Solutions for Tomorrow's Mobility

KIT MOBILITY SYSTEMS CENTER

KIT – University of the State of Baden-Wuerttemberg and
National Research Center of the Helmholtz Association

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Innovative mobility concepts: Further development of key technologies, such as alternative drive systems, lightweight construction, and energy efficiency, are on the scientific agenda of the KIT Mobility Systems Center.

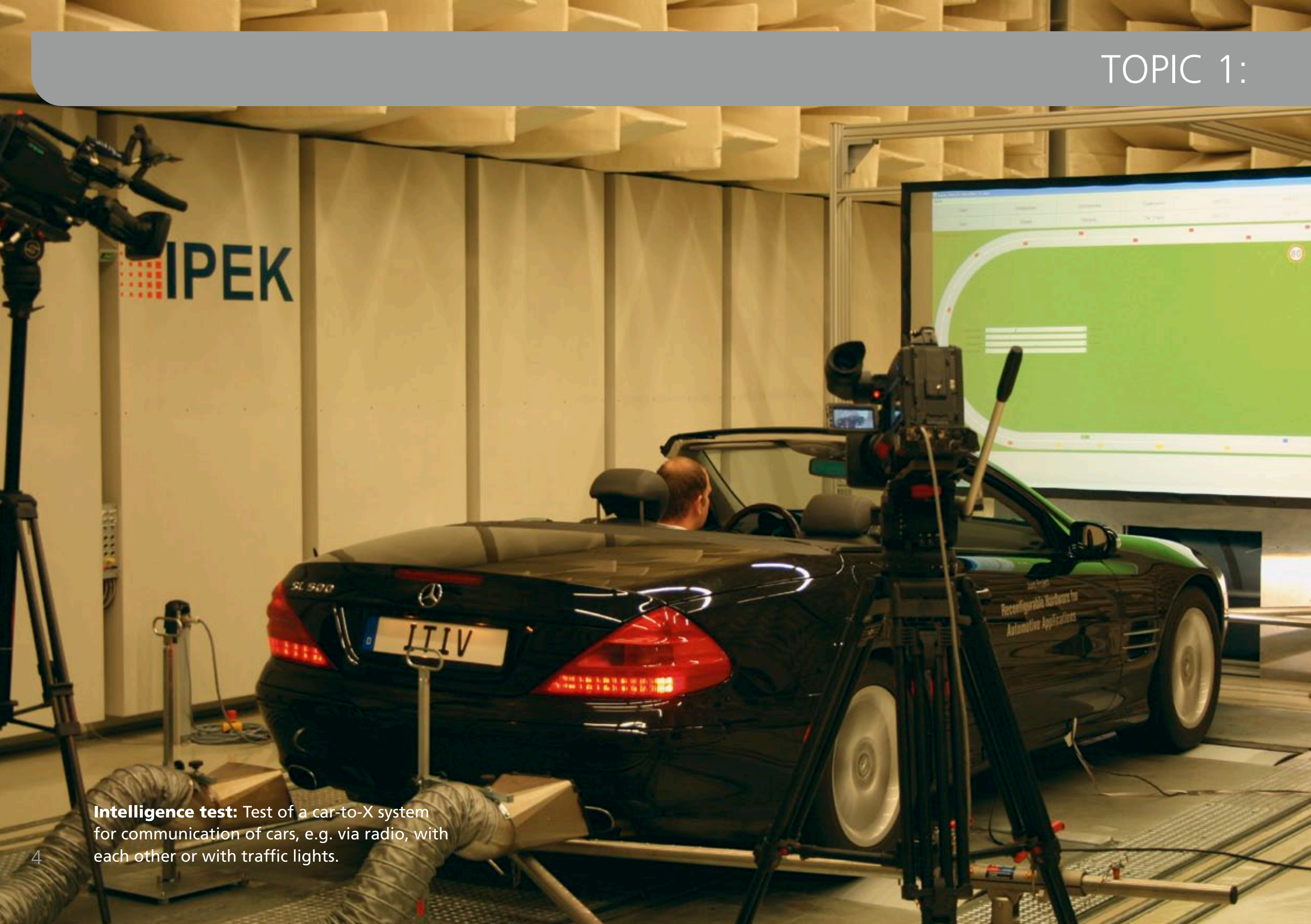
Mobility Research at Karlsruhe Institute of Technology

Compatibility of the transportation of goods and passengers with changing requirements in terms of ecology, energy efficiency, and quality of life will depend on future mobility concepts in many respects. At Karlsruhe Institute of Technology (KIT), mobility-related issues play a role in nearly all fields of research. The KIT Mobility Systems Center pools the vast competencies and resources in the field of ground-based traffic to develop multi-disciplinary solutions for tomorrow's mobility and traffic. The KIT Mobility Systems Center thus represents a major element of KIT's profile.

The KIT Mobility Systems Center features uniqueness in its approaches to systems vision and systems understanding as well as the implementation of the corresponding methods and processes. Comprehensive in-depth research is combined with interdisciplinary teaching in a consistent innovation process. This process covers the acquisition of fundamental know-how as well as the development of ideas for application, systems-oriented product development, and the fabrication of small series. In this way, the large innovation potential of KIT is strengthened sustainably and visualized to the inside and outside. Research, teaching, and innovation are the three main pillars of the KIT Mobility Systems Center. They are the basis of the successful work with research institutes, students, and external cooperation partners from industry.

The activities of the KIT Mobility Systems Center are organized in six topics:

- Drive systems
- Energy storage systems
- Chassis and body
- Build-up and manipulation systems
- Vehicle guidance, traffic routing, and logistics
- Infrastructure and society



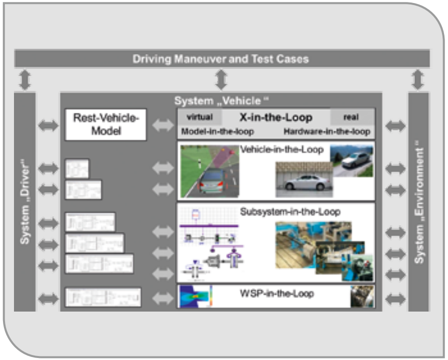
Intelligence test: Test of a car-to-X system for communication of cars, e.g. via radio, with each other or with traffic lights.

Drive Systems

Sustainable supply and conversion of driving energy in mobile systems is one of the central challenges of prospective mobility systems. The "Drive Systems" topic focuses on design methods, design processes, and technologies required to provide new, economically and ecologically prospective solutions for tomorrow's mobility.

Research concentrates on drive systems and their components, with the drive system being understood as a complex partial system that interacts with the whole vehicle. Based on fundamental, close-to-practice studies of technology demonstrators and processes, new, energy-efficient drive systems are developed up to the prototype scale.

Analysis of intrasystemic interactions e.g. between the combustion engine and vibration isolation and intersystemic interactions



X-in-the-loop framework for analysis and synthesis of complex systems.

e.g. between drive systems and chassis is the prerequisite for the development of new drive systems, including the control units, or the optimization of existing systems. The research areas are linked by validation methods and processes for analysis and synthesis of complex systems taking into account interactions with the driver and the environment.

As regards power machines, research concentrates on combustion processes and hybrid drive technologies. Appropriate vibration cancellation and isolation methods are applied. Work on power distribution, new gear concepts, as well as sliding and friction systems is aimed at solving problems of power transmission. NVH analysis and NVH design prevent undesired vibrations, oscillations, and noise taking into consideration the interactions between the drive system and the entire vehicle. Analysis of driving strategies, including operation, driving dynamics, and condition monitoring, is aimed at increasing the customer's benefit through optimized energy consumption and safety.

TOPIC 2:

Enhanced battery performance: The scanning electron microscopy shows cathode material for lithium-ion batteries, whose electrochemical properties have been improved by a special treatment.

Energy Storage Systems

Batteries, fuel cells, and storage systems of hydrogen are of central importance to future energy supply and mobility concepts doing without fossil fuels. Under the "Energy Storage Systems" topic, new materials, technologies, and design concepts for lithium-ion batteries (LIB) are developed. Their contribution to high performance is checked and optimized using special measurement methods and models. One focus is placed on innovative materials and structures. Nanocomposites, for instance, considerably enhance the insertion and extraction kinetics of lithium ions in electrodes and, hence, specific power density. Work on lithium-ion batteries, however, covers the complete chain of values added, from the selection of materials to synthesis, processing, and systems integration, to the complete battery module. In this way, comprehensive, model-based understanding of large-format batteries of high power density to be applied in future electric vehicles is acquired.

Energy storage: Test of a fuel cell.

As far as hydrogen storage systems are concerned, reversibility, specific storage density, and storage velocity are of crucial importance. Reversible storage of hydrogen in solids provides for a higher safety than pressurized gas storage, whereas storage capacity remains to be increased and loading times will have to shortened. Novel stores made of nanoscaled hydride composites are rather promising in this respect. To check their suitability for everyday use, they are combined with fuel cells and subjected to safety tests.

Fuel cells are important components of future hybrid concepts, as they are highly efficient converters having the potential of supplementing or even replacing the combustion engine and, thus, of drastically reducing the consumption of fossil fuels and carbon dioxide emissions. Development of physically based models for integration in real-time algorithms will allow for future on-board diagnosis and lifetime prediction of these complex electrochemical systems.

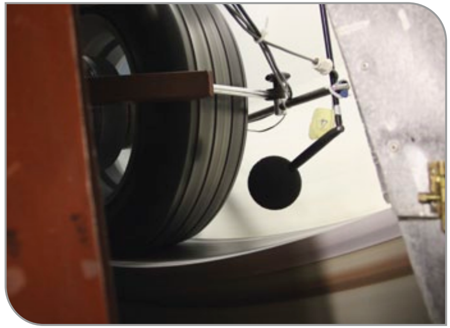
Technology in competent hands: With the help of universal, modular hardware and software for measurement data acquisition and control tasks, engineers test novel driver assistance systems in a test vehicle.

Chassis and Body

Various research activities relating to the complete vehicle and in particular to the chassis and body of the vehicle are pooled under the "Chassis and Body" topic. Here, solutions are developed in the fields of safety, energy efficiency, driving behavior, and user friendliness, including NVH (vibration and noise). It is focused on interactions of individual components in the vehicle as a mechatronic system, on driver-vehicle interaction as well as on the vehicle and its mobility environment. Methods are developed to handle systems interactions in the vehicle development process. Such methods require in-depth studies of the component behavior and physical mechanisms.

Complexity of the total vehicle system is reflected by the large number of issues covered: General aspects like vehicle concepts, operation strategies, and energy management are studied as are the interaction between tires and road surface or concepts for chassis, suspension, damping, steering, brakes, electric/electronic architectures, light, ventilation, and air conditioning systems. Research also focuses on innovative lightweight materials and their use in vehicle development or lightweight construction.

Thanks to their comprehensive, application-oriented work, the institutes working under the topic of "Chassis and Body" are attractive cooperation and research partners of industry. Multidisciplinary cooperation results in a systems competence that is hardly matched by other, also international universities in terms of depth and comprehensiveness.



Noise test: The tire-road noise is studied in the tire test rig.

Optimizing systems: Scientists at KIT develop technologies to enhance energy efficiency and performance of mobile machines like the machine for specialist foundation engineering shown here.

Build-up and Manipulation Systems

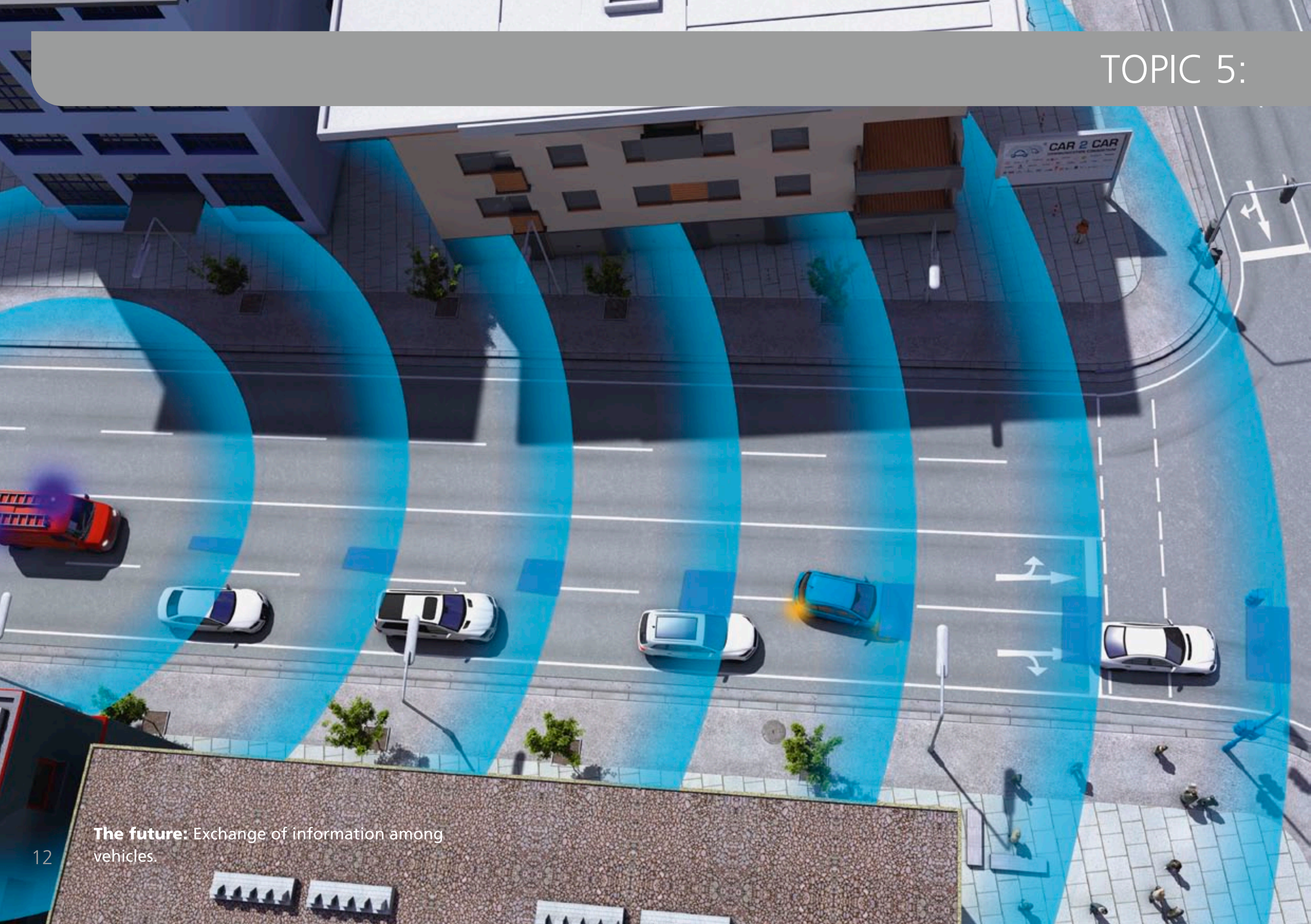
Under the "Build-up and Manipulation Systems" topic, research concentrates on technologies for the use and operation of build-up and manipulation systems and the fabrication or industrial production of these systems. The topic covers a very wide scientific field extending from field robotics or drives to general production technologies and process engineering. In these core areas, the technologies to be studied and development are subject to the same boundary conditions. They include, for example, energy efficiency, automation and the possibility of automation, ergonomics and its effectiveness, flexibility in terms of numbers of pieces and models, reproducibility, and quality or quality assurance.

Functional test: Subsystems of vehicles, such as the suspension of the front axle of a tractor shown, are installed in a test rig for measurements.

The following fields of research are covered:

- Working functions of mobile machines: Hydraulic, electric, and mechanical systems;
- Autonomous systems and field robotics: Recognition of the environment, approaches to automation, and intersystemic communication;
- Mechatronic mobility systems: Wireless energy and information transfer, man-machine interface, simulation technology, and condition monitoring;
- Production engineering: Metal and plastic lightweight construction, flexible production in terms of numbers of pieces and models, quality assurance, and production process development.

Working on the associated complex, multi-technology problems requires interdisciplinary cooperation. Interconnection of production, operation, and technology development for mobility systems results in clearly defined, comprehensive competencies that are offered to potential cooperation partners from industry. Based on these competencies, tasks of industry can be solved directly in an application-oriented and target-specific manner.



The future: Exchange of information among vehicles.

Vehicle Guidance, Traffic Routing, and Logistics

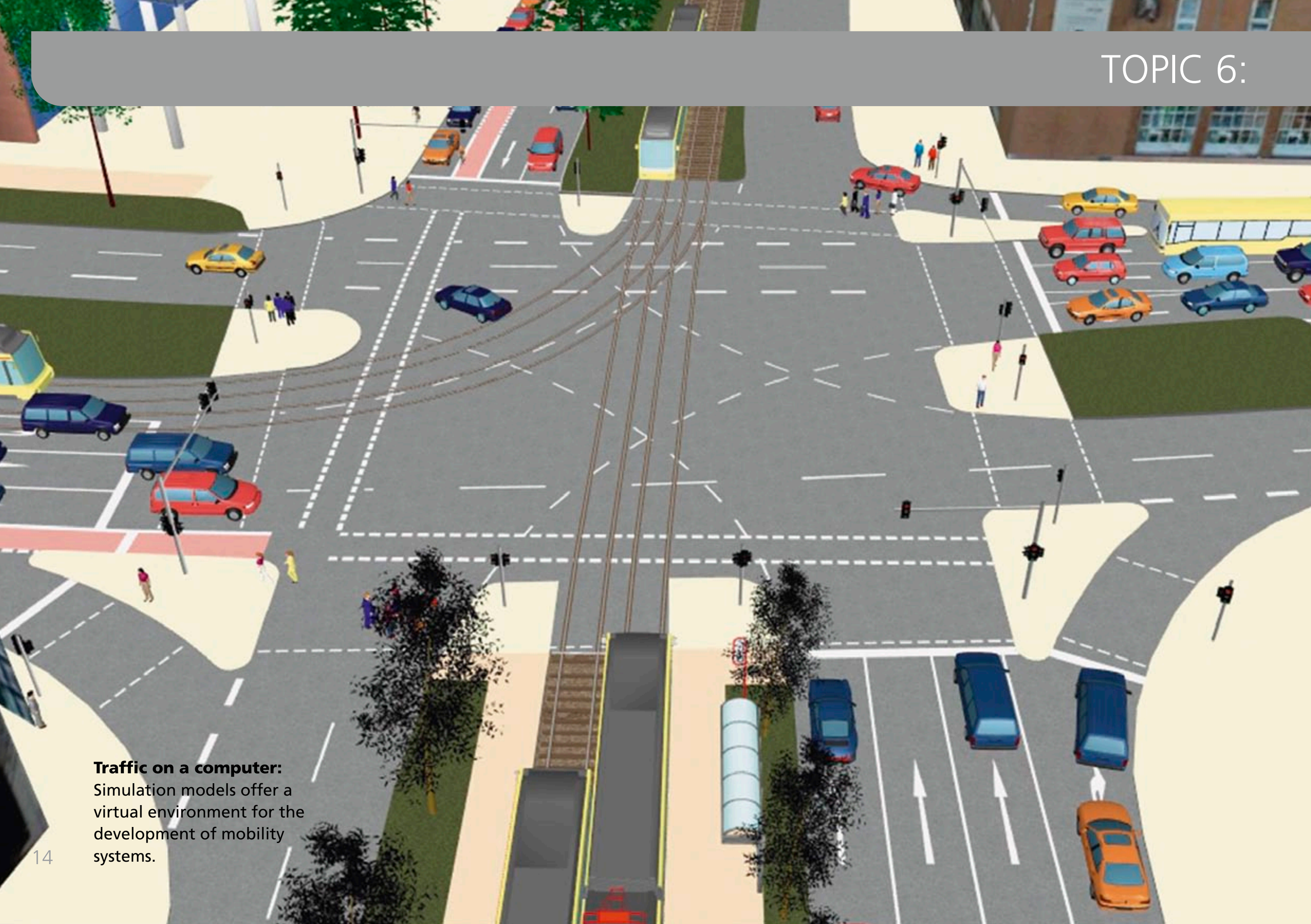
The topic "Vehicle Guidance, Traffic Routing, and Logistics" focuses on the methodology required to make all decisions needed for an efficient and safe control of vehicles, traffic flows, and logistics systems. For this purpose, the goals have to be known, the environment must be analyzed, and action options and effects have to be described. Hence, acquisition and processing of these data, the corresponding sensors, and measurement methods are of major importance.

The topic covers both methods for automatic decision-making as well as the support of the people's decisions. People have to be enabled to make good decisions. As the resources available to existing mobility systems for energy generation are limited, it is not only required to open up new and renewable energy sources, but also to enhance the efficient use of existing energy. This includes the selection of appropriate transport means, optimization of their use, selection of efficient routes, recognition of the environment by sensors and automatic interpretation, and influence on the driving behavior to enhance energy efficiency. Individually controlled in-plant and ex-plant traffic is associated with a high hazard potential. For this reason, vehicle guidance and traffic routing will be supported to ensure safe and eventually autonomous driving.

Completely autonomous: The KARIS transport system can communicate and navigate autonomously in space.

To reach these objectives, cooperation of researchers from various disciplines, i.e. of mechanical engineers, electrical engineers, construction engineers, and economists, is required.

TOPIC 6:



Traffic on a computer: Simulation models offer a virtual environment for the development of mobility systems.

Infrastructure and Society

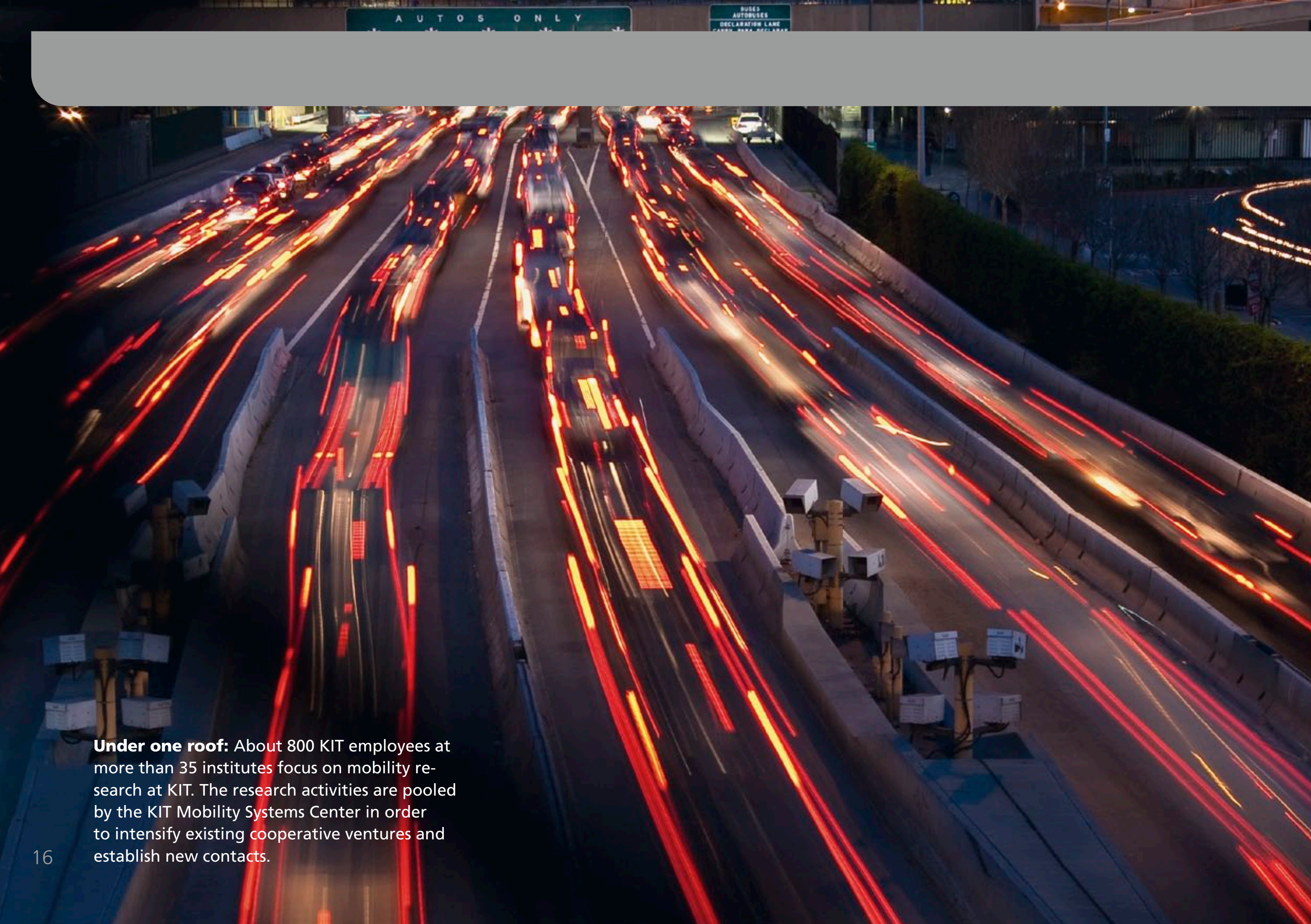
Mobility requires a high-performance infrastructure. Supply of transport routes determines the life of the people as does their need for mobility of all types. The "Infrastructure and Society" topic covers the construction, maintenance, and operation of infrastructural facilities as well as interactions of the infrastructure with mobility systems and their users. Apart from scientific analysis, it is aimed at optimizing the complete system of man – mobility system – infrastructure.

Mobility systems are analyzed in their real environment under the boundary conditions of traffic infrastructure. In addition to purely technological aspects, acceptance of innovative mobility systems by society is considered. These activities have a major share in the central KIT studies of the impact of technology on society. The basis is empirical mobility research. Specific observation and interviews of persons provide major mobility data as well as detailed insight into individual decision behaviors of the travelers. Economic studies and analysis and prognosis of transport policy complement the activities.

The interaction of supply and demand in the transport sector can be reproduced on various scales by simulation models. One model can determine the effects of a tram having priority at a certain intersection, another model might assess extensions of highways in the national context.

Ground-based traffic needs carrier systems that are loadable, safe, silent, efficient, and durable. Materials for concrete and asphalt roads are subject of research as are production processes associated with the construction of roads and railways and the technical and economic optimization of their operation and maintenance.

Mobility needs infrastructure: Construction and maintenance of traffic routes are optimized.



Under one roof: About 800 KIT employees at more than 35 institutes focus on mobility research at KIT. The research activities are pooled by the KIT Mobility Systems Center in order to intensify existing cooperative ventures and establish new contacts.

The KIT Mobility Systems Center

About 800 employees at more than 35 institutes partly or completely focus on aspects relating to mobility. The KIT Mobility Systems Center pools these mobility systems research activities at KIT and, thus, intensifies existing cooperative ventures and establishes new contacts. The projects and clusters associated with mobility research are already operating. Now, they are united under the roof of the Center that is structured as a "dynamic holding model" and, hence, represents an efficient basis. The six topics are jointly represented in the Steering Committee that is responsible for technical and scientific coordination. It is represented by the scientific spokesman. As an operative unit, the office has been established.

By means of this structure, cooperation of the institutions and facilities involved can be intensified considerably. At the same time, the information available is put on a broader basis. A competence map devel-oped by the Center allows for the retrieval of comprehensive data and facts about mobility research inside and outside of KIT and for the update, maintenance, and extension of the know-how developed at the different institutes. Efficient use of existing resources is enhanced sustainably by the Center's work. The

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KIT Mobility Systems Center is the visible contact point for industry partners and public institutions.

Karlsruhe Institute of Technology (KIT)

Karlsruhe Institute of Technology (KIT) is the merger of Forschungszentrum Karlsruhe, member of the Helmholtz Association, and Universität Karlsruhe (TH). KIT has a total of about 8800 employees and an annual budget of EUR 650 million.

The merger into KIT gave rise to one of the biggest research and teaching institutions worldwide, which has the potential to assume a top position in selected research areas. It is aimed at establishing an institution of internationally excellent research in natural and engineering sciences, outstanding education, promotion of young scientists, and advanced training. KIT closely cooperates with industry as an innovation partner. It is a leading European energy research center and plays a visible role in nanosciences worldwide. KIT focuses on the knowledge triangle of research, teaching, and innovation.

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