Fraunhofer
IVI

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

INSTITUTE REPORT

2009
2010
2011

FRAUNHOFER INSTITUTE FOR TRANSPORTATION AND INFRASTRUCTURE SYSTEMS IVI

INSTITUTE REPORT

2009
2010
2011

Fraunhofer Institute for
Transportation and Infrastructure Systems IVI

Zeunerstrasse 38
01069 Dresden

Phone +49 351 4640-800
Fax +49 351 4640-803

MOBILITY - A CONNECTING FORCE

»Building bridges« from Dresden to the world - this metaphor might meet with mixed responses in the city of Dresden, where controversial discussions about a new bridge divide the municipal politics. Still, when it crosses my mind as I am on board the Airbus taking the government delegation of Saxony to the Gulf States, it makes me smile. The city is covered in a contemplative calmness on that Sunday morning in November, a beautiful moment to reflect on the past years and their achievements.

The year of 2011 has in numerous respects been the most successful year for the Fraunhofer IVI since its foundation in 1999. Proceeds from research and development projects with industrial partners and national or European research projects have doubled within the past five years, allowing the number of employees to increase respectively. Despite the worldwide economic recession, the business areas of the three departments at the Fraunhofer IVI have turned out to be safe and sustainable ventures, largely stabilizing the amount of industrially commissioned projects even within the difficult economic situation in recent years. The institute has been actively involved in numerous technological developments in the context of national economic recovery programs and has never before been so successful in acquiring European research projects as in the past two years. Therefore, we can be proud not only of last year's budget balance, but also venture an optimistic outlook on the next year and even the year 2013.

New test stands, experimental vehicles and laboratory equipment have expanded the research infrastructure of the institute. The staff has been reinforced with new, young employees and interest from students of all subject areas in internships, study or final theses as well as subsequent employment at the Fraunhofer IVI is constantly increasing. In 2010, a new research group on the topic »Location, Information and Communication« was established, led by Oliver Michler, Professor of the chair »Transport Systems Information Technology«. The group combines university research and education at the TU Dresden (University of Technology) with the Fraunhofer IVI's expertise and research infrastructure.

The institute's involvement in Fraunhofer Alliances and Networks resulted in efficient, reliable and professional cooperation leading to ambitious projects with numerous Fraunhofer Institutes. Fraunhofer System Research for Electromobility (FSEM), in which the Fraunhofer IVI along with 32 other institutes is closely involved, is an outstanding example in that matter. Especially during the past few years it has become apparent that cooperating Fraunhofer Institutes generate enormous research capabilities, cover a versatile range of expertise and in this respect open up interesting markets in new directions.

The Fraunhofer IVI has received an exceedingly positive response from the public. One reason for this is the media who contribute a range of TV programs and newspaper articles reporting on transportation, communications and vehicle technology, practical deployment of rescue coordination technologies produced by the Fraunhofer IVI, electronic fare management, the nationwide introduction of the »HandyTicket« and route planning. Another reason was the successful participation in trade fairs within the past few years. The Fraunhofer IVI has meanwhile become a member of numerous committees and, like all Fraunhofer Institutes in Saxony, receives valuable support from the Saxon state ministries and local authorities. An invitation by Saxony's Prime Minister Stanislaw Tillich to accompany him to Abu Dhabi and Qatar was a particular sign of appreciation for the research achievements by the Fraunhofer Institutes, along with their contribution to the economy and involvement in universities and colleges across Saxony.

The journey for me means paving the way into a world which is new to me. It makes me think of my school years back in the GDR when I was a choir boy at the Dresdner Kreuzchor. On concert trips we used to sing »Ich fahr in die Welt«, a song about travelling, and the verse about having to stay back behind walls sent shivers down all our spines.

Times have changed radically and today it is understood that even the most remote places in the world can be reached securely and quickly. So, we fly over the Arab Peninsula after only a few hours and arrive in Abu Dhabi where we are taken in by the fascinating skyline, the modern civilization and the busy hustle surrounded by the hot desert and salty sea.

There is scarcely another place in the world where the need for the development of resource-saving transport technologies is so tangible. Oil and gas, which have brought inconceivable wealth to this region, will not be available for ever, as the example of Dubai has shown. Sustainability in transport in a globalized world is therefore an inexhaustible research topic that will stay with the Fraunhofer IVI for a long time to come. Exciting days full of new top-level contacts and conversations lie ahead of us. The name »Fraunhofer« is well established and one can feel the demand for controlling the various traffic streams efficiently everywhere. Potential partnerships for joint projects are emerging. Time will tell if they can convey some of the recent developments of the Fraunhofer IVI into this area too.

After such an interesting trip, I always enjoy coming back to Dresden, a city whose silhouette is adorned maybe not by the world's largest, but certainly some of the world's most beautiful baroque buildings. This institute report would like to refer to Dresden's colorful diversity in transportation systems by presenting some interesting perspectives, but most importantly give an account of the work at the institute and its everyday life which constantly brings us joy. In this respect, I would like to express my sincerest thanks to all colleagues, students, interns, trainees and all of our partners who we are glad to work with so ambitiously and trustfully.


P
Taschenbergpalais
Haus am Zwinger
DVB

CONTENTS

PROFILE OF THE FRAUNHOFER-GESELLSCHAFT

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. Founded in 1949, the research organization undertakes applied research that drives economic development and serves the wider benefit of society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

At present, the Fraunhofer-Gesellschaft maintains more than 80 research units in Germany, including 60 Fraunhofer Institutes. The majority of the more than 20,000 staff are qualified scientists and engineers, who work with an annual research budget of 1.8 billion euros. Of this sum, more than 1.5 billion euros is generated through contract research. More than 70 percent of the Fraunhofer-Gesellschaft's contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30 percent is contributed by the German federal and state (*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 until five or ten years from now.

Affiliated international research centers and representative offices provide contact with the regions of 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. 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 industry by virtue of the practical training and experience they have acquired.

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

Fraunhofer headquarters
Hansastrasse 27c
80686 Munich.

THE FRAUNHOFER IVI IN ALLIANCES

Fraunhofer Traffic and Transportation Alliance

At present, 16 Fraunhofer Institutes are combining their specific know-how, research infrastructures and long standing experience within the area of transport-related research to be able to offer complete system solutions to public and industrial customers. The alliance is actively involved in the following areas:

- Convenience and design concepts
- Active, passive safety and security systems
- Intelligent lightweight construction systems
- Logistical structures and processes
- Sustainable propulsion concepts
- Innovative mobility and transport strategies
- Intelligent transport management systems
- Innovative transportation systems.

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

Spokesman
Prof. Dr. Uwe Clausen

Central Office
Christiane Kollosche

Phone +49 231 9743-371
Fax +49 231 9743-372

www.verkehr.fraunhofer.de

Fraunhofer Lightweight Construction Alliance

»From concept to product« is the motto of the Fraunhofer Lightweight Construction Alliance which has formed in 2010. 14 institutes have established this joint platform to face up to projects dealing with lightweight construction and cover the entire development process from material through design, simulation and production until 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 more significance. Areas such as body work, chassis and interior offer weight reduction potentials that have positive effects on the design of innovative propulsion configurations, and accordingly contribute to fuel and emission reduction with conventional propulsion technologies.

Spokesman
Prof. Dr. Holger Hanselka

Central Office
Prof. Dr. Andreas Büter

Phone +49 6151 705-277
Fax +49 6151 705-214

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 are lacking the necessary infrastructure, but even modern industrialized countries are dealing with water supplies and wastewater treatment systems which are in need of renewal. Due to present day demographic changes, flexible, and at the same time economically viable solutions are needed.

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

Infrastructure systems, a department which is traditionally an integral part of the Fraunhofer IVI, is looking 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.

Spokesman and Central Office
Prof. Dr. Walter Trösch

Managing Director
Prof. Dr. Dieter Bryniok

Phone +49 711 970-4211
Fax +49 711 970-4200

www.syswasser.de

Fraunhofer Battery Alliance

Factors such as cost, range, durability, as well as size and weight, are weak spots within the field of electromobility and are largely dependent on one component: the battery.

In order to foster research activities in this area, more than 15 Fraunhofer Institutes have connected to form a network, which in 2011 became the Fraunhofer Battery Alliance. Competencies include material production, cell production and the development of entire battery modules.

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 strategies of energy management.

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

Spokesman
Dr. Jens Tübke

Phone +49 721 4640-343
Fax +49 721 4640-800343

www.batterien.fraunhofer.de

PROFILE OF THE INSTITUTE

Director	**Dr. Matthias Klingner**
Head of administration	**Kornelia Brüggert**

Transportation, Energy and Environment	**Intermodal Traffic Information and Management Systems**	**Vehicle and Transport System Engineering**
Dr. Ulrich Potthoff	Ulf Jung	Dr. Thoralf Knote
Electromobility	**Traffic and Transport Information**	**Vehicle Technologies**
Richard Kratzing	Andreas Küster	Dr. Jan Schubert
Power and Environmental Engineering	**Scheduling and Strategic Optimization**	**Transportation Systems/ Human-Machine Interaction**
Hans-Jürgen Petit	Dr. Kamen Danowski	Dr. Thoralf Knote
System Models and Process Control	**Ticketing**	**Sensor and Actuator Systems**
Dr. Ralf Bartholomäus	Dr. Torsten Gründel	Dr. Stephan Zipser
Operations Research		**Propulsion Technologies**
Axel Simroth		Dr. Holger Fichtl

TECHNISCHE UNIVERSITÄT DRESDEN

Locating, Information and Communication

Prof. Dr. Oliver Michler Dr. Georg Förster

The Schwebebahn Dresden, the world's oldest suspension railway still operating

Briefing

A progressive attitude towards thinking, along with concepts of sustainability are fundamental to the strategy of the Fraunhofer IVI. The institute puts particular emphasis on innovation, quality, customer orientation, solid patterns of financing, as well as an increase in value on a long-term basis. These are excellent conditions for unhindered growth in cooperation with the economy and the continuing successful development of the institute.

Within recent years, the proceeds from research and development projects with industrial partners and national or European research projects have grown steadily. The institute possesses attractive laboratories, innovative testing platforms and vehicles as well as outstanding IT structures, incorporating both hardware and software technologies.

The Fraunhofer IVI is confronting present day challenges, operating in a wide array of topics within several fields of research such as transport telematics, disposition, logistics, vehicle propulsion and sensor technologies, along with the information and communication sectors, traffic planning and traffic ecology.

Living up to the rising mobility demands of modern industrialized society while simultaneously combining economic, social and ecologic interests are issues which the institute perceives as its challenge and responsibility.

In order to consistently pursue this challenging goal within the research organization, as well as applying and disseminating it, the Fraunhofer IVI joined an initiative of 17 Fraunhofer Institutes and research institutions in 2007, which two years later became the Fraunhofer Sustainability Network.

ECONOMIC DEVELOPMENT OF THE FRAUNHOFER IVI

During 2011, the Fraunhofer IVI expanded its successful economic development of the preceding years and has thus achieved its best result so far, with an income from projects of 5.6 million euros and a balance surplus of 635,000 euros.

Research projects financed by the public sector - federal and state (*Länder*) governments - make up a share of 41 percent. Industrial partnerships have been expanded, raising the proceeds from industrial projects to 30 percent. Due to increased international activities, proceeds from European projects have risen to 15 percent.

Due to the volume of new projects being undertaken, the increasing range of competencies and the growing number of employees, an extension of the institute facilities is required. A new technical center, which will be built in 2012, offers workspace for 30 employees and also contains several new laboratories and a vehicle garage with workshop.

A new test track is planned for the testing of novel vehicle technologies. Thus, alternative propulsion systems, as well as steer-by-wire systems developed at the Fraunhofer IVI can be instantly evaluated in field tests.

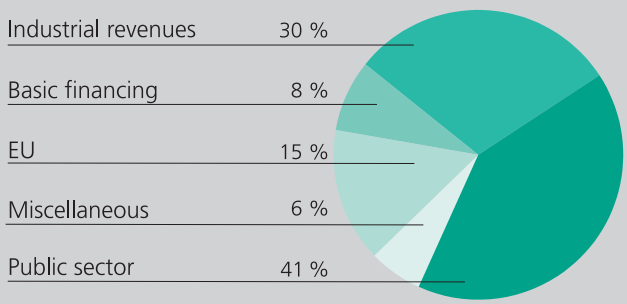
The Fraunhofer IVI may look to the future with confidence. Committed employees, who do their best each and every day, together with the institute's excellent infrastructure provide splendid preconditions for innovatively and successfully realizing present and future developments in promising industry sectors. With a focus on novelty, quality and customer orientation, stable yields and continuous growth are to be expected.

Kornelia Brüggert
Phone +49 351 4640-670
kornelia.brueggert@ivi.fraunhofer.de

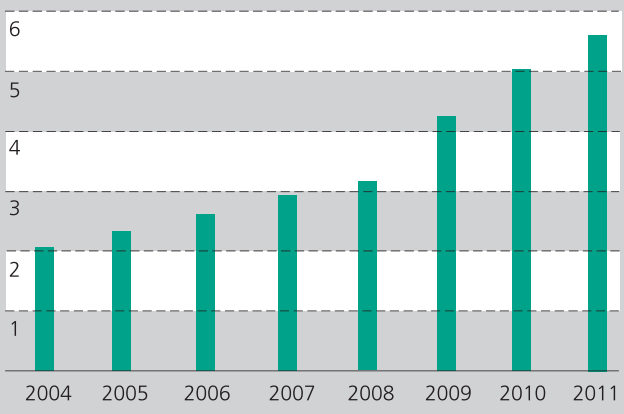
EMPLOYEES 2011

Research fellows	69
Research assistants	46
Trainees	6
Administrative and technical staff	12
Total	133

OPERATING BUDGET



FINANCIAL DEVELOPMENT
in € million



COMPETENCIES AND PROJECTS

Transportation, Energy and Environment

- Electrochemical, electromechanical and thermo-electrical energy storages and converters
- Observer-based battery management systems
- In-situ procedures for fault detection and state of health diagnosis on high power energy storages
- Operational strategies and design of dual storage systems, i.e. combined supercap and lithium-ion battery storages
- Liquid and air-cooled high power lithium-ion traction batteries
- Model-based simulation and design of advanced cooling systems
- Charge controllers for traction energy storage systems
- Grid integration of charging processes for electrical vehicle fleets
- FELICITAS - Fuel Cell Power Trains and Clustering in Heavy Duty Transport
- Hybrid power packs for buses and trams
- Predictive energy management for hybrid road and rail vehicles
- Model-based screening of environmental data
- Prediction of PM10 emissions
- Reduction potential of particulate matter
- Impact analysis for low emission zones
- Dynamic vehicle routing for transportation companies
- Simulation and control systems for wide-area energy supply
- Optimization of wastewater treatment plants
- Latent-heat storage systems for peak load shaping
- Advanced predictive thermal management
- Intelligent system management and grid connection of renewable energy systems
- Model-based SOC and SOH determination of lithium-ion batteries under uncertainty

Intermodal Traffic Information and Management Systems

- Intermodal information systems for public transport and cities
- SMART-WAY - Galileo Based Navigation in Public Transport Systems with Passenger Interaction
- 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
- WEATHER - Weather Extremes: Impacts on Transport Systems and Hazards for European Regions
- Electronic fare management based on Be-In/Be-Out technologies
- »HandyTicket Deutschland« (supra-regional mobile ticketing system for public transport and parking)
- INNOS - Innovative interoperable background system for electronic fare management
- MobiKat - Planning and operational arrangement in catastrophic events; systems for the planning of protection and rescue measures
- TourNET - Information and planning technologies integrating tourist and public transport offers
- Traffic IQ - Pilot project on information quality in traffic
- CLOSER - Connecting Long and Short Distance Networks for Efficient Transport
- DORIS REGIONAL - Information system for the Dresden and Upper Elbe region
- Geocoded database system for use in traffic and transportation
- STAR-TRANS - Strategic Risk Assessment and Contingency Planning in Interconnected Transportation Networks

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
- Ergonomic evaluation of control and display concepts in automotive engineering
- Driver assistance systems
- Life cycle cost analyses and cost-benefit analyses 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
- Model-based design, simulation and evaluation of novel steer-by-wire systems
- Multi-sensor lane detection systems for multi-axles steering
- Electronic lane detection systems for special vehicles
- Infrared and video measurement technologies, incl. image processing
- Steering-based dynamic stabilization of commercial vehicles
- Methods for object recognition and tracking
- Methods and systems for automatic determination of health and vital parameters
- 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 surveying

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 *Octocopter of Fraunhofer IVI by the banks of the river Elbe.*

FACILITIES AND LARGE EQUIPMENT

Hybrid bus of the Fraunhofer IVI, Elbe castles

Successful project work and customer acquisition in the fields of vehicle and transport system engineering, transport telematics, traffic ecology and traffic management would not be possible without high capacity laboratory equipment, innovative testing platforms and vehicles, as well as up-to-date IT infrastructures.

These attractive test carriers and laboratory facilities have been providing excellent conditions for working on industry-oriented developments and application-oriented research projects in numerous fields.

Test vehicles

- AutoTram®, test vehicle for 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 a modern management and planning system for decision support in emergency and crisis situations
- Platform »ELENA« for evaluation of steering strategies
- Urban transit bus with serial hybrid propulsion system

Laboratory facilities

- Sensor technology and image processing
- Communication and radio technologies
- Demo lab for transport telematics
- Experimental hall (Dresden-Reick)

Engine test stand of the Fraunhofer IVI.

Technical equipment

- 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 environment for control development of DC/DC converters
- Inertial measurement unit (ADMA)
- Mobile measuring data acquisition system (DEWETRON)
- Development control unit for mobile applications (AutoBox)
- Universal Receiver Tester (URT): dual-channel generator for high frequency radio signals
- Steering and accelerator robots

Software equipment

- Matlab/Simulink (calculation and simulation of complex systems)
- CATIA V5 (design)
- ANSYS, COMSOL (finite element simulation)
- SIMPACK (simulation of multibody systems)
- LabView (environment for the development of measurement, monitoring and control systems)
- Dewesoft (data logging and analysis)
- Halcon (image processing)
- Dymola (interdisciplinary simulation of physical systems)

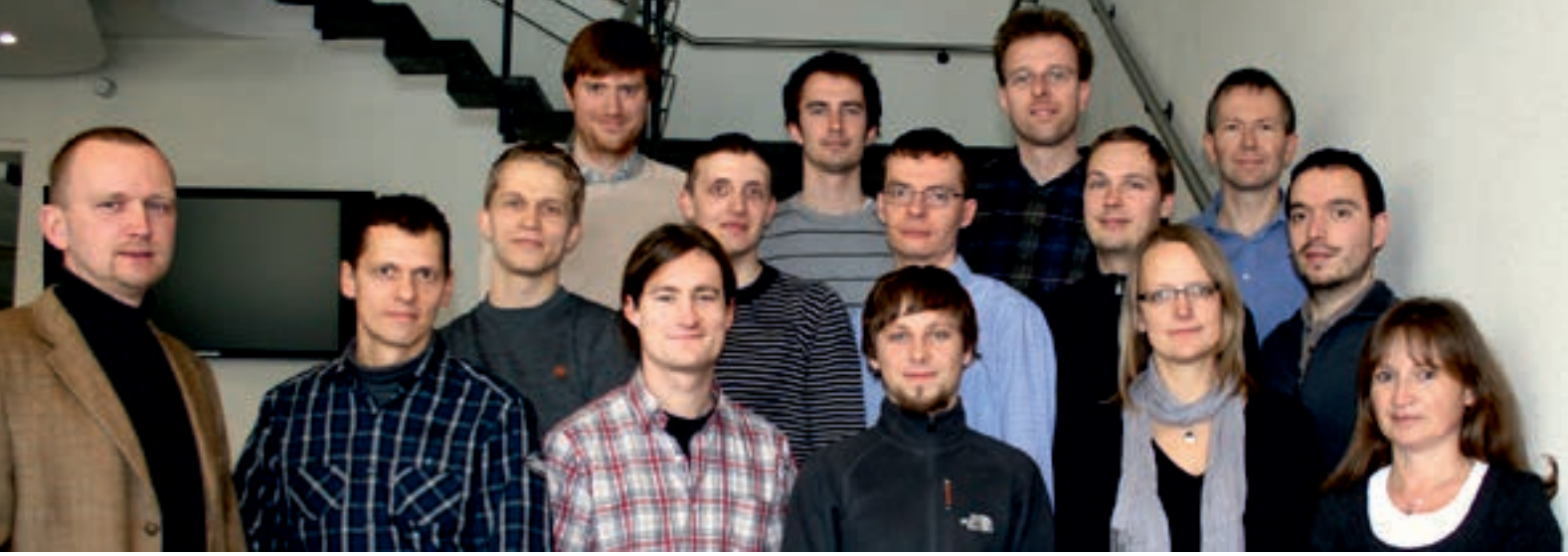
TRANSPORTATION, ENERGY AND ENVIRONMENT

Dr. Ulrich Potthoff
Phone + 49 351 4640-638
ulrich.potthoff@ivi.fraunhofer.de

The department »Transportation, Energy and Environment« focuses on technology developments which offer ecologically sound and economically sustainable solutions for the increasing traffic volume in modern industrialized societies. The public is currently emphasizing the idea of electromobility as a means for overcoming the negative effects of traffic and this is a well-established research topic at the Fraunhofer IVI. There are different project groups that have been dealing with applications of electromobility in the utility vehicle and public transport sectors for several years. Especially innovative vehicle concepts in public transport are regarded as an important migration path for introducing electromobility effectively and more extensively in greater urban areas in the future. Therefore, the research competencies in electrical and thermic energy converters, grid integration of charging infrastructure and fuel cell and hydrogen technologies have been united in the independent research group »Electromobility«.

The challenge lies in living up to modern mobility demands without straining natural resources too excessively. This is not just restricted to reducing the use of fossil fuels by the deployment of alternative propulsion or energy storages, or replacing them by renewable energies. Efficiency in route planning and the optimization of supply chains can also help in saving traction energy. Fossil fuels are not the only natural resource that needs to be taken into consideration. We must also consider the ambient air, the soil and the water that can be affected by pollutant emissions, noise exposure or the land use of transportation. The department is working on tasks in traffic ecology, which can often be a politically charged field. Research interests include traffic-related environmental impact and respective countermeasures.

In cooperation with other institutes, the department is providing their specific expertise in several Fraunhofer Alliances and Networks for the solution of interdisciplinary research and development projects. It is the goal and motivation of the department's research work to not only obtain individual mobility, but to constantly expand it and make it profitable and widely accessible. At the same time, the principle of sustainability regarding social, economic, and ecological matters shall be preserved.



Power and Environmental Engineering

Traffic volume, traction energy and the resulting environmental impact are largely complementary problems. On the basis of long-running analyses of extensive measurement data from national monitoring networks, the effects of traffic-related emissions can be detected by using appropriate methods of signal processing.

In addition to traffic and environment-oriented topics, the working group has been developing complex simulation and control systems for electrical grids and large wastewater plants, and has been implementing these into the customers' systems for many years.

System Models and Process Control

Nowadays the efficient solution of many development tasks in the area of vehicle system engineering relies on capable model-based simulations and algorithms for the design of complex control and automation systems.

Besides the necessary methodological skills, the group has experience in the implementation of supervisory control procedures into vehicle technology. Worth mentioning are technical solutions for predictive energy management in hybrid propulsion configuration, observer-based battery management as well as fault detection and ageing diagnosis for lithium-ion traction storages.

Electromobility

Electrochemical, electromechanical and thermo-electrical energy converters are part of an electric powertrain, providing the required traction energy as effectively as possible. The physical modeling, design and model-based diagnosis of these converter systems are the research focuses of the working group.

In this respect, cooling systems are particularly important. Their exact functioning often has crucial influence on life cycle, cycle stability or degree of utilization of converter and storage systems. Thanks to synchronous load thermal management, the climatization demands of hybrid components can be regarded as standardized and are therefore able to efficiently complement each other. By including driving and route information, business strategies are developed with an eye to the future.

Another topic is the grid integration of charging processes for electrical vehicle fleets. Control and automation procedures are being developed based on long-standing practical experience in simulation and control of electrical grid systems. These procedures contribute to the stabilization of mains operation. They also use the storage capacity of test vehicles to balance fluctuations in energy supply from renewable sources comprehensively.

Newly developed propulsion and storage technologies, charging mechanisms and energy management systems are evaluated with the technology demonstrator AutoTram® and presented to the public.

Technology demonstrator AutoTram®

Operations Research

The group's research focus lies on the application of methodological approaches and tools of Operations Research in specific traffic-related problems. Examples are capacity, position and storage optimization or routing in hauling and transportation.

A unique feature is the specialization in problems in planning under conditions of uncertainty. Doubtful and incomplete information, which in practice usually occurs, is handled by means of dynamic stochastic modeling.

Besides problem analysis, modeling and algorithm development, the range of services also includes the implementation of complex optimization solutions as well as the development of surveys and specifications.

PARTNERS

- AVL List GmbH
- Bombardier Transportation GmbH
- CCM Centre for Concepts in Mechatronics
- CEMOSA S.A.
- CWA Constructions SA/Corp
- DACHSER GmbH & Co.KG
- DMA S.r.l.
- Dresden Informatik GmbH
- Drewag
- Enso Energie Sachsen Ost AG
- fht Flüssiggas Handel & Transport GmbH & Co. KG
- Friedrich Schiller University Jena
- German Federal Ministry of Transport, Building and Urban Development BMVBS
- Göppel Bus GmbH
- Heinrichsthaler Milchwerke GmbH
- initions AG
- INRETS Institute nationale de recherche sur les transports et leur sécurité
- Kirsch GmbH
- Liebherr Hausgeräte GmbH
- Li-Tec Battery GmbH & Co. KG
- OPTIM-AL Ltd.
- Politecnico di Torino
- Scanmaster Systems Ltd.
- Siemens AG
- Spheros GmbH
- Tecnomatica S.A.S.
- Università degli Studi di Napoli Federico II, Napoli
- Universidad de Sevilla
- WSB Service GmbH Dresden
- 50 Hertz Transmission GmbH

FRAUNHOFER SYSTEM RESEARCH FOR ELECTROMOBILITY

Research and development of novel technologies and concepts in electromobility require repeated and sustained interdisciplinary cooperation. More than 30 Fraunhofer Institutes at 22 locations are collaborating in the project Fraunhofer System Research for Electromobility (FSEM), funded by the German Federal Ministry of Education and Research (BMBF). Over a period of two years, five focal points were considered:

- Power generation, energy transport and distribution
- Energy storage
- Vehicle concepts
- Technical system integration (demonstrators) and socio-economic aspects
- Function, reliability, testing and realization.

Thus, all the important stages relating to the deployment of electromobility were included. Researchers worked in optimal coordination. Their tasks ranged from power generation to energy transport, the interface between power supply and vehicle, energy storage and vehicle concepts, as well as a new infrastructure in customer trends and billing concepts.

The development of operational solutions was especially promoted and has been presented with good publicity using the examples of the two demonstrator vehicles Frecc0 and AutoTram®. Both vehicles, Frecc0 2.0 as technology platform for passenger cars and the AutoTram® of the Fraunhofer IVI as an example for the utility and public urban transport sectors, are operated with components which have been developed within the Fraunhofer System Research.

With the help of the AutoTram®, electric propulsion systems can be evaluated and tested for both road- and rail-bound transport. The futuristic vehicle provided excellent preconditions to function as an integration platform for all technology developments from the Fraunhofer Institutes.

The AutoTram® is notable for its synergy, which is created through the interaction of different vehicle components which do not seem to have a direct link to electromobility at first, but in the end contribute enormously to the increase in efficiency for the overall system.

Topics include:

- The recuperative use of thermal energy
- The multivalent use of air conditioning within a synchronous load thermal management
- The intelligent control of auxiliary equipment
- The precise electromechanical coupling by means of magnetorheologic clutch
- Predictive, GPS-based energy management of dual-mode storages
- High current transmission at the docking station.

Predictive thermal management

In between utility and comfort requirements, optimization considerations are increasingly focused on thermal conditioning. Energy efficient air conditioning is on the one hand needed to ensure the comfort of all passengers and, on the other, also necessary for the power electronics components to function safely and efficiently. Numerous aspects of an innovative air conditioning system in electric vehicles addressed this focal point by considering the possible recuperative use of thermal energy. This requires both an extensive modeling of relevant single components from thermal and electrical views, as well as the development of predictive control strategies under consideration of uncertain prognoses, the use of innovative (latent-) heat storage systems for peak load shaping or the development of functionally integrated parts from mechanical and thermo-physiological views.

Electromechanical coupling by means of magnetorheological clutch

Numerous physical principles from basic research are waiting to be applied in practice. One example is the magneto-rheological effect: caused by a generated magnetic field, a suitable magnetorheological fluid changes its viscosity within a very short time. This property is favorable for the use in a fast switching clutch. Within the System Research, this principle has been applied in various ways.

For instance, a magnetorheological clutch intervenes with the serial hybrid propulsion system of the AutoTram®. The aim is to use a variable coupling between the internal-combustion engine and the alternator to absorb short-time mechanic peak loads and thus treat the engine carefully. Magnetorheological clutches are suitable for such applications, as the transmitted torque between the two drive components can be controlled precisely by means of a magnetic field.

The magnetorheological fluid assumes virtually solid properties when activated by the magnetic field and thereby causes a variable »adherence« between the two coupling plates. This effect, which can be easily controlled, is reversible and will not require maintenance. Besides the skillful electromechanical construction of the couplings, the engineer's expertise must detect the suitable composition of the magnetorheological fluid.

High current transmission via docking station

Electric energy can be inserted into all-electric vehicles in numerous ways. One possibility, which has been demonstrated within the System Research project, is the chain of effects from the wayside voltage supply, the mechatronic contact system, high-current-ready DC/DC converter up to the energy storage in the vehicle. Charging capacitor-based storages with high currents (> 1000 A) on a high voltage level (700 V) requires current-carrying contact systems, which offer sufficient mechanical and corrosion resistance.

For use in the AutoTram®, numerous thin film systems with a film thickness between 0.1 and 10 µm have been tested on different metal bases. The first examinations were carried out on surfaces based on graphite-like and metal-doped amorphous carbons. Thin films of conductive titanium nitride show improved properties. They have been applied as a tribological carbide layer to a steel contact surface by means of vacuum-supported and plasma-activated PVD methods.

Within the course of the project, it became apparent that fast charging within 20 to 30 seconds is achievable. As a result of this, start-up and charging are controlled by an eloborate automated security concept.

Bundesministerium
für Bildung
und Forschung

Dr. Ulrich Potthoff
Phone + 49 351 4640-638
ulrich.potthoff@ivi.fraunhofer.de

1 *Coating of contact surfaces for high current transmission.*

INTERMODAL TRAFFIC INFORMATION AND MANAGEMENT SYSTEMS

Ulf Jung
Phone + 49 351 4640-663
ulf.jung@ivi.fraunhofer.de

The department of »Intermodal Traffic Information and Management Systems« has been successfully developing over the past ten years. It emanated from the Working Group »Intermodal Information and Control Systems« within the former Fraunhofer Research Institution for Process Control, and has since then been decisively shaping the Fraunhofer IVI's research profile in transport engineering.

Today, numerous topics are being creatively implemented by a diverse interdisciplinary team of scientists from the fields of computer sciences, information technology, transport engineering and automation engineering.

The key areas of practice-oriented transportation research are development projects for public transport, traffic state identification and coordination in greater urban areas, geocoded traffic control systems as well as information systems based on modern communication and navigation technologies.

Three specialized groups are working on assignments mainly from ministries, local authorities, transportation companies, industrial clients and the European Union. Information and management systems developed by the department are often very detailed and are normally employed by customers for a significant number of years. A particularly important task, which the department carries out responsibly, is the maintenance, constant updating and expansion of these systems. Outstanding customer retention and customer satisfaction have thus been achieved.

Traffic and Transport Information

The main focus of the Working Group »Traffic and Transport Information« is the realization of mobile and static information systems for passengers in public transport, using UMTS, GPS and Galileo. System design, transfer into practice as well as the operation of complete systems are carried out in close cooperation with transportation companies. By now, a set of competencies concerning the ideal data collection method and linking to the construction of large intermodal information systems has been established.

Another focus lies in the development and conceptual design of systems for collecting, analyzing and processing traffic data and information. Besides the application of modern imaging techniques in automatic traffic state identification, algorithm development for the analysis and state identification is an important task. In this respect, not only software solutions are being developed, but also the necessary camera hardware (Wireless & Low-Power) is assembled and deployed in various projects.

Furthermore, investigation concerning traffic development and future mobility patterns is conducted by the working group in close cooperation with European partners.

Scheduling and Strategic Optimization

Core competencies of this group are the development and implementation of processes of optimized scheduling and control of human and technical resources. By integrating novel algorithms, advanced information and communication technologies as well as methods of geosciences, solutions for disaster and emergency management, along with logistics and transportation demand management are created. Systems that have been developed in close cooperation with users and have been put into permanent operation are an effective decision support for public institutions and industrial clients. Transportation companies are supported by consultant and technical concept studies.

Ticketing

Electronic fare management, mobile ticketing, background systems and tools, automatic fare calculation and simulation as well as applications for mobility and tourism are core areas of the working group. These are supplemented by interrelating topics, such as interactive web applications with attractive digital maps or the integration of ticketing and regional information systems. In cooperation with industrial partners, transport associations and companies, the group carries out feasibility studies, creates technical concepts and develops innovative software solutions which are then put into operation.

Camera-based traffic surveillance on Dresden's »Blue Wonder bridge«

PARTNERS

- Akademie o.p.s. Brno
- CERTH-HIT Centre for Research & Technology Hellas
- DB Deutsche Bahn AG
- DLR German Aerospace Center
- DRK German Red Cross
- DVB Dresdner Verkehrsbetriebe AG
- GTT Gruppo Torinese Trasporti
- HanseCom
- INRETS Institute nationale de recherche sur les transports et leur sécurité
- IPM GmbH
- Landeshauptstadt Dresden
- Landkreis Meißen
- Landkreis Sächsische Schweiz-Osterzgebirge
- Leipziger Verkehrsbetriebe GmbH
- MDV Mitteldeutscher Verkehrsverbund GmbH
- Politecnico di Torino
- PTV Planung Transport Verkehr AG
- Region Ústí
- RVD Regionalverkehr Dresden GmbH
- RMV Rhein-Main-Verkehrsverbund GmbH
- Scheidt & Bachmann GmbH
- Siemens AG
- Siemens IT Solutions and Services
- taf the agent factory GmbH
- TLP spol. s.r.o.
- TU Dresden, Faculty of Transportation and Traffic Sciences
- TÜV Rheinland Industrie Service GmbH
- UPM Universidad Politécnica de Madrid
- VBB Verkehrsverbund Berlin-Brandenburg GmbH
- VDV Association of German Transport Companies
- VTI Swedish National Road and Transport Research Institute
- VTT Technical Research Centre of Finland
- VUFO Verkehrsunfallforschung an der TU Dresden GmbH
- VVO Verkehrsverbund Oberelbe GmbH
- VVV Verkehrsverbund Vogtland GmbH

PUBLIC TRANSPORT TICKETING ... EASY, MOBILE AND CASHLESS

»HandyTicket Deutschland«

In November 2010, the project »HandyTicket Deutschland« was put into permanent operation in over 50 transportation companies and associations after a 3-year test stage. By now, already 19 transport regions throughout Germany (fig. 1) have implemented ticketing via mobile phone under the lead management of the Association of German Transport Companies (VDV). The Fraunhofer IVI, in conjunction with its industrial partners HanseCom and DVB Logplay, has been significantly involved in the development of the system and created several essential components.

The aim is to make ticketing for public transport more attractive and more profitable in the future. The customer has the adequate ticket sent to his mobile phone and, if required, can also use the additional function for information about connections and stops. In that way, he is no longer dependent on conventional ticket machines and can buy his ticket conveniently at home. There are seven different ways of purchasing that the customer can choose from - starting with the simple order by sending an SMS or calling a charge-free phone number and ranging to mobile apps for smartphones including the iPhone. Without delays or worries about carrying the right cash, the customer can instantly board a bus or tram.

A novelty of the HandyTicket system is the possibility to purchase tickets nationwide in a unified way. Customers can thus buy tickets anywhere and have to register only once with their local transportation company, either online or on the phone. Payment can also be made independently of regional usage. The passenger can choose from using the electronic debit system, paying by credit card or opening up a prepaid account to which money must be transferred in advance. The HandyTicket website among other functions offers the possibility to view detailed transaction information and print receipts.

Universal fare product server

A worldwide innovation is the possibility to easily integrate the individual fare systems of an entire region into mobile ticketing and thus offer the potential to comprehensively implement the system. Regional product ranges feature at present more than 500 products in about 1000 product variants: not only single or day tickets but also family or group tickets, short, 4-trip or stripe tickets, transit passes, night and express bus tickets, as well as tickets for holidays, special events and many more.

The basis for this system is a central fare product server which has been developed by the Fraunhofer IVI. It maps different public transport fare structures in a standardized and flexible way and, in this respect, is able to integrate complete local fares and regional schedule information into the system (fig. 2). The mapping of fares is carried out on the basis of a comprehensive data model in the form of so-called XML fare product modules. Hence, new fares or fare changes can be implemented simply by data configuration without the need of modifying the software.

Such fare product modules have been developed and optimized over several years of research work. Besides the use in »HandyTicket Deutschland«, they can also be applied to other electronic ticket systems. The institute's research group »Ticketing« holds considerable experience in the field of the development of these fare product modules for public transport and supports respective standardization works of the VDV core application within the initiative »(((e-Ticket Deutschland«.

Advantages for customers and transportation companies

»HandyTicket Deutschland« offers manifold possibilities. The advantages for passengers are obvious: they can purchase tickets in an easy, cashless and mobile way, which is the same nationwide with a rising number of participating regions in Germany. One-time registration, one single bill, consistent service processes, a familiar user interface as well as versatile information functions offer excellent conditions to easily use public transportation despite regional fares which differ significantly. By December 2011, almost 150,000 users had registered.

Participating transportation companies and associations benefit by winning satisfied customers. Moreover, this distribution channel acquires new customer groups and offers the possibility to realize innovative customer loyalty programs with regard to mobile ticketing. For example, promotional weekends before Christmas, when tickets were on sale, were met with very positive response. Alongside such standard methods of customer acquisition, more individual customer referral programs have already been implemented. Synergy effects and minimized distribution costs for participating companies are a result of the profitable business concept, which not only consists of a jointly run background system designed to support multiple clients, but also of a centralized support as well as reusable marketing modules and training documents for employees. Therefore, all parties involved, including small and medium-sized transportation companies and associations, benefit from the advancement and the technological improvement of the complete system.

1 *Participating regions (as of 12/2011).*
2 *Fare product server with universal, easy to configurate XML fare product modules.*

Dr. Torsten Gründel
Phone + 49 351 4640-664
torsten.gruendel@ivi.fraunhofer.de

VEHICLE AND TRANSPORT SYSTEM ENGINEERING

Dr. Thoralf Knote
Phone + 49 351 4640-628
thoralf.knote@ivi.fraunhofer.de

The department of »Vehicle and Transport System Engineering« focuses on concepts for vehicles and their components respectively. The main emphasis lies on innovative vehicle systems for road-bound public transport, but the department is also working on other vehicle engineering projects, e.g. agricultural machines or passenger cars.

A comprehensive range of services is being offered, covering the fields of vehicle design, innovative propulsion systems, energy consumption, steering control and driver assistance systems as well as operational concepts. Hereby, the operators' and users' perspectives are in the foreground. Besides steering concepts for vehicles in public transport, the department develops modern, model-based techniques for electronic multi-axle steering systems in special applications.

Project work is supported by up-to-date hard- and software. A computer lab, equipped with efficient design software, is available for construction design works. Prototypical solutions can be tested and demonstrated with the test vehicle AutoTram®. Modern equipment is used to measure various parameters in vehicle dynamics, fuel consumption, load conditions or vibrations etc. in field tests.

The infrastructure of the department has been upgraded with engine test stands for hybrid powertrains and auxiliaries. This aspect of the department is appealing both to industrial partners and others.

The interdisciplinary application of specific research results or scientific expertise is a challenge for all Fraunhofer Institutes. A typical example for this department is the development of a high-capacity vehicle concept for road-bound public transport. In this project, the Fraunhofer IVI is involved, amongst others, in vehicle design and the development of the steering system.

Vehicle Technologies

The research group »Vehicle Technologies« is focused on the development of complete vehicles. This includes design; packaging; steering; body work and chassis concepts for buses and intermediate public transport vehicles.

The test vehicle AutoTram® allows ideas to be tested and conceived in a realistic environment. The expertise of the working group is also applied in field tests of hybrid buses in several German cities.

Propulsion Technologies

The research group »Propulsion Technologies« deals with concepts in propulsion, energy transmission and energy management for public transport vehicles. Innovative, and especially all-electric, propulsion systems with cutting-edge storage technologies are tested under different operational conditions using up-to-date simulation tools.

Owing to extensive analyses of the energy consumption of trams, conclusions for the design of hybrid propulsion systems can be drawn. Moreover, technologies for the transmission of electric energy into vehicles without the usage of catenaries are being developed and evaluated.

Transportation Systems/Human-Machine Interaction

This group's key tasks are the planning of systems for regional traffic and life cycle cost analyses of both conventional and innovative public transport vehicles.

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 possibility to test the planning and design of future workplaces for bus drivers.

Sensor and Actuator Systems

The group focuses on applications of sensor and sensor data processing as well as mechatronic actuator systems, which are closely connected in control systems. One field of interest is high performance guidance of more complex vehicles like buses for BRT (Bus Rapid Transit), but also heavy duty trucks. All applications developed are dedicated to the steer-by-wire technology. For vehicle guidance and steering, usually two methods are applied: a navigation strategy based on vehicle ego-sensors and a model driven control concept.

A second area of interest is the extraction of health and medical data based on advanced automatic processing of medical images from cameras for the visible, near infrared or the thermal infrared spectrum.

Multi-axle steering system »ELENA« by the banks of the river Elbe

PARTNERS

- Agro Agrarprodukte GmbH
- Anhalt University of Applied Sciences, Köthen
- Barnimer Busgesellschaft mbH
- Bombardier Transportation GmbH
- Carbo Fibretech GmbH
- Continental Safety Engineering GmbH
- DEKRA Automobil GmbH, Klettwitz
- DEKRA e. V.
- DERAP AG (Switzerland)
- DIAS Infrared GmbH
- DVB Dresdner Verkehrsbetriebe AG
- EvoBus GmbH
- GeneSys GmbH
- Göppel Bus GmbH
- Götting KG
- Hochschule Aschaffenburg, University of Applied Sciences
- HTW Dresden, University of Applied Sciences
- HTWK Leipzig, University of Applied Sciences
- Hübner GmbH
- KIT Karlsruhe Institute of Technology
- Langendorf GmbH
- LVB Leipziger Verkehrsbetriebe GmbH
- Li-Tec Battery GmbH & Co. KG
- MAN Nutzfahrzeuge AG
- MDV Mitteldeutscher Verkehrsverbund
- M&P Motion Control and Power Electronics GmbH
- Mobil Elektronik GmbH
- Münchner Verkehrsgesellschaft mbH
- OMT GmbH Oberflächen und Materialtechnologie
- Ortloff Technologie GmbH
- Paul Nutzfahrzeuge GmbH
- RALLE Landmaschinen GmbH
- Richter Spedition GmbH & Co. KG
- Robert Bosch GmbH
- Rose Versand GmbH
- RWS Railway Service GmbH
- SafeCourse GmbH
- Schunk Bahn- und Industrietechnik GmbH
- Solaris Bus & Coach S.A.
- STW Sensor Technik Wiedemann GmbH
- Thermotec GmbH
- Thielert Aircraft Engines GmbH
- Trinamic Motion Control GmbH & Co. KG
- TU Dresden
- Universal Transporte Michels GmbH & Co. KG
- üstra Hannoversche Verkehrsbetriebe AG
- VDV Association of German Transport Companies
- Volkswagen AG
- Vossloh Kiepe GmbH
- WITTUR Electric Drives GmbH
- Yoo GmbH

ENERGY MANAGEMENT OF DUAL-MODE ELECTRIC STORAGES

Background

Electric propulsions are an integral part of public transportation, which has, due to its operational processes, very good preconditions for deploying them. At the same time, both high investment costs for conventional energy supply technologies, e.g. catenaries or power rails, and their visual impacts, especially on historical town centers, are major obstacles for the extension or installation of, for instance, trolleybus networks.

Dual-mode electric storages, which can be used in different applications, are a way of approaching this problem. They can be used for:

- Constant electrical operation without catenaries
- Route extensions with electrical operation without catenaries
- The reduction of peak loads
- The increase in energy efficiency through improved energy recovery.

Dual-mode electric storages are made up of a part to cover the energy for normal traction, mostly battery storages, and a component to cover peak loads, e.g. supercapacitors, which can also be used to take up recovered braking energy. The characteristics of both storage technologies are combined to reach both high energy and power density, taking into account safety and life cycle aspects.

For the efficient use of dual-mode electric storages, their dimensioning, adapted to the respective use case, as well as adapted energy management strategies, are decisive factors.

Use case

In cooperation with Railway Service GmbH, a dual-mode electric storage was developed and prototypically installed into an articulated trolleybus of the Barnimer Busgesellschaft mbH in Eberswalde in 2010. The following components have been integrated:

- Maxwell UltraCaps
  - module BMOD0165P048, 48 VDC, 165 F
  - 1 phase, 13 modules, air-cooled
  - max. current: 1300 A
  - total energy content: 0.686 kWh
  - useable thereof (Umin = 300 V): 0.527 kWh
  - useable in normal operation: 0.247 kWh
  - useable in auxiliary operation: 0.394 kWh
- Lithium-ion cells of Li-Tec
  - cell type 40 Ah, HEI 40, ICS 12/203/245, 3.0 - 4.2 V
  - 120 cells in 12 modules, air-cooled
  - energy content: 17 kWh.

The Fraunhofer IVI realized the development and implementation of the energy management concept which controls the energy flow in the dual-mode electric storage and between the dual-mode electric storage and the other components of the electrical drive train. If required, the energy management can be optimized for two criteria:

- Maximum energy saving by energy recovery
- Maximum reduction of peak loads.

Both optimization criteria are implemented in the developed concept and can be applied as required. Both objectives are contrary to each other. It is possible to change the optimization criterion online according to the requirements by adapting the target function.

Converted bus (Barnimer Busgesellschaft BBG mbH)

Measuring data

For the first application, the reduction of peak loads together with a preferably high energy saving rate have been selected as optimization criteria. The management system was optimized for 75 passengers and not adapted to deadheading. The acquisition of measuring data was carried out during regular service.

Two loading cases, which have been executed with three different driving modes each, were the basis for the analysis:

- Catenary operation without energy storage, service at all stops (equivalent with former operation)
- Catenary operation with energy storage, service at all stops
- Catenary-free operation, no service at stops (to determine the operating distances).

Test runs for the evaluation and quantification have shown the following results:

- Reduction of peak loads (power in catenary network)
  - by approx. 25 % from 400 A to 300 A at a payload of 6 t
  - by approx. 27 % from 370 A to 270 A (deadheading)
- Reduction of energy consumption
  - by 7 % from 2.02 to 1.88 kWh/km (deadheading)
- Optimization of energy management
  - by 7 % from 2.02 to 1.88 kWh/km (deadheading with a payload of 6 t)
  - by 12 % from 2.02 to 1.78 kWh (deadheading).

The basis for the measuring results was the optimization criterion for the maximum reduction of peak loads.

For test runs with payload, an articulated trolleybus, type MAN NGE 152 M17 of manufacturer Gräf & Stift, with a payload of 6 t (equivalent with 75 passengers) was used.


1

1 *RWS dual-mode electric storage.*

In addition, the maximum operating distances for catenary-free operation were 8 km (payload 6 t) and 13 km (deadheading). By increasing the vehicle's speed, the distances are reduced to 5 and 8 km respectively by utilizing only 60 % of the total energy content.

Potential

The energy amount saved depends, for instance, on the requirements, the available construction space for energy storages as well as the power of the converter.

Due to preconditions in the project, the size of the storage was adapted to the available construction space after removing the autonomous power unit. To obtain higher energy efficiency, energy amounts in storages have to be adapted to the requirements. Further energy saving potentials can be used by including storages with higher energy content.

Christoph Barz
Phone + 49 351 4640-614
christoph.barz@ivi.fraunhofer.de

LOCATING, INFORMATION AND COMMUNICATION

Prof. Oliver Michler
Phone + 49 351 4640-629
oliver.michler@ivi.fraunhofer.de

Since June 2010, a new research group in cooperation with the TU Dresden (University of Technology) has been active at the Fraunhofer Institute for Transportation and Infrastructure Systems IVI. The aim of the group is to further strengthen the partnership of both institutions in the field of traffic research. Joint projects aim to make use of existing resources and competencies of both sides and thus contribute to better networking in order to assure the competitiveness of Dresden's and Saxony's cutting-edge research in the transportation sector.

The scientific leader of the group is Oliver Michler, Professor of the chair »Transport Systems Information Technology«, which is part of the Institute of Traffic Telematics at the TU Dresden. Professor Michler had been with the Fraunhofer IVI from 2000 until 2005 and is therefore well acquainted with the working methods and the business-oriented profile of Fraunhofer. On the part of the Fraunhofer IVI, the group is run by a team leader and several doctoral candidates who are being supported by specialized permanent staff, depending on the project topic.

With regard to content, the focus is on the subject fields of locating, information and communication, including all carriers. Base technologies make up the main emphasis, as the group is looking at problems of energy efficiency in sensors, the accuracy of locating processes and data transmission in optimized bandwidth. The research group can thus be regarded as the link between technology-oriented disciplines on the one hand, e.g. electrical engineering, electronics, telecommunications engineering and information technology, and, on the other hand, application-oriented disciplines, dealing with traffic information management and systems for decision support in transportation and maintenance processes.

In accordance with the statutes of the Fraunhofer-Gesellschaft, promoting the transfer of scientific and technological innovations into the products and processes of small and large enterprises is of great importance. The new research group is therefore recalling a tradition which had led to the foundation and development of the Fraunhofer IVI's profile more than ten years ago. Since then, the institute has become an established institution in traffic research.

Locating

Modern applications in traffic telematics are increasingly based on the linking of factual information with their corresponding location. This evolution can be observed in road, rail, air and waterborne transportation systems. Depending on the purpose, specific requirements concerning availability, accuracy, energy consumption and integratability, 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

Part of traffic telematics are methods and systems which can influence the behavior of traffic participants or technical components of traffic processes in the form of surveillance, protection, control or optimization by obtaining, transmitting and analyzing information.

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, which are relevant for future research.

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

Communication

In traffic telematics, both stationary infrastructures (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 is therefore focusing on the linking of competencies in traffic engineering, traffic telematics and telecommunications engineering and is closely interlinked within the institute itself, with other Fraunhofer Institutes and university institutions. The given topics relate to the fields of data transmission, digital signal processing including source encoding and also to problems linked 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.

PARTNERS

- ADAC e. V.
- Bayerische Straßenbauverwaltung
- DB Regio AG
- Delimon GmbH
- Dresden Elektronik Ingenieurtechnik GmbH
- IRK-Dresden
- KOMMZEPT-Ingenieurbüro Hausmann
- National Instruments Germany GmbH
- NOFFZ ComputerTechnik GmbH
- TCAC GmbH
- TU Dresden
- Thomas Werner Industrielle Elektronik e. Kfm.
- ZAFT e. V.
- ZIGPOS GmbH

COOL PUBLIC TRANSPORT INFORMATION (CPTI)

Increasing energy requirements for monitors and co.

Information and communication technologies form the backbone of traffic information systems. This also applies for public transport, in which dynamic passenger information in vehicles and at stops, automatic counting and surveillance systems as well as electronic ticketing systems are integral parts. Although energy consumption of sensors, display panels and for data transmission are quite low, compared to the traction energy for vehicles or vehicle fleets, cumulative effects of the wide and rapid spread of telematics applications cause the need of an overall economic review on these energy requirements. Projections have shown that the potential of saving by using energy efficient sensor and display technologies in public transport in Germany currently equals the energy requirements of a small town with 7,000 inhabitants [source: project proposal CPTI, 2011].

Zone-specific locating of passengers

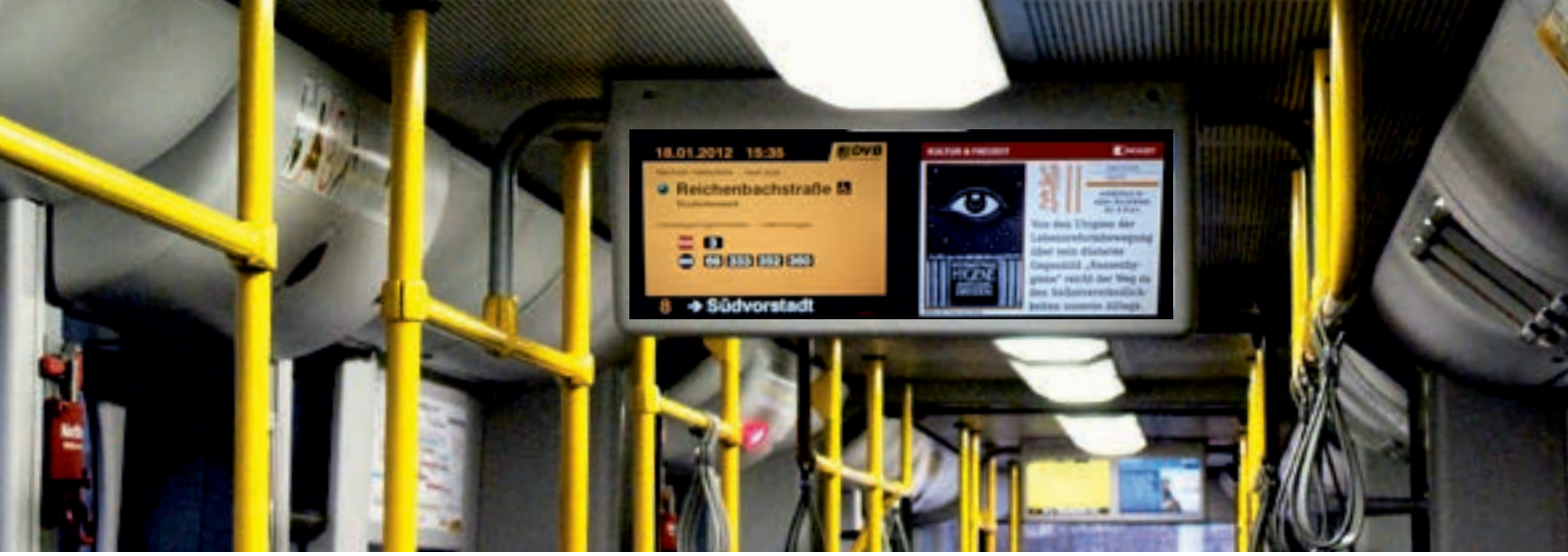
The focus of the project CPTI lies on the technological foundations of energy efficient, zone-specific locating of persons in public transport. Innovative methods, based on time of arrival, are used and developed, in which the passenger acts with a certain device, such as mobile phone or chip card, as part of a radio sensor network. Zone-specific means that the locating quality must be high at zone boundaries, but is subordinate within zones. The objective is to be able, for instance, to decide whether a passenger is inside or right outside a vehicle, or if he or she is currently in the front, middle or back part of the carriage. The knowledge gained from studying the passenger occupancy of zones can then be applied to decisions regarding secondary energy consuming systems.

Switching off unnecessary devices

Secondary energy consuming systems do not primarily contribute to the motion of the vehicle but serve as information or convenience systems for passengers. They include information displays of routes and stops, monitors for advertisements and information as well as devices for lighting, heating or surveillance. Practical use cases offer solutions for passenger perception for the electronic fare management with »Be-In/Be-Out« requirements and for the presence-controlled, zone-selective activation of energy-intensive systems (e.g. displays, lighting).

Multiple usage of existing sensors

A multitude of sensors are used in buses and trams today. Apart from speed and acceleration data, they often include door signals, counters for boarding and disembarking or videocameras. In addition to these, locating data from the vehicle, from connected devices or from mobile devices of passengers are available. One aspect of the project work is therefore the question of how these numerous measurement values can be combined usefully. The idea is to achieve energy efficiency by using the minimal amount of sensors, through the fusion of different sensor types and by the multiple use of existing sensors. Furthermore, the potential of so-called »Energy Harvesting« to support the energy supply of these sensors is discussed and evaluated.



Using vehicles as test beds

The Fraunhofer IVI contributes two realistic test vehicles, a city bus and the AutoTram®. The vehicles are used to evaluate the developed solutions regarding their functions and to assess their potential for energy saving. Plans have been developed to carry out extensive test scenarios with these vehicles, applying different occupancy rates, and thus validate the suitability of the results for practical use.

State of Saxony supports energy efficiency

The project Cool Public Transport Information (CPTI) is funded by the German Federal Ministry of Education and Research within the Saxon cluster of excellence »Cool Silicon« (www.cool-silicon.de). It is running from August 15th 2011 to February 14th 2014 and has a total budget of 1.8 million euros. A major share of funds originate from the state of Saxony and the European Union. The cluster has set the goal on creating the technological basis for the improved energy efficiency in information and communication technology and consists of three research areas, realizing joint projects in energy efficient micro- and nanotechnologies, communication systems and sensor networks. The project CPTI is part of the research area 3 »Sensor Networks« and is one of the few projects which deal with public transport systems. The Fraunhofer IVI is the coordinator and works alongside five other partners.

COOL Public Transport Information

COOL SILICON energy efficiency innovations from silicon saxony

Gefördert aus Mitteln der Europäischen Union

Europa fördert Sachsen.
EFRE
Europäischer Fonds für regionale Entwicklung

Bundesministerium für Bildung und Forschung

1 *Increasing use of display technologies in buses and trams.*

Dr. Georg Förster
Phone +49 351 4640-682
georg.foerster@ivi.fraunhofer.de

JUNIOR RESEARCH

TRAIN-LIKE GUIDANCE OF MULTIPLE ARTICULATED VEHICLES

Initial situation

Steadily growing traffic volume and limited resources require more efficient vehicle concepts for passenger and freight transport. Long articulated road vehicles with an increased transport capacity and higher energy efficiency in turn are a promising approach. A tough challenge regarding these vehicles is to minimize their swept path to make them highly maneuverable, enabling a safe operation in urban areas. A driver, for instance, is no longer able to control vehicles with more than one hinge, e.g. double-articulated buses, in reversing without the help of supporting systems. In forward movement, exact maneuvering of long vehicles, especially on narrow and winding roads, is difficult and tiring. However, even these vehicles can be properly controlled if they are equipped with automatic steering systems that offer train-like vehicle guidance.

To solve the problem described above, the Fraunhofer IVI designed a novel automatic steering system that considers two operational modes:

1. Automatic mode: all steerable axles of the vehicle follow a predetermined desired path.
2. Semi-automatic mode: the driver directs the first segment of the vehicle and all remaining segments follow the first one in a train-like way.

Outline

The automatic steering system uses a model-based two degrees of freedom (DOF) control scheme consisting of a feedback and a feed forward part (fig. 1). Within the feed forward control, a modular kinetic vehicle model and an additional tire model is used to calculate the steering angles γ_s necessary to follow the desired path theoretically. The separation of vehicle and tire model eases the calculation enormously, since the steering angle only appears in the tire model and the vehicle model stays linear in its inputs. The path tracking is stabilized by a nonlinear feedback controller that compensates model uncertainties and disturbances, such as wind gusts. The controller design follows the model-based approach and uses nonlinear decoupling techniques comparable to feedback linearization methods.

Modeling

The control system is based on a nonlinear single-track model describing the vehicle dynamics. Single-track model means that the wheels of an axle are replaced by a single wheel in the axle center. Furthermore, it is assumed that the vehicle is moving on a plane and that pitch and roll movements are neglected.

For control design, it is suitable to divide the single-track model into a vehicle and a tire model. The vehicle model describes the relation between the generalized acceleration $\ddot{z}$, the state of the vehicle $z, \dot{z}$ and the tire forces f_A by a nonlinear differential equation system:

$$\ddot{z} = f_1(z, \dot{z}) + J_A(z) f_A \qquad (1).$$

The tire forces f_A are considered as the inputs of the vehicle model. They are described by a nonlinear tire model

$$f_A = f_2(z, \dot{z}, f_M, \gamma) \qquad (2)$$

with the driving forces f_M and the steering angles γ as inputs.

Control design

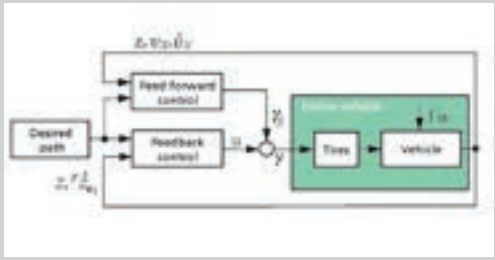
Fig. 1 gives a general survey of the model-based two DOF control scheme consisting of a feed forward and an additional feedback control. The approach for the feed forward control is illustrated by fig. 2. The vehicle is located in the actual position

L_0 and is intended to follow the desired path s(λ) in a train-like way. For clarification, L_0 differs widely from the desired position L_S. If the position of an axle (here A_0) is known, the desired position L_S on the path s(λ) can be calculated. Assuming the vehicle velocity v_x and the acceleration $\dot{v}_x$ are known, the desired vehicle kinematics z_S, $\dot{z}_S$ and $\ddot{z}_S$ can be calculated as well. The desired kinematic is applied to the vehicle model. Thus, the desired tire forces f_{AS} are the solution of the linear equation system

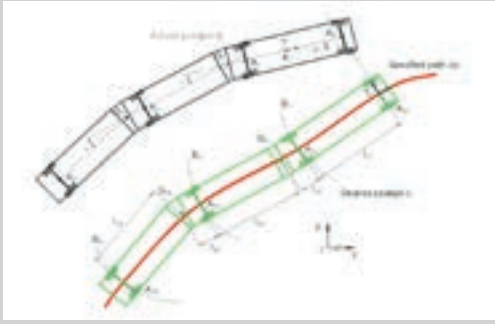
$$J_A(z_S) f_{AS} = \ddot{z}_S - f_1(z_S, \dot{z}_S) \quad (3).$$

The desired steering angles γ_S are calculated by applying the desired tire forces, desired kinematics, and the measured driving forces to the tire model (2). The calculated steering angles γ_S theoretically cause every single axle to follow a desired path exactly. Thus, the feedback part only has to compensate model uncertainties and disturbances.

The control structure enables the design of various feedback controllers which can be adapted to the available sensors. Both nonlinear MIMO controllers and axle-specific linear SISO controllers have been examined. The nonlinear MIMO controller minimizes the deviation of measured and desired minimal coordinates. The linear SISO controllers are designed as PD controllers that minimize the distance between the axles and the desired path directly.



1



2

1 *Block diagram of the automatic steering system.*
2 *Control strategy illustrated by means of a double-articulated vehicle.*

Results

The developed automatic steering system was successfully tested by simulation and test drives using the articulated test vehicle AutoTram®. The tests proved a good tracking performance combined with robustness against changing operating conditions, e.g. loading and road surface. Since the system is designed for articulation and steering angles of at least 50° and centripetal acceleration up to 4 m/s², practical requirements of passenger and freight transport are fully met.

The automatic steering system was developed within the project »AutoTram®« at the Fraunhofer IVI and has been submitted for dissertation at the TU Dresden, Faculty of Transportation and Traffic Sciences »Friedrich List«.

The author thanks the supervisors of the thesis, Prof. Dr. Bernard Bäker, Prof. Dr. Michael Beitelschmidt, TU Dresden and Dr. Matthias Klingner, Dr. Stephan Zipser as well as Dr. Ralf Bartholomäus of the Fraunhofer IVI.

Dr. Sebastian Wagner
Phone +49 351 4640-669
sebastian.wagner@ivi.fraunhofer.de

OPTIMIZED FRICTION COUPLES FOR SELF-ENERGIZING DISC BRAKES

Initial situation

Braking systems are of great importance for the active safety of vehicles. In recent years, brake-by-wire systems have been developed to improve the performance and comfort of braking systems. Additional functions increase the active safety and convenience of the vehicle. In this respect, electro-mechanical braking systems show considerable potential. However, electrical energy necessary for the braking operation is obtained from the vehicle's electrical system. This weak spot within the system can be opposed by using self-energizing effects, in which the kinetic energy of the vehicle contributes to the operation of the brakes.

One possibility is a wedge in circumferential direction, on which the brake pad is moving and performing the clamping motion. The necessary actuation force is then determined by the wedge angle and the friction coefficient between brake pad and brake disc (fig. 1).

The smaller the spread between the tangent of the wedge angle and the friction coefficient, the lower the actuation force and energy. The friction coefficient of a friction couple, however, is varying. A friction couple with a low variation of the friction coefficient is highly favorable for the design and operation of the brake. From this insight, the aim of the thesis - i.e. finding a friction couple with a friction coefficient margin as low as possible - derived. The following points have been taken into consideration:

- Investigation into the optimization potential of existing friction couples, especially the influence of the brake disc (cast iron) on the friction behavior
- Research into alternative friction couples
- Development of a suitable methodology for the investigation of friction couples.

Friction couples and friction behavior

Certain tribological, mechanical and thermal demands are placed on the friction elements and their interaction as a friction couple. Furthermore, special properties are required.

Numerous conflicts may occur, e.g. between lightweight construction and the necessary thermal mass. The best compromise today is the use of organic bound brake pads and cast iron brake discs. The brake pad influences the friction behavior, while thermal behavior is determined by the brake disc.

Research into alternative friction materials included:

- Established friction materials
  - in serial use with motor vehicles
  - as special applications
- New friction materials.

Thereby the most promising friction couple was found to be the established combination grey cast iron brake disc and organic brake pad, as the most extensive expertise is available for this option.

From the results of the investigation, the hypothesis has been derived that different parameters of the brake disc influence the interaction with the brake pad and thus have an effect on friction behavior. The testing plan tackled the following brake disc parameters:

- Brake disc material
- Mechanical processing of the friction surface
- Structural conditions within the friction surface
- Production batch (reproducibility).

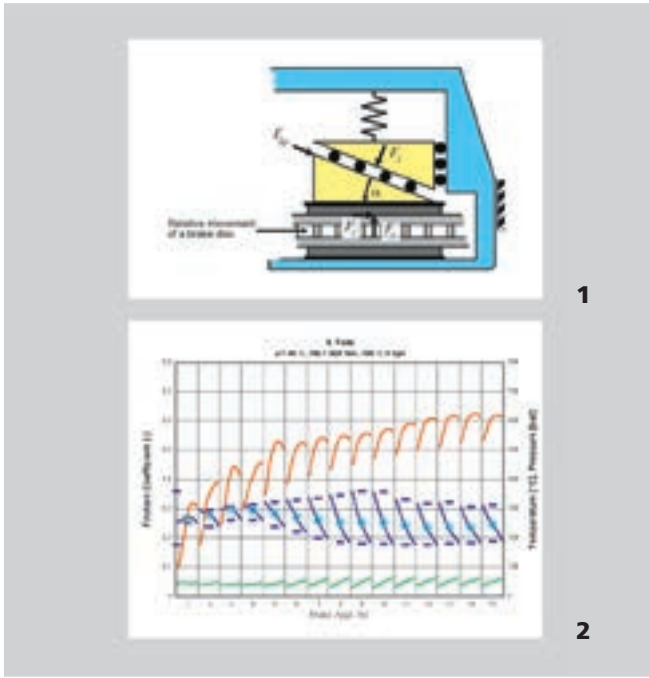
Research methods

The investigation of the friction behavior was performed on an inertia dynamometer for brakes in order to reproduce the operating conditions of a brake realistically. The basis for the performing of the investigation was the standard testing program AK-Master, in which different operating parameters vary during 300 braking applications. For the characterization of the friction behavior, the friction coefficient is calculated from the variables braking torque and brake pressure as well as other mechanical properties. The testing parameters were derived from a benchmark vehicle.
For the processing of measurement data, the approach has been adapted to the topic and partly new developed. Up until now, the analysis was based on the mean of the friction coefficient, calculated for each braking application. The variability of the friction coefficient curve was not taken into consideration. With the newly developed analysis software, all relevant instantaneous friction coefficients could be taken into consideration. This was achieved by characterizing the friction coefficient curve of each braking application through the lowest and the highest instantaneous friction coefficient and the mean of the friction coefficient curves (fig. 2).

The test runs analyzed in this way were subjected to qualitative and quantitative considerations as well as statistic methods.

Results

For a limited period of use, the brake disc parameters can have both significant and relevant effects on the friction behavior within the range of dispersion. Thus, they can contribute to the optimization of friction characteristics and the operating behavior of a self-energizing brake.



1

2

1 *Operating principle of a self-energizing disc brake with a constant wedge angle.*
2 *Cycle of an evaluated test run.*

The examinations have been carried out at the chair of Automobile Engineering, TU Dresden, with the support of the Robert Bosch GmbH, and have been submitted for dissertation at the Faculty of Mechanical Engineering at the TU Dresden.

I would like to thank Prof. Dr. Horst Brunner and Prof. Dr. Berthold Schlecht for the supervision and evaluation of the thesis, as well as Buderus Guss GmbH and TMD Friction GmbH for their cooperation.

Dr. Sven Boden
Phone + 49 351 4640-810
sven.boden@ivi.fraunhofer.de

MULTIVARIATE APPROACH FOR ANALYSIS AND RECONSTRUCTION OF TRAFFIC DATA

Initial situation

Modern traffic management systems require dynamic data on traffic flow. With reference to road networks, this data can be collected using stationary sensors (e.g. induction loops) or probe vehicles (e.g. Floating Car Data, FCD). It becomes apparent that in the future, a mix of different heterogeneous data sources and types will be available for the same traffic network. Therefore, methods are necessary which contribute to the fusion, analysis and prediction of traffic data from different sources and of different qualities.

Objectives

Depending on spatial and temporal availability of link-related FCD travel time information present in a specific road network, there will at any point in time be a subset of links for which, due to missing measurement data, traffic conditions will have to be estimated. Such a model-based assessment can be supported by stationary detectors. In this context, the question arises how road links supporting this assessment of measurement data in the best possible way can be identified with the help of historical FCD measurements (fig. 1).

Model approach

The problem described can be divided into two sub-problems:

1. Design of an estimation method: based on a given number and distribution of fixed sensor locations in the road network, substitute values for the remaining spots without metrological information are to be determined with as little error of estimation as possible.

2. Design of a selection method: Based on historical measurement data, the sections in the road network which promise the most success in estimation are to be determined.

In general, the estimation problem can be put as in (1). An error metric ε (to be defined) between the vector of the estimated value a_G and the corresponding real values a^*_G is minimized. The number f of fixed sensor locations is considered as given.

Minimize $\varepsilon\ (a_G, a^*_G)$
under the secondary condition $\sum_{i=1}^{n} b_i = f \quad b_i \in \{0, 1\}$ (1)

The base line for the chosen approach to solve this problem is the observation that the actual information on traffic conditions lies in the diversity and variance of measuring data (e.g. traffic volume, FCD journey speed). Measuring data records quite often include redundant signal sequences of different measuring channels. Experience with traffic networks has shown that, over certain periods of time, characteristic patterns of traffic parameters unfold, e.g. in terms of time variation curves. These patterns alter very little over longer periods of time.

For the analysis of such data records, different multivariate methods are available. Within the course of the studies carried out, singular value decomposition is applied to identify the relevant parts of information of a historical data record in the form of distinctive signatures. Original measured values from matrix A are transferred into a new coordinate system, in which one axis is pointing in the direction of the maximum variance of measured value. Information on the rotation angles can then be found in the transformation matrix U (2). The transformed measured values relative to the new coordinate system are in the scoring matrix Z (3).

$$A = VWU^T \quad (2)$$

$$Z = VW \quad (3)$$

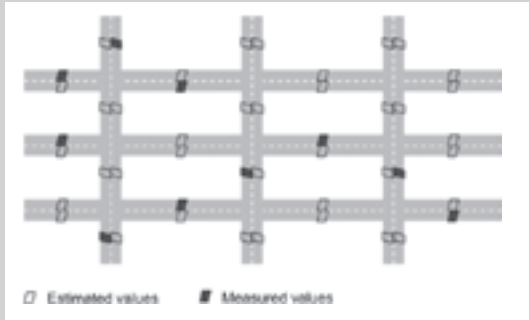
When applying the transformation to historical traffic data, the distinctive and, to a great extent, constant coherence between the actual information and the measured values are coded in U. In analogy with the time variation curves in

original measured values, distinctive signatures of certain signal characteristics, e.g. morning peak, are identified in $\boldsymbol{Z}$. These signatures are also relatively constant over a certain period of time and can be described with parameters of distribution after adequate classification. At the point of estimation, current manifestations of the elements in $\boldsymbol{Z}$ are detected with the help of $\boldsymbol{U}$ in a way that the actual available measured values can be exactly determined after reconstruction (4).

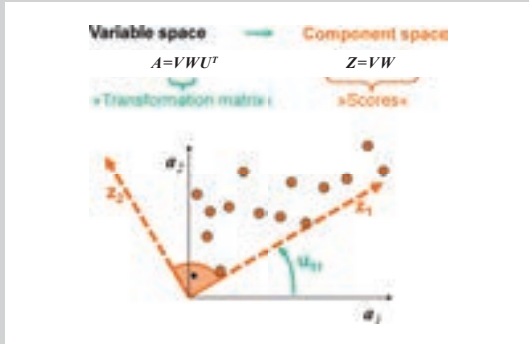
$$\tilde{\boldsymbol{A}}^T = \boldsymbol{U}\boldsymbol{Z}^T \qquad (4)$$

The data points to be estimated can be calculated with the help of the equation (2). The original optimization problem (1) is thus merging into the problem of the optimal determination of the score values in $\boldsymbol{Z}$. The solution is achieved with the help of a Maximum Likelihood Estimator.

The selection problem is formulated in a way that measuring points are detected for those sections in the network whose data contribute as sampling points to the optimal estimation of the score values. Information-theoretic considerations, whose goal is the maximization of the variance space, spanned by the vectors in $\boldsymbol{Z}$, are applied.



1



2

1 *Problem: placing sensors in the network in the best possible way.*

2 *Rotation transformation by means of singular value decomposition.*

Results

On the basis of exemplary studies with real FCD journey speed and local traffic volume measurements, the plausibility of the proposed method can be demonstrated. Even from fragmentary traffic data, e.g. fleet specific FCD sources, typical signals in traffic flow can be identified and used for the optimal estimation of defects. An interesting corollary is the observation that the method cannot only be applied for spatial, but also for temporal perspectives to optimally estimate, for instance, time variation curves.

The studies have been carried out within the project ORINOKO (FKZ: 19B4036B), funded by the German Federal Ministry of Economics and Technology BMWi, and the results have been published in the context of a dissertation.

The author would like to thank Dr. Matthias Klingner and Prof. Dr. Jürgen Krimmling.

Dr. Georg Förster
Phone +49 351 4640-682
georg.foerster@ivi.fraunhofer.de

CROSSING BORDERS

EUROPEAN COOPERATION

A key area within the 7th EU Framework Programme for Research and Technological Development (FP7) is devoted to transport-related development projects. Environmentally friendly propulsion systems and vehicle concepts for all road and rail carriers and for shipping and air traffic are being focused on. In addition, the problems of efficient coordination and linking of traffic streams; the protection of transport networks under extreme weather conditions or from terrorist attacks; the use of modern information and communication technologies in transport and the introduction of mobility concepts which are adapted to demographic changes are tackled, to name only the most significant topics.

In the past three years, the Fraunhofer IVI has been involved in eight European research projects, in many cases in the role of project coordinator, and future projects are continually being proposed. Participation in such projects is not always easy, due to geographical distances, the different mentalities of the partners and the variety of topics within the numerous interlinked work packages.

Nonetheless, European projects altogether are a great asset for the Fraunhofer IVI, as international partnerships widen our horizons, offering new possibilities exceeding and including both methodological insights and scientific and technical skills.

Conference of the European network POLIS, November 25-26, 2010: Lord Mayor of Dresden, Helma Orosz, at the exhibition stand of the Fraunhofer IVI.

»ACEM RAIL«

AUTOMATED AND COST EFFECTIVE MAINTENANCE FOR RAILWAY

Rail transport significantly contributes to European mobility, both with passenger and freight transport at national and trans-European level. To guarantee the normal operation of the whole system and to increase the safety, reliability and quality level, an efficient maintenance management for the railway infrastructure is indispensible.

ACEM Rail project deals with systems for automation and optimization of railway infrastructure maintenance. The aim is to minimize the impact of maintenance actions on rail services, to improve the infrastructure capacity and to reduce the costs, use of resources and time exposure.

The infrastructure is comprised of different subsystems which make their own demands on service and maintenance. The project ACEM Rail focuses on the following elements:

- The track and track bed, also called superstructure, which consists of the rails, sleepers, fastenings, ballast and subballast
- Switches and crossings
- Installations for electrification, signaling and telecommunications
- Engineering structures, such as bridges, tunnels and platforms.

The maintenance of all these subsystems is a complex challenge, requiring optimal planning of preventive and corrective actions. An efficient maintenance management has significant influence on the safety, reliability and quality of the services - defined through train punctuality - as well as on the capacity utilization and cost structure of modern railway companies.

Project objectives

The aim is to develop a completely automated maintenance procedure through the following steps:

- The analysis and development of several technologies to achieve an automated inspection of the track, e.g.

  - Hollow shaft integrated acoustic sensor systems
  - Non-contact thermographic testing system for rail surface inspection
  - Fibre optics sensors
  - Ultrasonic non-destructive fuzzy inspection techniques
  - Eddy current distance measurements.

  These measuring systems are integrated into conventional trains and thus inspection tasks will be made by a train on service, avoiding the need of reserving the track and the need for the extremely expensive special testing vehicles.

- The development of predictive algorithms to estimate track defect evolution:
  Automated analysis of measured data is carried out to define the necessary preventive and corrective maintenance actions.

- Design of a Decision Support System for optimal maintenance planning:
  Based on mathematical optimization models and using novel algorithms, preventive and corrective maintenance actions are planned. The aim is to achieve a cost-efficient realization without limiting rail service.

- The development of mobile technologies to assist field maintenance staff:
  The execution and monitoring of maintenance tasks will be computer-assisted through mobile applications.

Decision Support System

This subproject of the Fraunhofer IVI deals with mathematical modeling, design and implementation of optimization algorithms for the Decision Support System for optimal maintenance planning.

When planning maintenance tasks, decisions have to be made concerning

- Selection of preventive actions
- Scheduling of preventive and corrective actions and
- Provision of necessary resources for their implementation.

Track possession planning is also included. It is just these decisions which influence the service level of rail operation significantly and have to be carefully coordinated with train schedules.

Optimal planning and scheduling of maintenance actions entail some characteristics resulting from the dynamic and stochastic nature of the process:

- Corrective actions are inherently unpredictable and often come to light on-line during maintenance procedures.

- Preventive actions have to be scheduled without exact knowledge on the work to be done. Possibly a short checking is sufficient but it could yield to longsome repair work. Hence it follows that processing times are uncertain and highly fluctuating.

The design of a Decision Support System considers the following requirements:

- Rather than an enclosed, singular optimization step, the planning is a dynamic process. Solutions resulting from the planning have to be adapted permanently to new situations which are arising when new information is available.

- Rather than solutions that are optimal for the current situation, so-called robust solutions should be found. These are solutions which are flexible and effectively adjustable in case of possible future changes or new information.

Particularly the idea of robustness contributes to the achievement of the project's main goals, i.e. reducing the impact of the maintenance process on rail services.

acem_rail

SEVENTH FRAMEWORK PROGRAMME

Axel Simroth
Phone + 49 351 4640-665
axel.simroth@ivi.fraunhofer.de

»CLOSER«

CONNECTING LONG AND SHORT DISTANCE NETWORKS FOR EFFICIENT TRANSPORT

Situation

The issue of how our daily activities correspond with energy efficiency, safety and the environment is among the most discussed topics in Europe today. Mobility and transportation are at the top of the agenda when looking for potential improvements. Co-modality, that is the efficient use of different transport modes separately as well as in combination, is an essential instrument to achieve a high level of mobility while respecting environmental protection.

The existing transport system still remains far away from realizing that concept. The interface between long and short-distance transport in a door-to-door trip frequently remains the weak link in the transport chain. The current situation favors the use of uni-modal solutions by users, hindering the developments of more competitive and more sustainable transport chains.

The project CLOSER, co-funded by the European Commission within the 7th Framework Programme, deals with these problems. It started January 1st, 2010 and is running over a period of three years.

Main objectives of CLOSER

Based on existing research and practice, the project CLOSER is developing innovative tools for the analysis of interfaces and evaluate these tools in a number of case studies.

As a result, specific recommendations to stakeholders will be provided which enable a systematic analysis of interfaces connecting different modes, from planning and design to operation.

Guidelines for future transport projects aim to utilize the potential of co-modality and the territorial and economic developments more efficiently, foster cooperation between all organizations acting at the interface and describe a favorable regulatory environment. Based on EU framework conditions, improved mechanisms for the funding of those concepts with a high degree of integration are presented.

Project work

Eight partners from different European countries identify and analyze trends and their effect on interfaces. They are looking at a set of selected interchanges covering different modes, ranges and purposes and establish a number of indicators which should help practitioners to categorize the long/short distance interface issue, so that they can propose to decision makers a more standardized approach to the definition of an interface at an early stage in the project cycle. Stakeholders from politics, planning, technology or operation are identified and obstacles for the creation of an adequate solution are detected.

Role of the Fraunhofer IVI

The Fraunhofer IVI is the coordinator of the project and involved in several tasks. It is responsible for the identification of mobility trends (WP 2 New Mobility Schemes), the analysis of the state of the art, the detection of weak spots and the lookout for future trends and the respective effects. The results of an extensive literature research, including previous projects, recent publications and popular scientific articles, have been correlated and made available.

New mobility schemes

The increase in freight transport, the enhanced use of containers in transportation, as well as the orientation on low-cost airlines in passenger traffic and the rising trend of work at home and video conferences are aspects taken into consideration by new mobility schemes. Novel technologies such as electromobility, Peoplemovers and the development of bicycles to Pedelecs have been studied regarding their significance for co-modality. Problems of modality, resulting from environmental issues and trends in society, have also been considered.

Although some changes are occurring across a number of European countries, Europe cannot be regarded as a unit in this respect. Many of the above trends only partly follow a sequence based on the development state of a country, for instance its car ownership rate. Some changes can be observed in a few regions only, others occur at different times or within different parameters.

Similarly, irregular patterns can also be observed in the freight sector. In some countries, large companies rule the market whereas in other countries, a multitude of small enterprises prevail. Individual freight segments show different initial situations, problems or trends. In parcel handling, for instance, the use of computer-based solutions is widespread. In other segments however, this development is still in its infancy. Within these segments, investment was made for other areas such as fleet improvement. Therefore, it is only possible to identify trends and requirements when taking these differences into consideration.

Even within one country, the situation might not be uniform. Individual regions and municipalities can create, reinforce or slow down trends with their politics. Examples are fees for driving in a city center, environmental green zones, bicycle paths or the subsidization of public transportation. CLOSER has to take these specific characteristics into consideration.

Project progress

The results from WP 2 have been used as a basis for the following work packages within CLOSER. Another precondition for the ongoing project work was the categorization of interchanges and transshipment terminals (WP 3), which have been tested in a set of terminals, including a future scenario, and which are used for the evaluation of such interfaces. Furthermore, legal and organizational framework conditions for transportation in selected European countries were compared to each other and to EU guidelines (WP 4). The information obtained in these work packages will be verified in case studies (WP 5) and integrated into the recommendations for the design of interfaces and the operation (WP 6).

closer

SEVENTH FRAMEWORK PROGRAMME

Ingrid Nagel
Phone + 49 351 4640-695
ingrid.nagel@ivi.fraunhofer.de

»SMART-WAY«

GALILEO BASED NAVIGATION IN PUBLIC TRANSPORT SYSTEMS WITH PASSENGER INTERACTION

Finding your way within transport networks of large cities, choosing individual means of transport, changing or leaving the vehicle at any stop and reliably reaching your destination, guided by your own smartphone - all this is made possible by the mobile, real time public transport navigation system SMART-WAY. It has been developed by the Fraunhofer IVI together with seven partners from five European countries within the framework of an EC-funded project. After project-related pilots of the navigation technology in the cities of Dresden and Turin, SMART-WAY will be introduced into the market in summer 2012. Numerous well-designed information apps related to public transport are already available for many regions all over Europe. They usually provide public transport schedules, connections and network information.

Although occasionally a map with a visualization of the designated route enriched with some additional routing information has been integrated, these are not navigation applications in the strictest sense as they are already the main component of traditional road traffic systems. SMART-WAY accompanies the costumer constantly and always finds its way to the desired destination. All that is required is a smartphone, which should be GPS-ready and use an adequate data tariff. In the project, SMART-WAY is being developed for Android, but the portation to other mobile platforms will follow on request.

Starting the navigation, the first step is to find an adequate route, which can be done before departure or after boarding a vehicle. The user can enter the starting point of the trip and the destination, or use the current location to calculate a route. The navigation process is initiated aboard the vehicle. If the customer has not reached the departure station, the smartphone will show the remaining time until departure as well as the way to the station. All following stations will be announced during the trip. In addition, important points along the route, such as interchanges or exit stops, are signalized by vibration of the smartphone.

Management application

Besides system administration and maintenance of the public transport network, the management application offers the transport operator the opportunity to insert and manage network disturbances in a simple way. This information can easily be passed on to the customer's smartphone via SMART-WAY. To navigate passengers around disturbances within the public transport network, these reports are also forwarded into route finding algorithms.

High locating accuracy

Whereas in car navigation, wherein the position of vehicle and driver is identical, the differential locating of passenger and vehicle as well as the detection of the vehicle currently used have been scientific and technical challenges. In order to detect the vehicle which the customer is using, the technology »Snap Passenger« has been developed. By means of direction of movement, the stop which the passenger is currently approaching can be determined. He is thus located within the transport network and subsequently, only a limited number of vehicles are left which the customer could possibly be in.

SMART-WAY combines multi-sensor methods to achieve a precise and interference-free lane sensitive locating. For instance, the process of coming to a halt at a stop is determined by the movement pattern of inertial sensor technology, the GPS position of driver and vehicle as well as the time component (arrival time). To ensure the protection of the customer's privacy, all actual localization and navigational processes are exclusively running on the smartphone.

Advantages for customers

SMART-WAY addresses everybody: business travelers, having to find their way around in a foreign city; tourists searching for a comfortable connection between sights, hotels and events as well as regular customers wishing to travel their daily trip to work reliably and efficiently. Barriers to using public transport are lowered and passengers can move freely within the network, which will make more customers opt for these means of transportation.

The navigation application recognizes deviations and adapts respectively - analogous to car navigation. Therefore, reliable guidance from start of trip to the destination is guaranteed. Due to the connection to the operator's real time data information system, the application considers all early arrivals and delays as well as missed or incidentally occurring changes of vehicles.

Advantages for transport operators

Transport companies can profit from SMART-WAY in numerous ways. Besides the acquisition of new circles of customers, more intensive usage of the company's offers by casual passengers can be expected due to lowered barriers to using public transport. Specific personalized information about relevant disturbances in the network increase customer satisfaction. Low communication costs by using mobile internet as well as easy connection to the operator's own ICTS and schedule information systems plus the integration of the company's design are advantages which make the SMART-WAY application a profitable investment.

Andreas Küster
Telefon + 49 351 4640-667
andreas.kuester@ivi.fraunhofer.de

»STAR-TRANS«

STRATEGIC RISK ASSESSMENT AND CONTINGENCY PLANNING IN INTERCONNECTED TRANSPORTATION NETWORKS

Transport chains typically contain more than one mode of transport. Inter- or multi-modality leads to the physical and logical interconnections of different urban transport systems. The individual urban networks connect to a network of networks which is characterized by an increased vulnerability: an incident (e.g. bomb attack) in a critical infrastructure (e.g. Syntagma station, Athens, Greece) in a network ***M*** (underground network) often causes subsequent incidents, affecting components in networks linked to ***M*** (***S*** - road or bus network, ***V*** - energy supply network and ***K*** - communication network) and limiting their availability (fig. 1).

This article deals with methods and models of risk assessment which are applied in the project STAR-TRANS. The project is funded by the European Commission within the 7th Framework Programme and will be running until 2012.

Project objectives

The focus of STAR-TRANS is on the development of a framework for risk assessment at safety-related incidents, such as technical malfunctions, mass events, natural disasters or terrorist attacks. The strategic assessment tool addresses transport companies, first responders, safety officers, health authorities, civil protection, insurance companies and political decision makers. With the help of historical data and geo-referenced maps, vulnerabilities and weak points in the network of networks can be detected by means of a GIS-based approach. Incidents and their consequences on interconnected networks can be simulated and required response procedures for the management of a targeted incident can be devised. The results in the form of charts, reports or data serve as a decision basis for responsible parties or as input data for other optimization processes.

General framework

To identify vulnerabilities in traffic networks, a classification for modeling the network structure, its components and inter-dependencies is introduced. According to this, a transportation system consists of direct components of the traffic network (nodes, edges, overlaps), means of transport (road, rail, air and water vehicles) and transport demand (people, freight, institutions). Networks for energy supply, transport safety and security as well as information and communication represent indirect components. To depict incidents in interconnected assets, link types of the components are defined: physical (P), geographic (G), system-related (S) and logical (L).

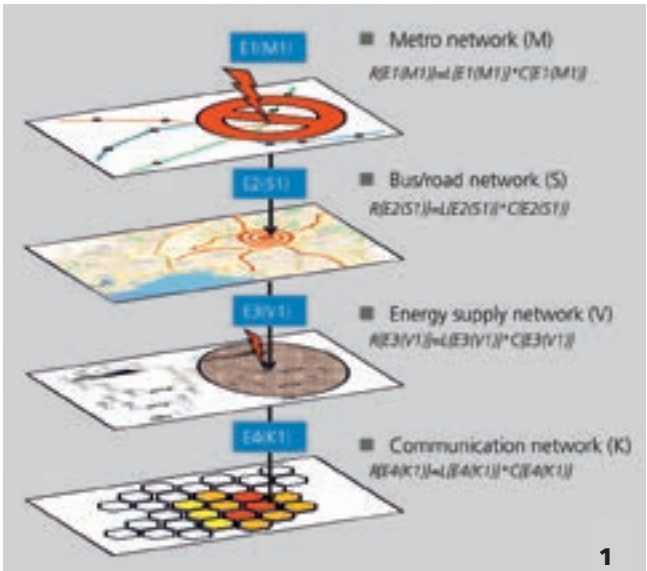
STAR-TRANS features a database of safety-related risk incidents which can have human or natural causes. Human causes can for example imply terrorism, mass or traffic accidents, whereas blizzards, earthquakes or floods are natural caused threats. The risk ***R*** associated with these events ***E*** is defined as a combination of the likelihood ***L*** and the consequences ***C*** of the respective scenario. The likelihood is calculated with the help of expert opinions and historical data and classified into a 5-stage scale (fig. 3). Consequence of a risk is defined as a measurement of the number of casualties, operational disturbances, environmental impact, economic losses or effects on society. In order to combine these calculated occurrences and to categorize the overall consequences with the help of an ordinal scale, mathematical means are applied, for instance median, maximum, mode, weighted mean or rules (e.g. fuzzy logic). The resulting risk potential is estimated using a risk matrix, the classic tool for semi-quantitative risk analysis, within a 5-class system (fig. 3). This matrix serves as a base for decision makers.

In order to also identify indirect effects, STAR-TRANS uses an input-output matrix. As figure 1 shows, the consequences of the incident E1 (input) can possibly cause the incidents E2, E3 and E4 (output). The resulting risks of these incidents are again determined with the method described in figure 2.

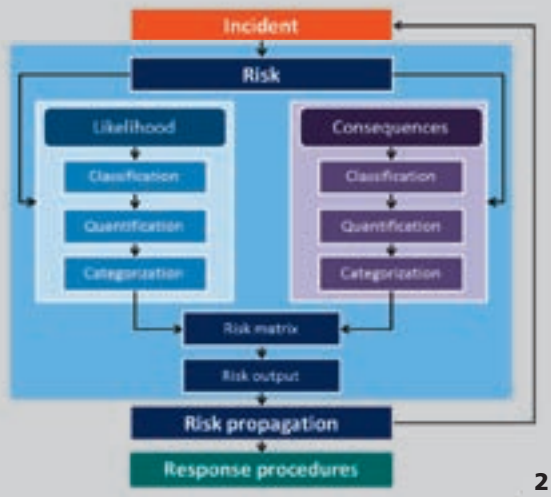
Results and outlook

As a result of the project, an innovative software tool - the Impact Assessment Tool - will be available to evaluate incidents and impacts, identify vulnerabilities in critical infrastructures, support incident management and prepare response procedures. This specialized software system, which will be made available as a web-based service, fills in the current security gap on European interconnected transport networks and supports end users' needs. Thanks to the STAR-TRANS Impact Assessment Tool system, end users will be able to see at a glance the impact of a risk management action on interconnected and interdependent transport networks through a multimedia representation, allowing them to determine alternative flows for affected elements in the transport networks.

The STAR-TRANS Impact Assessment Tool is being set up, run and evaluated during two specific demonstration activities, using the Bologna and Athens transport networks. These specific use cases allow for assessment of systems efficiency, performance, capabilities and usage. As a result, the end users have a chance to take advantage of the only risk assessment tool of its kind covering the network of transport networks.



1



2

LIKELIHOOD L	CONSEQUENCES C				
	NEGLIGIBLE	SMALL	HIGH	SERVERE	CRITICAL
VERY LOW	VERY LOW	VERY LOW	VERY LOW	VERY LOW	LOW
LOW	VERY LOW	VERY LOW	LOW	MEDIUM	MEDIUM
MEDIUM	VERY LOW	LOW	MEDIUM	MEDIUM	HIGH
HIGH	VERY LOW	MEDIUM	MEDIUM	HIGH	CRITICAL
CERTAINTY	LOW	MEDIUM	HIGH	CRITICAL	CRITICAL

3

1 *Risk propagation.*
2 *General framework.*
3 *Risk matrix.*

Stefan Tönjes
Phone + 49 351 4640-627
stefan.toenjes@ivi.fraunhofer.de

EUROPEAN BUS SYSTEM OF THE FUTURE

MODULARLY DESIGNED BUS CONCEPTS

Due to rising fuel prices and cost pressure, transport companies are increasingly forced to offer their services in a more efficient way. Costs for the operation of urban transit buses are essentially made up of expenses for staff, fuel, service and maintenance, as well as vehicle depreciation. The European research project EBSF - European Bus System of the Future -, coordinated by the UITP, has set the aim of making urban bus transit in Europe more attractive and cost efficient. One of its work packages in which the Fraunhofer IVI is actively involved deals with modularly designed bus concepts.

Bus-trailer-combinations

Urban bus networks usually feature sections with high demand, in most cases in city centers, and sections with little passenger demand. Demand is also subject to enormous fluctuations, depending on the time of day. Vehicle capacities, which are reserved for a specific route, are determined through the highest demand. Taking into account maximum time intervals between buses, many buses are underutilized. Figure 1 shows demand and capacity patterns on working days. Due to the fact that, at any time of day, a minimum schedule which is defined through certain quality aspects has to be offered, large capacity reserves open up between demand peaks and in the evening hours. Modularly designed bus concepts, made up of a towing vehicle and an easily coupleable trailer, contribute to successfully adapting the transport capacities of a bus route to the actual demand by using the trailer only at certain times of day or on certain sections of a route. Thus, fuel costs and vehicle depreciation in particular, along with service and maintenance expenses, can be lowered. In addition, the number of buses used during peak hours may be reduced, as so-called bus-trailer-combinations show a higher transport capacity than conventional buses.

Coupleable buses

Bus routes usually have more than two terminal stops and in most cases, the branching sections towards the endings show lower passenger demand than the middle sections of the route (fig. 2). Coupleable buses offer the advantage of more direct connections to and from the branched terminal stops with about the same staff expenditure. If two coupled buses have a higher transport capacity than conventional buses, services in the middle section of a route, and thus also staff costs, can be saved.

Results

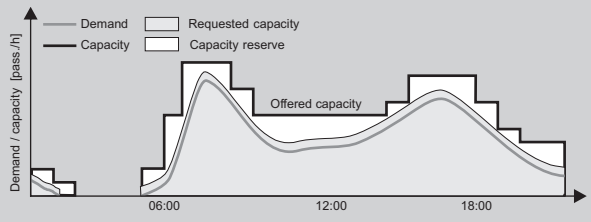
The focus of the studies was on detecting suitable framework conditions for the use of modularly designed bus concepts and the set-up of generalized requirement specifications. As bus-trailer-combinations and coupleable buses, which can be used more flexibly in city traffic, mean significantly higher procurement costs, additional calculations of allowable marginal procurement costs were necessary. The results are based on practical use cases, in which 28 existing bus routes have been analyzed in several steps:

- Calculation of the vehicle and staff expenditure in the present situation
- Creation of an alternative operational concept by using modularly designed bus concepts
- Calculation of the vehicle and staff expenditure for the alternative operational concept
- Calculations of marginal procurement costs.

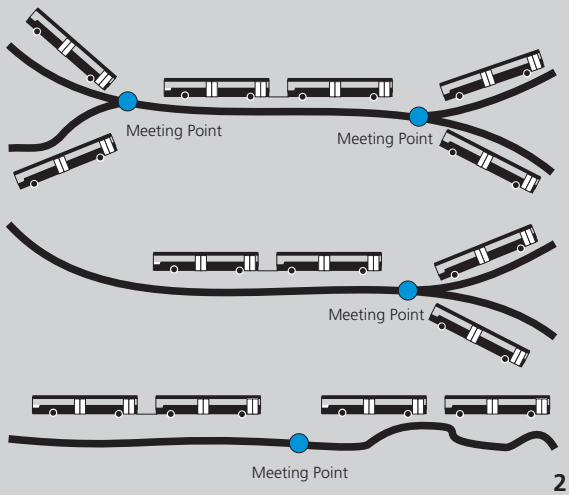
The calculated marginal procurement costs of modularly designed bus concepts are listed in figure 3. For comparison, the distinctly lower procurement costs of conventional buses are recorded as well.

Further results are listed below:

- A flexible operation of bus-trailer-combinations in urban public transport is only possible if all trailers are compatible with all towing vehicles and if they can be parked outside of the bus depot.
- The use of coupleable buses is only recommendable for routes which have an overall travel time of more than 45 minutes in each direction, because only under these circumstances can losses in working hours due to coupling be compensated.
- The share of sections operated with single vehicles must not exceed 30 percent within the total travel time of a route with coupleable buses.
- If articulated buses are to be replaced by coupleable buses, a vehicle must have ca. 75 percent of the capacity of an articulated bus.
- Coupleable buses can only be operated efficiently if they save at least 30 percent of the services compared to the use of articulated buses. If conventional standard buses are to be replaced, the amount of journeys must be divided in half.
- Routes with just one branched end can be operated more efficiently with coupleable buses than routes which have various terminal stops on both ends.
- Couplings must not take longer than two minutes, they must be performable by the driver himself and must not require special road infrastructure.



1



2

Type of vehicle	Marginal procurement costs
Bus-trailer combination	≈ 640,000 € (depending on capacity)
Coupleable bus	≈ 360,000 € (1 vehicle)
Standard bus (12 m)	none (procurement costs ≈ 220,000 €)
Standard articulated bus (18 m)	none (procurement costs ≈ 330,000 €)

3

Dr. Thoralf Knote
Phone + 49 351 4640-628
thoralf.knote@ivi.fraunhofer.de

1 *Characteristic demand and capacity patterns of a bus route (working days).*

2 *Bus routes with branched ends, modularly designed bus concepts.*

3 *Calculated marginal procurement costs.*

FROM DRESDEN INTO THE WORLD

TRADE FAIRS AND HIGHLIGHTS 2009 - 2011

Development issues about transportation and infrastructure are not only relevant to Germany or Europe, but most of all to Asian or Latin American emerging economies, in which urban settlements are growing with a dynamic intensity inconceivable to Central Europe. To face these global challenges in the future is a long-term strategic goal of the Fraunhofer IVI. The expenditure, however, in establishing lasting international contact with these distant regions is hardly ever in reasonable relation to the risk of success.

For that reason, the Fraunhofer IVI has participated to a greater degree in various international trade fairs in Germany, and also in some other countries, e.g. Malaysia. These successful participations in exhibitions as well as long-term cooperation with experienced industrial partners have brought many promising business contacts for the Fraunhofer IVI, with good prospects for extended development partnerships.

Continuative partnerships are also emerging with the Arabian market. These business contacts, which resulted from the entrepreneur trip of the Saxon government delegation, have to be strategically pursued and extended in the forthcoming months and years. However, as positive as the reactions to research and development offers of the Fraunhofer IVI might be in these distant regions, the focal points of the institute's work will primarily be oriented towards problems of transportation, vehicle engineering and infrastructure in national and European contexts.

Saxon entrepreneur trip
Abu Dhabi / Qatar,
November 21-26, 2010.

TRADE FAIRS

During the 12th international trade fair for logistics, mobility, IT and supply chain management, several Fraunhofer Institutes presented the first results for the possibilities and chances of Galileo in transport logistics.

A newly developed localization platform was introduced, allowing for the connection of indoor and outdoor locating. The user is guided optimally through the station building from when he leaves the train until he reaches the next tram or bus stop.

1 *Trade fair »transport logistic 2009«, Munich, May 12-15, 2009.*

Busworld is the world's largest trade fair for buses and coaches, taking place every other year in Kortrijk, Belgium. From 16th to 21st October 2009, about 28,000 experts from the bus industry informed themselves about new developments and trends on the bus market.

The Göppel Bus GmbH and the Fraunhofer IVI took advantage of this internationally established event and presented the innovative research project AutoTram® to the experts. Potential customers could gain insight into the AutoTram® technologies through a large-format poster presentation and numerous expert talks.

2 *Busworld Kortrijk, October 16-21, 2009.*

In cooperation with the TU Dresden (University of Technology) and the small and medium-sized enterprises Dresden elektronik ingenieurtechnik gmbh and Ingenieurgesellschaft Zuverlässigkeit und Prozessmodellierung Dresden IZP, the project WiTraM was presented at the Suissetraffic in Bern from 11th to 14th November 2009. The main focus of the exhibition display was the development of a model for the transfer of knowledge as well as the respective practical example for the control of transport nodes.

3 *Suissetraffic, Bern, November 11-14, 2009.*

Institutes, research institutions and alliances of Fraunhofer presented current results and trends under the motto »research for new energies«. The model of the AutoTram®, which had been constructed for the exhibition stand of the Fraunhofer System Research for Electromobility, attracted the interest of many visitors.

In addition, the Fraunhofer IVI exhibited a high current energy transmission system for public transport vehicles, which was developed by the institute. With the help of this vehicle, high energy quantities are to be transmitted between the wayside supply station and the energy storage system of the vehicle itself without affecting regular operation.

4 *HANNOVER MESSE, April 19-23, 2010.*

The GPEC is closed to public and specifically focuses on experts from security-related authorities such as police, border protection or state services for internal and external security matters.

The Fraunhofer IVI presented new modules of the MobiKat system, which optimizes strategic planning and operational decisions, to invited guests and other experts. Thus, new valuable contacts for future cooperative partnerships were established.

5 *GPEC - General Police Equipment Exhibition & Conference®, Leipzig, May 4-6, 2010.*

The participation of the Fraunhofer IVI at the Monorailex 2010 in Kuala Lumpur was mainly down to the results of the study »Alternative propulsion systems for monorails«, which had been carried out for the Swiss company Derap AG. A great market potential is opening up for monorails in urban areas and megacities of emerging countries and it will be useable in the future not only with conventional electric propulsion systems and power rails, but also with diesel-electric variants with regenerative braking systems.

6 *International Monorail Conference and Trade Show (MONORAILEX), Kuala Lumpur, June 3-4, 2010.*

More than 1350 exhibitors from 46 countries presented their products and services in the specialist fields of rescue, fire protection, disaster control and security at the trade fair INTERSCHUTZ, which takes place once in five years.

The Fraunhofer IVI welcomed several invited guests and numerous other visitors at the exhibition stand and a lot of interest was shown for the current developments of the MobiKat technology. New projects and orders were agreed during and after the trade fair.

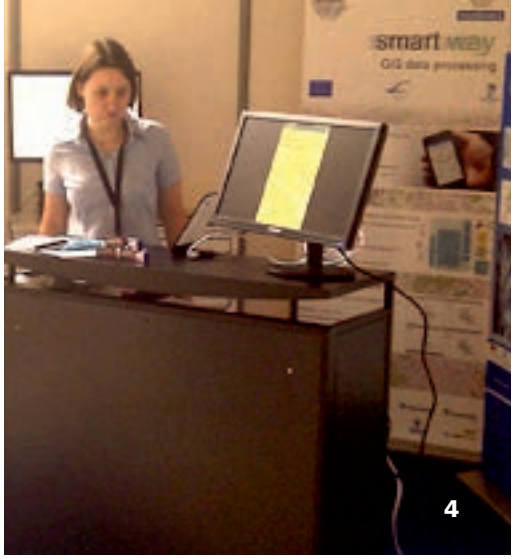
1 *INTERSCHUTZ Leipzig, June 7-12, 2010.*

InnoTrans, the International Trade Fair for Transport Technology, is an excellent platform for the Fraunhofer Traffic and Transportation Alliance to present the most recent developments to an international audience at a joint exhibition stand.

During a tour of the trade fair, the Saxon Minister of Economy, Technology and Transportation, Sven Morlok, visited the exhibition stand of the Fraunhofer IVI.

The project INNOS was presented at the joint exhibition stand of the Association of German Transport Companies (VDV). It is funded by the initiative of the Federal Ministry of Transport, Building and Urban Development (BMVBS), »Introduction and establishment of an inter-operable fare management« for public transport, »(((eTicket Deutschland«. As a project partner, the Fraunhofer IVI was involved in the development and implementation of the exhibited prototype.

2 *InnoTrans Berlin, September 21-24, 2010.*



An impressive line-up of 13 flagship international trade fairs took the stage at the HANNOVER MESSE 2011 (April 4-8) under the banner of »Smart Efficiency«. Exhibiting companies presented intelligent solutions aiming at cutting costs, optimizing process efficiency and conserving resources at every stage of the production chain. At a joint Fraunhofer stand, the Fraunhofer IVI showed the simulation environment »SmartCity«, integrated with SMART-WAY, within the exhibition »Mobility of the future«. The project was greeted with interest by private visitors as well as industrial representatives and transport operators. Following the HANNOVER MESSE, SMART-WAY was included into the central media service of Fraunhofer, leading to a high number of publications and reports in newspapers, magazines, on the radio and on TV.

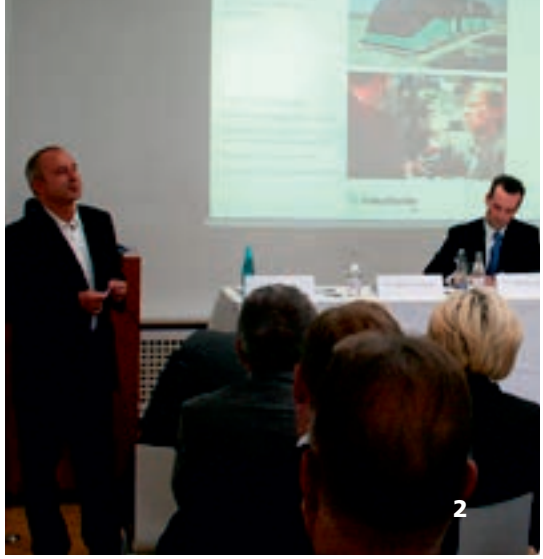
3 *HANNOVER MESSE, April 4-8, 2011.*

Lyon hosted the 8th European ITS (Intelligent Transport Systems) Congress with the main focus on »Intelligent mobility - ITS for sustainable transport of persons and goods in urban regions« in early June 2011. The Fraunhofer IVI, UPM and VTI made their way to France, which was an excellent platform for presenting the achievements of SMART-WAY in terms of the current smartphone application and the simulation environment »SmartCity«. SMART-WAY was one of the few exhibitors with a public transport focus and the project stand attracted a lot of attention. The present project staff got in touch with interested fair participants, many of whom will follow the project in the future.

4 *ITS European Congress, Lyon, June 6-9, 2011.*

The alumni association of the Faculty of Transportation and Traffic Sciences at the TU Dresden organized the trade fair »Kontaktmesse Verkehr«. The Fraunhofer IVI seized this opportunity to establish contact with students of different traffic and transportation-related subjects through an exhibition stand and presentations. Besides offering a wide range of topics for internships and study theses as well as current job vacancies, the institute informed about the field of TMC, a technology for delivering travel and traffic information. The TMC demonstrator was designed and supervised by students of the Working Group »Locating, Information and Communication«.

5 *Kontaktmesse Verkehr, Dresden, November 3, 2011.*



HIGHLIGHTS

Under the auspices of the Federal Ministry of Transport, Building and Urban Development, the German Aerospace Center (DLR) organized the second national conference on electric bus propulsion systems. The main focus of the event »The electric bus - environmentally sound and energy efficient transportation system for the city of the future« was the integral consideration of new technological developments, possibilities in town and traffic planning as well as economic aspects of trolley and electric buses with energy storages.

The series of lectures »Technical innovations for electric buses« was presented by the head of the department »Vehicle and Transport System Engineering« of the Fraunhofer IVI.

1 *Conference on electric buses, Esslingen am Neckar, June 18-19, 2009.*

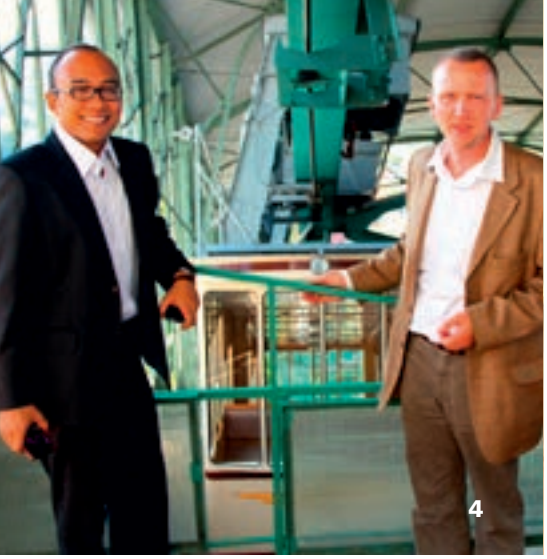
The UBS Deutschland AG hosted the second UBS Cleantech Forum in Munich on July 9th,2009. Representatives from the economy and research institutions participated in the panel discussion under the motto »Mobility of the future - How can tomorrow's society stay mobile?«. The main emphasis of the event was on lectures about technical and economic challenges of future propulsion technologies for passenger cars and public transport. Questions from the audience were answered afterwards.

2 *UBS Cleantech Forum, Munich, July 9, 2009.*

With environmentally friendly public transport as the main focus, pilot applications of electromobility are funded by the Federal Ministry of Transport, Building and Urban Development in Dresden, Leipzig and other areas of Saxony. The Fraunhofer IVI was actively involved in the design, implementation and coordination of the model project.

During the expert forum of the Saxon Energy Agency SAENA, »Saxony - Model Region Electromobility«, the Fraunhofer IVI presented results from research and development which will be piloted within the Saxon model region.

3 *SAENA (Saxon Energy Agency) - Expert Forum, February 24, 2010.*



Numerous industry contacts with system manufacturers and monorail operators were established during the Monorailex 2010 in Kuala Lumpur. Scomi, one of Malaysia's leading monorail system manufacturers, negotiated with the Swiss Derap AG and the Fraunhofer IVI about a strategic development partnership. The first visible step in these cooperation efforts was the visit of Scomi executives at the Fraunhofer IVI in Dresden.

4 *Visit of the Derap AG and Scomi, June 26, 2010.*

Within the EU project CLOSER, a workshop, in which not only project partners, but also external experts participated, was held at the Fraunhofer-Forum in Berlin. Existing and expected trends in mobility patterns of passengers and freight were identified and discussed. Their importance for the interface between short- and long-distance travel and the last mile has been outlined.

The results of the workshop were used as a basis for the ongoing work within the project CLOSER, which develops innovative tools for the analysis of interfaces and thus works out specific recommendations for the new or further development of interfaces.

5 *CLOSER Workshop, Berlin, September 27-28, 2010.*

Hosted by the Leibniz Institute for Solid State and Materials Research IWF in Dresden, Parliamentarians of the Saxon State Parliament informed themselves about the diversity of research in Saxony. Distinguished guests, e.g. the State Minister for Science and the Arts, Prof. Sabine Freifrau von Schorlemer, the President of the Saxon State Parliament, Dr. Matthias Rößler as well as representatives from the economy participated in the event. The Fraunhofer Institutes of Saxony jointly presented the results from their research under the motto »Fraunhofer - concentrated research in Saxony«. Dr. Ullrich Potthoff, head of department at the Fraunhofer IVI, successfully presented a model of the AutoTram®.

6 *Parliamentary evening, November 2, 2010.*

Lead by the deputy Minister of Economic Development, Innovation and Export Trade, Mr. Jean Séguin, a government delegation of the Canadian Province Québec visited the Fraunhofer IVI.

Although the focus of the talks was primarily set on innovations in the public transport sector, an interesting discussion about the German research landscape soon emerged. The main subject was the Fraunhofer model, which the Canadian guests believed to be a successful basis for applied research and development.

Furthermore, the cooperation of universities and non-university research institutes and their respective importance within the German research and educational landscape were discussed.

1 *Delegation from Québec, November 23, 2010.*

At Dresden's Trade Fair Centre, the Annual congress of the European transport network POLIS, »Innovation in Transport for Sustainable Cities and Regions«, took place, featuring approx. 240 experts in mobility, city and regional traffic, traffic and transport management, freight transport and traffic safety as well as representatives from politics, administration, science and economy. The congress was accompanied by an exhibition showing current developments of regional and international companies.

Lord Mayor of Dresden, Helma Orosz, visited the exhibition stand of the Fraunhofer IVI and took the opportunity to take a look at the institute's AutoTram® in the outdoor area of the exhibition.

POLIS is a European urban and regional transport network located in Brussels. It has about 70 members from 17 European countries and cooperates closely with the European Commission. The state capital Dresden has been a member of the network since 2004 and held its presidency in 2010.

2 *Annual congress of the European transport network POLIS in Dresden, November 25-26, 2010.*

3

4

At Schloss Wackerbarth, a 12-meter hybrid bus - financed by the state of Saxony and the European Union - was presented to the public. The State Minister for Science and the Arts, Prof. Sabine Freifrau von Schorlemer, participated in the ceremonial presentation (fig. 3). Simultaneously, current research topics were presented at exhibition stands, e.g. the »HandyTicket Deutschland« (fig. 4) as well as various other exhibits.

The new serial hybrid bus is the first testing vehicle of its kind for the Fraunhofer IVI which can be applied in public transportation. Various technological developments of the institute, such as energy flow control systems, storage solutions, the intelligent management of auxiliaries and the synchronous load thermal management or the quick energy reload at docking stations, which had until then only been investigated on the experimental vehicle AutoTram® in the test ground, can now be gradually transferred into practical application.

The development, design and construction of the bus were exclusively carried out in Germany. Manufacturer is the Göppel Bus GmbH, a medium-sized company, which had in the same year caused a sensation among experts when it introduced the go4city-Train. The company has been successfully cooperating with the Fraunhofer IVI for several years.

3/4 *Hybrid bus presentation, November 30, 2010.*

The EC-funded research project ACEM Rail was officially launched at the kickoff meeting on January 13th and 14th, 2011. The event was hosted by the Spanish project coordinator CEMOSA in Málaga. Together with nine research and industrial partners from five European countries, the Fraunhofer IVI is working on the development of novel methods and systems for the automated and cost efficient maintenance of railway infrastructure. After the project duration of three years, newly developed measurement devices, automated assessment methods and optimization systems for the maintenance are going to be demonstrated in a pilot application in Gargano, South Italy.

1 *Kickoff ACEM Rail, January 13-14, 2011.*

A SMART-WAY Expert Workshop was held in Dresden on January 18th. Experts from the fields of research, transportation and politics were invited to see a presentation of the SMART-WAY prototype and were asked to express their opinion on the potential, requirements and the next steps within the project. For testing purposes, the first mobile application of the SMART-WAY public transport navigation system with limited functionality has been implemented. The official start of the prototype was presented during a live demonstration bus tour within the Expert Workshop.

2 *SMART-WAY Expert Workshop, January 18-19, 2011.*

More than 40 experts and decision makers of all relevant system manufacturers attended the workshop on the R&D joint project INNOS HGS. Supported by three important German transport associations and with the Fraunhofer IVI being strongly involved, new concepts, specifications, and prototypes for the nationwide linking of e-ticket background systems in public transport have been developed in the project.

The participants informed themselves about recent results and the integration into the nationwide standard VDV core application of the initiative »(((eTicket Deutschland«. The effects on the development of e-ticket systems, on the products and systems of the companies as well as future requirements and needs of public transport companies have been discussed with reference to the project results.

3 *INNOS Industrie-Workshop, February 10, 2011.*

In May 2011, the EC-funded research project IDIRA was launched. The large-scale project is focusing on the improvement of technical and organizational cooperation of relief units at national and international level. 18 partners from eight European countries are working on practical solutions which prove their efficiency in extensive field exercises. IDIRA is funded for four years and has an overall budget of around 11 million euros. On May 5th and 6th, 2011, the kickoff meeting took place, hosted by the project coordinator Fraunhofer IVI in Dresden. The meeting featured an introduction of the partners, a description of the project management as well as a discussion of the tasks to be completed in the individual work packages.

Another highlight in the project so far was the presentation of IDIRA on the »Information Day on Interoperability« in Venice, Italy, May 19th, 2011. Besides representatives from the EC, the Mayor of Venice and the director of the Italian National Fire Corps participated in the event. Experiences in rescue services and disaster control as well as technical solutions have been presented which may improve the cooperation of different relief units.

From June 21st until June 22nd, 2011, the workshop for the IDIRA project's »End User Advisory Board«, which is going to give advice to the project partners, took place in Vienna, Austria. Users from state institutions of disaster control and civil defense as well as representatives of Red Cross societies from various countries were invited. Following a presentation of the IDIRA project, expectations about the »End User Advisory Board« were discussed.

4 *Kickoff meeting IDIRA, Dresden, May 5-6, 2011.*

On May 10th, 2011, partners of the STAR-TRANS project met at the premises of the Fraunhofer IVI in Dresden to hold the project's 3rd steering committee meeting in order to discuss the progress made in the individual work packages, evaluate the latest review by the European Commission and assess the further work to be done with respect to contractual deadlines. The project focusing on risk assessment started entering a critical phase with the development of the Impact Assessment Tool (IAT) and testing of its main outputs. The partners were able to explore the science behind the scenes in a lunch break.

5 *Project meeting STAR-TRANS, May 10, 2011.*

With the system MobiKat, the Working Group »Scheduling and Strategic Optimization« supported several large-scale operations of the fire department, rescue services, disaster control and police in 2011. Examples include the Elbe flood in January, the German Protestant Kirchentag, the FIFA Women's World Cup, the Dresden Stadtfest, the »Tag der Sachsen« in Kamenz and several fire protection and disaster control exercises. MobiKat was successfully used in practice with the support of the Fraunhofer research team.

1 *German Protestant Kirchentag, June 1-5, 2011.*

The Federal Minister of Transport, Building and Urban Development, Dr. Peter Ramsauer, the Saxon State Minister of Economy, Work and Traffic, Sven Morlok, as well as other representatives from politics, research and media visited the Fraunhofer IVI at its testing facilities. In front of the AutoTram®, the institute's technology platform for electromobility, the employees explained current developments in the field of all-electric city buses. The presentation included the topics storage technologies, efficient propulsion systems as well as recharge concepts.

2 *Visit of Federal Minister Ramsauer, August 4, 2011.*

Within the Fraunhofer System Research for Electromobility (FSEM), more than 30 Fraunhofer Institutes are working on the development of individual components and their integration in the demonstrator vehicles Frecc0 and AutoTram®. After two years of research work, the prototypes were presented on the ATP test track in Papenburg.

The project was funded by the German Federal Ministry of Education and Research BMBF with 44 million euros from the economic stimulus plans I and II.

3 *Papenburg, September 2-3, 2011.*

The event »Dresdner Lange Nacht der Wissenschaften« (Science Night) is a joint project of the city of Dresden, universities, research institutions and companies. The Fraunhofer IVI, among other Fraunhofer Institutes, participates every year, offering information and activities for both young and old.

2009
While school children were busy answering questions about traffic rules, adult visitors had the chance to test their driving skills in the driving simulator - using special glasses which simulate driving under the influence of alcohol. Staff members of the institute also informed the audience about modern steering control systems which help circumventing obstacles skillfully.

2010
In 2010, the Science Night at the Fraunhofer IVI was all about electromobility. Visitors could inform themselves about novel storage technologies or take a test drive in an e-car, which was provided by Citysax. Young visitors made AutoTrams® from paper and took part in traffic quizzes.

2011
The drawing card of the 2011 Science Night was the test vehicle AutoTram®. The institute also presented topics such as the SMS timetable information and »HandyTicket Deutschland«. A novelty for the visitors was the presentation of the SMART-WAY project. By means of a mobile application, the public transport user is guided until the desired destination - similar to the car navigation. The introduction of the application is planned for 2012.

4/5/6 »*Lange Nacht der Wissenschaften*«.

PUBLIC BODY MEMBERSHIP AND PATENTS

PUBLIC BODY MEMBERSHIP

- Saxon Innovation Advisory Board (Klingner, M.)
- Network »Dresden - Stadt der Wissenschaften« (Klingner, M.)

Transportation and traffic

- DIN-NA NI-17.11 »Identification cards/ Transport applications« (Gründel, T.)
- Working Group kontiki - Contactless smart card systems for electronic ticketing (Gründel, T.)
- DGES German Electrical Road Vehicle Association (Bartholomäus, R.)
- UITP International Association of Public Transport (Jung, U.)
- CNA Center for Transportation & Logistics Neuer Adler e. V. (Jung, U.)
- Fraunhofer Traffic and Transportation Alliance (Jung, U.; Zipser, S.)
- Fraunhofer Lightweight Structures Alliance (Schubert, J.)
- Railway Industry Cluster Saxony (BTS - Bahntechnik Sachsen) (Klingner, M.)
- Working Group AG 3.10 of the FGSV (German Road and Transportation Research Association) »Theoretical Basics of Road Traffic« (Knote, T.)
- Working Group SatNav Saxony (Jung, U.)
- Silicon Saxony e. V., applications division (Jung, U.)
- Deutsche Gesellschaft für Ortung und Navigation e. V. (Förster, G.)

Energy and environment

- Steering Committee Fraunhofer System Research for Electromobility (Klingner, M.)
- Forum on Electromobility (Klingner, M.)
- Fraunhofer Battery Alliance (Potthoff, U.)
- Fraunhofer Water Systems Alliance (SysWasser) (Klingner, M.)
- Fraunhofer Sustainability Network (Klingner, M.; Sähn, E.)
- Network »Applications of fuel cells in small vehicles«, Berlin (Klingner, M.)
- Fuel Cell Initiative Saxony (BZS) (Klingner, M.)

PATENTS

Klausner, S.; Gamsizlar, Ö.: Vorrichtung zur Herstellung eines wieder lösbaren elektrischen Kontaktes zwischen einem stationären Energieversorgungssystem und einem mittels elektrischer Energie angetriebenen Fahrzeugs unter Nutzung des am Fahrzeug vorhandenen Stromabnehmersystems.
Patent no.: DE 10 2009 023 072 A1,
Publication: December 2, 2010

Klausner, S.; Lehnert, M.: Einrichtung zur galvanischen Hochstromübertragung in ein Fahrzeug mit elektrischem Antriebssystem bei Fahrzeugstillstand.
Patent no.: DE 10 2009 013 822 A1,
Publication: September 23, 2010

Klingner, M.: Leistungssteuereinrichtung und Verfahren zum Lastausgleich eines Netzes.
Application no.: DE 10 2011 115 344.4 ,
Application Date: September 21, 2011

Wagner, S.; Zipser, S.: Verfahren zur automatischen oder teilautomatischen spurtreuen Mehrachslenkung eines Straßenfahrzeugs und Vorrichtung zur Durchführung des Verfahrens.
Patent no.: DE 10 2006 037 588 B4, 2011

Zipser, S.; Wiel, M.; Möhler, N.; John, D.: Bilderfassungssystem für Kraft- und Schienenfahrzeuge sowie Verfahren zur elektronischen Bilderfassung.
Patent no.: DE 102 00 601 4504 B3, 2007

TRADEMARKS

AutoTram®
DE 304 17 949,
Registration: June 2004

PUBLICATIONS

Amditis, A.; Bimpas, M.; Thomaidis, G.; Tsogas, M.; Netto, M.; Mammar, S.; Beutner, A.; Möhler, N.; Wirthgen, T.; Zipser, S.; Etemad, A.; Da Lio, M.; Cicilloni, R.: **A Situation Adaptive Lane Keeping Support System: Overview of the SAFELANE Approach**. IEEE Transactions on Intelligent Transportation Systems 11.3, September 2010, pp. 617-629, ISSN 1524-9050

Bartholomäus, R.; Schultheiß, E.; Steinert, F.: **Ein Verfahren zur energieeffizienten Steuerung der Geschwindigkeit und Gangwahl für ein Fahrzeug**. Internationaler ETG-Kongress 2011, Würzburg, November 8-9, 2011, presentation: E. Schultheiß

In: Proceedings, Berlin, VDE Verlag, 2011, 8 pp., ISBN 978-3-8007-3376-7

Bartholomäus, R.; Klingner, M.: **Prädiktives Energiemanagement in Hybridfahrzeugen**. 1st Commercial Vehicle Technology Symposium Kaiserslautern, TU Kaiserslautern, March 16-18, 2010, presentation: R. Bartholomäus

In: Proceedings, Berns, K. (ed.): Aachen, Shaker, 2010, pp. 95-108, ISBN 978-3-8322-9040-5

Bartholomäus, R.; Lehmann, T.; Wittig, H.: **Zuverlässige Echtzeit-Ladezustandsschätzung von Li-Ionen Batterien**. Internationaler ETG-Kongress 2011, Würzburg, November 8-9, 2011, poster presentation

In: Proceedings, Berlin, VDE Verlag, 2011, 5 pp., ISBN 978-3-8007-3376-7

Beyersdorfer, S.; Wagner, S.; Zipser, S.: **Obstacle Avoidance for Multi-Axle Steered Multi-Body Vehicles**. 56th IWK International Scientific Colloquium, Ilmenau, September 12-16, 2011, presentation: S. Beyersdorfer

In: Proceedings, Ilmenau, Universitätsverlag, 2011, 6 pp., ISBN 978-3-86360-001-3

Danowski, K.: **Wissenschaftliche Optimierungsmethoden für die strategische Planung und die operative Einsatzführung in der Gefahrenabwehr - Implementierung und praktische Anwendung**. »INFORMATIK 2010«: 40. Jahrestagung der Gesellschaft für Informatik, Leipzig, September 27 - October 1, 2010

In: Proceedings, Fähnrich, K.-P., Franczyk. B. (eds.): Informatik 2010: Service Science - Neue Perspektiven für die Informatik. Bonn, Gesellschaft für Informatik 2 (2010), pp. 137-142, ISBN: 978-3-88579-270-3

Förster, G.: **Chancen der Telematik in der Elektromobilität**. »POSITIONs 2010« Der SatNav-Anwender Kongress. Kongresszentrum SpOrt, Stuttgart, November 4, 2010

Franze, U.; Geidel, S.; Heyde, U.; Schroth, A.; Wirthgen, T.; Zipser, S.: **Evaluation of the Potential of Infrared Thermography for Automatic Animal Health Monitoring Systems in Milk Production**. 17th European Conference of Information Systems in Agriculture and Forestry, ISAF, Czech University of Life Sciences Prague, July 11-14, 2011, presentation: U. Franze

In: Conference Proceedings, pp. 38-46, ISBN 978-80-213-2189-2

Saxon State and University Library Dresden (SLUB).

Franze, U.; Geidel, S.; Heyde, U.; Schroth, A.; Wirthgen, T.; Zipser, S.: **Automatische Gesundheitsüberwachung bei Milchkühen mittels Infrarot-Thermographie**.
10. Internationale BTU-Tagung »Bau, Technik und Umwelt in der landwirtschaftlichen Nutztierhaltung«, Kiel, September 27-29, 2011

In: KTBL proceedings, Darmstadt, Kuratorium für Technik und Bauwesen in der Landwirtschaft, pp. 379-386, ISBN: 978-3-941583-55-9

Gründel, T.: **Flexible Tarife - Anwendungsmöglichkeiten, Nutzen und Hindernisse**. 5. ÖPNV Innovationskongress: Mobilitätskonzepte für Bus und Bahn, Freiburg, February 22-24, 2011

Gründel, T.: **Technische Möglichkeiten und Grenzen des eTarifs**. Impuls-Referat. 42. Kontiki-Konferenz, Hamburg, September 22-23, 2011

Gründel, T.: **Elektronische Tarife**. Nahverkehrs-Tage 2011, Innovationen in Tarif und Vertrieb, Kassel, October 13-14, 2011

Huber, R.; Jäkel, J.; Wagner, S.; Zipser, S.: **Track Estimation for Multi-Axle Steered Truck-Trailer Vehicles**. Mechatronics 2010, Swiss Federal Institute of Technology ETH, Zurich, Switzerland, June 28-30, 2010, presentation: R. Huber

Huber, R.; Röbenack, K.; Zipser, S.; Wagner, S.: **Beobachterentwurf zur Spurschätzung eines mehrachsgelenkten Fahrzeuges**. VDI-Fachtagung »Mechatronik 2011«, Dresden, March 31 - April 1, 2011, presentation: R. Huber

In: Proceedings »Mechatronik 2011«, pp. 43-48, ISBN 978-3-00-033892-2

Huber, R.; Röbenack, K.; Zipser, S.; Wagner, S.: **Fault-Tolerant Track Estimation Algorithm for Truck-Trailer Vehicles**. 56th IWK International Scientific Colloquium, Ilmenau, September 12-16, 2011, poster presentation

In: Conference Proceedings, ISBN 978-3-86360-001-3

Huber, R.; Jäkel, J.; Wagner, S.; Zipser, S.: **Track Estimation for Multi-Axle Steered Truck-Trailer Vehicles**. Mechatronics 2010, June 28-30, Swiss Federal Institute of Technology ETH, Zurich, Switzerland

In: Proceedings, 8 pp., ISBN 978-3-03-302507-3

Jäkel, J.; Huber, R.: **Spurschätzung bei mehrgliedrigen Straßenfahrzeugen**. »AALE 2010«: 7. Fachkolloquium für Angewandte Automatisierungstechnik in Lehre und Entwicklung an Fachhochschulen, Vienna, Austria, February 11-12, 2010

In: Proceedings, Malisa, V. (ed.), pp. 117-122, ISBN 978-3-902759-01-6 (Online Issue)

Jonas, K.; Klingner, M.: **Alterung von Brennstoffzellen in Fahrzeugen - Prinzipien und Analysemethoden**. In: MTZ Motortechnische Zeitschrift 72.11 (2011), pp. 908-913 Vieweg Verlag Wiesbaden, 2011, ISSN 0024-8525

Jung, U.: **Ortsbezogene mobile Applikation**.
6. Silicon Saxony Day, ICC Dresden, March 9, 2011

Keller, P.; Schubert, J.: **MONORAIL Drive System**.
MONORAILEX 2011, Las Vegas, USA, December 14-16, 2011

Klingner, M.; Potthoff, U.; Fichtl, H.: **Auswirkung der elektrischen Antriebstechnik auf die Landtechnik - was kann die Wissenschaft dazu leisten?** Kolloquium »Elektrische Antriebe in der Landtechnik«, Lehr- und Forschungszentrum Francisco Josephinum, BLT Wieselburg, Austria, July 5-6, 2011, presentation: U. Potthoff

Klingner, M.: WING-Zentrum: **Batterie - Mobil in Sachsen**. 4. Verbundtreffen Dresdner Innovationszentrum Energieeffizienz DIZEeff. Fraunhofer IWS, Dresden, November 8, 2011

Klingner, M.: **Beiträge zur Elektromobilität im ÖPNV**. »KONGRESS 2011«, Forum ElektroMobilität e. V., SpreePalais am Dom, Berlin, May 31 - June 1, 2011

Klingner, M.; Jonas, K.: **Component Specific Degradation Analysis of Running PEFCs**. Hydrogen + Fuel Cells 2009, Vancouver, British Columbia Canada, May 31 - June 3, 2009, presentation: K. Jonas

Klingner, M.: **Die Antriebe der Zukunft - Innovationen auf dem Prüfstand**. 13. EUROFORUM-Jahrestagung »ÖPNV - Mobilität 2030«, Berlin, May 17, 2011

Kingner, M.: **Einsatz von Brennstoffzellen in Schienenfahrzeugen - ausgewählte Ergebnisse des FP7 Projektes FELICITAS**. FUELLING THE CLIMATE 2011 »Klimaschutz und Schienenverkehr: Herausforderungen, Handlungsbedarf und innovative Ansätze«, Forschungs- und Transferzentrum »Applications of Life Sciences«, Hochschule für Angewandte Wissenschaften (HAW) Hamburg, May 20, 2011

Klingner, M.: **eMobility: A Solution for the Last Mile, Today?** CLOSER- International Workshop »Emerging Mobility Schemes in Terminals and Interchanges«, Fraunhofer-Forum Berlin, September 27-28, 2010

Klingner, M.: **Entwicklungen in der Elektromobilität**. Impuls-Referat, Abschlusskolloquium »Produktion für Elektromobilität«, Fraunhofer IWS, Dresden, November 9, 2011

Klingner, M.: **Fraunhofer-Technologieträger AutoTram für e-mobility Demonstrationen im Nutzfahrzeugbereich**. Forum ElektroMobilität e. V., Fraunhofer-Forum Berlin, February 3, 2010

Klingner, M.: **Supercaps in Demonstratorfahrzeugen**. Dresdner Konferenz »Zukunft Energie«, ICC Dresden, May 11-13, 2011

Klingner, M.; Potthoff, U.: **The AutoTram: A System Integration Platform of Multiple Energy Storage and Transfer Concepts**. VDE-Kongress »E-Mobility«, Congress Center Leipzig, November 8-9, 2010, presentation: U. Potthoff

Knote, T.: **Elektromobilität im ÖPNV: Nachlade- und Speichertechnologien**. enertec 2011 - Internationale Fachmesse für Energie, Leipzig, January 25-27, 2011

Knote, T.: **Energiemanagement in Bussystemen - Ergebnisse aus dem EBSF-Projekt**. Bremerhaven Bus System Day and European Bus System of the Future, VDV-Akademie-Congress, Bremerhaven, May 24-25, 2011

Knote, T.: **The Determination of Conflicting Flow Rates for the Calculation of Capacities of Minor Traffic Streams on Priority Intersections**. 6th International Symposium on Highway Capacity and Quality of Service (ISHC), Stockholm, Sweden, June 28 - July 1, 2011

In: Procedia Social and Behavioral Science 16 (2011), Amsterdam, Elsevier Ltd., pp. 642-652, ISSN 1877-0428

Knote, T.: **Schlüsseltechnologien für den elektrischen ÖPNV**. Fachkonferenz »Zukunftsorientierter ÖPNV - Der Weg zum Elektrobus«, Dresden, October 10, 2011

Knote, T.: **SaxHybrid - Hybridbusse für Sachsens Straßen**. Konferenz Elektromobilität in Modellregionen - Ergebnisse und Ausblick, Berlin, November 29-30, 2011

Knote, T.: **SaxHybrid / Stepwise Migration to Hybrid Buses in Public Transportation**. NOW CONFERENCE: »CLEAN MOBILITY INSIGHTS«, September 15-16, 2010, Berlin Tempelhof Airport

Koch, K.: **The Electric Field Gradient: A Useful Tool to Study Complex Questions in Solid State Physics/ Chemistry**. DFT meets Solid State Chemistry & 8th Tutorial Hands-on-FPLO, MPI CPfS Dresden, October 25-29, 2009

Küster, A.: **ÖV-Navigation - Wie weit sind wir bereits?** Seminar »Fahrgastinformation - Forschung, technische Grundlagen und praktische Handhabung« der ÖPNV Akademie GmbH - Institut für Personennahverkehr, Nuremberg, April 7-8, 2011

Küster, A.: **Project IDIRA - Interoperability of Data and Procedures in Large-Scale Multinational Disaster Response Actions**, 2nd International Conference on Interoperability in Rescue Services & Information Day on Interoperability, Venezia, Italy, May 19, 2011

Küster, A.: **Eine echte Navigation im ÖPNV - Vision oder Wirklichkeit?** Fachtagung »Flexible Mobilität durch innovative Kommunikationsdienste«, TU Dresden, November 24, 2011

Lehmann, T.; Bartholomäus, R.; Wittig, H.: **Electro-Thermal Modeling of Li-Ion Batteries**. VDE-Kongress »E-Mobility«, Congress Center Leipzig, November 8-9, 2010, poster presentation

Lehnert, M.: **Saving Energy by Using Energy Storage in Light Rail Sector - Potential, Dimensioning, Control Strategy**. European Convention for Sustainable Transport (Rencontres i-Trans) 2010, Lille, France, June 15-16, 2010

Michler, O.: **Herausforderungen an satellitengestützte Ortungsverfahren in der Schienenverkehrstelematik**. Cluster Bahntechnik, Telematik-Kongress 2011 »Telematik - Schlüssel zur Intermodalität«, Nuremberg, June 30 - July 1, 2011

Michler, O.; Richter, R.; Bogedain, M.; Solbach, M.; Förster, G.: **Laborgestützte Validierung von satellitengestützten Ortungs- und Navigationssystemen in der Verkehrstelematik**. NI-Konferenz »Virtuelle Instrumente in der Praxis«, Fürstenfeld bei München, October 12-13, 2011

In: Virtuelle Instrumente in der Praxis VIP (2011), Berlin, VDE Verlag, pp. 150-154, ISBN 978-3-8007-3329-3

Nagel, I.: **Experiences Gained Within the CLOSER Project**. Seminar of the EU-project HERMES »Interconnectivity & intermodality barriers of passenger transport«, Berlin, February 18, 2011

Nagel, I.: **CLOSER - Connecting LOng and Short-distance networks for Efficient tRansport**. INTERCONNECT E-Conference, May 3-9, 2011

Nitzsche, G.; Wagner, S.; Zipser, S.: **Ein Beitrag zur Stabilisierung von Lastkraftwagenzügen mit elektronischen Lenkachsen**. 15. Internationaler Kongress mit Fachausstellung »Elektronik im Kraftfahrzeug«, Baden-Baden, October 12-13, 2011, presentation: G. Nitzsche

In: Elektronik im Kraftfahrzeug (2011), Düsseldorf, VDI-Verlag, pp. 607-616, ISBN 978-3-18-092132-7

Double decker bus passing by the Frauenkirche

Partzsch, I.: **Informatik angewandt - Einblicke in die Verkehrstelematik**. Sommerakademie Informatik »IT is your turn girls«, TU Chemnitz, July 14, 2011

Partzsch, I.: **Ortungsaufgaben in der verkehrstelematischen Praxis**. Kontaktmesse Verkehr, TU Dresden, Fakultät Verkehrswissenschaften »Friedrich List«, November 3, 2011

Partzsch, I.; Michler, O.; Förster, G.; Dürrschmidt, G.: **Multisensorielle Ansätze für gleisselektive Ortung in innerstädtischen bebauten Gebieten**. DGON-SYMPOSIUM Positionierung und Navigation für Intelligente Verkehrssysteme 2011, POSNAV ITS 2011, Darmstadt, November 22-23, 2011, presentation: I. Partzsch

Partzsch, I.; Tönjes, S.: **Forschen auf europäischer Ebene - Erfahrungen aus aktuellen EU-Verkehrsforschungsprojekten am Fraunhofer IVI**. Kompetenzzentrum für operatives Verkehrsmanagement. 7. VIMOS-Tagung, TU Dresden, Fakultät Verkehrswissenschaften »Friedrich List«, December 1, 2011, presentation: S. Tönjes

Potthoff, U.: **AutoTram E-Mobility Demonstrator for Public Transportation**. Workshop »Supercapacitors: materials, processes and applications«, Fraunhofer IWS Dresden, May 6, 2010

Potthoff, U.; Rose, K.; Klingner, M.: **Netzstützende Ladevorrichtung für Elektrofahrzeuge.** VDE-Kongress »E-Mobility«, Congress Center Leipzig, November 8-9, 2010, poster presentation

Richter, R.; Michler, O.; Lüddecke, K.; Förster, G.: **Laborgestützte Validierung von satellitenbasierten Fahrzeugortungssystemen in der Schienenverkehrstelematik**. DGON-SYMPOSIUM Positionierung und Navigation für Intelligente Verkehrssysteme 2011, POSNAV ITS 2011, November 22-23, 2011, Darmstadt, presentation: R. Richter

Rose, K.; Süßenbecker, M.; Potthoff, U.: **Battery Preserving and Grid Sustaining Charging Device**. VDE-Kongress »E-Mobility«, Congress Center Leipzig, November 8-9, 2010, poster presentation

Rost, J.; Holst, T.; Sähn, E.; Klingner, M.; Anke, K.; Ahrens, D.; Mayer, H.: **Variability of PM10 Concentrations Dependent on Meteorological Conditions**. In: International Journal of Environment and Pollution (IJEP) 36.1/2/3 (2009), Inderscience Publishers, Geneve, Switzerland, pp. 3-18

Ruhren, S. von der; Partzsch, I.: **Traffic IQ - Pilotprojekt zur Informationsqualität im Verkehrswesen - Überblick und ausgewählte Ergebnisse**. Kompetenzzentrum für operatives Verkehrsmanagement, 7. VIMOS-Tagung, TU Dresden, Fakultät Verkehrswissenschaften »Friedrich List«, December 1, 2011

Schnabel, W.; Lohse, D.: **Grundlagen der Straßenverkehrstechnik und der Verkehrsplanung - Band 1 Straßenverkehrstechnik**. With contributions from: Knote, T.; Korn, J.; Lätzsch, L., Berlin, Beuth, 2011, ISBN 978-3-410-17271-0; Bonn, Kirschbaum, 2011, ISBN 978-3-7812-1815-4

Seydel, I.; Klingner, M.; Förster, G.: **Estimating Traffic Data in Traffic Networks by Singular Value Decomposition and Maximum-Likelihood**. 23rd European Conference on Operational Research, Bonn, July 5-8, 2009

Simroth, A.; Zähle, H.: **Travel Time Prediction Using Floating Car Data Applied to Logistics Planning**. In: IEEE Transactions on Intelligent Transportation Systems 12.1 (2011), pp. 243-253, ISSN 1524-9050

Simroth, A.; Souza, A.: **On an Online Traveling Repairman Problem with Flowtimes: Worst-Case and Average-Case Analysis**. In: Proceedings of the 15th International Computing and Combinatorics Conference (COCOON 2009), Niagara Falls, USA, July 13-15, 2009, Springer-Verlag, Berlin & Heidelberg, 2009, LNCS 56 09, pp.168-177

Standfuß, J.; Schedewey, R.; Nieberle, R.: **Laser Welding of Lithium-Ion Batteries for the Automotive Industry**. International Laser Symposium Fiber & Disc, Fraunhofer IWS Dresden, October 5-6, 2010, presentation: J. Standfuß

Steinert, F.; Knote, T.: **Optimierung der Betriebsstrategien von Nebenaggregaten im konventionellen Nutzfahrzeug**. 2. VDI-Fachkonferenz, Getriebe in Nutzfahrzeugen 2011, Friedrichshafen, June 7-8, 2011, presentation: F. Steinert

In: Proceedings, 20 pp., ISBN 978-3-942980-01-2

Steinert, F.: **Optimierung der Betriebsstrategien von Nebenaggregaten im konventionellen Nutzfahrzeug**. Fachkolloquium der Professur für Baumaschinen- und Fördertechnik, Dresden, June 29, 2011

Steinert, F.: **Einsatzmöglichkeiten von UAVs im Umfeld der Bergbausanierung**. Symposium »Wasser in der Lausitz«, Lauta, December 2, 2011

Tönjes, S.: **Automatisierte Identifikation von Verwundbarkeiten und Abhängigkeiten in verknüpften Verkehrsnetzen**. HEUREKA '11, Optimierung in Verkehr und Transport, Stuttgart, March 16-17, 2011

In: Proceedings, Cologne, FGSV-Verlag, 16 pp., ISBN 978-3-941790-72-8

Vetter, M.; Schwunk, S.; Armbruster, N.; Spies, P.; Lehmann, T.; Klaucke, C.: **Modeling for Determination of State of Charge, State of Health and Thermal Behavior of Lithium-Ion Batteries**. 2. Deutsches Symposium »Kraftwerk Batterie«, Lösungen für Automobil und Energieversorgung, Mainz, February 1-2, 2010

Wagner, S.; Bartholomäus, R.; Zipser, S.; Bäker, B.: **A Novel Two-DOF Control for Train-Like Guidance of Multiple Articulated Vehicles**. In: Proceedings of the ASME 2009 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference DETC2009, San Diego, California, USA, August 30 - September 2, 2009, ISBN 978-0-7918-3856-3

Wirthgen, T.: **Automatic Veterinary Health Monitoring System - VIONA**. BMT 2011, 45. DGBMT Jahrestagung, Freiburg, September 27-30, 2011, poster presentation

Wirthgen, T.; Zipser, S.; Franze, U.; Geidel, S.; Dietel, F., Alary, T.: **Automatic Segmentation of Veterinary Infrared Images with the Active Shape Approach**. 17th Scandinavian Conference, Image Analysis, SCIA 2011, Ystad, Sweden, May 23-27, 2011, presentation: S. Zipser

In: Proceedings, Heyden, A.; Kahl, F. (eds.): Image analysis: 17th Scandinavian Conference. Berlin: Springer, 2011, Lecture notes in computer science; 6688, pp. 435-446, ISBN: 978-3-642-21226-0

Wirthgen, T.; Zipser, S.; Geidel, S.; Franze, U.: **Precise IR-Based Temperature Measuring - a Case Study for the Automatic Health Monitoring of Dairy Cows**. SENSOR + TEST - IRS², Conferences 2011, Nuremberg, June 7-9, 2011, presentation: T. Wirthgen

In: Proceedings, Wunstorf, AMA Service, pp. 51-56, ISBN 978-3-9810993-8-6

Dresden Funicular Railway

Wirthgen, T.; Zipser, S.; Franze, U.; Geidel, S.; Zimmerhackl, M.: **Automated Infrared Based Health Monitoring System for Veterinary Application**. EUROSENSORS XXV, Athens, September 4-7, 2011, presentation: T. Wirthgen

In: Procedia Engineering 25, Elsevier, pp. 1405-1408, ISSN 1877-7058

Wirthgen, T.; Zipser, S.; Franze, U.; Geidel, S.; Lempe, G.: **Automatic Infrared Based Temperature Measuring System for Health Monitoring in Veterinary Applications**. IEEE SENSORS 2011, Limerick, Ireland, October 28-31, 2011, poster presentation

In: Proceedings, IEEE, pp. 1800-1803, ISBN 978-1-4244-9288-6

FRAUNHOFER IVI
LIFE AT WORK AND BEYOND









Ferry on the river Elbe

If daily work is not a burden but something that one enjoys and likes to devote time and effort to, then work can promote the personal well-being and self-esteem of each employee and also the success of the entire company.

A high priority of the Fraunhofer IVI is to create a pleasant working atmosphere, offering more freedom for private activities and supporting a trustful way of working together.

Flexible working hours, part time or telework allow employees with children to optimally reconcile work and family life. Young fathers on parental leave are nothing out of the ordinary. Joint leisure activities make daily life at the institute more attractive and varied. Hiking, bike tours or soccer tournaments are very popular among the employees.

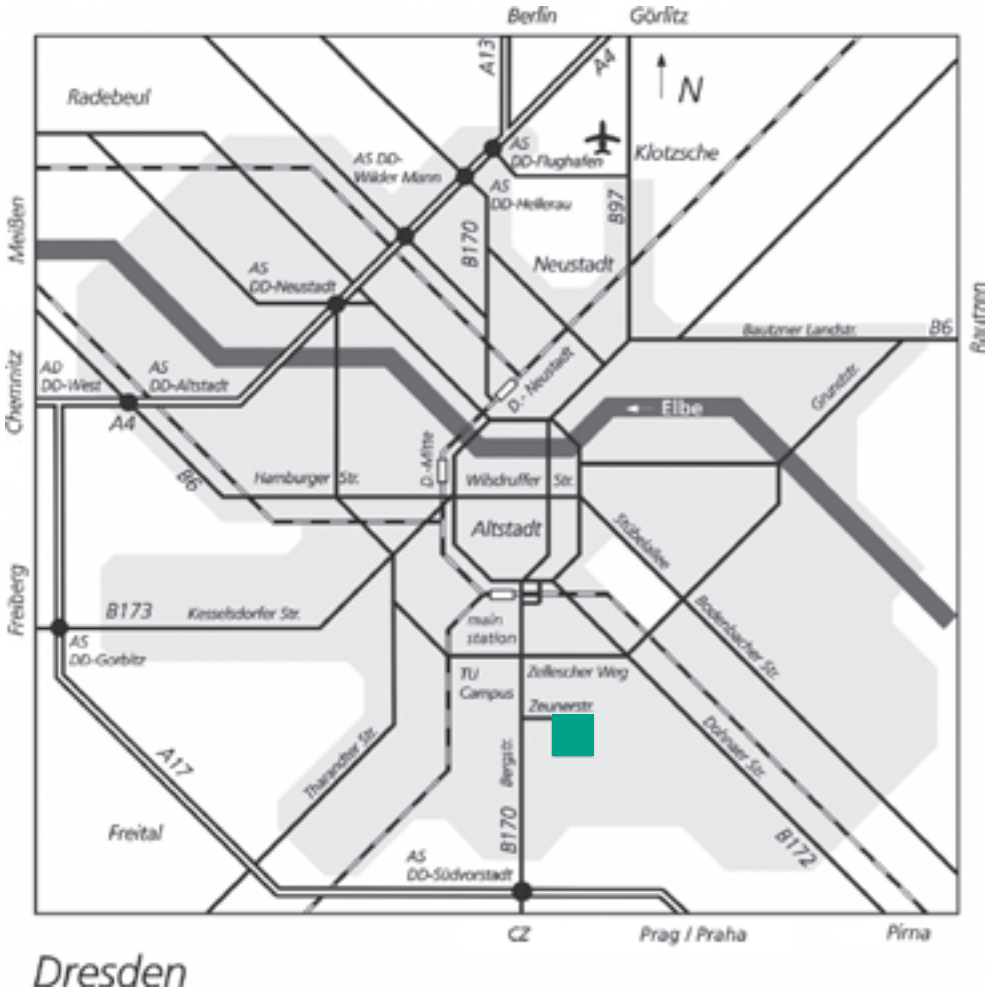
Since 2009, an annual health day has been held at the institute. The staff can inform themselves about how to best cope with stress, what strains our backs most or how road traffic safety can be improved. Besides the opportunity to receive the annual influenza immunization, employees can also participate in a cardiovascular check-up or have their blood sugar tested.

As the year comes to an end, it is time to celebrate the traditional Christmas party. The institute looks back on the past months while Santa Claus is greeted by the employees' children with fear and likewise joy. Together we have achieved our goal.

HOW TO REACH US

By public transportation

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 go for about 3 km on B170 (Bergstrasse), then take a right into 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 railway via Dresden Neustadt station to Hauptbahnhof/main station (approx. 22 minutes).

Fraunhofer Institute for Transportation and Infrastructure Systems IVI

Zeunerstrasse 38
01069 Dresden

Phone +49 351 4640-800
Fax +49 351 4640-803
www.ivi.fraunhofer.de

EDITORIAL NOTES

Fraunhofer IVI
Zeunerstrasse 38
01069 Dresden

Phone +49 351 4640-800
Fax +49 351 4640-803
www.ivi.fraunhofer.de

Public Relations
Elke Sähn
Phone +49 351 4640-612
presse@ivi.fraunhofer.de

Editorial team
Elke Sähn
Bettina Adler

Setting and layout
Gitta Neumann
Manuela Stahr

Translation
Bettina Adler

Photo acknowledgements
Elke Sähn
Manuela Stahr

Fraunhofer	p. 8/9
Frank Steinert	p. 17
HVV	p. 31/1
Barnimer Busgesellschaft (BBG) mbH	p. 37
Gerd Fischer, F&S Prozess-automation GmbH, Dohna	p. 62
Göppel Bus GmbH	p. 64/2
Jürgen Lange, VCDB	p. 68/1
Universidad de Sevilla	p. 72/1

Printed by
Stoba-Druck
Am Mart 16
01561 Lampertswalde

Phone +49 35248 814-68
Fax +49 35248 814-69
www.stoba-druck.de