RWTHAACHEN CAMPUS
SMART LOGISTIK

Digitally Connected Enterprises

Initiator

FIR at RWTH Aachen University

The Institute for Industrial Management, FIR for short, is a non-profit, inter-sectoral research and educational institution at RWTH Aachen University concerned with business organization and information logistics with the aim to establish the organizational basis for the digitally connected enterprise of the future. By developing and transferring innovative solutions, FIR contributes to enhancing the competitiveness of companies. This is achieved within an infrastructure that is ideally suited for experimental organizational research – methodologically sound, scientifically rigorous, and conducted in close collaboration with experts from business and industry.

The institute supports companies and provides research, qualification programs and lectures in the fields of business transformation, services management, information management, smart work and production management.

As a Johannes Rau Research Institute, FIR supports the research strategy of the Federal State of North-Rhine Westphalia (NRW) and participates in state clusters to strengthen NRW as a hub of research and innovation. As a member of the German Federation of Industrial Research Associations, FIR promotes research and development for the benefit of small, medium-sized and large enterprises.

Vision

Digitally Connected Enterprises

Around 500 company employees and scientists have been collaborating at the Smart Logistics Cluster to realize concepts and solutions for the company of the future since 2012. The business of the future uses the potential of digitization for a comprehensive integration of information and communication technologies with production – in short: Industrie 4.0. Crucial to the success of Industrie 4.0 are intelligent logistics, which organize the demand-driven flow of goods, commodities and information along the value chains. These complex contexts are researched at the Smart Logistics Cluster, brought to life and made tangible, and are tested and implemented directly in practical environments. This is considered a prerequisite for meeting demands for maximum process efficiency and maximum productivity, while meeting the needs for sustainability, as well as climate and environmental protection.

The various centers of the cluster collaborate actively with industry representatives in the following fields of application:
- Industrie 4.0 for manufacturing companies
- Smart Services and Smart Products
- Business model innovation
- Future logistics
- Business applications
- Mobility
- Buildings

Central Research Objectives
- The use of data for a systematic transformation of businesses in the direction of Industrie 4.0.
- The development and expansion of profitable digital businesses, which includes innovation, development and market launch of new digital products and services, as well as viable business models.
- The establishment and testing of a sensor-based infrastructure with an unlimited number of Internet IP addresses, fast data transmission via e.g. 5G, cloud computing, as well as IT service platforms that reflect real conditions much better than traditional test environments.
- Design, further development and implementation of integrated business applications (ERP, MES, …) that support and optimize the production process of the future.
- Development and implementation of new digital business models, management and utilization concepts for commercial real estate of the future.

Mission

The complex interrelationships in logistics, production, services, mobility and buildings are made tangible and explorable in the Smart Logistics Cluster, enabling companies and institutions to participate in the potential of digitization in the best possible way while undergoing their own successful digital transformation.

The concept of the **digital transformation** of enterprises, used in this context, is strongly marked by four developments:

1. The **omnipresent social connectedness of individuals**, which has led to an unforeseen level of information exchange and a vast accumulation of knowledge in communities and forums.

2. This development is complemented by the **exponentially increasing interconnection of physical objects** subsumed under the concept of Internet of Things. Through this connectedness, massive amounts of data on the conditions of technical objects and systems are provided. Furthermore, data analysis and interpretation results in a massive increase in knowledge and enables a completely new basis for predictions and decisions.

3. The emergence of **new software and IT architectures** can be seen as the third major development. Turning away from local, monolithic systems to distributed, but fully integrated systems in the cloud facilitates the implementation of an explicitly unique and redundance-free database concept and prevents versioning conflicts. New database architectures and in-memory processing techniques make it possible to perform database operations and analytics in near real-time.

4. The forth decisive development is due to technological progress in the areas of **data transmission** and networking technologies. New transmission techniques and standards such as 5G make it possible to achieve unprecedented bandwidth efficiency and thus high transmission speeds and a more efficient use of available bandwidths.

These four trends describe, in particular, developments in the area of information and communication technology that enable people as well as machines to connect, integrate software systems, process data in real-time, and transmit data and content of any kind with – in the near future – basically unlimited bandwidth and speed.

The four developments outlined above will be supplemented by data analysis techniques to process big data. Using augmented reality techniques, decision-relevant information will be integrated into the work process. Moreover, data analytics and machine learning capabilities provide the foundation for new data-based services and business models.

The interplay of these developments and technology trends not only raises the question of which innovative services and products will be offered in the future and how they will be developed, but also which **types of enterprise and organizational structure** are emerging in the process. Moreover, new roles and job requirements are emerging as part of the development of new **organization and information architectures**. Both the significance and the self-conception of work will change and result in new forms of work organization. From a results-oriented perspective, the new, emerging services and structures can be understood to result from digital transformation. When developing and implementing new offerings, speed is a key factor for competitiveness. Aside from the results-oriented dimension, the question of what
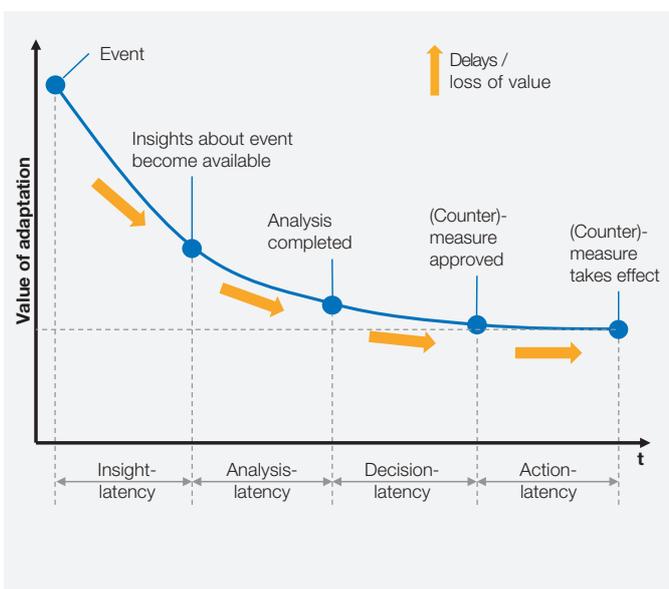
organizational forms – in interplay with **information systems** – will be able to achieve speed and agility is of central importance. The ability to control and reduce latency periods will become a relevant criterion of competitiveness.

Against this backdrop, the overarching goal of the digital transformation of companies is to create a learning, agile enterprise which, based on suitable IT-based technologies and the capability of organizational learning, is able to adapt to changing market framework conditions.
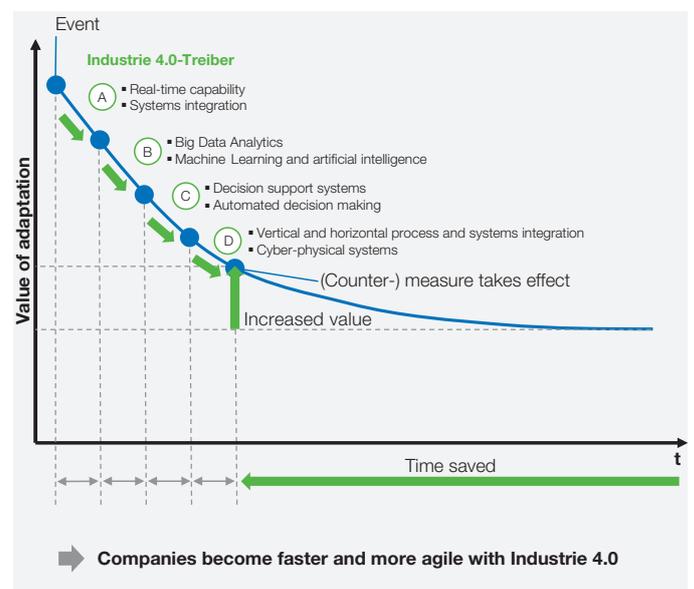
The ability to process and interpret data offers entirely new perspectives on the design of business models as well as production and logistics systems. The traditional understanding of a product as a tangible good at the center of the market offering is replaced by a perspective which understands the product as a platform for services.

In this context, the Aachen approach of the **Internet of Production** plays a decisive role. The Internet of Production is the central enabler of an increase in agility of

Adaptation processes in the company

Event

Delays / loss of value

Insights about event become available

Analysis completed

(Counter)- measure approved

(Counter)- measure takes effect

Value of adaptation

Insight- latency

Analysis- latency

Decision- latency

Action- latency

t

Organizational learning: Improving the benefits of the adaptation process

Event

Industrie 4.0-Treiber

A
- Real-time capability
- Systems integration

B
- Big Data Analytics
- Machine Learning and artificial intelligence

C
- Decision support systems
- Automated decision making

D
- Vertical and horizontal process and systems integration
- Cyber-physical systems

(Counter-) measure takes effect

Increased value

Value of adaptation

Time saved

t

Companies become faster and more agile with Industrie 4.0

Digital, agile companies outperform traditional companies due to reduced latencies

Mission
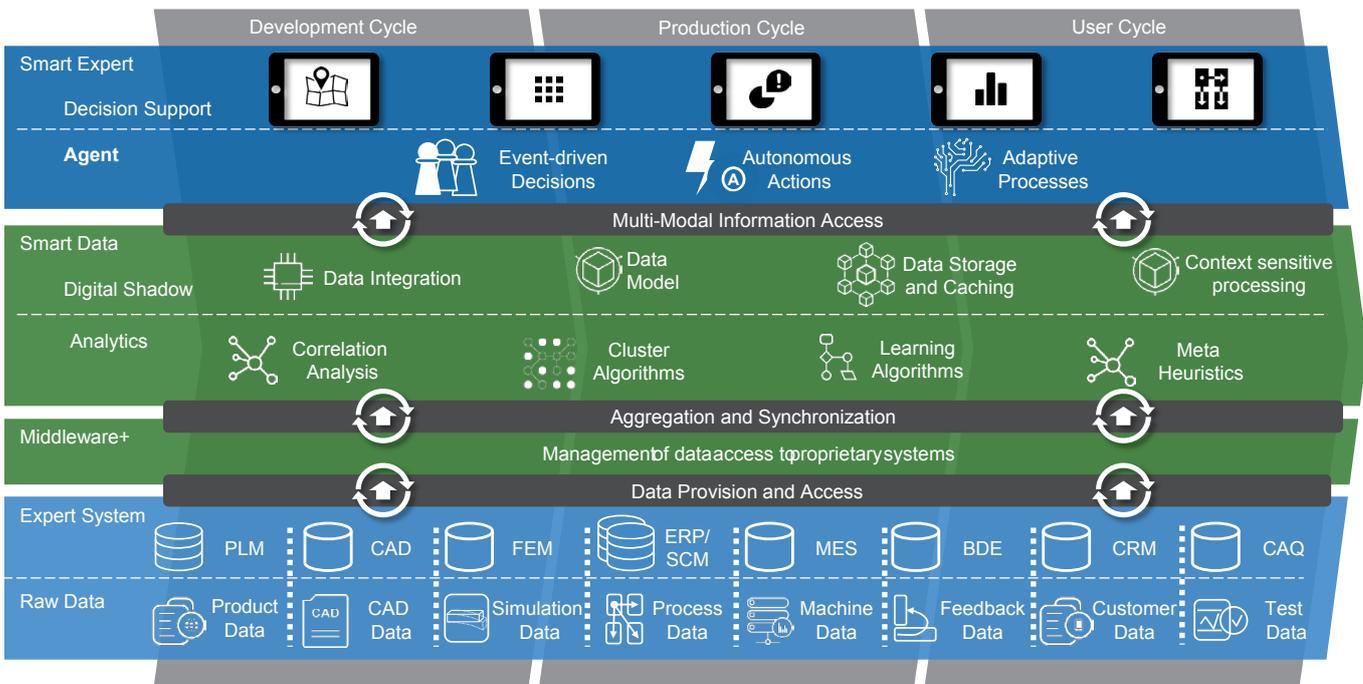
Infrastructure of the Internet of Production – IoP

manufacturing companies. Agility is the strategic ability to open up new markets – predominantly proactively. This requires the introduction of highly iterative development processes in the development cycle and the establishment of proactive, adaptive production systems in the production cycle. In the user cycle, new forms of business opportunities are emerging, e.g. in the form of data-based services, the so-called Smart Services.

The consistent application of the Internet of Production principle enables companies to make faster, informed decisions on issues that require data and information from different domains. In this context, the Smart Logistics Cluster is developing concepts and solutions for an efficient information logistics.

The Smart Logistics Cluster predominantly applies the Internet of Production paradigm to the following industrial use cases: Smart Mobility based on the e.GO electric mobility concept, Future Logistics, Smart Maintenance, Smart Services, and Smart Commercial Buildings.
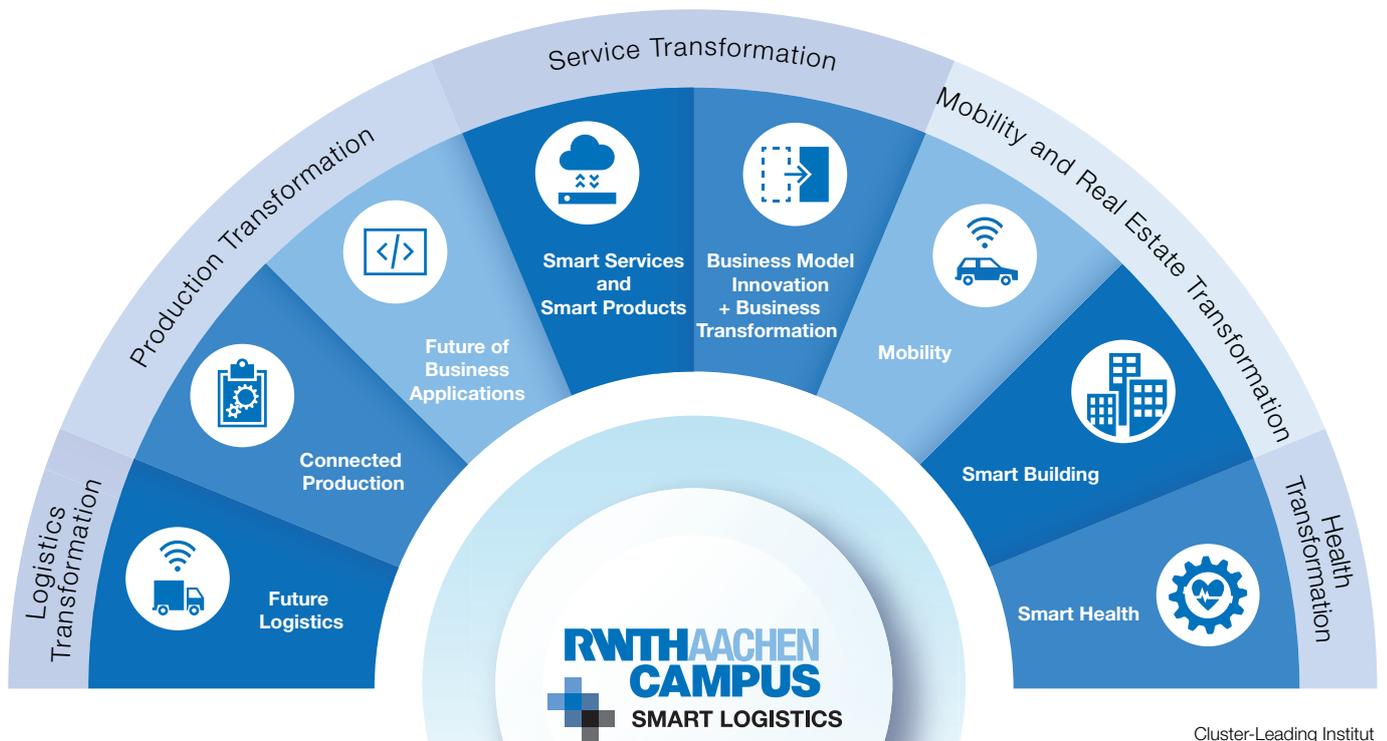
Strategy

**Logistics in a Cyber-Physical World –
Information Logistics**

The Smart Logistics Cluster is one of the six initial clusters on Campus Melaten. Already today, more than 500 individuals from science and industry conduct research and develop solutions on how goods and information can be optimally connected in the digital world of tomorrow.

The cluster understands the term "logistics" in a much wider sense than its traditional usage: RWTH's researchers and their partners from industry jointly investigate the entire flow of goods and information within a digital world that is soon to be connected in near real-time via the internet. This approach is captured by the term Information Logistics. Within the cluster,

various centers are working conceptually and experimentally with both supplier and customer companies to investigate the potentialities and implications for manufacturers, service providers, logistics companies, and ICT suppliers.

Sensor-equipped production machines, tools and facilities, sensor-equipped load carriers and workpieces, an unlimited number of internet IP addresses, fast internet access and real-time-capable mobile and landline communication coupled with cloud computing and IT service platforms create an infrastructure that is unique in Europe and comes significantly closer to real-world scenarios than traditional test environments. The

CENTER CONNECTED INDUSTRY

INTEGRATED BUSINESS APPLICATIONS

SMART COMMERCIAL BUILDING

SERVICE PERFORMANCE CENTER

EUROPEAN 4.0 TRANSFORMATION CENTER

Cluster-Leading Institut

fir at
RWTH Aachen University

Infrastructure:
Demonstration Factory as Digital Experience Factory
Electromobility Lab & e-Charging Park
Innovation Labs and Theme Park
Marketing Services & Conference Center

complex interplay of components in such an infrastructure must be aligned, coordinated and tested in order to increase productivity in real-life industrial application.

Under the rubric of "Industry 4.0" or "Internet of Things (IoT)," the integration of system environments is currently being pursued by industrial companies worldwide. Particular problems are posed by the heterogeneity of IT systems and the lack of interoperability of data, which are both barriers to achieving increased productivity. On this account, the Smart Logistics Cluster investigates how different system environments can be integrated and data repositories homogenized to facilitate the further automation of processes.

Integrated data and systems can be optimally combined and connected with physical objects, such as machines and products. Sensors and automation enable the merging of the physical world with the world of information. The result will be huge leaps in productivity and the emergence of new business models and services, offering vast opportunities for growth. To tap this potential, the Smart Logistics Cluster operates three Innovation Labs and a Demonstration Factory, all of which address questions surrounding the integration of IT systems, their connection with real machines and products, and the implementation of new business models and "Smart Services."

The objective is to shape the company of the future, an agile, learning enterprise that is largely understood as an information-processing system. Addressing questions surrounding the processing and preparation of data and their targeted use in terms of an Information Logistics are at the heart of the cluster and its centers' activities.

Cluster Centers

CENTER CONNECTED INDUSTRY

Center Connected Industry

By early evaluation and testing, the Center Connected Industry seeks to leverage new technologies like 5G or blockchain and the opportunities offered by Industrial Internet of Things and transfer them from proof-of-concept into productive use in short sprints. The innovative technologies are refined or combined to achieve application-oriented solutions, with the aim to identify and exploit the potentials offered by digitalization. Sparking a cross-domain innovation process using the broad range of expertise of our industrial members generates a special dynamic allowing for truly fast prototyping and integration of new connected solutions. With the help of data-driven process analysis and optimization, the competitive edge created by the use of innovative technologies can be maintained and enhanced. The testbed run by the Center lets industrial users recreate their own use case scenarios to experience and measure the potential outcome before the actual rollout and supports the economic decision-making process as well.
www.connectedindustry.net/en
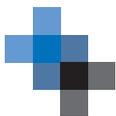
INTEGRATED BUSINESS APPLICATIONS

Center Integrated Business Applications

The Integrated Business Applications Center drives the establishment and expansion of networked IT system landscapes to increase the added value of manufacturing companies. For companies, the center provides decisive impulses in design, further development and implementation of integrated business applications that support and sustainably optimize future business processes. The Center's services are aimed at software providers, system houses and users. As a Trusted Industry Advisor, the center uses the ImplAiX® implementation methodology and tools for integrated business applications along the entire supply chain, which were developed in the Smart Logistics Cluster. It also designs, builds and operates its reference implementation, which is set up and operated in cooperation with its members in the Innovation Labs and the Demonstration Factory. Accordingly, the center's training program now offers topics such as process mining, blockchain and the introduction of business applications. This allows companies to adequately prepare their employees for current challenges.
www.center-iba.com

SMART COMMERCIAL BUILDING

Center Smart Commercial Building

Together with its international members and customers, the Smart Commercial Building Centre develops solutions for modern commercial real estate and thus opens up new usage and business models. The centre's offer is primarily aimed at project developers, real estate investors, operators and planners, as well as technology providers and software companies that focus on digital real estate. Together, they examine how digital solutions can increase the overall productivity of buildings through optimised use of space, how the quality of use can be improved and how sustainability can be ensured.
www.smart-commercial-building.de

**SERVICE
PERFORMANCE
CENTER**

Service Performance Center

In cooperation with its members, the Service Performance Center develops market-ready data-based services. Our portfolio is targeted at companies in the machinery and plant engineering sector as well as the production industry that seek to open up new business segments with smart services or generate value from available company data with the help of modern data analysis methods (such as machine learning). Services provided by the center include the development and application of methods for the creation of digital business models as well as education and training programs, and industrial services assisting companies with the introduction of digital business models.

www.spc-campus.com/en

**EUROPEAN
4.0 TRANSFORMATION
CENTER**

European 4.0 Transformation Center

The European 4.0 Transformation Center (E4TC) structures and supervises the 4.0 transformation program of e.GO Mobile AG. The start-up company e.GO has been organized following the model of a digitally native, agile company that closely collaborates with a network of partners. Major technology and industrial business are 'enrolled' in the E4TC, providing a unique platform for the 4.0 transformation of products and processes. Together with its members, in short-cycle iterations or "sprints," the center develops the IT architecture and tools which enable the agile development of innovative electric cars as well as correspondingly flexible business processes including production, sales and service processes.

www.e4tc.rwth-campus.com/en/

Cluster Building

The Smart Logistics Cluster on RWTH Aachen Campus

The first building on RWTH Aachen Campus was built to host the Smart Logistics Cluster, consisting of FIR at RWTH Aachen University, the five cluster centers, and currently 32 partners from research and industry.

Aside from office space and a conference center, a large proportion of the available space is used to test and demonstrate innovative solutions. In Innovation Labs, a Demonstrator Theme Park, and a Demonstration Factory, ideas are being developed, validated, and turned into marketable solutions. In this environment, the robustness of the processes under investigation can be demonstrated; moreover, it allows the future 'world of processes' to be actually experienced by the participating industrial and commercial companies.

The building complex was planned and developed by the Aachen company ante4C GmbH in collaboration with MSVA Architects, Amsterdam, the Netherlands.

The cluster building was inaugurated at the end of 2013; all available space has been allocated to the companies participating in the cluster.

In a subsequent construction phase, the building has been expanded to allow research on the production of electric vehicles. The Electromobility Lab (eLab) provides an open infrastructure for the purpose of electric mobility research. The facilities and resources of the eLab, which can be flexibly used, are available for rent. The eLab has been developed by the Derichs & Konertz Group, Aachen.

Connected Clusters and Centers

Production Engineering Cluster

The Production Engineering Cluster is set to become one of the largest research labs on the topic of production technology and Industrie 4.0 in Europe, with a research focus on digitally integrated production. Industry and research join forces to open up and leverage, in an experimental approach, the opportunities provided by Industrie 4.0 and the Internet of Things (IoT) for the product development process as well as cyber-physically intergrated production. The electric mobility initiative StreetScooter has been developed in this cluster; in 2014, the company StreetScooter GmbH was sold to Deutsche Post AG. Currently, the new e.Go electric mobility concept is being developed at RWTH Aachen University.

■ WBA Tooling Academy Aachen
The WBA Tooling Academy Aachen is the leading partner of the tool and die industry in the business areas of industry consulting, further education and research. The WBA is capable of reproducing the entire process chain of tool making with its own demonstration tool shop and is developing innovative solutions together with over 80 member companies for the tool and die industry.
www.werkzeugbau-akademie.de/en

■ AZL – Aachen Center for Integrative Lightweight Production
Together with partner institutes, the AZL development center, located on RWTH Aachen Campus, conducts research on and implements integrated process chains which enable the large-volume production of lightweight components, in particular multi-material systems.
www.azl.rwth-aachen.de/en

■ INC Invention Center
The INC Invention Center on RWTH Aachen Campus is the place where corporate planners and futurists redefine the strategies of their companies. The INC provides experts from research and industry with the opportunity to discuss current topics in technology and innovation management and to fuel their innovative spirit.

■ Complexity Management Academy
With its three core topics – Best in Education, Best in Practice, and Best in Research –, the Complexity Management Academy is focused on the development of competencies in complexity management. It offers open and in-house seminars, encourages best practice sharing between interested companies, and develops solutions in collaboration with industry. At its heart of the academy is the so-called Complexity Community, a consortium of companies that are actively addressing the challenge of complexity.

■ Ramp-Up Factory
Building on the research results of the Electromobility Lab (eLab), the Ramp-Up Factory is focused on the producibility of electric vehicles and the reduction of ramp-up time. By providing the required resources, the Ramp-Up Factory empowers developers, manufacturers and suppliers to prepare components or vehicles for mass production under near-series production conditions.

Sustainable Energy Cluster

■ Center for Windpower Drives (CWD)
The CWD coordinates RWTH Aachen University's interdisciplinary research activities in the area of wind turbine drive train systems. These research activities comprise both fundamental scientific analyses and pre-competitive research and development projects.

PEM – RWTH Chair of Production Engineering of E-Mobility Components

PEM undertakes research on topics related to the automotive value chain in the field of electric mobility. Its researchers hold key positions in numerous research projects that receive national and international funding. Six groups conduct research on the topics of Battery Production, Electric Powertrain, Automotive Assembly, Body Shop, Plastic Components, and Autonomous Systems.

RWTH Aachen Campus

RWTH Aachen University is one of the leading universities of technology in Germany. With its excellent researchers, it has the expertise and experience to develop solutions to the challenges posed by today's megatrends. Recognizing the necessity of interdisciplinary, consortial collaboration, the University initiated the RWTH Aachen Campus project in 2009.

Interdisciplinary and Consortial Research and Development

Megatrends change the world and present all actors with big challenges. To stay competitive, science, business and society seek solutions. Individual scientific disciplines can no longer provide these on their own. This makes interdisciplinary cooperation indispensable. It can often be challenging for individual companies to finance mid-term to long-term research on their own. Cooperation within a consortium paves the way for a joint financing. The RWTH Aachen Campus project promotes breaking down spatial and institutional barriers by means of strategically organized cooperation in buildings that support integration, providing a base for the consortiums. Enrolled members share resources with university institutes, use synergies and share knowledge on-site.

Room for Research

For this project, Campus Melaten and Campus West have been designated as expansion areas. In 2009, the initial stage of construction to develop Campus Melaten began. The campus is home to six initial clusters: Bio-Medical Engineering, Sustainable Energy, Photonics, Production Engineering, Heavy-Duty Drives and Smart Logistics. In the second expansion stage, Campus West will be developed. By connecting these two areas, one cohesive campus will be created which is fully integrated into public life. Thus, one of the largest technology research environments in Europe is being created on 800,000 sqm.

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