partners from 7 countries is dealing with this challenge.

In order to overcome barriers, IDIRA aims to improve the interoperability in critical communication layers by developing a Mobile Integrated Command and Control Structure (MICS) including, for instance, a COP (common operational picture) and modules for resource management, missing person tracing and donation management. The Fraunhofer IVI is the project coordinator and responsible for Work Package 5 – Interoperable Response Management.

The intended end-users of the IDIRA developments are on-scene commanders and those overseeing the response to a disaster in the command and control rooms as well as strategic and tactical civil protection staff. The fixed IDIRA infrastructure will support them with relevant information from manifold sources for the preparation and response phases. During the Dresden flood in June 2013, IDIRA components were used for the first time in the field. A fully operational prototype of the Donation Management Module provided valuable experience for the future improvement of the system.

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CATO – CBRN Crisis Management: Architecture, Technologies and Operational Procedures
2012 - 2015

The key challenge of managing chemical, biological, radiological or nuclear incidents is the fragmentation of operational response actions, of specialist knowledge, of processes and of systems.

Pulling together stakeholders, technology providers and scientific experts, the CATO project will allow for a great step forward in preparedness and resilience regarding CBRN crises. CATO seeks to bring an innovative and comprehensive solution to the diversity of organisational set-ups and of legacy systems for emergency preparedness and management, including information technology, equipment and sensors. CATO brings together a consortium of 25 partners with a great deal of practical experience in terror emergency management, existing CBRN information systems and related areas.

The challenge of fragmentation will be met by providing a toolbox consisting of suitable interfaces, a comprehensible knowledge base and a holistic situation overview, together with components that help analyze the situation and offer the possible actions and their consequences. The Fraunhofer IVI is developing the decision support components, which present the probable outcomes of the actions that could be taken and which compare different alternatives in real time.

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FROM DRESDEN INTO THE WORLD

In the past two years, numerous universities, research institutions and also epecially industrial enterprises visited the Fraunhofer IVI. The institute had the chance to welcome guests from diverse countries such as Ecuador, Russia and Israel on its premises. One very high-profile guest was the British Ambassador. In addition to this, the institute's employees themselves traveled many miles on numerous business trips to Saudi-Arabia, New Zealand, Switzerland and the Czech Republic.

Collaboration with Chinese partners was one main focus of the past year. In addition to a Bachelor program initiated by the Fraunhofer IVI together with the Beijing Vocational College of Transportation and the TU Dresden, the contact established with TEWOO is of special interest. Through this partnership, batteries for the design and construction of a fully electric bus could be obtained. However, other products developed at the Fraunhofer IVI also raised the interest of Chinese enterprises, including a fast-charging system for electric propulsions and the SMART-WAY technology for navigation in public transport.

The Auto Tram® Extra Grand has again received much attention in the past year. Inquiries reached the Fraunhofer IVI from India, China and Ecuador. The institute's contact with South America seems especially promising. In order to assess the feasibility of an introduction of the Auto Tram® Extra Grand in Quito, Ecuador's capital, a study was conducted as a first step. If the city decides to introduce the intermediate vehicle, this would mark the first licensing of AutoTram® technologies for extensive public use.

Collaborating with international partners requires a great amount of personal commitment, and the development of mutual projects can be lengthy at times. However, the international perspective is of great benefit to the work at the institute and the institute's outlook on the future expansion of its international projects remains promising.

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HIGHLIGHTS

1 *»German High Tech Champions Award«, March 5, 2012.*

Two researchers from the Fraunhofer IVI have received the »German High Tech Champions Award in Sustainable Transportation« for their innovative product ideas. The awards were presented by representatives of the German Federal Ministry of Education and Research (BMBF) during a festive ceremony in India's capital, New Delhi.

Andreas Küster succeeded with SMART-WAY, a navigation system for public transportation that users can install on smartphones as an app. In contrast to widespread timetable and route information apps, it provides real-time navigation for public transport that is comparable to car navigation.

Dr. Jan Schubert convinced the judges with the »world's longest bus«, the AutoTram® Extra Grand, which is a 30 meter long vehicle able to carry up to 256 passengers. Thanks to its novel multi-axle steering system, it can be maneuvered as easily as an 18 meter bus both in forward and in reverse speed. This steering system, along with the energy storage system allowing for emission-free operation over a distance of eight kilometers, was developed at the Fraunhofer IVI. A compact range extender makes underway recharging possible. The AutoTram® Extra Grand was built by Göppel Bus of Thuringia.

2 *STAR-TRANS final event, Athens, April 20, 2012.*

The EU-funded project STAR-TRANS was completed with a presentation in Athens in front of an expert audience of about 50 persons, consisting of project consortium members as well as professionals and end-users from Greece, Serbia, Cyprus and other countries. The decision support tool for the risk assessment of damage incidents in interconnected transport networks developed within the project was presented and demonstrated with the help of a test scenario located in Athens. A questionnaire served to evaluate the end-user acceptance as well as the end-users' specific requirements. In addition, it was used to identify potential service offers.

As a closing event for the project SMART-WAY, project coordinator Fraunhofer IVI together with the Dresdner Verkehrsbetriebe (DVB) AG organized a scientific conference at which the developed results were presented. In addition to the SMART-WAY project partners, representatives of different companies in the areas of transportation and location-based services (LBS) were invited to the Technology Day under the title »Smart Solutions from Bright Ideas«.

The event offered opportunities to discuss the potential of innovative ideas for mobile applications in this research area. As a special guest, the consortium was pleased to welcome Project Officer Boris Kennes. In his function as a representative of the European GNSS Agency, he gave an overview of recent developments in Galileo and EGNOS.

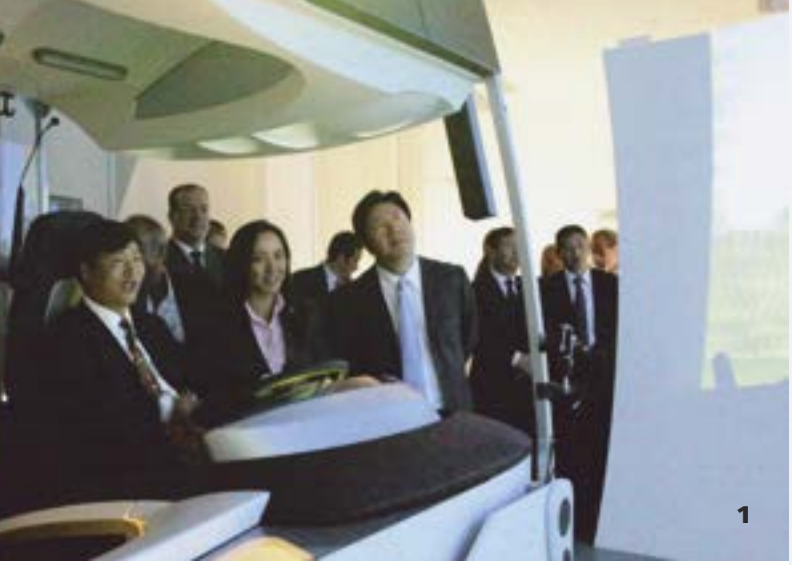
3 *SMART-WAY Technology Day, June 26/27, 2012.*

In the presence of hundreds of guests and a great number of journalists, an impressive spectacle had its world premiere on the Theaterplatz in Dresden: for the first time, the AutoTram® Extra Grand was presented to the general public. In the early afternoon, the German Federal Minister Prof. Dr. Annette Schavan, Saxony's Prime Minister Stanislaw Tillich and the President of the Fraunhofer-Gesellschaft Prof. Reimund Neugebauer had already had the opportunity to inspect the over 30 m-long intermediate vehicle in the company of high-profile personalities from the areas of economy, science and politics.

The Fraunhofer IVI, DVB AG, Göppel Bus GmbH, and other project associates had jointly developed the vehicle in a Wachstumskern established in the context of the BMBF initiative »Unternehmen Region«.

The AutoTram® Extra Grand represents a novel concept in public transport services in that it combines the advantages of both conventional buses and trams. In response to current demands for sustainable urban mobility, diverse technologies and applications from electromobility and other fields have been implemented in the vehicle.

4 *Premiere of the AutoTram® Extra Grand, August 22, 2012.*



1 *Delegation from China, August 27, 2012.*

Liu Xiaoming, the city of Beijing's Minister of Transportation, visited the Fraunhofer IVI in the company of a prominent delegation. The framework for this visit was set by a joint conference arranged by the TU Dresden's Institute for Further and Continuing Education (TUD FaCE).

After the visitors had gathered information on innovative traffic engineering and transport concepts, they inspected the Fraunhofer IVI's AutoTram® Extra Grand as an example of pioneering automotive technologies for public transport.

In addition to this, the delegation expressed interest in establishing a common course of studies in the field of transport engineering. An agreement was signed that aims to foster collaborations in transportation research and development as well as collaborations with Saxon transport companies.

2 *Seminar »Automated and Elevated Public Mass Transit«, September 17, 2012.*

In view of rapidly growing mega-cities in Asia and South America, high-capacity monorails are an attractive addition to conventional transportation systems, as is demonstrated by the numerous projects being planned or built all over the world. Current developments in vehicles, infrastructure, safety and operation were discussed by participants from ten countries at the »Automated and Elevated Public Mass Transit« seminar, which was held at the Fraunhofer IVI for the first time. The institute organized the event together with the INTERNATIONAL MONORAIL ASSOCIATION, of which the Fraunhofer IVI has been a member since 2012.

Highlights of the accompanying program were a visit to the world's oldest monorail, the Bergschwebebahn in Dresden, and a trip to Meissen on a historic paddlewheel steamboat.

The results of the project »European Bus System of the Future« (EBSF) were presented by the UITP (Union Internationale des Transports Publics) in the context of the project's final event in Brussels. The Fraunhofer IVI had contributed to the research topics »energy sustainability of bus systems« and »European bus drivers' workplace« of the project EBSF. For the study about the ergonomic optimization of the workplaces of European bus drivers, a mock-up of a bus driver's cab had been built in the driving simulator at the Fraunhofer IVI which allowed the simulation of test runs with bus drivers from Dresden, Rome and Gothenburg. This workplace mock-up was shipped from Dresden to Brussels for the exhibition accompanying the conference, where it could be observed in operation.

3 *EBSF project final event, Brussels, October 15, 2012.*

The indian summer had already yielded to the cold storms of fall when a delegation led by Saxon Minister of Economics Sven Morlok visited Canada in October of 2012. The incentive for this trip were close economic relations between Saxony and the Province of Quebec going beyond the recently agreed-upon collaboration within the context of the Saxon-Bavarian showcase project on electromobility. Canada, and especially the Quebec city region, has much to offer with regard to electric vehicles, electromobility in public transport and the comprehensive expansion of charging infrastructure. Promising commercial contacts, the signing of a cooperation agreement, the lively exchange of ideas on bilateral development foci and the mutual interest in German-Canadian collaboration are reasons enough for the Fraunhofer IVI to actively seek out cooperative projects with Canadian partners in the future.

4 *Saxon entrepreneur trip to Canada, October 20-25, 2012.*

After a duration of three years, the EU-funded project CLOSER, which had been coordinated by the Fraunhofer IVI, ended in December 2012. Its objective was the observation of interfaces between local and long-distance transportation for both passengers and freight. The closing conference was held in Prague in November of the same year. On the first day, the conference participants' awareness of the research topic was enhanced in technical excursions to major transport hubs. On the second day, the consortium presented the results of their work. The program was rounded off by practical examples and the presentation of follow-up projects that make use of the insights gained in CLOSER project.

5 *CLOSER final conference, Prague, November 12/13, 2012.*

1 *IDIRA 1st Review Meeting, November 22, 2012.*

Within the EU-funded project IDIRA, 18 organizations from 7 different countries jointly develop intelligent software and hardware systems which will form a link between different internationally cooperating emergency response organizations in European disaster management.

The first official interim presentation of the IDIRA project results was held at the DRK-Zentrum Saxony in the presence of European Union representatives. The project partners introduced several operational prototypes in different typical scenarios. Additionally, several components of the IDIRA system were presented, for example, the COP (Common Operational Picture) – a central module enabling the uniform visualization of data from the different parties – as well as the typical integration of sensor data and a method for international collaboration in the search for missing persons.

This important milestone paved the way for further research to take place during the next project phase. For 2013 and 2014, both small-scale and large-scale training sessions are scheduled in order to test the results. At these training sessions, flood scenarios in Saxony and its neighboring regions of Poland and the Czech Republic will be predominant.

2 *Delegation from Israel, June 12, 2013.*

Initiated by the Federal Ministry of Economics and Technology (BMWi), high-profile representatives of Israeli transport providers, research institutions and industrial concerns visited the institute in order to gather information on intelligent traffic solutions in Germany.

The Fraunhofer IVI was one of seven German enterprises of excellence chosen for the round trip of the Israeli partners. During the talks, which were held in a very open and friendly atmosphere, the Fraunhofer employees presented the results of their research. The discussed topics were navigation solutions for public transport, electronic ticketing and, as a special highlight, the AutoTram® Extra Grand.

Since the »flood of the century« in 2002, the Fraunhofer IVI has significantly expanded its competencies in the field of disaster management. The institute has optimized its units and resources and was therefore able to strategically apply them at important locations during the floods of June 2013. Technologies developed within the projects MobiKat and COSMOD were successfully applied in mission planning and management – especially in the county Sächsische Schweiz-Osterzgebirge, the cities of Dresden and Chemnitz and by the German Red Cross.

During this difficult time, the Fraunhofer IVI team, led by head of department Dr. Kamen Danowski, gave on-site support to command staff and relief forces. Fraunhofer solutions helped the command and control staff to identify infrastructure imperiled or affected by the flood. On that basis, relevant measures and crisis assistance could be initiated and coordinated. Mobile and stationary cameras developed by the institute provided live imagery of the flood. A vital radio communication line to the technical command and control center on site was swiftly established in cooperation with the institute's IT department. In this context, the longstanding and trusting collaboration with the Fraunhofer IVI's Czech partners was further strengthened.

At the formal closing meeting of the joint project COSMOD in Ústí nad Labem, insights gained from numerous field operations were presented. The developed system components will continuously help to improve cross-border disaster prevention in the regions of Sächsische Schweiz-Osterzgebirge and Ústí nad Labem. Due to the system's high level of user acceptance on both sides of the border, the positive assessment of operations and the praise offered by politicians, action forces and the general public, Dr. Kamen Danowski and the district fire chief of Sächsische Schweiz-Osterzgebirge were presented with medals of honor issued by the Ústí Regional President. The results of this successful collaboration will now be transfered to other border regions in follow-up projects.

3 *Flood of the Elbe river, June 18, 2013.*

4 *Award ceremony and closing meeting of project COSMOD, June 18, 2013.*

Jean-Francois Lisée, Minister of International Relations, La Francophonie and External Trade of the Province of Quebec (Canada), and his delegation visited Munich and Dresden in order to gather knowledge on current developments in the field of electromobility in the free states of Bavaria and Saxony as well as within the showcase project Bayern-Sachsen ELEKTROMOBILITÄT VERBINDET. The focus of the delegation's stay in Dresden was placed on current activities, research priorities and emerging trends. Two workshops offered the guests an opportunity to discuss the topics of electric public transport and vehicle engineering. The event was concluded with a ride in the AutoTram® Extra Grand.

5 *Delegation from Canada, June 21, 2013.*

1 *Delegation from TEWOO, August 21, 2013.*

Liu Hong, Executive Director of the Chinese TEWOO Group (Tianjin Material Equipment Group Corporation), visited the Fraunhofer IVI in the company of a high-profile delegation. The purpose of the visit was to hold exploratory talks concerning possible collaborations and common research activities.

In addition to several different speeches and a tour of the institute, various presentations were held and a ride in the AutoTram® Extra Grand was offered. The interested Chineses guests were also delighted to become acquainted with Dresden's historic city center during their evening entertainment.

The TEWOO Group, with locations all across China, has subsidiaries in the USA, Germany, Japan, Singapore, the Philippines, as well as in Hong Kong, and is among the 25 largest enterprises in China.

2 *Doors open day of the German Federal Government, August 24/25, 2013.*

For an entire weekend, the German Federal Government, the Chancellery and the Ministries invited the public to a doors open day. The Federal Minstry for Education and Research also presented itself in Berlin by offering presentations, tours and various forms of children's entertainment.

The AutoTram® Extra Grand, as an example of the transport system of the future, could also be visited. In a flurry of media flashbulbs, even Prof. Dr. Johanna Wanka, the Federal Minister of Research, was happy to take the wheel herself.

3 *Delegation from South Africa, September 18, 2013.*

During their stay in Germany, the South African Free State MEC (member of executive council) for Police, Roads and Transport, the Honourable Butana Komphela, and his accompanying delegation met with the Fraunhofer IVI's Director, Prof. Dr. Matthias Klingner. They exchanged information about current developments in the field of transport systems. A visit of the AutoTram® Extra Grand sparked great interest. In addition, the delegation and Prof. Klingner discussed potential future research collaborations.

The British Ambassador to Germany visited the institute in the company of Embassy Councillor Kenan Poleo. The purpose of the meeting was to explore the possibility of strategic cooperation between British scientific institutions with the Fraunhofer IVI under special consideration of the conditions in the new EU Research Framework Program Horizon 2020.

The concluding photo shoot proved to be a highlight of the visit. For once, vehicles (and not people) were the center of attention: on the institute's new test track, there was ample opportunity to take pictures of the GREAT Britain MINI next to the AutoTram® Extra Grand. Within the Mini-Tour of the British Embassy under the motto »16 Federal States – 12 Themes – 12 Months«, the Fraunhofer IVI had been chosen as one of the stops.

4 *British Ambassador Simon McDonald at the Fraunhofer IVI, October 9, 2013.*

From all the expressions of interest for the AutoTram® Extra Grand that have reached the Fraunhofer IVI in the past two years, the newly established cooperation with South America is especially promising. After an initial visit of Director Prof. Dr. Klingner and a follow-up visit of Dr. Knote to Quito, the local partner RECORSA S.A., owned by Mr. Conto Patiño, assigned the Fraunhofer IVI with a feasibility study to explore the potential of introducing the world's longest bus in several Ecuadorian cities. Resulting in the recommendation that the introduction of the vehicle system in Quito and the Guayaquil metropolitan area would considerably relieve the existing BRT lines in these cities, the study paved the way for a future licensing of the AutoTram® technologies in South America.

5 *Visit to transport authority of Ecuadorian city Manta, November 2013.*

The European space program presented itself in the »European Space Solutions« conference and the associated interactive traveling exhibition »European Space Expo« in Munich's Bavariapark. From November 5 to 10, visitors could gain insight into selected projects from the fields of satellite navigation (both Galileo and EGNOS) as well as earth observation (Copernicus). The conference was accompanied by a reception held under the title »Space Solutions for Smart Cities« by the European Commission. The European GNSS Agency (GSA) invited the Fraunhofer IVI to present its successfully completed EU-funded project SMART-WAY as one of seven flagship projects within the research area. The public transport navigation solution was met with great interest. At the same time, it was announced that the technology had won second place in the European Satellite Navigation Competition.

6 *Space Solutions for Smart Cities, November 6, 2013.*

1 *Beijing International Transport Information Service Conference – BITISC, November 14/15, 2013.*

Two Fraunhofer IVI employees participated in the Beijing International Traffic Information Service Conference (BITISC). The conference addressed current developments in traffic information services and traffic management. In front of an international expert audience, there was the opportunity to introduce both the institute and the SMART-WAY technology.

Beyond that, the focus of the trip was the demonstration of collaboration options between the Fraunhofer IVI and Chinese partners. First steps in that direction could be taken during an experts' discussion that took place following a visit to the Traffic Operations Coordination Center (TOCC), Beijing's center for traffic information and traffic guidance.

2 *Visit to Geely Holding in Hangzhou, December 17, 2013.*

Answering an invitation by Li Shufu, Chief Executive of Geely Holding, Institute Director Prof. Dr. Matthias Klingner and Bernhard Schmidt, CEO of Göppel Bus GmbH, traveled to Hangzhou, headquarters of the Chinese car manufacturer that had taken over the Swedish VOLVO Group in 2012. Mr. Li Shufu and his fellow executive board members were very interested in attempting a large-scale installation of the AutoTram® Extra Grand in China as a cost-efficient means of transportation.

3 *Dresdner »Lange Nacht der Wissenschaften«.*

The Fraunhofer IVI participated again in Dresden's »Lange Nacht der Wissenschaften« (Late Night of Science). In 2012, visitors received information about the new digital radio and competed with a computer in travel route planning under the motto »Seeing-Listening-Driving«. Due to inclement weather conditions, the airshows of the Fraunhofer IVI's octocopter HORUS could only be held sporadically. However, the rainstorm also had advantages: The youngest guests could stay at the crafts tables longer than usual and had enough time to complete their »helicopter pilot's license«.

In 2013, Dresden's Deputy Mayor Dirk Hilbert kicked off the »Dresdner Lange Nacht der Wissenschaften« at the Fraunhofer IVI in the presence of representatives of science, economy, politics and administration. Under the motto »Colorful diversity on gray tarmac«, the institute presented current research topics, its new technical center and test track to over 1400 visitors, who could take a ride in the AutoTram® Extra Grand, try to maneuver the truck-trailer ELENA in reverse or watched the flight of HORUS. School kids had the chance to compete in a scooter race, while younger children had fun riding Bobby Cars.

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TRADE FAIRS

By presenting a prototype of the public transport navigation technology SMART-WAY, the Fraunhofer IVI and the Fraunhofer ITWM took part in the appearance of the Fraunhofer-Gesellschaft at the IT-TRANS. 150 exhibiting companies from 23 countries presented their newest products and technological developments. 3132 participants, among them 528 conference delegates from around 50 nations, had come to Karlsruhe to inform themselves about recent developments, IT trends and innovations in the public transport sector. This was a great opportunity for the Fraunhofer IVI to communicate their results from the EU research project to the general public. During a number of expert discussions, application scenarios for public transport navigation as well as possible collaboration opportunities were explored. Through its international character, the trade fair offered excellent opportunities to search the market for a quick implementation of a concrete product and to address potential clients.

4 *IT-TRANS, Karlsruhe, February 15-17, 2012.*

The Fraunhofer IVI did not only act as an exhibitor at the HANNOVER MESSE 2012, but also as a provider of ideas to the »Haus der Nachhaltigkeit« (House of Sustainability), the Fraunhofer-Gesellschaft's central booth. During a tour of the house's separate rooms, visitors could gather information on current research topics.

The octocopter HORUS found its place in the trade fair's outdoor area. It offers a clear, all-round view for photo, video or thermal recordings. In contrast to quadrocopters and due to its eight instead of only four rotors, it has an increased vehicle load capacity as well as a higher reliability. Because of its technical variability and low costs, the aircraft is a true alternative to manned as well as to other currently operating unmanned flying objects for scientific field studies.

5 *HANNOVER MESSE 2012, April 23-27, 2012.*

Visitors to the HANNOVER MESSE 2013 had the opportunity to marvel at both the exterior and the interior of the world's longest bus. Information on technical details was given by the experts from Göppel Bus GmbH as well as by Fraunhofer IVI employees, who had been responsible for the project management but also (most importantly) for the development of the multi-axle steering system. Among the interested guests were prominent economical and political representatives. In this context, the advantages of the intermediate vehicle were presented, among others, to the Prime Minister of Thuringia and the Thuringian Minister of Economics.

6 *HANNOVER MESSE 2013, April 8 -12, 2013.*

LIBRARIES IN TRANSITION

Over the past decades, the growing digitalization of society has had a profound impact on scientific practice, and by extension also on specialized academic libraries. While scholars used to visit libraries in order to research their subjects, they can now log into databases and e-book portals from anywhere via the internet. The same holds true for scientific journals: while formerly printed journals used to be the standard, e-journals and newsletters now exist to keep people up-to-date on current developments.

This shift has many consequences for the work of academic librarians. Their traditional tasks, including cataloging, booking and giving research advice to their customers, are becoming obsolete. Instead, legal issues and technical aspects concerning the long-term storage and provision of scientific literature are in the foreground. The great challenge that libraries are faced with in the 21st century is maintaining an overview of the rapid changes in a developing market and to simultaneously select the products from within this market that best suit the needs and demands of the scientists.

The architecture of modern research libraries often deliberately addresses these changes. The digitization of both catalogs and collections has paved the way for a more open and spacious design of the reading rooms in which books are much less present as physical objects than they used to be. In this way, modern libraries are able to adapt to the altered habits and requirements of their readers. In a society in which information is available virtually anytime and anywhere thanks to global networking, and in which even specialized information can often be viewed from home or work, libraries are becoming meeting points where people can study together or discuss scientific topics with their colleagues.

In the library of the Fraunhofer Institutes IVI and EAS, which has gradually grown over time, this trend has also been observed in recent years. In order to respond to the needs and customs of the employees, its collection of digital media has continuously been expanded with the help of the Fraunhofer-Gesellschaft. The design concept for the renovation undertaken throughout 2013 was intended as an architectural interpretation of this development: today, the institute library is no longer a silent room full of bookshelves. It does not only provide the researchers with a space for reading, but it also invites scientific exchange and mutual inspiration among one another. It is thus the ideal space for fostering excellent research.

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TU Bergakademie Freiberg,
Faculty of Mechanical, Process and Energy Engineering,
Institute of Electrical Engineering, WS 2013/14

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Institute of Traffic Telematics, WS 2011/12, WS 2012/13

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Hochschule Mittweida (FH),
Faculty of Economic Sciences, WS 2013/14

Schubert, Jan
Vorlesungsreihe Querdynamik der Kraftfahrzeuge.
Dresden International University DIU, WS 2011/12

PUBLIC BODY MEMBERSHIP AND PATENTS

PUBLIC BODY MEMBERSHIP

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- DGES German Electrical Road Vehicle Association

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- Deutsche Gesellschaft für Ortung und Navigation e. V.

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- ECTRI European Conference of Transport Research Institutes
- Fraunhofer Traffic and Transportation Alliance
- Network »SatNav Saxony«
- Silicon Saxony e. V., applications division
- kontiki – Contactless smart card systems for electronic ticketing

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- Dresden-concept e. V.
- Forum on Electromobility
- Fraunhofer ICT Group
- Fraunhofer Lightweight Construction Alliance
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- UITP International Association of Public Transport
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Nagel, Ingrid
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Eigenständigkeit

LIFE AT WORK AND BEYOND

Achieving a favorable work-life balance is becoming increasingly important today. The majority of employees wish for more flexibility in their work to the benefit of their private lives. On the other hand, employers are under great pressure from their competitors. The reconciliation of the two parties' requirements – the giving as well as the taking – the expression of demands and the willingness to provide one's best work and personal commitment – all these factors substantially contribute both to the institute's success and to the satisfaction of its staff.

Difficulties in managing family and job – for example, by having to organize appropriate care for children or relatives – will probably arise at some point and to some extent in the course of every employee's career. At the Fraunhofer IVI, we are aware of this. That is why the institute has greatly improved conditions for the reconciliation of work and family life during the past two years, reaching beyond the development of various working time models.

Thanks to the Fraunhofer incentive program for the »support of institute-specific measures for the reconciliation of job and family«, the Fraunhofer IVI was able to establish its own day care under the name of »Fraunhofer Forscherkids«. For this, two adjacent apartments were remodeled and furnished in order to meet children's needs and cooperation agreements were signed with one male and one female day care provider. Now, the care and supervision of up to ten children in the age group of six months to three years is guaranteed daily from 8 A.M. to 5 P.M. Beyond that, the institute will financially support further training of the care providers on a regular basis, the individual support of the children and any necessary replacement of equipment.

In addition to the institute's own day care, a so-called Kid's Office is now on site – a nursery and bedroom for babies as well as a combined playroom for toddlers and working space for parents. In case of unforeseen events such as unscheduled closing times of the day care, the illness of a private caretaker or canceled classes, it is possible for parents to watch over their children in comfortable surroundings. During this time, work-related arrangements can be made and urgent matters can be attended to. In the end, both parties – the parents as well as the institute – will profit from this.

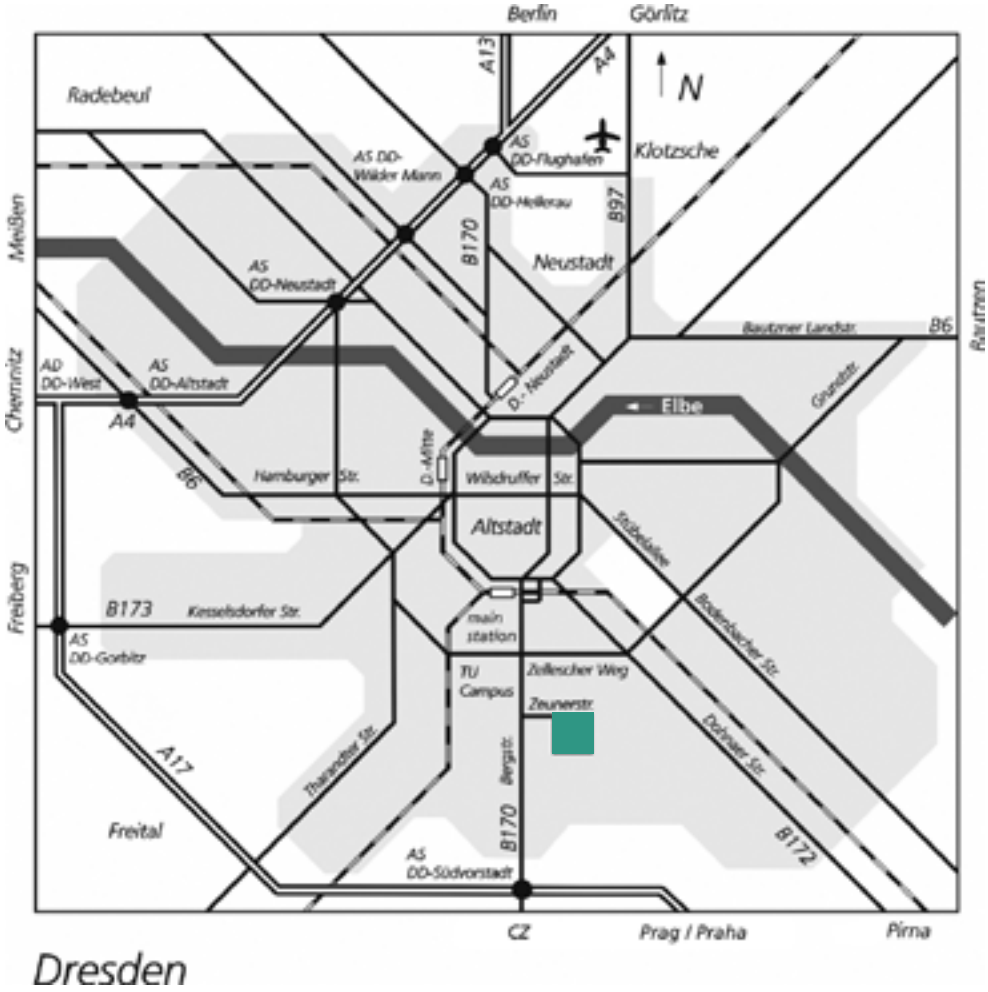
HOW TO REACH US

WITH PUBLIC TRANSPORT

From Dresden Hauptbahnhof/ Main Station, take bus 66 to »Mommsenstrasse«, 10-minute walk from there or take a taxi from Dresden Hauptbahnhof/Main station (approx. 2 km).

BY CAR

From all directions, follow Autobahn A17 to exit »Dresden-Südvorstadt/ Zentrum«. Follow signs leading to Dresden and drive for about 3 km on B170 (Bergstrasse), then take a right at Zeunerstrasse. Information about parking facilities will be given at the reception desk.



BY PLANE

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

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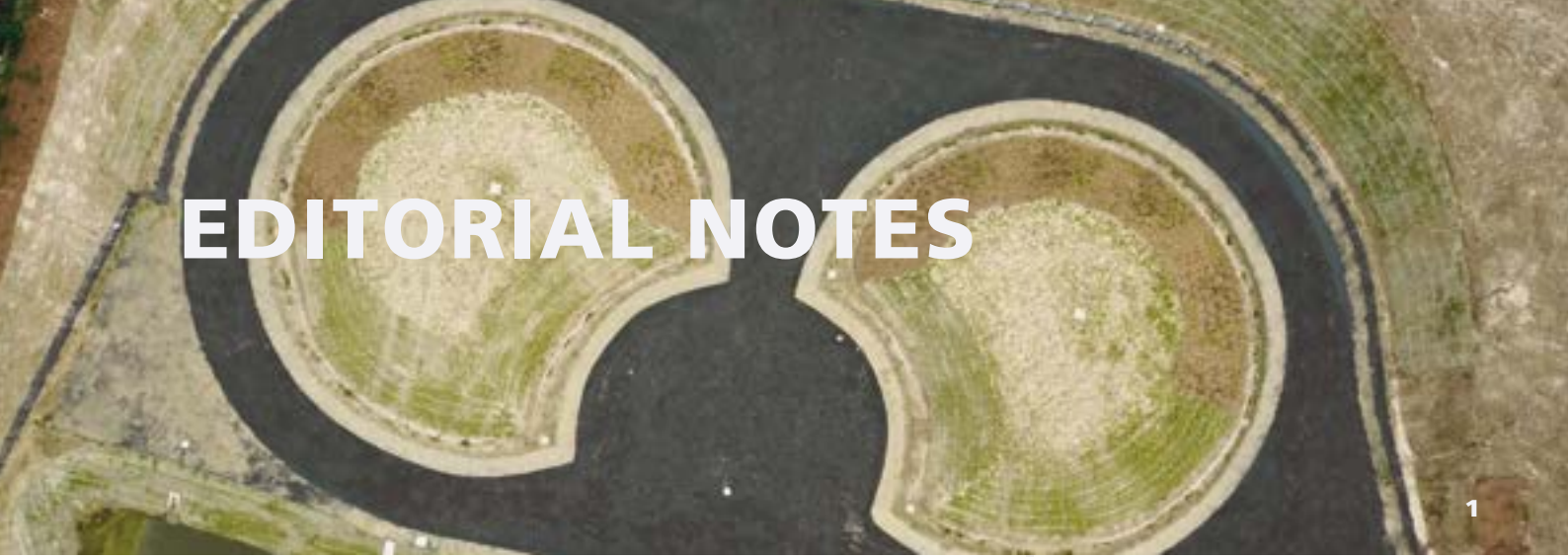

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1 *Aerial view of the Fraunhofer IVI test track.*