

# The Integrated Interdisciplinary University of Science and Technology

Knowledge. Impact. Networks.

Excellence Strategy of the Federal and State Governments  
Universities of Excellence Funding Line

The Integrated Interdisciplinary University of Science and Technology  
Knowledge. Impact. Networks.

RWTH Aachen University

Commencement of funding 1 November 2019

## Brief profile of the university

**Established in:** 1870

### **9 Academic structural units (e.g. faculties):**

Faculty 1 – Mathematics, Computer Science and Natural Sciences

Faculty 2 – Architecture

Faculty 3 – Civil Engineering

Faculty 4 – Mechanical Engineering

Faculty 5 – Georesources and Materials Engineering

Faculty 6 – Electrical Engineering and Information Technology

Faculty 7 – Arts and Humanities

Faculty 8 – School of Business and Economics

Faculty 10 – Medicine

**173 Study programmes:** 50 bachelor, 70 master, 1 Staatsexamen (medicine), 1 Staatsexamen (dentistry), 25 bachelor (teaching post), 26 master (teaching post)

**3 Clusters of Excellence:** Internet of Production (IoP), The Fuel Science Center (FSC), Matter and Light for Quantum Computing (ML4Q)

### **8 Profile-forming areas of research and other performance areas:**

Computational Science & Engineering (CompSE)

Energy, Chemical & Process Engineering (ECPE)

Information & Communication Technology (ICT)

Materials Science & Engineering (MatSE)

Medical Science & Technology (MedST)

Molecular Science & Engineering (MSE)

Mobility & Transport Engineering (MTE)

Production Engineering (ProdE)

Interdisciplinary Comprehensive Analysis and Understanding of Complex Systems  
 Jülich Aachen Research Alliance (JARA)  
 RWTH Center for Young Academics  
 Research-oriented Teaching  
 Transfer – Orchestrating Entrepreneurship  
 Agile Governance

<b>Data for 2017</b>	
<b>Total budget including medicine (revenues) [Dr137]</b>	€ 948 million
of which third-party funding (revenues/proceeds) [Dr1a or Dr1b]	€ 360 million
<b>Total budget excluding medicine (revenues) [Dr137]</b>	€ 789 million
of which third-party funding (revenues/proceeds) [Dr1a or Dr1b]	€ 317 million
<b>Professors [Be19]</b>	547 FTE [Be1] 555 persons [Be2]
of which male/female/not specified [Be7]	83% m   17% f 0% n.s.
of which from other countries [Na58]	12%
<b>Academic staff (excluding professors) [Be68 minus Be19 minus Be18]</b>	5,564 FTE [Be1]
of which male/female/not specified [Be7]	70% m   30% f 0% n.s.
<b>Doctoral students [Na46/Na38a]</b>	4,436 persons [Be2]
of which male/female/not specified [Be7]	69% m   31% f 0% n.s.
of which from other countries [Na58]	23%
<b>Academic support and administrative staff [Be63 plus Be28]</b>	2,786 FTE [Be1]
of which male/female/not specified [Be7]	55% m   45% f 0% n.s.
<b>Students (excluding doctoral students, 1st subject in 1st course, full-time students in winter semester 2017/18)</b>	40,941 persons [Be2]
of which male/female/not specified [Be7]	68% m   32% f 0% n.s.
of which foreign students	21%

## **A. Text of proposal**



## A. Text of proposal

### A.1. Summary

RWTH Aachen University gains insights into bold scientific questions, transfers forefront knowledge to the next generation of researchers, industry as well as society and develops solutions that impact today's and future challenges.

Major accomplishments over the past decade include (i) developing a strong profile nationally and internationally in the natural sciences, (ii) maintaining excellence in the engineering sciences, (iii) exploiting the Jülich Aachen Research Alliance (JARA), a unique strategic partnership with the Helmholtz Forschungszentrum Jülich to pursue frontier research, share infrastructure and recruit top talent, (iv) implementing a tenure track program and targeted initiatives to close the gender gap and (v) establishing eight Profile Areas to promote convergence of different disciplinary expertise. All Profile Areas focus on frontier research at the interfaces of different disciplines and tackle questions of societal relevance. Topics include sustainable synthetic fuels, data mining, computational science, production technology, high-performance materials, health, renewable resources and mobility. The majority of recently initiated large-scale research networks including the three new Clusters of Excellence have their roots in the Profile Areas and involve the strategic partner Forschungszentrum Jülich. These facts and analyses from the recent DFG Funding Atlas 2018 testify to RWTH's strong networks and the successful implementation of its Institutional Strategy.

RWTH's vision is to further grow beyond a unique integrated, interdisciplinary university by embracing the **convergence of knowledge, approaches and insights** from the humanities, economics, engineering, natural and life sciences, i.e. biology and medicine. A common core activity of RWTH's research portfolio will be the comprehensive analysis, description, understanding and design of complex systems. In the past, measures were enacted that bolstered the natural sciences. In the future, measures will be implemented that (i) strengthen **disciplinary depth** as well as **knowledge networks** accelerating the convergence of life sciences and data science in the Aachen research landscape, (ii) identify, recruit, retain and **empower excellent researchers** and (iii) ensure the University's capacity for **organizational renewal** and ability to foster its **collective creativity** through an agile governance and strong alliances. These initiatives will create a unique education, research and transfer hub with dynamic research networks crossing disciplinary and organizational borders. RWTH's ambition is to be Germany's academic cornerstone for providing sustainable solutions that impact today's and future's challenges.

## A.2. Status quo and prior achievements

### A.2.1. Overall profile and starting situation

#### A.2.1.1. Today's role of RWTH

RWTH Aachen University was founded in 1870 as a “Polytechnic School” to support the local industry, primarily steel and textile. By mastering problem-oriented research in engineering, practice-oriented teaching, and technology transfer, RWTH emerged as one of Germany’s leading universities of science and technology during the second half of the last century. Benchmarking itself with world-class universities convinced RWTH of the need to strengthen the natural sciences and to systematically bolster interdisciplinary research addressing global challenges. The Excellence Initiative gave RWTH the unique opportunity to do both.

Today, RWTH is an Integrated Interdisciplinary University of Science and Technology committed to excellence in research, education and transfer. RWTH leverages its interdisciplinary research culture and works synergistically with the Forschungszentrum Jülich (FZJ), a member of the Helmholtz Association, in the Jülich Aachen Research Alliance (JARA). The University employs the intellectual curiosity of its staff to understand fundamental principles and develop sustainable solutions for grand **technical and scientific challenges** for the advancement of future generations. These include digitalized production processes, sustainable energy and resource supply, innovative mobility concepts and discoveries in the natural and life sciences.

RWTH embodies a broad **knowledge and competence landscape** that supports frontier research. Within eight interdisciplinary **Profile Areas**, internationally recognized researchers with expertise from **basic research** to highly specialized **applications** work together to develop innovative and sustainable solutions for the future, transforming ideas into innovations. This is accomplished with worldwide partners. The Profile Areas are the University’s breeding ground. Their achievements are reflected in new research networks and five proposals for **Clusters of Excellence (CoEs)**. Three of these CoEs (*Fuel Science Center – FSC*, *Matter and Light for Quantum Computing – ML4Q* and *Internet of Production – IoP*) have been granted. The CoEs exemplify RWTH’s research model and serve as a blueprint for RWTH’s further development. This approach is ultimately based on the University’s genetic code, namely the ability to create **knowledge** and transfer it to increase the **impact** of research.

#### **BOX 1: Knowledge Creation – Transfer – Impact**

**RWTH’s genetic code** is exemplified by numerous RWTH professors. Theodore

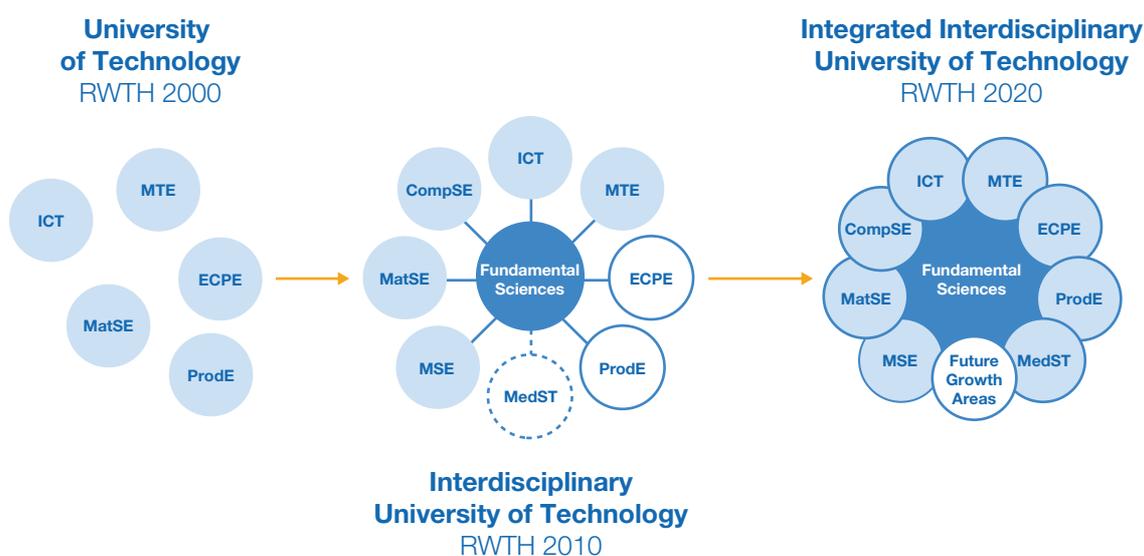
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<sup>1</sup> Throughout the proposal the examples in textboxes highlight RWTH success stories and special details.

**von Kármán** († 1963) was an outstanding theoretician in fluid mechanics known for mathematical description of fluid flow. His results for turbulent flow are still used to design current jet aircraft. Helmut **Zahn** († 2004) is known for his work on peptide and protein chemistry which led to the first total synthesis of a bioactive protein (insulin) and also a series of technical achievements in the field of keratin fibres. A recent example is the work of [REDACTED] team on molecular fundamentals of catalysis and their partnership with industry to incorporate CO<sub>2</sub> into the backbone of performance polymers.

### A.2.1.2. Scientific profile of RWTH

The Profile Areas were developed over the last 20 years and represent the core interdisciplinary research fields of RWTH (see Fig. 1). In the Profile Areas, researchers from different disciplines and faculties join forces in order to transfer results from basic and applied research into societally relevant innovations. They share state-of-the-art infrastructure, coordinate their research activities and form large research networks. Based on an internal survey conducted among all professors, more than 70% consider their research to pertain to one or more Profile Areas. The Profile Areas have been developed with the support of various structural instruments: Exploratory Research Space (ERS), Project Houses and the Strategy Fund (see A.2.1.4). In 2014, the status-quo and perspectives of the Profile Areas were analyzed as part of a roadmap process. Opportunities were identified to facilitate internal research networks as well as external cooperations, for example through the JARA sections (see A.2.1.4, page 14). The Profile Areas are described below.



**Fig. 1** Directed evolution of the Profile Areas over the period of the DFG-institutional funding with the vision of further networking internally and externally.

## **Production Engineering (ProdE)**

The engineering sciences are a traditional core competence of RWTH. ProdE bundles the strengths in production technology with the goal of increasing the effectiveness of high-wage production sites. The focus of the research activities is on the individualization, virtualization, technology integration and self-optimization of production. Within the CoE *Integrative Production Technology for High-Wage Countries* (2007-2018), concepts have been developed and implemented that ensure the future competitiveness of the production industry. The vision of the new CoE IoP is to enable a new level of cross-domain collaboration in production engineering by providing semantically adequate and context-aware data from production, development and usage in real-time on an appropriate level of granularity. IoP will design and implement a conceptual reference infrastructure for the internet of production that enables the generation and application of digital shadows. ProdE together with the Profile Area Information and Communication Technologies (ICT), will lead new science at the forefront of the digitalization and interconnection of production technology. This will be enabled by research on cyber physical production systems and by integrating emerging data science concepts into existing and novel production processes.

## **Materials Science and Engineering (MatSE)**

Novel materials are often the technology drivers for new developments in the fields of energy, mobility and information technology. Research within MatSE focuses on structural as well as functional materials. Activities range from basic science to synthesis and process technology enabling new high-performance materials. The Collaborative Research Center *Steel – ab initio* (CRC 761) is a preeminent example for basic research conducted in the area of structural materials in industrial applications. Functional materials for future applications in electronics are researched within *Nanoswitches* (CRC 917) and the *Aachen Graphene & 2D Materials Center* aiming at making two-dimensional materials ready for applications. A further research initiative aims at bridging the gap between materials design at the microscale and the development of advanced high-performance alloys. The research within MatSE is enabled by unique infrastructure especially in **electron microscopy** available at the Ernst Ruska-Centre.

### **BOX 2: Joint Infrastructure of FZJ and RWTH: Ernst Ruska-Centre**

The Ernst Ruska-Centre (ER-C) for Microscopy and Spectroscopy with Electrons is a joint center of FZJ and RWTH. It is one of the internationally leading centers and operated as an open user facility. It cooperates with more than 120 partners worldwide and expands into soft matter and biological structures.

## **Molecular Sciences and Engineering (MSE)**

MSE is an example for the development of a growth area to a Profile Area, among others, with instruments of the Exploratory Research Space (see page 13). In MSE, scientists from chemistry, biology, process engineering, industrial engineering and medicine conduct joint research projects in the fields of molecular chemistry, biotechnology, molecular materials and hybrid material systems. Numerous highly cited publications, prizes and awards (see C.2.5 and C.2.6) provide evidence for high international visibility. Research in the areas of molecular transformations, bio-catalysis and synthetic fuels form the basis of a strategic collaboration with the Max-Planck-Society (MPI for Chemical Energy Conversion, Mülheim an der Ruhr). The research network *Functional Microgels* (CRC 985) aims at tailored design and synthesis of macromolecular soft colloids to control their structure and behavior for a multitude of applications (see C.2.5, [REDACTED]). [REDACTED] CRC 985 provides an excellent example of interdisciplinary research within MSE and fruitful cooperation with JARA-SOFT and the DWI – Leibniz Institute for Interactive Materials. The University together with the State of North Rhine-Westphalia strongly supported the competitive process that resulted in the admission of DWI to the Leibniz Association in 2014. DWI serves as an inspirational nucleus and role model for the paradigm of convergence by integrating knowledge, approaches and insights in the disciplines of biotechnology, bio-macromolecular material science and chemical engineering.

## **Energy, Chemical and Process Engineering (ECPE)**

ECPE focusses on the processes to transform energy and matter. ECPE prominently demonstrates how a Profile Area improves the capability to initiate and implement large interdisciplinary collaborative research projects. ECPE focuses on generating improvements in energy efficiency as well as the transition to renewable resources. In the CoE *Tailor-made Fuels from Biomass* (TMFB, 2007-2018), a process was designed leading to new fuels from biomass with exceptionally low soot and NO<sub>x</sub> emissions ([REDACTED]). [REDACTED]. Within the recently granted CoE FSC, researchers will expand the TMFB concept by integrating CO<sub>2</sub> and renewable electricity. Together with researchers from other Profile Areas, RWTH is involved in three out of four of Germany's Flagship Projects to advance energy transition initiatives (Kopernikus projects funded by the Federal Ministry of Education and Research (BMBF), e.g., *Power-to-X* coordinated by RWTH). These large collaborative research projects emerged out of several internal funding instruments, such as the Project Houses *Power to Fuel* and *Center for Automotive Catalytic Systems Aachen*. The strategic partnership with FZJ in JARA-ENERGY is particularly important for energy research activities at RWTH.

## **Information and Communication Technologies (ICT)**

The Profile Area ICT builds on strong research fields at RWTH, ranging from computer science and information technology (e.g., software engineering, data science, commu-

nication technology) to fundamental topics in physics (e.g., quantum computing or materials for IT). It takes advantage of this basis to foster research with other research areas, like engineering and social sciences, or with relevant application fields, like mobility and health. As a concrete example, with the help of the Strategy Fund, ICT funded several projects, where computer scientists, mechanical and electrical engineers, sociologists, economists or medical scientists worked together. The successful impact of ICT on interdisciplinary research at RWTH is indicated by the fact that ICT experts are centrally involved in two of the three new CoEs. Principal investigators (PIs) from ICT develop the necessary expertise in information systems and data analysis in the CoE IoP. The ICT members and directors of the JARA-FIT Institute *Quantum Information* (QI), are PIs in the CoE ML4Q [REDACTED]

### **Mobility and Transport Engineering (MTE)**

MTE pursues an integrated approach to improve traffic safety, counter congestion and prevent further climate deterioration and environmental pollution. Electrification, connectivity and automation serve as enablers to create new forms of mobility for every member of a society. RWTH coordinates the BMBF flagship project *UNICARagil*, which aims to develop software and hardware architectures for driverless vehicles. In conjunction with various interest groups and funding organizations, MTE has created a unique research infrastructure, ranging from multi-scale simulation to the *Aldenhoven Testing Center* (ATC), a joint project of RWTH and the neighboring district of Düren. In addition to the test track, ATC includes an urban traffic environment enabling a representation of relevant traffic situations. Communication technologies including simulated GALILEO signals make ATC a unique site for researchers as well as for industries in the field of automated and connected mobility. ATC is at the heart of the *Future Mobility Center* (FMC; measure M2, page 44). In the *Center for Mobile Propulsion* (CMP, §91b research building, page 31), researchers develop and utilize cyberphysical systems focusing for instance on the hybridization of internal combustion engines. Simulated virtual city traffic is integrated with physical hybrid systems enabling a detailed situational monitoring of emissions and efficiency.

### **Computational Science and Engineering (CompSE)**

CompSE combines the expertise of RWTH at the interface of engineering sciences, mathematics and information technology. The emphasis on software is visible in the four main fields – data, modelling, computing, methods. Together with the JARA section on high-performance computing (JARA-HPC), new approaches in computational science were formulated that define the scientific program of the DFG-funded International Research Training Group *Modern Inverse Problems* (IRTG 2379) with the University of Texas, Austin. CompSE illustrates how a Profile Area can grow and develop as a result of

strategic alliances. Many of the research successes of CompSE are the result of strong alliances with JARA-HPC, the Graduate School *Aachen Institute for Advanced Study in Computational Engineering Science* (AICES) and the *German Research School for Simulation Sciences* (GRS). To build on these achievements, RWTH and FZJ merged the different structures into a joint *JARA Center for Simulation and Data Science* (CSD, founded in November 2018). The new Center represents the future of the Profile Area CompSE.

### **Medical Science and Technology (MedST)**

Research in MedST focuses on investigating and developing new technologies and processes for medical applications. It draws on existing competencies and infrastructures along the value chain from fundamental to applied research such as the *Telenotarzt* (telemedicine in emergency medicine). Interdisciplinary research within MedST focuses on biohybrid medical systems, imaging and cyber medical systems. Academic structures were founded such as the JARA-BRAIN Institutes, the *Integrated Interdisciplinary Institute of Technology for Medicine* (I<sup>3</sup>TM), the *Center for Biohybrid Medical systems* (CBMS), the *Center for Telemedicine*, the *Center for Robotics in Healthcare* and the *Center for Translational and Clinical Research* (CTC-A). Three bridging professorships for Neurobiological Research, Biohybrid & Medical Textiles and Biomedical Image Analysis were established. These are involved in the development of new diagnostic instrumentation such as the first fully digital positron-emission tomography (PET) and the first application of motion model ultrasound localization microscopy (mULM). Moreover, progress has been made in the acquisition of collaborative DFG projects like a Priority Program, a Research Unit, several Research Training Groups and the national research network *Smart Medical Information Technology for Healthcare* (SMITH) funded by the BMBF.

### **Project Houses**

Besides Profile Areas, Project Houses were another structural instrument that contributed significantly to shaping the research profile of RWTH in the past decade. With the help of Project Houses, faculties were able to strategically align their research direction. As such, the Project Houses *Interdisciplinary Management Factory* (IMF) and *Human Technology Centre* (HumTec) contributed to integrating social and economic aspects in projects with the engineering and natural science faculties.

The Project House **Interdisciplinary Management Factory** (IMF) helped transform the Faculty of Business and Economics into an internationally competitive institution for interdisciplinary, technology-related research and teaching in the field of management and economics. Theories, methods and research tools were developed. For example, in close collaboration with experts from computer science as well as control and mechanical engineering, modern man-machine interfaces were designed. IMF propelled RWTH from below position 25 in 2012 to the top ten (No. 7) faculties of business and economics

in Germany in 2014 (“Handelsblatt” study, No. 15). As a result of IMF, the faculty became strongly integrated into the core of the University. 80% of the faculty members actively participate in joint research projects with colleagues from other faculties.

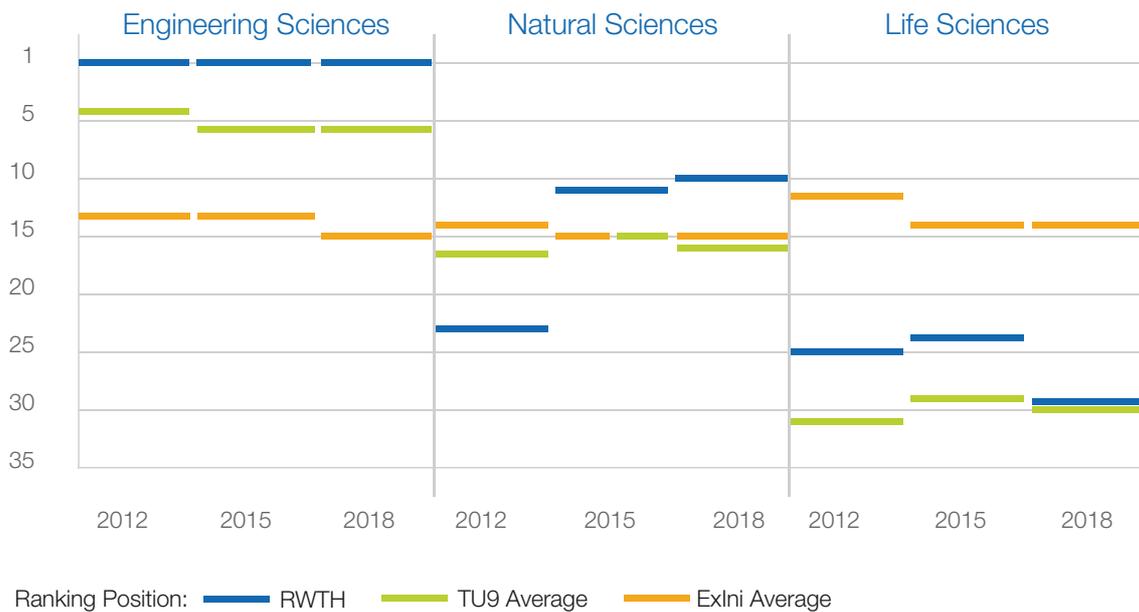
The Project House **Human Technology Centre** (HumTec) accelerated integration of the social sciences and humanities with the natural sciences and engineering. In particular, HumTec added social perspectives in interdisciplinary research and teaching programs and advocated for human-centered and ethically responsible development of science and technology. This partnership reinvigorated and empowered the Faculty of Arts and Humanities and pioneered a stronger alignment with the strategic goals of RWTH. It also fostered the establishment of interdisciplinary research projects that serve as role models for human orientated and responsible technological developments. All RWTH faculties have collaborated in HumTec projects covering topics such as health care, demography, ambient-assisted living, urban planning and the energy transition. The new *Department of Society, Technology, and Human Factors* (STH) at the Faculty of Arts and Humanities consisting of five recently appointed professorships will build interdisciplinary bridges within RWTH. The Department was set up with the support of the Strategy Fund.

### **A.2.1.3. National and international positioning of RWTH and its Profile Areas**

The **DFG Funding Atlas** is the main reference for the national positioning and research profile of German universities. In terms of granted projects, the DFG ranking is considered the most relevant, because granting of a DFG proposal is based on a rigorous peer review of the past performance of the applicants as well as the novelty and the originality of the proposal. The total sum of all granted DFG proposals hence reflects both research quality as well as the scientific impact.

In the current DFG report, RWTH ranks third regarding overall DFG funding and first regarding overall federal funding. Among all German universities, RWTH holds the top position in DFG funding in the field of engineering sciences with a clear distance to the second-placed. The natural sciences are now on tenth place in the national ranking of all German universities. The life sciences, i.e. biology and medical sciences, hold position 29. A comparison between **RWTH and other German universities** (the selected reference group are the nine universities of science and technology (TU9) and the ten other universities with funding of Institutional Strategy, the “Universities of Excellence” out of the Excellence Initiative (ExIni)) regarding funding in the natural, engineering and life sciences confirms both the strengths and weaknesses of RWTH (see Fig. 2). In the engineering sciences, RWTH received more DFG funding than the average of both groups. Since 2015, the DFG funding position in the natural sciences has continuously improved and has now surpassed both the average of the TU9 and ExIni universities. This is a distinct

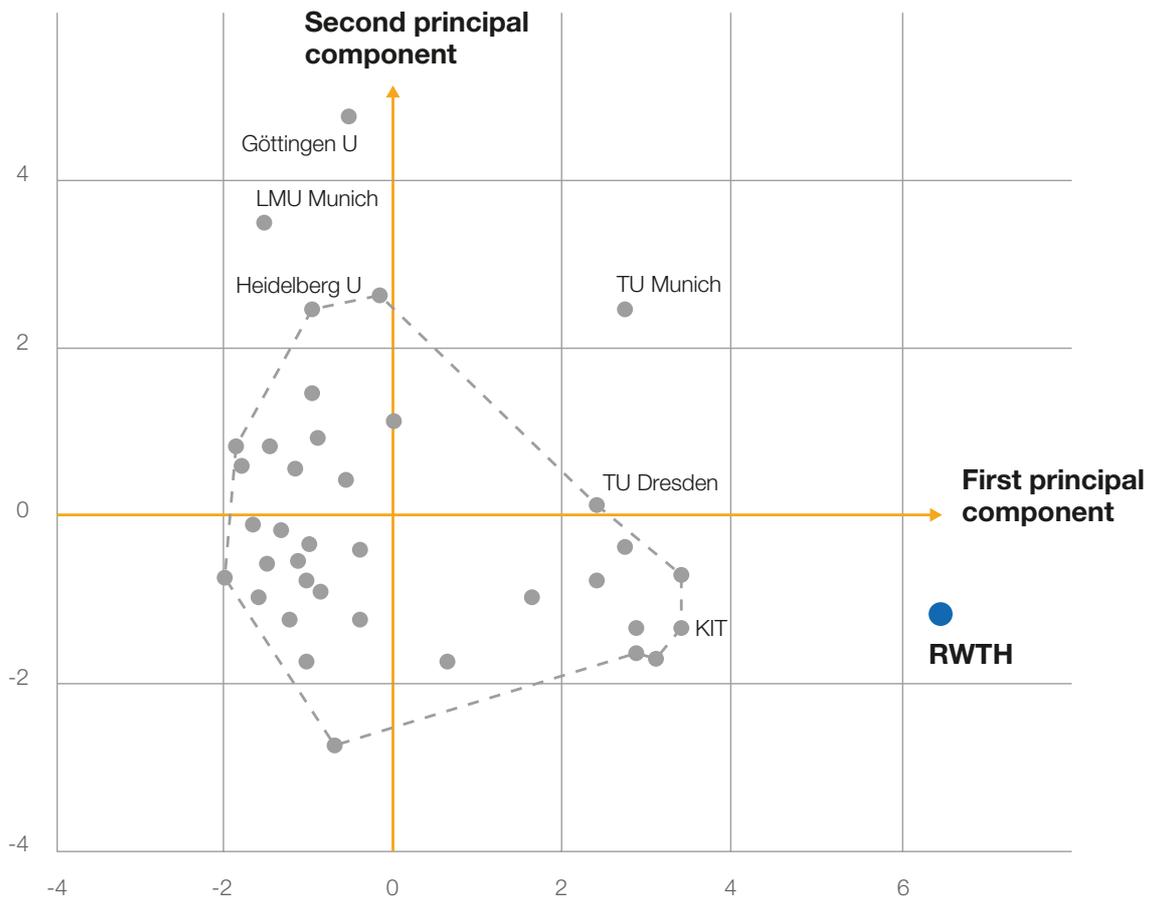
indicator for the success of RWTH's institutional measure *Strengthening Natural Sciences* (A.2.1.4, page 11).



**Fig. 2** The positioning of RWTH in the DFG Funding Atlas 2018 in comparison to TU9 and the “Universities of Excellence” (Exlni).

A detailed look at disciplines reveals that both chemistry and physics at RWTH have improved their DFG ranking positions. Chemistry is in first place. Physics has risen to 13<sup>th</sup> place, even though the major fraction of the third party funding in elementary particle physics at RWTH stems from large scale BMBF projects. Major efforts will be taken to improve the performance in both biology and medicine and strengthen their links to other natural and engineering sciences, to achieve a unique research landscape with three pillars: engineering, natural sciences and life sciences.

Figure 3 is taken and redrawn from the DFG Funding Atlas 2018 and visualizes a principal component analysis performed by DFG. The first principal component aggregates the engineering sciences and chemistry, the second principal component the life sciences and physics. Universities with a similar research profile are located in close proximity and deviations from the origin of the graph indicate a positive or negative deviation in the component. The position of RWTH at the very right depicts its outstanding profile in engineering sciences including application-oriented chemistry. It also indicates the development potential in the field of life sciences.



**Fig. 3** Principal Component Analysis resulting in a similarity comparison of the German universities, the x-axis quantifying the contributions in the engineering sciences and chemistry, the y-axis contributions in the life sciences and physics. Representation taken from the DFG Funding Atlas 2018, page 99.

There are currently no benchmarks for interdisciplinary research. Hence, it is difficult to make direct comparisons regarding the quality of the Profile Areas. A benchmarking can only be attempted indirectly by considering the core disciplines involved. Mechanical engineering/production technology, which is a core discipline in ProdE, is in first place in the DFG Funding Atlas 2018. Chemistry, which is a core discipline of the Profile Area MSE is also in the top position. Thermal engineering/process engineering, which has strong overlaps with ECPE and MSE, also ranks first. Material sciences/materials engineering are core disciplines of MatSE and rank second (first in 2015). Computer science/systems technology/electrical engineering in Aachen rank eighth in DFG funding (first in 2015 and 2012) and fourth regarding federal funding. These are core disciplines of ICT, CompSE, MSE, and ECPE.

The position of RWTH regarding acquisition of industrial funding is also very strong. The share of industrial funding of RWTH increased between 2006 (28%) and 2015 (31%), while on average, the reverse trend was seen for all German universities from 2006 (26%) to 2015 (19%). This reflects the success of RWTH in utilizing gained knowledge to generate industrial and societal impact. Based on the latest published data from the Federal Statistical Office of Germany, RWTH has raised the most third-party funds of all universities

in Germany with € 297m in 2016. RWTH also ranks first with € 844k in annual third-party funding per professor.

For international comparisons based on **Times Higher Education Ranking** (THE), the universities of the **IDEA League** (TU Delft, ETH Zurich, Chalmers University, Politecnico di Milano and RWTH) have been chosen as reference. Regarding the overall ranking, RWTH is positioned behind ETH Zurich and TU Delft and above Chalmers University and Politecnico di Milano. RWTH ranks slightly better than TU Delft regarding citations and much better than ETH Zurich, and just behind TU Delft regarding funding from industry. Peer-reviewed **publications** are an important proof of quality and international reputation. Since about 2010, the growth of RWTH's publication rate is significantly above the average of German universities. Besides the increase in the quantity of publications, enhanced perception of RWTH publications is documented in the Web of Science by the increasing number of highly cited papers. The overall yearly number of publications at RWTH increased by 78% from 2007 to 2017 in comparison to 53% in the average of the other German "Universities of Excellence". The publication figures and the number of highly cited publications at RWTH are developing parallel to those of the other IDEA League universities.

#### **A.2.1.4. Framework conditions**

The organizational and managerial conditions necessary to actively shape the research profile of RWTH were established within the framework of the Institutional Strategy "The Integrated, Interdisciplinary University of Technology. Meeting Global Challenges" of the **Excellence Initiative**. The main measures to transform the University into an Integrated Interdisciplinary University of Science and Technology were:

1. *Strengthening the Natural Sciences* to raise their national and international standing,
2. *Fostering Interdisciplinary Research* to develop research networks and communication in multi-disciplinary teams as well as to lay the foundations for joint publications and coordinated projects,
3. Establishing *JARA, the Jülich Aachen Research Alliance*, to evolve the strategic partnership with Forschungszentrum Jülich,
4. Coordinating initiatives under *Place to Be* that value gender and diversity and attract young talents,
5. Enhancing *Corporate Governance and Structures* to ensure that strategic goals are translated into tangible actions.

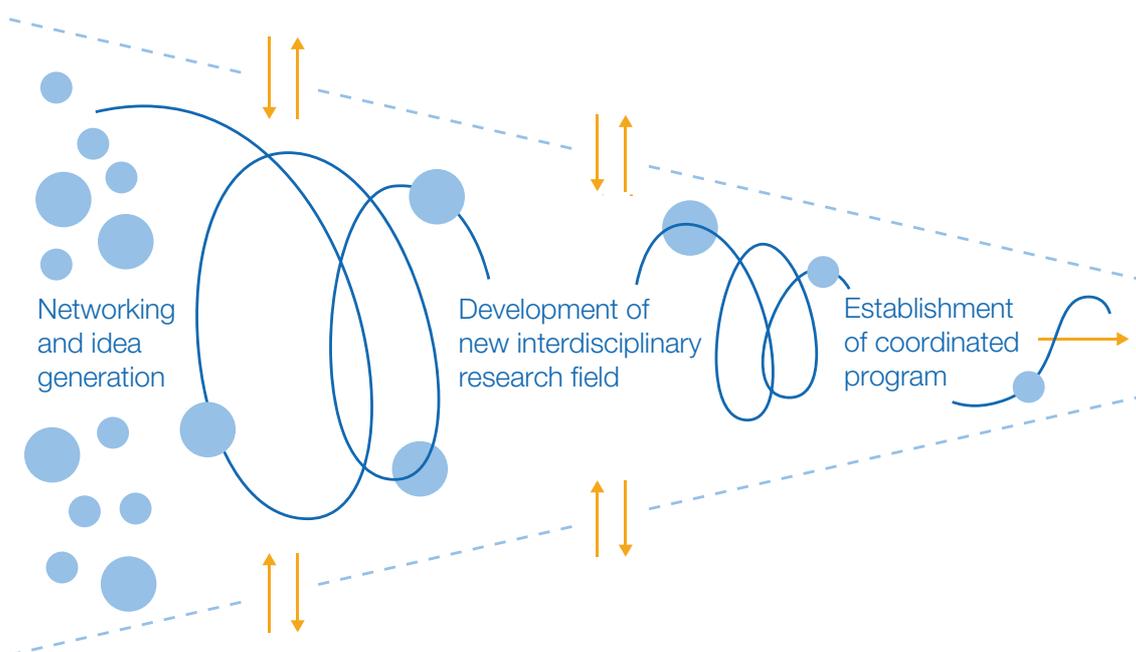
In the following, the instruments and governance structures used in the profile-forming process of the Excellence Initiative are briefly introduced.

In order to **Strengthen the Natural Sciences**, various measures were introduced in the Faculty of Mathematics, Computer Science and Natural Sciences in order to enhance

the research environment. Researchers were supported at all levels along their career path. Competitive Undergraduate Funds were granted to promising young talents, who became involved in research projects during their bachelor studies. Researchers, from doctoral researchers to professors, benefitted from the faculty Seed Fund. From eight tenure track junior professors appointed within the faculty, five (two males, three females) received tenured positions at RWTH. In a competitive process, ten Distinguished Professorships were awarded to senior researchers and used to enable promising bold research.

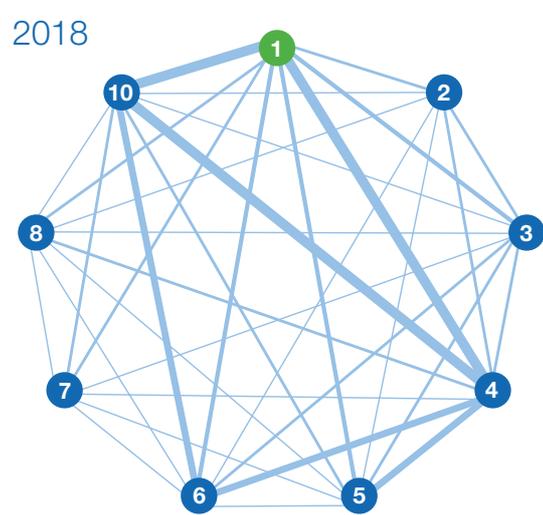
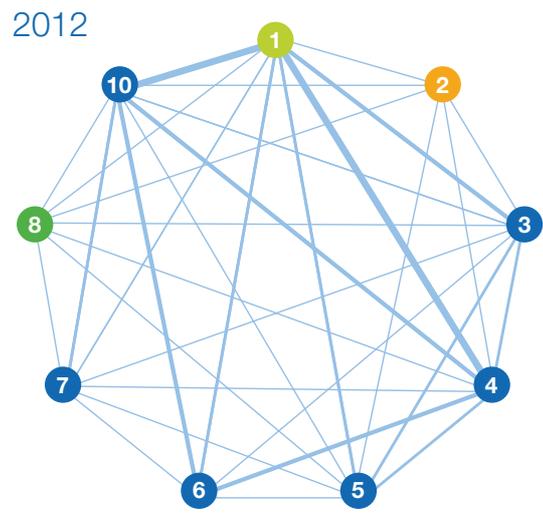
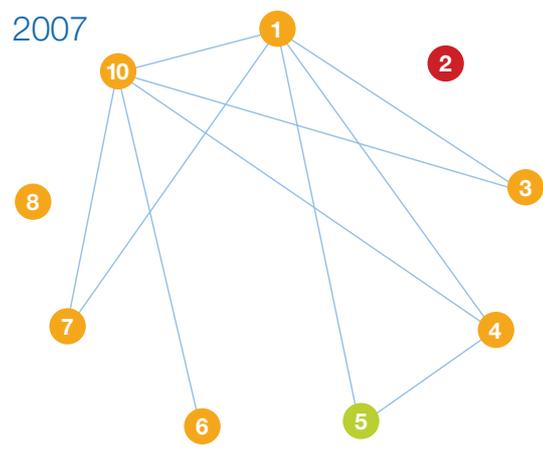
### BOX 3: Distinguished Professors

██████████ Chair of Organic Chemistry, Distinguished Professor and speaker of the Profile Area MSE, was selected as “Clarivate Highly Cited Researcher” in 2014-16 ██████████ ██████████ Chair of Software Modeling, and ██████████, Chair of Computer Graphics, each received a Distinguished Professorship in 2013 and later an ERC Advanced Grant for their research in Computational Geometry and Stochastic Programming, respectively (██████████). In the case of ██████████, a Leibniz Prize was awarded, too. ██████████ I. Institute of Physics (IA), was supported with a Distinguished Professorship. He chaired the Strategy Board of RWTH, is JARA professor, holder of an ERC Advanced Grant and speaker of *Nanoswitches* (CRC 917).

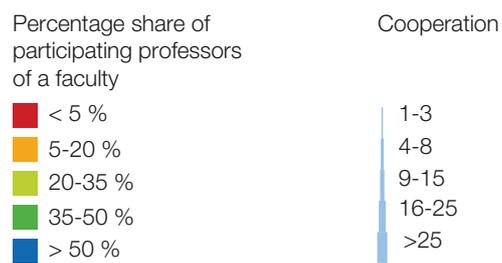


**Fig. 4** Promoting interdisciplinary research and profile building via the “ERS Funnel”. ERS supports the dialogue between disciplines and provides Seed and Boost Funding for interdisciplinary and unconventional or bold research ideas.

The **Exploratory Research Space (ERS)** is the central instrument of RWTH to foster interdisciplinary research and to develop emerging fields with the potential to shape the University's research profile (see Fig. 4). An ERS project team combines researchers from at least two different faculties, typically experienced as well as promising young researchers. ERS uses two different, but complementary approaches to fund projects. The first approach used open calls to fund bottom-up ideas via Seed or Boost Funds. The second approach used topic-specific calls to fund selected strategic research areas such as MSE (see page 5). ERS funding helped to empower the Profile Areas and generate publications and follow-up funding. ERS-supported researchers and consortia received several patents and scientific awards. Over the last ten years, more than 80% of the RWTH-professors applied for ERS funding. The increasing number of involved researchers and joint projects established a significant network of cooperation among the faculties (see Fig. 5).



**Fig. 5** Growing network by means of ERS projects. Snapshots for 2007, 2012 and 2018 are given. The color code indicates the percentage share of professors of a faculty who participated in ERS-Calls, the line thickness represents the number of joint projects. The numbers in the circles represent the faculties (for historical reasons, no faculty no. 9 exists).



#### **BOX 4: Exploratory Research Space**

The research team of [REDACTED] Chair of Nephrology and Clinical Immunology, was supported by a Seed Fund as well as two Boost Fund Projects. Their research led to a paradigm shift in nephrology and one coworker, [REDACTED] received the Franz-Volhard Prize, the most prestigious award of the German Society for Nephrology.

The Boost Fund Project Mehzell established a new research focus on mechanical forces influencing cell differentiation and led to the Marie Skłodowska-Curie Innovative Training Network *Integrated Component Cycling in Epithelial Cell Motility* and a recently DFG-funded RTG (*Mechanobiology in Epithelial 3D Tissue Constructs*), headed by [REDACTED] Chair of Molecular and Cellular Anatomy.

#### **Strategic Partnerships**

The **Jülich Aachen Research Alliance** (JARA) is a unique strategic alliance between RWTH and FZJ based on a joint governance and joint appointments. It is organized in six sections which build an excellent breeding ground for collaborative projects, international visibility, and attracting young talents and outstanding researchers as reflected in 55 joint appointments.

**JARA-BRAIN** is dedicated to translational brain research. Initially, eight junior professors were appointed, all of which are either tenured in Aachen or have accepted appointments at other universities (see Box 5). In 2016, two JARA-BRAIN Institutes were founded. Activities are complemented by the Center for Translational & Clinical Research (CTC-A) and the clinician scientist program of the University Hospital Aachen (UKA). Proof of excellent and interdisciplinary research are several collaborative research projects like DFG International Research Training Groups (IRTG 1328, IRTG 2150) with the Ivy League University of Pennsylvania, BMBF and EU funded projects, leading roles in the Big Data national Platforms for Imaging and participation in the Human Brain Project (EU Flagship). Other recent initiatives include a focus on computational neuroscience methodologies and integration in the Bernstein Network as well as the JARA-BRAIN Center Translational Neuroscience (JARA-BC).

**JARA-FIT** pursues research on the fundamentals of future information technology coordinating research across fields of physics, chemistry and electrical engineering. Joint research groups located at RWTH and FZJ include an Alexander von Humboldt [REDACTED] [REDACTED] and a Heisenberg professorship [REDACTED]. Prime examples of the success of JARA-FIT are two collaborative DFG research projects (CRC 917 and RTG 1995), 12 ERC grants, one Leibniz Prize [REDACTED], participation in the EU Flagships *Graphene*

as well as the establishment of the Helmholtz Nano Facility (HNF). The two JARA-FIT Institutes in the field of energy-efficient information technology (GreenIT) and quantum information (QI) have been major driving forces for the CoE ML4Q which is a joint proposal of the universities of Cologne, Aachen, and Bonn and FZJ.

**JARA-HPC** takes account of the fact that next to theory and experiment, simulation science has become the third pillar of research. With its Simulation Laboratories, Cross-Sectional Groups, and the JARA partition, a partial merger of the Jülich and Aachen HPC systems, JARA-HPC provides an outstanding research position. Due to strong synergies of JARA-HPC with other structures (see CompSE, page 6), these structures were merged into the joint *JARA Center for Simulation and Data Science* (CSD). With the CSD, RWTH and FZJ create an internationally visible competence center where computer and data infrastructures, user support as well as methodological and disciplinary research of both partners are consolidated. The CSD will utilize its unique infrastructure, computer centers at FZJ (JSC) and RWTH (IT Center), for data analytics, machine learning and simulations addressing grand challenges, for example in medical science, environmental and energy research.

**JARA-ENERGY** and the Profile Area ECPE complement each other. Both are dedicated to investigating sustainable, i.e. efficient, resource-conserving, environmentally compatible and safe energy production, use and optimization. Researchers within JARA-ENERGY are united by the vision of sustainably securing the future energy supply and mobility systems. Successes mentioned under ECPE coincide much with those of JARA-ENERGY, like the Kopernikus projects and the approved CoE FSC, and thus reflect the successes of this cooperation. Also four interdisciplinary §91b research buildings demonstrate its momentum (see page 31).

**JARA-FAME** strives to understand the evolution of the universe and the fate of anti-matter therein. The three experimental pillars for this fundamental physics research are: (i) the search for antimatter with the Alpha Magnetic Spectrometer on the International Space Station, (ii) the search for differences between matter and antimatter with baryons in electrostatic storage rings, (iii) the search for differences between matter and antimatter in neutrino oscillations.

**JARA-SOFT**, the youngest JARA section, integrates knowledge in the research field of soft and living matter to fundamentally understand and rationally design synthetic and biological macromolecular, supramolecular and cellular systems with relevance in functional materials, biotechnology and medicine. The research groups in JARA-SOFT provide a state-of-the-art multi-method platform, which includes structural characterization using NMR, X-rays, light, electrons and neutrons, as well as multi-scale computational approaches. JARA-SOFT has strong links to the Profile Area MSE and includes research

chers from the DWI – Leibniz Institute for Interactive Materials. JARA-SOFT researchers contribute to the successes of MSE such as *Functional Microgels* (CRC 985).

#### **BOX 5: Prominent Researchers in JARA**

██████████, Fundamental Electrochemistry at FZJ, coordinates together with ██████████ the NRW State Initiative *Competence Center for Sustainable Electrochemistry*. ██████████ is board member of the World Energy Council Germany. ██████████ Chair of Psychiatry, Psychotherapy and Psychosomatics, is member of JARA-BRAIN, speaker of *The Neuroscience of Modulating Aggression and Impulsivity in Psychopathology* (IRTG 2150) and Vice-Rector for International Affairs of RWTH. ██████████ Chair of Electrical Engineering Materials, is director of the Peter Grünberg Institute (PGI-7) at FZJ and director of the JARA-FIT Institute Green IT. In 2014, he received the Leibniz Prize and since 2010 he is spokesperson of the research program Fundamentals of Future Information Technology (FIT) of the Helmholtz Association.

**Strategic partnerships and networking** with other universities and extramural research institutions have enhanced the international reputation of RWTH in many relevant research fields. The Faculty of Medicine is embedded in the University Hospital Aachen which facilitates translation of research into clinical application and vice versa. In addition to the Helmholtz Association, cooperations with other extramural research institutions such as the Aachen Fraunhofer Institutes, the DWI – Leibniz Institute for Interactive Materials, and the Max Planck Society were intensified, for example through joint appointments and complementing research infrastructure. Furthermore, the RWTH Aachen Campus GmbH (see page 21) provides an outstanding breeding ground for partnership with industry. Research institutions affiliated to RWTH (“An-Institute”) are independent in terms of organization, economy and law. They are often supported by industry and are an important part of the University’s transfer landscape.

RWTH has strong and long-standing strategic partnerships with the universities of Cologne, Bonn and Düsseldorf, for example within the Bioeconomy Science Center (BioSC) and the geoscientific network of the Aachen-Bonn-Cologne/Jülich research area (Geoverbund ABC/J). The rectorates of these universities meet to identify synergistic cooperation opportunities and to strategically plan and coordinate their future development. This highly cooperative approach resulted in joint third-party funded research projects such as CRC and CoE.

European partnerships and cooperations comprise the IDEA League, CESAER, the T.I.M.E. Network, Maastricht University and the German-French University (DFH). Furthermore, RWTH has strategic partnerships with international partners such as Tsinghua

University in China, University of Alberta in Canada and Indian Institute of Technology Madras in India.

### **The Place to Be**

People are the core of RWTH and the University strives to represent their “Place to Be”, an attractive and **welcoming place of research, work and study** for national and international students, employees and scholars. The University and the City of Aachen work closely together to address the specific needs of students and researchers, such as providing an online service helping students find affordable housing.

**Staff Development** as well as **Equal Opportunities and Diversity** are central to the overall strategy of RWTH. Staff development activities serve to identify, recruit and retain excellent researchers, expand the University’s continuing training offerings, secure equal opportunities, good employment conditions, foster individual career development and quality of life at the workplace regardless of gender or socio-cultural background. Already in 2007, RWTH committed itself to promoting gender and diversity through its “People Policy”. The Equal Opportunities Action Plan 2017 – 2022 now complements the existing activities at a new strategic level.

**Early career researchers** play an important role in the research culture and achievements of RWTH. The Center for Doctoral Studies (CDS) and the Center for Professional Leadership (CPL) prepare early career researchers in pursuing their individual career paths. CDS currently offers about 100 different courses for the development of general professional and scientific skills and competences for 4,000 enrolled doctoral researchers. The CPL offers workshops and individual, peer group and team coaching to prepare researchers beyond the postdoc stage for different career paths. The Advanced Talents Program provides special support to Emmy Noether, EU Marie-Curie, ERC Starting Grantees, junior professorships and the like.

#### **BOX 6: 30% Share of Funds for Projects with Female Researchers**

For several project formats, a share of 30% of funds was reserved for projects involving female researchers, in order to promote equality. Only in a few cases this earmark could not be fulfilled. The unused resources were used to facilitate appointments of female professors contributing to an increase of female professors from 12.9% in 2010 to 17.8% in 2018.

RWTH members are “citizens of the world” with 23% of the students coming from abroad and 13% international staff members. RWTH believes that sustainable globalization requires tolerance, respect and intercultural understanding. Internationalization is a cross-cutting topic that permeates all areas of the University and contributes to its reputation. RWTH’s objectives and measures in internationalization are defined in the **Inter-**

**nationalization Strategy** and are aligned with the present staff development objectives. In the framework of the Institutional Strategy, the **appointment strategy** was further developed and implemented. Since 2002, RWTH has appointed 109 **junior professorships**. Even though most of the junior professorships did not include individual tenure track options, the University provides suitable resources for the creation of tenured positions. From 69 junior professorships completed so far, 22 (32%) were tenured at RWTH, 9 thereof women (41% of the tenured candidates). Another 30 (43%) continued their academic career with a professorship at another university. As the numbers demonstrate, junior professorships have become an important instrument for recruiting and developing young academic talent. By winning ERC grants, for example, or by making important contributions to Clusters of Excellence, young academics have developed into key researchers of RWTH.

#### **BOX 7: Junior Professors**

██████████ professor of Translational Molecular Catalysis, was appointed in 2009 and tenured in 2016. He is PI in the CoE FSC. ██████████ professor of Computer Vision, was appointed from ETH Zürich in 2008 and tenured in 2011. He received an ERC Starting (2012) as well as a Consolidator Grant (2017). ██████████ ██████████ Imaging in Neurodegenerative Diseases, was appointed JARA-BRAIN junior professor in 2009 and tenured at RWTH in 2014. She was funded by the BMBF initiative for independent research groups in neurosciences. ██████████ ██████████ professor of Synthetic Enzyme Cascades, was appointed junior professor together with FZJ in 2015 and tenured in 2018. She received an ERC Starting Grant in 2017 and is PI in the CoE FSC.

#### **Corporate Governance**

The corporate governance structure of RWTH (see C.7.2) reflects the University's understanding of management as the interplay between top-down guidance and bottom-up processes. The triangle of rectorate, council of deans and Strategy Board forms the core of RWTH's governance and ensures participative, open and transparent decision-making processes. The senate with representatives from all groups of the University (professors, students, non-scientific staff, scientific staff) is the main legislative unit and ensures internal reflection. The Board of Governors (Hochschulrat) consisting of external members from industry, business, and academia is responsible for external reflection and supervision.

Several instruments support strategic decision making even across faculty boundaries. **ERS** (see page 13) provides funding for new, highly innovative, interdisciplinary research topics. The **Strategy Fund** sharpens the research profile by enabling structures and

initiatives with a mid- and long-term perspective. Fed by resources from the Excellence Initiative and by the University's own resources, the Strategy Fund supported the establishment of 22 new professorships and helped to recruit and retain outstanding researchers. Additional resources granted by the state of North Rhine-Westphalia (NRW) helped to finance these professorships in the long-term. In addition, the Strategy Fund provided funding for novel infrastructure and **Project Houses**. As strategic allocation of the Strategy Fund was mutually agreed upon, it initiated and contributed to a close interaction between rectorate and the deans in general. Most elements of the current governance structure of RWTH have proven to be effective and will be further fine-tuned to meet upcoming challenges (see measure M10, page 54).

#### **BOX 8: Project House *Power-2-Fuel***

In the Project House *Power-2-Fuel*, researchers pursued the approach of transforming electricity obtained from renewable sources into energy intensive fuels, to use them as temporary energy storage, prior to re-transforming them into electricity when needed. The interdisciplinary research concept encompasses the optimization of the entire process chain. It has been the foundation for the Kopernikus projects and the CoE FSC.

#### **A.2.1.5. Other performance areas and areas of activity**

Teaching, transfer, and research infrastructure are important pillars for the top-level performance at RWTH. The following chapters give a brief description of their cross-fertilization with research.

##### **Teaching**

RWTH offers competence-, research- and practice-oriented training with the goal of developing highly qualified and responsible graduates for leading positions in society, business and science. Benefitting from its intensive research activity, RWTH has a long-standing tradition of involving students in innovative research early on via activities such as science assistant or research modules.

Already in 2008, **RWTH's Teaching Concept *Students in Focus of Excellence*** made student centricity an integral part of the overall strategy. The University initiated the Exploratory Teaching Space (ETS) as a counterpart to ERS to support innovative teaching concepts. More than 100 teachers have already realized their ideas and created an innovative teaching spirit throughout the University.

More recently, the University has developed a **concept for research-oriented teaching and learning**. The main objective is to integrate research and teaching at an early stage of education. The Profile Area MTE for example created the bachelor and master

courses *Mobility and Vehicles*, and the new CoE FSC will establish a new international master course *Molecular Science and Engineering*. On an international level, the Undergraduate Research Opportunities Program (UROP) has successfully opened doors into some of the most prestigious North American universities (MIT, Harvard, Yale, UC Berkeley, UPenn, University of Toronto).

The growing importance of digitalization and computational sciences presents new opportunities and challenges with respect to teaching. The balanced blending of classical teaching methods and effective new digital teaching formats has already been embraced by RWTH's digitalization strategy to provide scientifically grounded knowledge as well as sustainable skill development to over 45,000 students. In 2017, RWTH became the first university to be awarded the Germany-wide institutional Genius Loci Prize for Teaching Excellence by the Stifterverband für die Deutsche Wissenschaft for implementing a teaching strategy. To verify the effectiveness of the measures taken, a quality management system for studies and teaching was established in recent years and was accredited in April 2018.

### BOX 9: The Exploratory Teaching Space

██████████ ██████████ and colleagues developed the **phyphox app**, which enables students and others to use the sensors in their smartphones to conduct physics experiments themselves. Within a period of 2 years, phyphox has rapidly advanced to an app with more than half a million downloads. ETS funding helped to launch this project in 2016 which is currently focusing on the integration of Bluetooth interfaces. This will open up new opportunities for phyphox-supported experiments in other natural and engineering sciences, which are not accessible with the sensors available in smartphones.

### Transfer

RWTH understands transfer as the continuous and mutual exchange of ideas, knowledge, technologies and people within RWTH, with partner organizations, societal groups and industry. This broad understanding of transfer at RWTH<sup>2</sup> is in line with the position paper "Knowledge and Technology Transfer" of the German Science Council, 2016. Transfer at RWTH is driven by its belief that successful innovation requires research which leads to added value for industry and society and vice versa. A proactive approach to successful transfer includes start-up support, invention and patent management, industry cooperation, research collaborations and, last but not least, engagement of people. A current example of the latter is RWTH's partnership in the *Smart City* initiative of

<sup>2</sup> In 2015, RWTH developed the understanding in the framework of the "Transfer Audit" of the Stifterverband für die Deutsche Wissenschaft and the Heinz Nixdorf Foundation.

the City of Aachen which aims at tackling the high complexity and digital transformation of urban mobility. Citizens participate in the decision making process and become co-developers to jointly find solutions for societal challenges. This initiative is integrated with a first R&D activity<sup>3</sup> providing researchers with direct feedback from users and enabling them to benefit from an urban day-to-day live test environment. The direct contact with citizen interested in digital technologies, municipal decision-makers and companies is an example for the rapid transfer.

RWTH transfer was shaped over the last decades by the strong relation with national and international industries. To further integrate industrial research activities with basic research, **RWTH Aachen Campus GmbH**, one of the largest technology-oriented research landscapes in Europe (800,000 m<sup>2</sup>) was developed. Founded in 2009, RWTH Aachen Campus GmbH contributes towards highlighting the research competence at RWTH. The project creates a unique symbiosis of academia and industry in interdisciplinary consortial cooperation. In a first step, areas of research are represented in 16 Campus Clusters<sup>4</sup>. These Campus Clusters are subdivided into Campus Centers, in which interdisciplinary teams and industry consortia work jointly on specific issues of the future and develop visionary solution approaches. Six Campus Clusters with more than 30 Campus Centers are currently being developed: Bio-Medical Engineering, Sustainable Energy, Photonics, Production Engineering, Heavy-Duty Drives and Smart Logistics. More than 360 national and international companies are already participating. In a second step, initial innovative lighthouse projects are developed based on results from the various Campus Centers. In the area of electro mobility, the electric vehicle manufacturers *StreetScooter* and *e.GO* emerged from this network.

To foster entrepreneurial initiatives, the **RWTH Transfer and Entrepreneurship Center** provides comprehensive support for business start-ups from RWTH students, graduates, and researchers. Enabled by the EXIST IV program, funded by the Federal Ministry of Economic Affairs and Energy (BMWi), RWTH developed and implemented a holistic strategical approach for its future entrepreneurs. Concrete outcomes of this initiative are the integration of entrepreneurial activities in the University's strategy, implementation of transparent guidelines for launching start-ups, building networks of entrepreneurial ambassadors in the faculties, reach out to students and researchers with events and formats as well as lean coaching processes. In 2017, 55 start-ups linked to RWTH were founded. In 2017, **RWTH Innovation GmbH** was founded with the perspective of bringing all transfer activities at the University together in an entrepreneurial environment and to serve as vital contact point for everyone involved in the transfer process.

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<sup>3</sup> "Erlebnisswelt Mobilität Aachen – die Zukunft gemeinsam erfahren" - "Experience the world of mobility in Aachen – Experience the future together".

<sup>4</sup> Campus Clusters and Campus Centers are different from Clusters of Excellence (CoE).

### **BOX 10: Entrepreneurship and Start-ups**

**Silexica** is an example of a high-tech start-up that emerged out of the Profile Area ICT, based on research results around multicore-processing in the group of [REDACTED] [REDACTED] Chair for Software for Systems on Silicon. Silexica addresses one of the biggest challenges in the electronics industry, the growing gap between software and hardware development in multicore processors. In 2016, the Aachen based Company Silexica became the first-ever foreign company nominated to the prestigious StartX accelerator of Stanford University. Two years later, they raised \$ 18m in their Series B in Silicon Valley.

**indurad GmbH** exemplifies how engineering competence of RWTH can contribute to operator assistance and automation in the mining and bulk port industry. Founded 10 years ago and based in Aachen, indurad today employs more than 100 engineers worldwide. Most globally active mining companies such as RioTinto, Glencore, BHPbilliton, Vale and Codelco are indurad's customers. Four years ago, thyssenkrupp Industrial Solutions AG acquired a 37% share of indurad.

### **Infrastructure**

Research networks at RWTH thrive because the University, together with its strategic partner FZJ, is in a position to guarantee access to cutting-edge research infrastructure. As a Helmholtz Centre, FZJ has unique large-scale research infrastructure at its disposal including JUQUEEN and JURECA which are operated by the Jülich Supercomputing Centre. These are among Europe's most powerful supercomputers and coordinated together with RWTH's High Performance Computing Infrastructure "Claix". They serve as a unique example for large scale infrastructure platforms. Other assets available to RWTH and JARA researchers include **large-scale facilities and instruments** in the area of micro and nanofabrication as well as **information technology infrastructures** and services such as **Research Data Management**. In the Profile Areas and in large coordinated projects such as the CoEs and CRCs, members have access to shared infrastructure. This access is especially important for young researchers and serves as a strong recruitment incentive for top talent. With regard to shared facilities, e.g. within JARA and the §91b research buildings (see Box 12, page 31), an outstanding research infrastructure has been systematically generated over the past decade. New infrastructure platforms are currently developed with funding from the State of NRW. These are in the areas of entrepreneurship in sustainable chemistry (QuinCat, RWTH), sustainable electrochemical process engineering (Electra, RWTH and FZJ) and translational medical product development (First-in-Translation, RWTH and DWI).

## **A.2.2. Analysis of strengths and weaknesses based on previous achievements and successes**

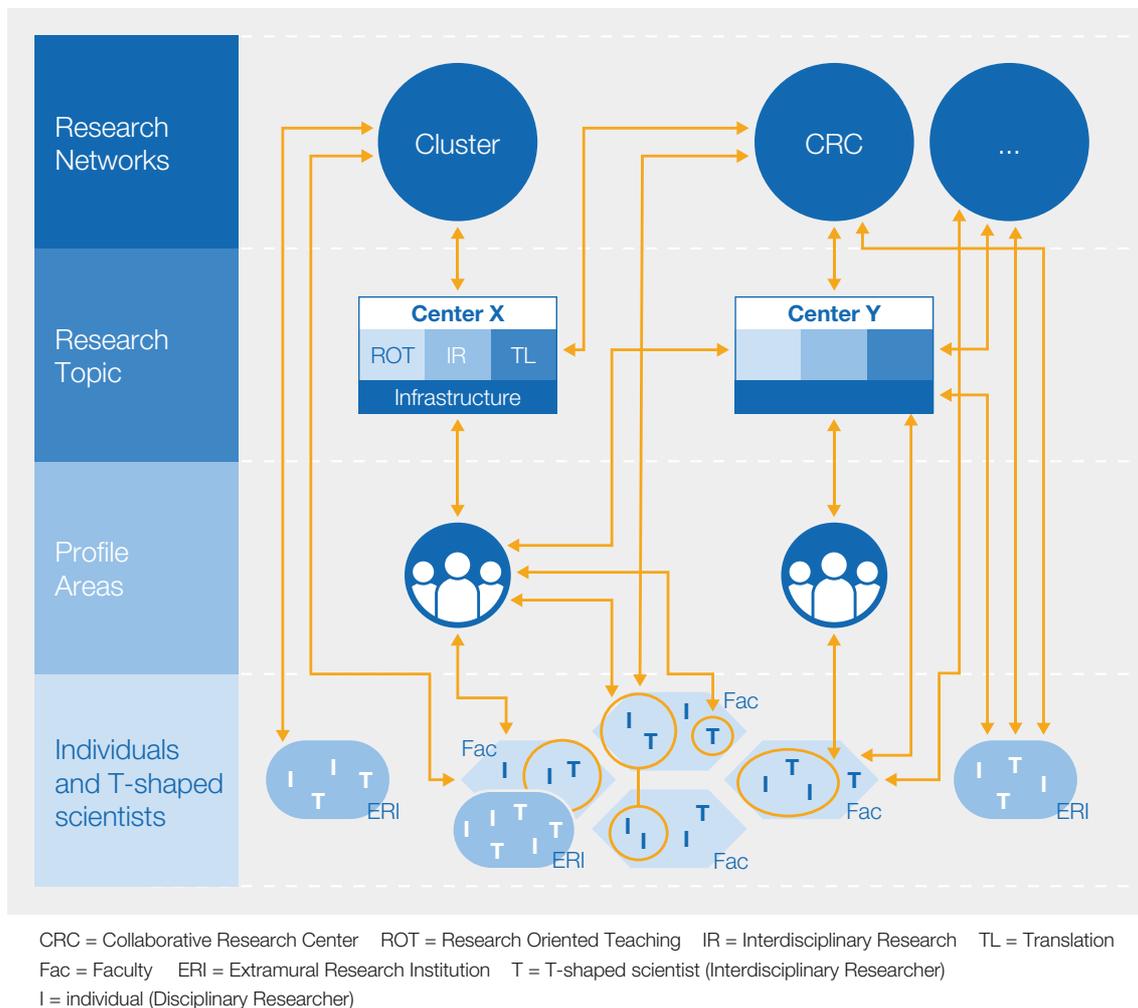
The strategic analysis of research and other performance areas is an ongoing process in RWTH's efforts to continuously strengthen its profile. All groups and bodies of the University including the rectorate, senate, Strategy Board, deans, faculties including faculty councils, and Profile Areas are involved. The results of these analyses include the structural and development plans of the faculties and the roadmaps of the Profile Areas. Starting in 2017, several workshops took place to discuss RWTH's strategy 2030. The topics of research, teaching, early career researchers, gender and diversity as well as governance were addressed in different working groups. The SWOT analysis of this proposal is based on a one-day workshop with almost 100 participants representing all groups of the University.

### **A.2.2.1. Organization and quality of research**

The areas of research, governance, personnel development, teaching, transfer and infrastructure are strongly interwoven and jointly influence many cross-cutting topics including the support of early career researchers, internationalization or quality management. The strengths and weaknesses of the University in each of these areas are described below. Tables 1 and 2 summarize Strengths (S) and Weaknesses (W) that are further described here and in A.2.2.2.

## Research

In the past phase of the Excellence Initiative, Profile Areas were established as a means of stimulating interdisciplinary research and integration beyond the classical faculty structure. This resulted in the highly networked and integrated organization of research at RWTH as summarized in Figure 6. Disciplinary (“I” for individuals) and T-shaped researchers<sup>5</sup> join forces within their faculty, with colleagues from other faculties, within the Profile Areas and with external partners such as the FZJ within JARA. The Profile Areas stimulate and facilitate the identification and founding of potential new Centers as well as new research networks. The Centers can then more effectively cooperate in national and international research networks such as CoEs, CRCs, EU networks and so on.



**Fig. 6** Organization of research at RWTH: from individuals to research networks.

<sup>5</sup> Following Guest 1991, in “Convergence. Facilitating Transdisciplinary Integration of Life Sciences, Physical Sciences, Engineering, and Beyond”, The National Academy Press, 2014, p. 62, we use the term for “...those with an ability to collaborate across a broad set of disciplines, but who maintain a depth of expertise in a single field...”.

RWTH has long been recognized worldwide for its engineering sciences and recently also for its natural sciences. Research at RWTH is highly interdisciplinary as indicated by the fact that the majority of newly initiated large-scale research projects, such as Clusters of Excellence (CoEs), Collaborative Research Centres, Research Training Groups, and Centers are interdisciplinary by nature. These achievements are proof of strengths S1 and S2. Although RWTH holds a leading position nationally in the acquisition of third-party funds (strength S6), the publication of interdisciplinary research results has to be promoted (weakness W6, measure M3).

RWTH has a strong international reputation in production engineering, not least of all due to the CoE *Integrative Production Technology for High-Wage Countries* (2007-2018). In a further development, simulation and data sciences will play a pivotal role in the newly granted CoE *Internet of Production* (IoP). The strategic partnership with the Fraunhofer network (Aachen Fraunhofer Institutes for Production Technology (IPT), Laser Technology (ILT) as well as Fraunhofer Institute for Applied Information Technology (FIT) in Sankt Augustin) will play an important role in disseminating the results from the CoE IoP into production processes.

In the field of sustainable mobility and energy supply, the Profile Areas ECPE, MSE, and MTE contributed to the approved CoE FSC. Here, synergies between the engineering sciences, chemistry and biotechnology have been successfully established. All research activities are considered in a societal and economic context. Furthermore, the close collaboration with FZJ, the Max Planck Institute for Chemical Energy Conversion and the Max Planck Institute for Coal Research will be strengthened through this CoE.

Researchers in the Profile Area ICT are PIs in the approved CoE ML4Q, RWTH's first collaborative CoE with the universities in Bonn and Cologne. The new research area dealing with neuro-inspired computing, proposed as CoE *NeuroIC*, emerged from networks in the intersection of MatSE, ICT and neuroscience. The proposal for the CoE *Predictive Hierarchical Simulation* linked models, methods and data sciences for different application areas from engineering and life sciences. The latter two CoEs were not granted. However, they both represent important future areas of development integrating aspects from simulation and data sciences with the life sciences (weakness W1) and exploiting convergence of disciplinary competences (weaknesses W2). Their overlapping scientific questions are currently anticipated to represent a potential growth domain for a new profile area. RWTH is determined to reap the great potentials in these areas (see measure M1, page 40).

## **Governance**

During the last ten years, RWTH advanced its governance, for example, by establishing the Strategy Board, strengthening its faculty management and expanding coordination

structures with FZJ (see C.7). This governance structure reflects the University's understanding of management as the interplay between top-down guidance and bottom-up processes (strength S3). It has proven its ability to realize renewal processes for example within the Faculty of Arts and Humanities, where closing the Department of Romance studies freed up resources for new professorships to support the HumTec approach (see page 8) and in the biology department, where two new professorships were strategically implemented to strengthen the links between biology and medicine. These developments were supported through the Strategy Fund.

As illustrated by the CoEs, the successful and sustainable development of research networks depends on the convergence of competences and resources across faculty, institutional and Profile Area borders. Future challenges will require further tuning in order to guarantee the capacity for organizational renewal and necessary responsiveness (weakness W3, see measure M10, page 54). The broad research profile of RWTH and the increasing interdisciplinary orientation and cooperation with strategic partners will require that the rectorate and the faculties work even closer together. The strategies of the faculties, the plans and needs of the Profile Areas, CoEs and external partners will be taken into account when considering the general strategy of the University. To further improve its effectiveness, RWTH will develop a stronger culture of shared resource responsibility between rectorate and faculties and will continue to fine tune its governance to keep it agile (see measure M10, page 54).

## **People**

Personnel development measures at RWTH cover all career stages and comprise course offerings, as well as coaching and advice for different career paths within and outside academia (strength S4). The success of these measures is reflected in the outstanding recognition of RWTH's graduates (strength S5). As described below (A.2.2.2, page 29), research-oriented teaching is a central element at RWTH. Typically, young researchers start off deeply anchored in a given discipline. During their academic career at RWTH, they are given the chance to broaden their perspective and become T-shaped researchers. Already in the past, RWTH has created framework conditions enabling junior researchers to establish their own field of expertise through RWTH Start-Up projects and the mentoring program for Advanced Talents. The latter are researchers who acquired an ERC Starting Grant, an Emmy Noether Research Group or other grants to establish independent research groups. Upon request and decision by the faculties, Advanced Talents may receive the right to supervise doctoral theses.

Nonetheless, the University recognizes its potential with regard to the identification and promotion of young talents and tenure track options for outstanding young faculty (weakness W4). Increasing the share of female researchers, integrating people with diverse

backgrounds and expanding internationalization continue to be challenging (weakness W5 and W7). Measure M6 – Nurture Talents and Teams, Boost People – will address these fields of activity.

### **Quality Management**

In 2011, RWTH published its **Guidelines to Secure Good Scientific Practice** that apply to all those involved in research. The document provides rules on research integrity including the supervision of young researchers and how to deal with potential scientific misconduct. Furthermore, ethical and legal issues and the differences between the disciplinary cultures are taken into account. RWTH has also appointed independent mediators (“ombudspersons”) to whom the researcher may turn with questions concerning good scientific practice or suspected misconduct.

The provision of internal funds for research projects or the promotion of individuals requires particular **quality management**. For the selection and evaluation, a procedure was established and published. It is as standardized as possible and involves external peer reviews for larger projects. The participants in the respective selection groups express their integrity by agreeing on a code of conduct. As a central quality management element, grantees are obliged to submit reports upon completion of the supported activities. For cooperations with industry partners, a code of conduct for collaborations with third parties refers to existing rules and behavioral norms for all RWTH members.

#### **A.2.2.2. Structure and quality of other performance areas**

## Teaching

The performance area Teaching will help attract top students to join cutting-edge research teams at RWTH. This will ensure that RWTH educates the next generation of excellent researchers. The teaching strategy of the University successfully integrates current research topics (strength S7) in the curriculum. This concept of **research-oriented teaching** consists of two phases. In the first phase, “Scientific Principles”, all students are familiarized with methodological standards, scientific writing, ethical questions, and academic integrity. The second phase, “Research Orientation”, comprises individualized activities, for example, many RWTH students work as science assistants and get directly involved in research projects.

As another major activity, **research modules** and comparable offerings have been anchored in the curricula of almost all degree programs. These are voluntary offerings to work in research projects made to particularly qualified students. To identify and promote the top 5% students in each study year, several faculties established a **Dean’s List** which is used to propose students for the prestigious award of the German Academic Scholarship Foundation (Studienstiftung des Deutschen Volkes). Dean’s List students are offered special seminars and given additional opportunities to receive funding and scholarships. RWTH developed a coherent quality management system for teaching, which has been accredited this year by the Swiss Agency for Accreditation and Quality Assurance (strength S7). 15 quality objectives are addressed by measurable criteria. The faculties use these criteria to regularly analyze their curricula following binding evaluation procedures and make adjustments, if necessary.

The digitalization strategy enables RWTH to develop innovative, effective and target group-oriented formats that make it easier for students to acquire skills in self-study outside the regular study environment, make teaching and learning more flexible, individual and attractive for international students.

## Transfer

Transfer contributes to the expansion of top-level research at RWTH in several ways. The first contribution is cultural. It is inherent in RWTH’s genetic code to consider future application early in the research cycle. This approach is facilitated by technology scouts and by having researchers and application engineers work together in interdisciplinary teams. The close cooperation with companies provides RWTH researchers with early insights from society and industry.

### **BOX 11: Open Innovation Format “RWTH-Techathon”**

As part of the strategic partnership with the BMW Group, Techathons are organized at RWTH. Students and scientific staff work together with BMW experts to develop technology solutions for use in the production areas of the automotive group. The last Techathon had the motto Printed Production. 60% of the solutions developed have already been evaluated and accepted by BMW.

The second main contribution is through RWTH's extensive transfer portfolio (strength S8) with an exceptionally high number of invention disclosures and start-ups. Strategic partnerships are foreseen for example with the IDEA League universities to provide capital needed to realize ideas. Such a partnership also supports **internationalization** efforts in research by close networking of transfer structures (weakness W7).

Several actors are involved in transfer at RWTH, like the Transfer and Entrepreneurship Center, institutes affiliated to RWTH (“An-Institute”), RWTH Aachen Campus GmbH and Innovation GmbH. Integrating them into a common strategy and uniform communication concept is one of the foremost challenges in transfer (weakness W8). To exploit the unique transfer potential and to accommodate different levels of technology readiness, the University has to develop a holistic transfer strategy.

#### **Research infrastructure**

RWTH has identified specific infrastructures which are directed at specific strategic needs and research priorities of the University. These include central scientific facilities such as the IT Center, the *Central Facility for Electron Microscopy* (GFE), and the new clean room building at the Faculty of Electrical Engineering and Information Technology.

The most important funding source for research infrastructure at RWTH is the Federal/State Program §91b “Major Research Instrumentation”. Acquisition of funding for nine research buildings (see C.5.2) and 83 large instruments (acquisition costs  $\geq$  € 200k) since 2007 testify to the success of RWTH in this highly competitive funding lines for research infrastructure (strength S9). The final report of the evaluation commission for the §91b Program of December 2017 lists RWTH on position 1 regarding funded research buildings and position 3 regarding large instruments of all German universities.

### **BOX 12: §91b Research Buildings**

The Center for *Mobile Propulsion* and *Center for Next Generation Processes and Products* provide infrastructure that advanced the research of the CoE TMFB and contributed to the successful application of the new CoE FSC.

The high performance compute cluster *CLAI*X (Cluster Aix-la-Chapelle) is the RWTH infrastructural backbone of JARA-HPC, where experts on massively parallel computing, medicine and engineering develop new methods for the engineering, natural and life sciences.

At the *Center for Biohybrid Medical Systems*, the integration of technical components and biological materials is investigated with a special focus on their production methods and testing. The CBMS cooperates with the DWI – Leibniz Institute for Interactive Materials and the Fraunhofer Institute for Production Technology.

**Research Data Management** (RDM) associated with the operation of experimental platforms, execution of experiments and generation of data requires a unique computational infrastructure. Availability and maintenance of this data infrastructure is an integral part of the digitization strategy of RWTH. Together with national partners, RWTH strives for integrating RDM into the national and international scientific landscape also through the offering of a unique IT infrastructure (see measure M3, page 46).

An **evaluation of the research infrastructure** shows that RWTH, together with its partners, was able to build up several lighthouse core facilities with national and international visibility (see strength S9 and C.5.1) that follow the respective standards in terms of operation and access. Nevertheless, there is still a lack of overview about existing infrastructure, long-term infrastructure planning, a procurement concept and agreements on intellectual property rights (see weakness W9). Especially, early career researchers and junior research group leaders need guaranteed access to research infrastructures and core facilities. The University recognizes the high potential gains in coordinating decentralized structures and bringing them into a standardized process. This will also enable effective coordination with partners, national and international road map processes. RWTH will place special emphasis on the concurrent planning and implementation of instruments/facilities and e-infrastructures including RDM.

### A.2.2.3. Excellence of researchers and framework conditions

The following indicators confirm the strong scientific accomplishments, international reputation and networks of RWTH (see C.2.4 and C.2.6):

- 19 ERC Starting Grantees, 7 ERC Consolidator Grantees, 9 ERC Advanced Grantees and 3 ERC Proof of Concept Grantees<sup>6</sup> since 2007
- 2 Leibniz Prize awardees in 2014
- 4 Alexander von Humboldt professorships since 2010, 9 Heisenberg professorships since 2009 and 2 Lichtenberg professorships in 2009
- 5 Clarivate Highly Cited Researchers in 2014-2017, one of them listed for the first time in 2017, the others being listed 2-4 times in a row
- 23 current members of DFG review boards (DFG Fachkollegien)

Many RWTH scientists are active in scientific academies including the National Academy of Science and Engineering (acatech) with 27 RWTH members. RWTH is home to several award winners, honorary doctorates and honorary professors of renowned international universities, chairs of international conferences, editors of leading journals, and board members of international scientific organizations (see C.2.8).

#### BOX 13: Excellent Researchers

RWTH is the “Place to Be” for outstanding researchers like [REDACTED] plant molecular cell biologist and Clarivate Highly-Cited Researcher in 2014 and 2015, who conducts research on cell biological phenomena in the context of plant-microbe interactions. [REDACTED] Institute for Combustion Engines and speaker of the recently granted CoE FSC, and [REDACTED] Institute for Combustion Technology, appointed from Stanford University, ERC Advanced Grantee (2016) and PI in the CoE FSC, are both T-shaped researchers based in engineering sciences spanning the bridge to chemistry of novel fuels, economical and societal aspects. [REDACTED] Institute for Communications Engineering, has been awarded two Emmy Awards (2007-2008, 2017) for his contributions to the development of video compression standards.

RWTH put in place an appointment process to recruit outstanding researchers (see Fig. 7). The strategic partnership with FZJ in JARA provides access to highly competitive research infrastructure that helps to recruit top researchers. In the future, joint appointments with non-university research institutions will be exploited further (see measure

<sup>6</sup> Of these, three Starting, two Consolidator and one Advanced Grantee have since left RWTH. One Starting and two Advanced Grantees have contracts with DWI. One Starting Grantee is affiliated with FZJ and one Proof of Concept Grantee with AMO - Gesellschaft für Angewandte Mikro- und Optoelektronik mbH, an institute affiliated to RWTH.

M9, page 53). The creation of tenure track options for early career researchers in all faculties serves to attract young academic talent and to advance careers (see measure M6, page 47). Further, the process of developing profile-forming research areas goes hand in hand with the appointment strategy and the increasing visibility of RWTH researchers. Successes have already been realized by strengthening the natural sciences, in particular in chemistry. In many cases, the appointment of outstanding scientists, including cross-faculty professorships, was made possible with support from the Strategy Fund.

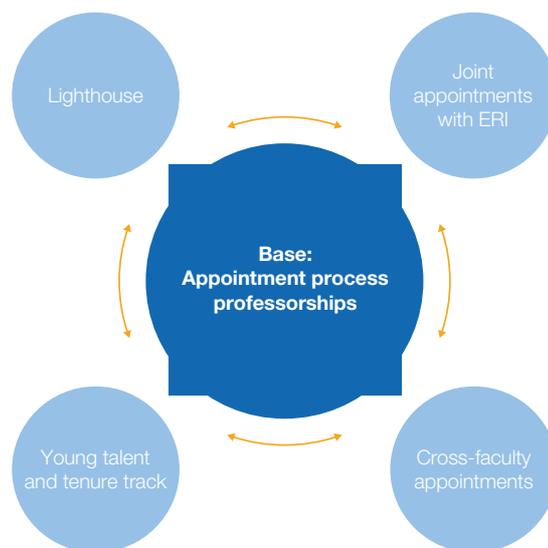


Fig. 7 Appointment process for professors at RWTH.

#### BOX 14: Prominent Appointments of Excellent Researchers

In a joint effort with FZJ, RWTH was able to attract [REDACTED] director of the JARA Institute for Quantum Information, as a Humboldt professor in 2011 from the IBM Watson Research Center. Another Humboldt professor, [REDACTED] [REDACTED] Chair of Chemical Process Engineering, ERC Advanced Grantee (2015), Vice-Rector for Research and Structure of RWTH since 2018 joined RWTH from the University of Twente in 2010. A number of exceptional former Emmy Noether junior research group leaders have been won. These include [REDACTED] Lichtenberg professor since 2009, Chair of Chemosensorik and speaker of the recently acquired *MultiSenses – MultiScales* (RTG 2416). Application for the RTG was strengthened by the orchestrated, cross-faculty appointment of [REDACTED] Chair of Neurobiological Research and ERC Starting Grantee 2012. Other highly visible appointments include [REDACTED] Chair of Experimental Physics III A, former Emmy Noether junior research group leader at Hamburg University and holder of a ERC Consolidator Grant who joined RWTH at the beginning of 2018 with a W2 Heisenberg professorship and W3 tenure track option. [REDACTED] Chair of Organic Chemistry I, ERC Starting Grantee (2014), was recruited from ETH Zurich in 2013 with the help of the return program of the State of NRW. Many prominent appointments were supported by the Strategy Fund. These include the proactive recruitment of [REDACTED] [REDACTED] Chair of Bioinorganic Chemistry and winner of the Innovation Award of the State of NRW in the category “Young Talent”.

Despite successes in the proactive recruitment of outstanding female scientists, RWTH still needs to develop extraordinary efforts to achieve its gender and diversity goals (see weakness W5). The fierce international competition for top-talent makes careful **talent management** all the more important. RWTH seeks to retain excellent scientists by offering **personal development opportunities** for all career levels regardless of gender, ethnicity, disability or background (see strength S4).

Within the framework of the graduate school AICES and numerous national and international Research Training Groups, RWTH has established standards for the **structured training of doctoral researchers**. For all doctoral researchers, the **Center for Doctoral Studies** (see A.2.1.4, page 17 and C.2.7) in conjunction with supervision agreements ensures that these standards are maintained. Within some faculties, supervision agreements outlining personal development of young researchers are already mandatory. The Research Schools within the recently granted CoEs, national and international Research Training Groups provide excellent research and training opportunities to doctoral researchers. International seasonal schools for example in cooperation with ACalNet, the Aachen-California Network of Academic Exchange, DFG-funded IRTGs or the IDEA League universities promote the internationalization of doctoral researchers. The Research Schools and the planned Honors College (measure M7) allow for flexible fast track graduation of outstanding master students and doctoral researchers.

The **Center for Professional Leadership** (CPL, see A.2.1.4, page 17 and C.2.7) provides career advice and support for postdoctoral researchers, junior and established professors. 38% of the researchers in ERS Seed Fund projects were junior researchers. They benefited from the mentorship offered by senior researchers. **RWTH Start-Up projects** (see C.2.7) supported post-doctoral researchers and junior professors in gaining their scientific independency. Female researchers were successful in winning 40% of the 120 Start-Up projects. Outstanding well-established professors were recognized as **RWTH Fellows** or **Distinguished Professors** within the Faculty of Mathematics, Computer Science and Natural Sciences. These awards honored special services to the University and outstanding research and were connected with flexible research funds. The funds were used to enhance research efforts and led in many cases to increased international visibility (see A.2.1.4, page 12).

### **BOX 15: Talent Management at All Career Levels**

In 2013, [REDACTED] [REDACTED] started a junior research group at DWI – Leibniz Institute for Interactive Materials and was recently appointed professor for Polymer Biomaterials. She became one of five researchers supported within the program for female professors of the Leibniz Association. Doctoral researcher [REDACTED] [REDACTED] received an Undergraduate Fund and did his master thesis as a visiting student at the Joint BioEnergy Institute, University of California, Berkeley. He was member of RWTH's winner team at the international iGEM competition on synthetic biology in Boston in 2014. [REDACTED] [REDACTED] was recruited as junior professor but immediately appointed as full professor of Heterogeneous Catalysis and Chemical Technology, supported by the Robert Bosch Foundation. In 2010 she received the Innovation Award of the State of NRW. [REDACTED] [REDACTED] professor of Digital Additive Production, was recruited from industry in 2016 and supported by means of the Strategy Fund. His professorship Digital Additive Production is central part of the §91b Research Building *Center for Digital Photonic Production (CDPP)*. Coming from the Massachusetts Institute of Technology, [REDACTED] [REDACTED] was appointed junior professor at the Graduate School AICES in 2010. In 2014 she became professor of High Performance Computation for Engineered Systems with tenure track option.

In addition to outstanding scientific achievements, **high employability** of RWTH researchers and graduates in academia and industry demonstrate their excellence. In the QS Graduate Employability Ranking 2018, RWTH ranks 60<sup>th</sup> in the world, second nationally behind KIT in Karlsruhe. According to the Wirtschaftswoche-Ranking, RWTH graduates from mechanical, electrical and industrial engineering are the No. 1 choice and from computer sciences No. 2 choice for hire by top companies in Germany. The University views the outstanding recognition of RWTH graduates as one of its strengths (see strength S5).

## A.3. Plans and potential

### A.3.1. Strategy and objectives

#### A.3.1.1. Vision and strategic objectives

During the previous two funding phases of the Excellence Initiative, RWTH Aachen University established Profile Areas and made strategic appointments to strengthen the natural sciences and foster cross-faculty research. Today, RWTH is converging towards an excellent Integrated Interdisciplinary University of Science and Technology committed to leveraging its interdisciplinary research culture and fueling the intellectual curiosity of its staff.

The **vision** of RWTH is to foster a unique educational and research environment that creates **knowledge**, **transfers** it to next generation researchers, industry and society and discovers solutions that **impact** today's and future technical and scientific challenges. In the future, a common core activity of RWTH's research portfolio will be the interdisciplinary comprehensive analysis, description, understanding and design of complex systems. Interactions of single system elements determine the dynamics of complex systems and need to be comprehended with disciplinary depth. Yet, a holistic understanding of complex systems requires interdisciplinary breadth with integration of numerous competences and methodologies across disciplines being a fundamental necessity. Increasing societal and governmental demands on knowledge valorization affect the balance between curiosity driven knowledge creation and application-driven engineering solutions. Therefore, RWTH strives and embraces the **convergence of knowledge, approaches and insights** from the engineering, natural, life sciences and beyond where research is organized and conducted in interdisciplinary, international teams and research networks. This requires

- a joint passion to discover innovative and sustainable solutions to meet global challenges and serve the needs of the society,
- a common goal of analyzing, describing, understanding, influencing and designing complex systems,
- the reflection on ethics and responsibility in research and innovation as an indispensable way to approach science, in both teaching and research,
- an open research culture promoting knowledge and technology transfer to increase the impact of research and
- access, maintenance and development of unique infrastructure platforms.

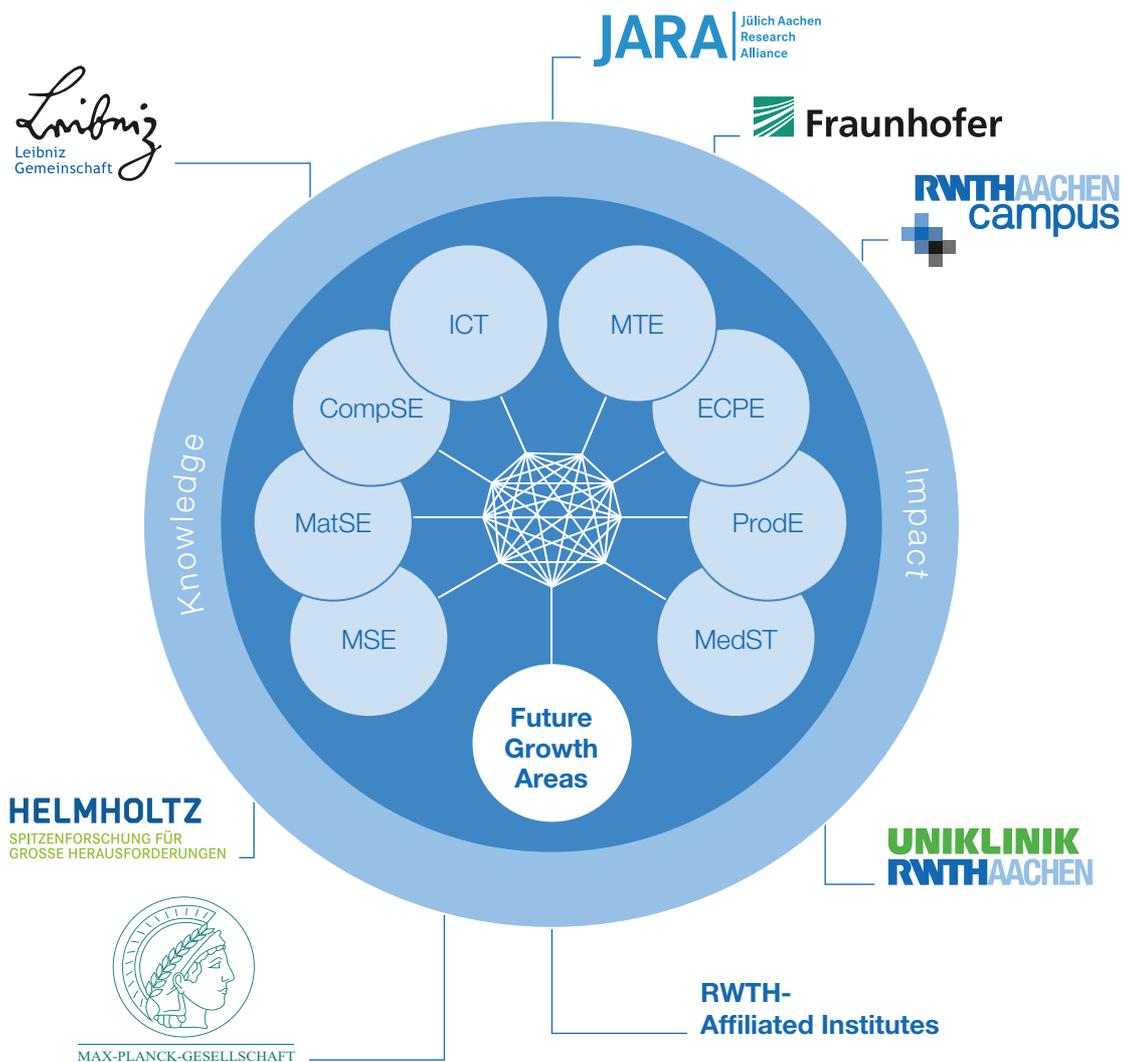


Fig. 8 The research network landscape of RWTH Aachen University.

The Profile Areas shown in Figure 8 represent RWTH's answer to meet these challenges. The eight Profile Areas are in the center of the research landscape of RWTH, characterized by many links to extramural research institutions.

They are pivotal organizational parts of the research landscape of the University and serve as incubators toward larger structures, such as centers and research networks and as communication channels within the University, to the scientific community as well as to outside stakeholders. Profile Areas serve also as instruments to implement convergence. They will be strengthened both in terms of their scientific strategy as well as their organizational structure.

RWTH has formulated five strategic objectives and ten related measures that will (i) foster an open **research culture**, (ii) **empower people** at all career levels by acknowledging their different professional developmental needs, and (iii) establish an **agile institutional framework**, governance structures and strategic partnerships.

## The Five Strategic Objectives

### Objective 1: Leverage RWTH's interdisciplinary research culture

RWTH will bolster interdisciplinary research through **growing and integrating disciplines** to tackle the challenges of complex systems. A major focus will be the strengthening of **life sciences** and **simulation and data sciences** in an Aachen-specific way. The foundation of this ambition will be measures to **accelerate integration**, to **push research frontiers**, to create an **open science culture** and to initiate **living labs**.

### Objective 2: Develop a value-chain of knowledge from teaching to transfer

Current and future cross-disciplinary research topics will be seamlessly integrated into **teaching** and forwarded into **transfer**. Research-oriented teaching will enhance undergraduate and graduate education and rigorously prepare students for future careers. Catalyzing an entrepreneurial mindset will warrant that relevant research results are shared and utilized with partners.

### Objective 3: Nurture talents, empower people and boost teamwork

This objective aims at growing skills and competencies of RWTH researchers to develop their **T-shaped scientist** profile and connect them through research networks. Strategic faculty development through tenure track appointments will lead to a **balanced scholarly population** hallmarked by a significant increase in the number of independent junior faculty.

### Objective 4: Strengthen existing and building new alliances

Strategic alliances will be strengthened to continue to boost RWTH's research by joining forces with complementary approaches and expertise. New alliances with extramural research institutions will be systematically established to enhance the scientific depth and impact of the current and future research networks.

### Objective 5: Tune the agile governance culture

The planned far-reaching developments will be supported by an agile governance. This governance culture will improve the resilience of the University and the ability to adequately **respond** to changing societal and political boundary conditions. The Strategy Fund will build the capacity for **organizational renewal** and foster **collective creativity**.

### **A.3.1.2. Opportunities and threats**

Our vision of RWTH's future and its strategic objectives is based on an extensive SWOT analysis (see A.2.2, page 24). The opportunities and threats identified are listed in Table 3.

### A.3.2. Planned measures and anticipated effects

The implementation of the five strategic objectives will occur through a set of ten measures. The first five measures M1–M5 will establish a convergence culture beyond interdisciplinary research. Additional three measures M6–M8 will empower people. Finally, two measures (M9, M10) will continuously adapt and advance our administrative effectiveness and consolidate alliances with external partners. These measures are subsequently described in detail.

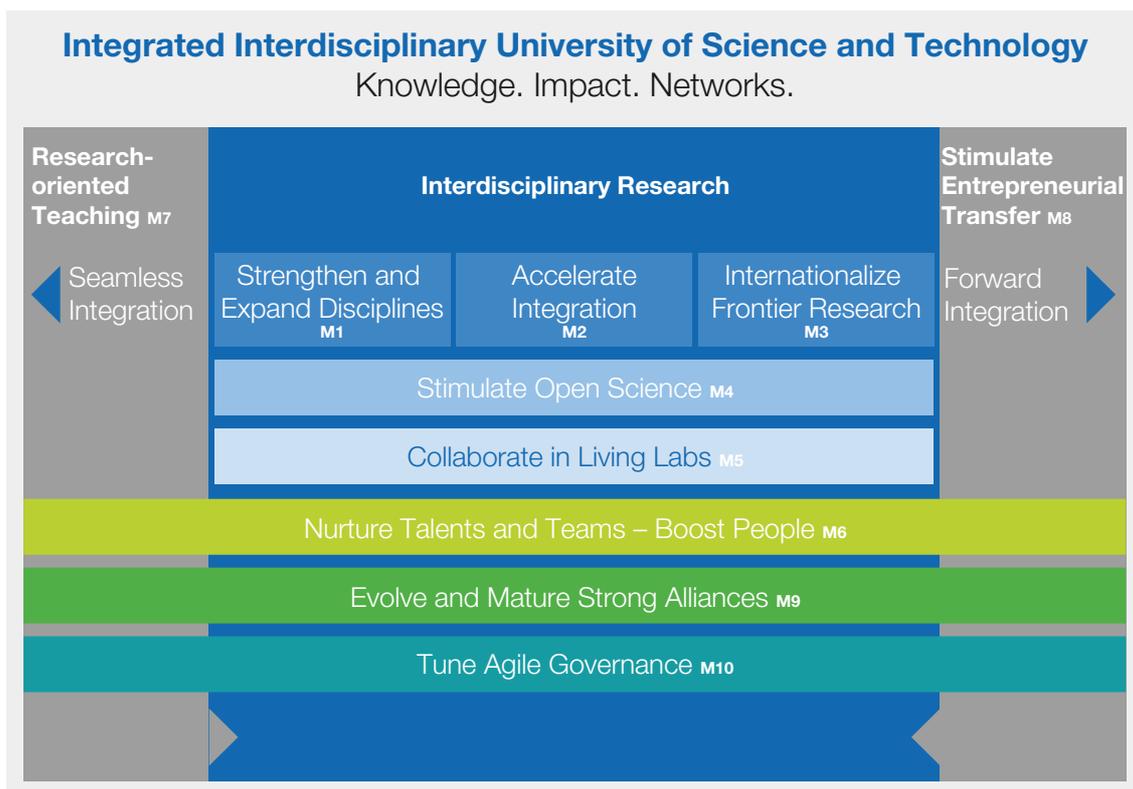


Fig. 9 Visual representation of the strategic framework with the measures one to ten to transform RWTH's research beyond interdisciplinarity, to empower people and to govern future organizational challenges.

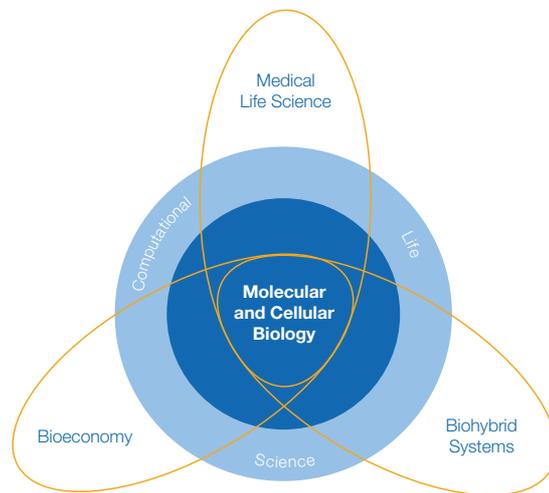
#### Measure 1: “Strengthen and Expand Disciplines”

The proven effectiveness of the past strategic decision to boost relevant fundamental disciplines outside of engineering motivates RWTH to pursue this strategy and to strengthen two distinct scientific disciplines.

##### Strengthening Life Sciences

RWTH aims at strengthening the life sciences, i.e. biology and medicine, embedded in the rapidly growing field of Computational Life Science. This will be done in an RWTH-specific way by building up specializations in molecular and cellular biology and medicine that exploit the University's strengths in the computational, engineering and natural sciences and vice versa. RWTH will establish two new professorships as well as a new interdisciplinary Center for Computational Life Science to facilitate creation of this **RWTH-specific**

**life science ecosystem.** These activities will be in strong alliance with our strategic partners and boost the research profile of RWTH in the computational life sciences and position the disciplines as strong research partners for tackling challenges centered around complex systems. Research programs in the life sciences that are aligned to and exploit RWTH's strong competence in the application domains of medical life sciences, biohybrid systems and the bioeconomy related life sciences will be strategically supported. Building up the shared infrastructure and expanding the knowledge base through new professorships will drive convergence of disciplines and nurture the development of T-shaped life science scholars.



*Fig. 10 Molecular and Cellular Biology at RWTH comprises several areas of research.*

### **Expand Simulation and Data Sciences**

In the future, machine learning, artificial intelligence, their application in data science as well as their integration with simulation science will be pivotal for the Aachen research landscape. Predictive science is only possible through the strong interaction of theory, experiment, data science, computer simulation and artificial intelligence. For the physical, life sciences, and engineering systems being subjected to simulation analysis or design, improvements in computational technology cannot cope with the increasing system complexity required to be simulated. The next generation in scientific computing cannot rely solely on improved hardware, but has to follow an integrated predictive approach based on the simulation tripod consisting of the three cornerstones: Models, dealing with mathematical descriptions of reality; Methods, translating these descriptions to a computable form; and Data, as input to the models and methods. The new JARA Center for Simulation and Data Science (CSD) is a **unique breeding ground** with its approach exploiting the strong mutual interaction between models, methods and data for the development of the **next generation of simulation**.

Next to simulation science, machine learning, artificial intelligence and their application in **data science** are expected to improve the quality and the depth of conclusions drawn from analyzing massive data from multiple sources having heterogeneous quality. RWTH considers machine learning and in particular data science as a critical science domain to achieve convergence in key research areas including life sciences, personalized medicine, social sciences, physics, production, process engineering and future mobility.

In order to induce convergence nucleated from the field of data science, RWTH will establish a new W3-professorship for “Machine Learning” in the department of Computer

Science. This will be accompanied by the allocation of a W3-professorship in the area of “Mathematics of Machine Learning” from university resources. A highly qualified, internationally recognized researcher is envisioned combining his/her call to Aachen with an application for an Alexander von Humboldt professorship (AvH). This is a thematic continuation of the successfully acquired AvH professorships by [REDACTED]

[REDACTED] In 2019, the Faculty of Mechanical Engineering will contribute to this convergence in data science by allocating a domain-specific professorship in the field of production engineering. Two more tenure track professorships within the CoE IoP will be funded from university resources.

To strengthen life sciences as well as simulation and data sciences, RWTH will also appoint five new W1/W2 tenure track professorships. Scientific domains addressed by the new professorships will be defined within the new governance structure where rectorate, faculties and Profile Areas interact.

- 1.7 Funding of € 7.3m is requested for two new W3-professorships targeting molecular and cellular biology and computational life science.
2. RWTH will establish an Interdisciplinary Center for Computational Life Science (budgeted in measure M2) and a new joint infrastructure platform (budgeted in measure M10) via the Strategy Fund.
3. Funding for ERS Seed and Prep Fund Projects is allocated in measure M2.
4. Two new W1/W2 tenure track professorships in Computational Life Science will be funded by RWTH resources.
5. Funding of € 3.6m is requested for a new W3-professorship in machine learning.
6. Funding of € 8.7m is requested to install five new W1/W2 tenure track positions, including a research budget, infrastructure and one doctoral researcher each<sup>8</sup>.

## Measure 2: “Accelerate Integration”

Three main activities will be developed to accelerate the growth and sustainability of interdisciplinary research. They are designed to identify problems whose solutions require a convergence approach leveraging RWTH’s scientific profile and to implement the enabling structures.

### Exploratory Research Space (ERS)

ERS Seed Funds proved to be very effective in developing new research topics as well as generating publications and follow-up peer-reviewed third party funding. Therefore, they will be continued. Profile Areas will now act as scouts, identifying strategic research areas for topic-specific calls and guarding the quality of these ERS projects.

<sup>7</sup> The following boxes summarize the requested funding per measure.

<sup>8</sup> Planned to be funded by the University Allowance of the Excellence Strategy.

As a new project format, ERS Prep Funds will be introduced, varying in size and duration according to the needs of the specific project. Prep Funds will be awarded competitively following periodic calls. The criteria are (i) identification of a gap in an area of high strategic importance, (ii) definition of project goals to close this gap, (iii) description of tangible deliverables. For ERS projects together with strategic partners, for example in the framework of JARA, partners are expected to provide matching funds.

**The International Research Space (IRS)** will be implemented to provide additional funding options for ERS projects with international partners, who are expected to provide matching funds. IRS funds can be used for research exchanges (Kármán Fellowships, usually 1-3 months) with tandem partners. Additional funds (IRS +) will be awarded to support scientific cooperation with emerging and developing scientific communities.

For the ERS administration, € 158k p.a. is allocated and for all projects € 2.0m p.a.<sup>9</sup> 25% of the ERS funds will be earmarked to support new developments in life sciences and simulation and data sciences (measure M1). 25% will be used to strengthen JARA and other cooperations with German and international research institutions (measure M9).

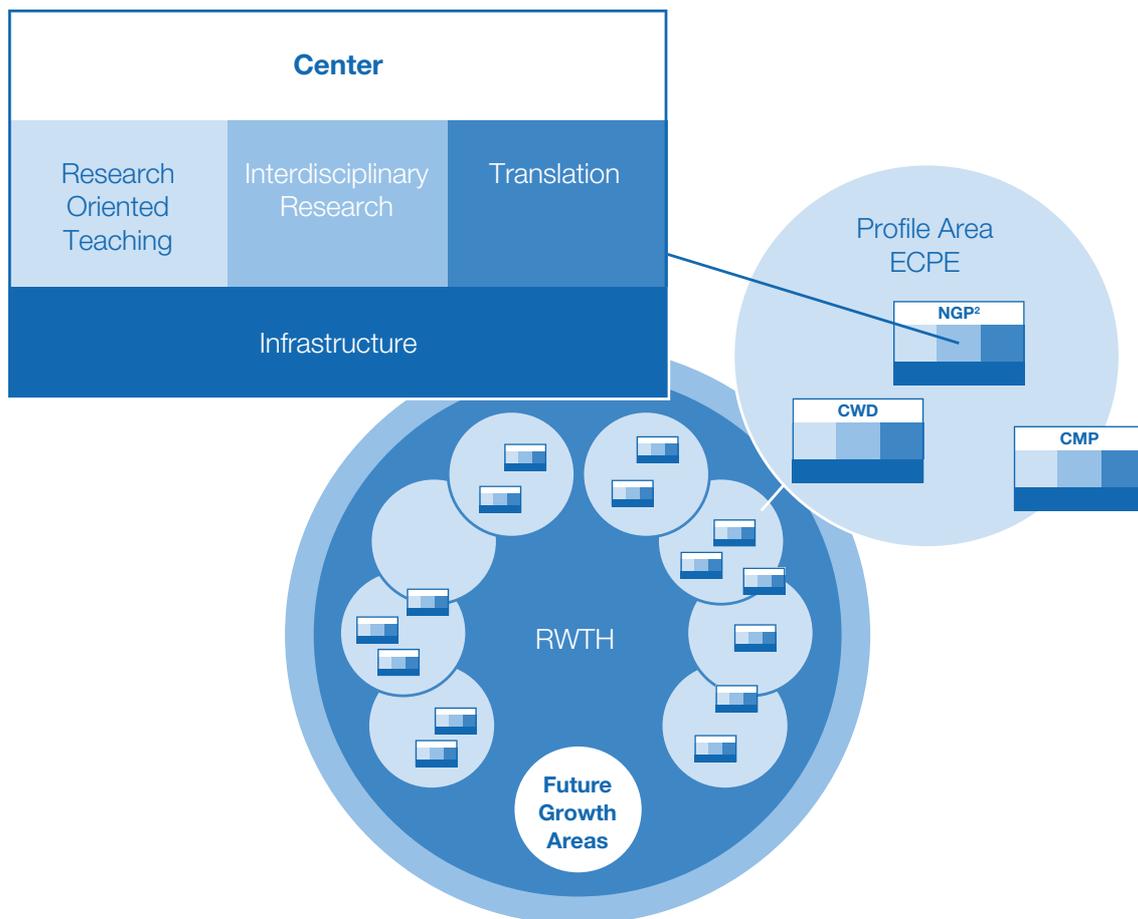
### **Centers as Interdisciplinary Research Structures**

Centers will be formed via a self-organizational bottom-up process (see Fig. 11) that is coordinated with the Profile Areas and supported by the rectorate. Centers are adaptive entities comprising (i) a core research program, (ii) open and shared infrastructure for center and associated members, (iii) research-oriented teaching activities, and (iv) transfer into industry and society. The interplay of a unique research program, forefront infrastructure, young talent and scientific and industrial network makes every Center unique. Initial financial ramp-up support will be granted by the rectorate upon decision of the Planning and Allocation Committee (measure M10, page 54) depending on the needs, relevance and strategic fit, as well as the size and degree of network formation. Centers will be open to include scientists from external institutions, in particular Leibniz and Max-Planck Institutes, Helmholtz Centers and Fraunhofer Institutes.

An example of a very large Center is the JARA Center for Simulation and Data Science (CSD) which will bring together the Profile Areas CompSE and ICT, JARA-HPC, the German Research School for Simulation Sciences (GRS) and the Graduate School AI-CES. Most centers, however, will be smaller. They can exist within one faculty, such as the Center for Next Generation Processes and Products (NGP<sup>2</sup>), or across faculties such as the Center for Biohybrid Material Systems (CBMS), or the Comprehensive Diagno-

<sup>9</sup> Planned to be funded by the University Allowance of the Excellence Strategy.

stic Center Aachen (CDCA). Currently, the JARA-BRAIN Center is in preparation. The Center will integrate the two JARA-BRAIN Institutes and aims at fostering translational neuroscience in psychiatry and neurology. The Future Mobility Center (FMC) is a prominent example integrating competences of the Profile Area MTE and the Aldenhoven Testing Center (see page 6). In FMC, researchers from different disciplines collaborate to create innovative elements for future mobility systems. They exploit both internal and external networks to have these elements integrated into future products.



**Fig. 11** Visualization of the scalability of Centers as interdisciplinary research structures contributing to the continuous evolution of Profile Areas. In the example given here, the Center for Wind Power Drives (CWD), the Center for Mobile Propulsion (CMP) and the NGP<sup>2</sup> contribute to the evolution of the Profile Area ECPE.

RWTH is applying for € 3m to support the set-up and development of at least three new centers including an Interdisciplinary Center for Computational Life Science (see measure M1). If more than three centers are established and additional funding is required, it will be provided by the Strategy Fund (see measure M10).

### Empowering and Elevating Profile Areas

The Profile Areas represent the most prominent structures for interdisciplinary research at RWTH (see A.2.1 and C.2.8). The Profile Areas will be further empowered and ele-

vated. The members of the Profile Area Steering Committees are expected to scan the international field to identify strategic topics for ERS Calls, emerging fields and the best global talent. Additionally, the Profile Areas will prepare roadmaps, keep them up to date and coordinate short, medium and long-term research activities to realize the roadmaps. Moreover, they are responsible for defining and planning new professorships in close cooperation with the rectorate and faculties. Profile Areas will play a key role in forging new and intensifying existing alliances with external organizations, coordinating related Centers and moving technology through the pipeline with industrial partners. Through their research and networking activities as well as their acquisition of third-party funding with international partners, the Profile Areas are expected to enhance their reputation and increase internationalization. With respect to a structural embedding of the Profile Areas in the governance of the University, representatives of the Profile Areas will be part of the Strategy Board.

RWTH intends to fund the coordination of the Profile Areas (1.0 FTE per Profile Area plus overall coordination). An additional amount of € 400k p.a. is requested to support strategic and networking activities (e.g., workshops, conferences).

### **Measure 3: “Internationalize Frontier Research”**

Initiatives to drive international frontier research and allocation of their respective budgets are interwoven throughout this proposal, for example in the International Research Space (IRS), networking activities of the Profile Areas (measure M2), strategic alliances (measure M9), the European Open Science Cloud (measure M4), talent recruitment and management strategy, the Advanced Research Opportunity Program (AROP), the Junior Principal Investigator (JPI) program (measure M6), the Honors College (measure M7) or Frontier Workshops (measure M8). These initiatives also contribute to strengthening the strategic cooperations with our international partners. Increasing the number of interdisciplinary peer-reviewed publications will be supported by writing workshops addressing online collaboration, team writing and interdisciplinary communication.

To promote and discuss frontier research topics at the interfaces of different disciplines on an international top-level, **Kármán Research Conferences** were established within the Institutional Strategy and will be continued. Chaired by at least two outstanding researchers from different disciplines, they attract internationally visible speakers. Typically, meetings have 50 to 100 participants and last three to five days, thus providing invaluable networking opportunities especially for early career researchers.

RWTH will fund Kármán research conferences and writing workshops with € 100k p.a.

#### **Measure 4: “Stimulate Open Science”**

Today’s global research enterprise is characterized by an exponentially increasing amount of data. This humungous amount of data represents an invaluable asset of explicit or implicit knowledge. However, data used in publications are generally only accessible to a limited extent through publishing houses. The “Open Science” movement strives for greater and FAIR access and usability of data, methodologies, codes, algorithms and publications. FAIR means that data are Findable, Accessible, Interoperable, and Reusable. RWTH comprehends Open Science under the technical term Research Data Management. RDM is part of the digitization strategy for the University’s core processes. The goal is to establish a consistent RDM covering the complete data life cycle/research cycle. This comprehensive methodology was recently developed and will be implemented during the next years. RWTH expects this to result in (i) more rigorous and reliable data, (ii) new and exciting questions, (iii) fast and inclusive dissemination of knowledge, (iv) intensified participation in research, (v) effective use of resources, and (vi) transparent peer-reviewed publication for public benefit. RWTH strives to lead the integration of RDM in the national and European scientific landscape by implementing the FAIR principles. In fact, RWTH aims at being the pacemaker to build an open science ecosystem relying on the preparatory work of the University Library and the Patent and Standards Centre (PNZ). RWTH will lead a national consortium (NFDI4Ing) with partners FZJ, TU Darmstadt, Leibniz Information Center for Science and Technology / University Library at Hannover and Karlsruhe Institute of Technology. It will be part of the German Research Data Infrastructure (NFDI) and will be interoperable with the European Open Science Cloud (EOSC).

These future activities at RWTH can be operated out of newly created processes in the IT Center and Central Library. They are coordinated by the RWTH RDM-Manager, who is responsible for all activities in RDM. The structures and processes will be supported by data-stewards who support researchers with their data management. This will be the base of an RWTH-internal RDM network.

RDM is already becoming the standard in research networks such as CRCs, bigger research projects and the CoEs. To initiate and spread central RDM activities, additional staff will be responsible for central coordination, first level support, training and consulting to proactively and sustainably embed RDM in research networks at RWTH. One of the main tasks until 2020 is to strengthen the integration of the existing tools into an RDM process layer and create a user-friendly interface, which hides complexity of the processes. Large shared central research infrastructures, such as electron microscopes (GFE) and supercomputers (IT Center), which are used by researchers from different disciplines will be utilized to develop best practice examples and guidelines based on a rigorous evaluation of user behavior.

To foster RDM-infrastructure, RWTH will provide adequate staff and technical infrastructure. An annual budget of € 760k is designated<sup>10</sup>.

### **Measure 5: “Collaborate in Living Labs”**

In the past phases of the Excellence Initiative, the Project Houses *Interdisciplinary Management Factory* (IMF) and *Human Technology Centre* (HumTec) (see A.2.1, page 8) helped to redirect the research activities in the School of Business and Economics and the Faculty of Arts and Humanities. Starting from these Project Houses, context-sensitive, situation-related methods for **Living Labs** will be initiated to foster the cooperation between science and civil society in order to find meaningful solutions to complex challenges. Living Labs are the place for innovative research with participation of citizens and stakeholders. RWTH plans to install and fund a coordinator who is expected to foster method development and build a Living Lab **network** to apply for joint projects in close cooperation with the Profile Areas.

Responsible research and innovation (RRI) is one of the guiding principles of RWTH and one of the research topics that will be addressed by a Living Lab, the **RRI Hub**. An essential component of the RRI Hub is to integrate students in interdisciplinary research teams working on solutions to real problems with non-profit organizations. Elements of social responsibility and sustainability will be gradually integrated in the educational framework of all curricula. The Collective Incubator (see page 52), where students can explore their own innovation potential, will serve as a potential link to transfer.

Coordination of the Living Labs will be supported with € 200k p.a. Project funding can be realized via ERS, the installation of a joint Living Lab infrastructure may be backed by resources of the Strategy Fund.

### **Measure 6: “Nurture Talents & Teams – Boost people”**

Attracting, recruiting and retaining top talent is vital to sustain the University’s continuous improvement and success. RWTH will proactively recruit high potentials, especially internationally, and equip them with the competencies they need to make an impact in interdisciplinary environments in academia or industry.

#### **Talent Acquisition Strategy**

Providing attractive infrastructure and career paths is crucial to the proactive recruitment strategy of RWTH and has already been effective in recruiting outstanding people

<sup>10</sup> Planned to be funded by the University Allowance of the Excellence Strategy.

including international researchers as well as female candidates for professorships. In continuation thereof, an enhanced comprehensive Talent Acquisition Strategy with target group specific recruiting, welcome services, dual career offerings and marketing measures will build an attractive employer brand with high international visibility.

RWTH will implement an **Advanced Research Opportunity Program (AROP)**, as a further expansion of the very successful undergraduate program UROP (see A.2.1.5, page 20), established in the first phase of the Institutional Strategy. AROP will offer excellent international doctoral and postdoctoral researchers from key strategic partners, emerging countries and crisis regions the opportunity to work on short-term research projects at RWTH. AROP researchers will be provided with travel stipends and an intensive mentoring program including cultural and language training.

RWTH will offer a total of 16 new **Junior Principal Investigator (JPI)** fellowships aimed at bringing excellent and experienced young academics to Aachen for four years with an optional fifth year. 70% of the fellowships will be reserved for international or national researchers who have been abroad for at least two years. At least one third will be awarded to female candidates. These positions will give young scholars envisioning an academic career an enviable opportunity to build their own field of research, establish strong networks, develop a T-shaped profile and generate high impact publications. This will prepare them for highly competitive personal grant programs of the DFG and ERC. The JPIs are expected to take advantage of the Profile Areas and strategic alliances of RWTH (measures M2, M9) and strengthen the relationships between labs. Even though the fellowships are awarded based on open calls, the applicants must be associated to a specific Center or Profile Area. They will also need to identify a responsible host to ensure that the JPIs have access to space and basic infrastructure including secretarial and technical support. Each JPI will supervise doctoral researchers and will have a research budget and one full doctoral researcher. Mentoring of the JPIs will be guaranteed by the RWTH Center for Young Academics in the context of the Advanced Talents program.

In the first two phases of the Institutional Strategy, junior professorships were widely established to attract young academic talent. This approach will be improved by establishing **tenure track professorships** in all faculties.

### **Talent Management**

RWTH provides a vigorous and inspiring learning environment for early career researchers of all levels and with diverse backgrounds. The **RWTH Center for Young Academics** will be the umbrella for the CDS, the CPL (see A.2.1.4, page 17) and the various research schools and will ensure the standardized training of all early career researchers. The offerings become more individualized with advancing career and more topic-specific by integration of the research schools of the CoEs and national and international Research Training Groups. Tailor-made offers will be provided especially for international

young scientists. Mandatory elements comprise creating sensitivity to and acceptance of Scientific Integrity and Responsibility in Research and Innovation. The coordinator of the Center for Young Academics will manage the cooperation between the research schools, faculties and institutions for personnel development and research funding. The strategic cooperation between Center and faculties will comprise a common data base on the development of early-career researchers. A central advisory board reporting to the rectorate will safeguard the quality and implementation of the initiatives. A representative of the Center will be a member of the Strategy Board.

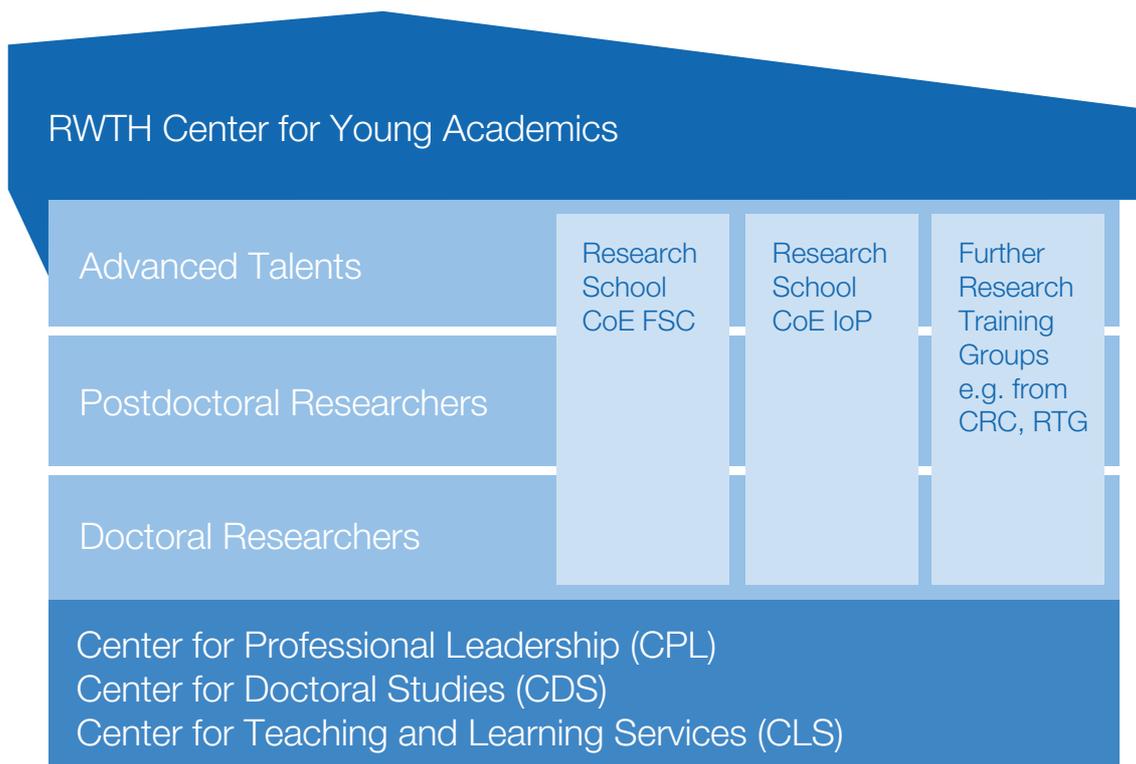


Fig. 12 The RWTH Center for Young Academics.

### Equal Opportunities and Diversity Management

Equal opportunities and diversity are cross-cutting issues of the University's strategy and the overall Staff Development Concept for all members of RWTH. Sensitization offers and competency development will actively promote diversity awareness and avoidance of implicit bias of all university members as well as in different processes and institutions. Coaching and mentoring of managers and senior faculty will promote leadership skills so that they can support every single employee in achieving their potential. To close the gender gap in research, RWTH will proactively recruit high potential and highly qualified women for all levels of research positions and invest in their professional development. While there has been indisputable progress, the gains in the promotion of women remain below the targets of RWTH. With the goal of reaching at least a 25% share of female professors by 2030, RWTH has agreed to a cascade model applying for all career levels

starting with the level of doctoral researchers. In the past, a share of 30% of internal research project funds was allocated each for projects with female researchers (see Box 6, page 17). It will be applied for ERS/IRS projects as well as AROP and JPI positions. The wide range of family-friendly measures including child care, re-entry coaching and workshops for dual career couples at the beginning of their academic careers will be expanded. The group of disabled students and scientists will be systematically and actively supported.

To implement the Junior Principal Investigator fellowship (2 calls \*8 fellows/call for 4+1 years) RWTH is applying for a total budget of € 14.3m. At least one third will be awarded to female candidates. To strengthen the talent acquisition and management activities and gender & diversity efforts, financial support of € 705k p.a. is requested.

### **Measure 7: “Research Oriented Teaching”**

RWTH is committed to developing world-class researchers who contribute to finding sustainable solutions to scientific and global challenges. Discovering these solutions requires a holistic research approach since the problems are complex and have multiple interacting facets. As such, researchers will need to have a T-shaped profile to effectively integrate scientific depth in their discipline with broad knowledge and understanding of other relevant disciplines. Interdisciplinary master courses (see A.2.1.5, page 19) and the interdisciplinary training of doctoral researchers for example in the research schools of the CoEs contribute to this necessary convergence in teaching.

Measure 7 aims at taking the next step by empowering students to grow beyond borders of disciplines and will allow the seamless integration of current research topics in teaching.

### **Honors College**

The Dean’s List of RWTH (see A.2.2.2, page 29) will be further developed and utilized to establish Honors College programs at both the bachelor and master level. The Honors College will identify and attract promising students and help shape them into top international researchers with the envisioned T-shape profile. On the bachelor level, the Honors College will provide an additional curriculum of 30 European Credit Transfer System (ECTS) credits for courses on professional skills, responsible research and innovation (RRI) and for interdisciplinary research projects. On the master level, students in the Honors College will largely define their own curriculum within a basic study framework and with the support of a personal mentor. This independence puts students on a fast track towards their doctoral graduation through selection of their master curriculum in line with

their doctoral topic. For fast track and Honors College students, international research or training experience will be mandatory. They will be supported by travel grants with specifically defined educational and training objectives. These stays will preferably be in institutions of strategic international partners such as IDEA League universities or international partners of the Profile Areas and CoEs.

### **Digitalization Strategy for Teaching**

Digitization is key to scale-up individualized research-oriented teaching. RWTH aims to have an extensive offering of courses supplemented with a variety of digital formats for online training, in order to meet the needs of individual students regarding when, where and how they learn best. Digital formats will enable independent, self-paced learning. Research-oriented teaching will be supported by making research results available in digital formats and integrating these into RWTH courses. The digital material can be made available as Open Educational Resources under a Creative Commons license, serving to enhance the visibility and reach of RWTH's research and efforts in research-oriented teaching. Existing measures will be further strengthened by establishing Learning Analytics Services. The aim is to use learning analytics and educational data mining to help students as well as teachers optimize their individual learning and teaching strategy.

### **Exploratory Lecturer Space**

In the spirit of empowering people, the aim of this instrument is to promote continuous qualification for educators. New professors will be given and obliged to use a free budget to develop their individual training plan with support of the Center for Teaching and Learning Services. All lecturers at RWTH can apply for budgets to develop ideas on how to use research-oriented teaching and innovative teaching technologies to increase internationalization in their courses. The Exploratory Lecturer Space is realized by RWTH resources.

To put the described activities on track, RWTH is asking for a total of € 647k to provide necessary personnel and means. After an initial phase, RWTH will run the activities with its own resources.

### **Measure 8: “Stimulate Entrepreneurial Transfer”**

This measure is based on the broad understanding of transfer at RWTH which entails the continuous and mutual exchange of ideas, knowledge, technologies and people within the University, with partner organizations and societal groups as well as industry (see A.2.1.5, page 20). The term “entrepreneurial” is not meant in the restricted sense of spin-offs and start-ups only. At RWTH, entrepreneurship refers to a mindset of thinking and acting proactively under uncertainty. With this understanding, the activities in Measure

8 focus on developing personal entrepreneurial competencies and providing structural support for entrepreneurial transfer. Orchestrating entrepreneurship is the vision of the recently submitted proposal to the “Exzellenz Start-up Center.NRW” program. As such, the measure fuels the RWTH innovation landscape with entrepreneurial spirit and tangible activities.

The RWTH Center for Young Academics will provide corresponding formats to infuse this paradigm of thinking and acting early on. To provide students with the opportunity to practice entrepreneurship, RWTH recently submitted a proposal to fund the **Collective Incubator** as part of the Exzellenz Start-up Center.NRW program. One of the goals of the Collective Incubator is to create a place where students can explore their own innovation capabilities.

There are already many transfer activities and structures in place at RWTH. To drive and support entrepreneurial transfer activities in emerging fields, RWTH recently founded the **RWTH Innovation GmbH** as a central technology transfer organisation. The RWTH Aachen Campus GmbH together with the Collective Incubator and the planned Innovation Factory provide a unique transfer and innovation ecosystem.

Furthermore, **Techathons** dedicated to the development of entrepreneurial skills of young RWTH researchers will be supported. **Frontier Workshops** will be organized in close cooperation with the Profile Areas. Here, selected representatives from industry and society will be invited to discuss their ideas and vision about future requirements of knowledge and technology in fields relevant to the Profile Areas. The format will allow RWTH researchers to reflect on and refine their own ideas. In addition, the workshops provide a platform to learn from and network with top-class international researchers and entrepreneurs. Specifically, the workshops aim at igniting new product, process and service related research and development activities. The outcome of the sessions will be documented in roadmaps specifying transfer domains and concrete objectives for further research. The benefit for participating representatives from the industry will be a better sense for RWTH research, which is considered as the first step of successful transfer.

To facilitate knowledge transfer into society, the **Knowledge Hub** will be the new instrument for a two-way communication between RWTH researchers, the general public and further target groups such as media, educational institutions and political decision makers. The Knowledge Hub will be an essential part of an open science and network culture at RWTH facilitating bidirectionality with citizen science projects.

For organisation of Frontier Workshops, Techathons, the Knowledge Hub and for follow-up funding to test the feasibility of the resulting ideas, a budget of € 300k p.a. is reserved.

### **Measure 9: “Evolve and Mature Strong Alliances”**

JARA, the **Jülich Aachen Research Alliance** is the strongest and most developed strategic partnership of RWTH. In order to further bundle expertise, jointly manage resources, ensure research-oriented teaching and integrate industry and society, the six sections of JARA will be more strongly interlinked with other structures at RWTH and FZJ, such as the Profile Areas or Helmholtz infrastructures. Currently, the sections JARA-HPC and JARA-BRAIN are pioneering the integration of JARA structures into large joint centers. In the next years, other sections will be analyzed for their integration and combination possibilities. RWTH and FZJ have recently developed an extended roadmap to even further institutionalize the JARA cooperation in research domains such as future energy systems, future information technologies and neurosciences. Further coordinated development of unique joint user facilities will ensure world-leading methodological platforms. An amended contract specifies further improvements in the governance and future development of JARA. RWTH and FZJ will work even more closely in offering joint professorships to address new scientific topics and to hire outstanding scientists. Both partners will coordinate their applications for junior research groups and professorships, particularly related to the funding procedures of the DFG, the Helmholtz Association of German Research Centers, Alexander von Humboldt-Foundation, and the BMBF.

RWTH pursues effective cooperations with other extramural research institutions besides FZJ. Relationships will be strengthened with the **Fraunhofer Society, the Leibniz Association, the Max Planck Society** and additional institutes of the **Helmholtz Association**. The level of cooperation will vary depending on the history and focus of the different cooperation topics. Multilateral cooperations in research networks will increase in the future.

With Fraunhofer, the strong ties have a long history. The Fraunhofer Institutes for Laser Technology (ILT), Production Technology (IPT) and Molecular Biology and Applied Ecology (IME) are located on the premises of the RWTH Aachen Campus. A recent activity is the cooperation in the CoE IoP with the Fraunhofer Institute for Applied Information Technologies, St. Augustin (FIT), the ILT and IPT. Due to the increasing importance of simulation and data sciences in the CoE IoP and at RWTH in general, the cooperation with FIT will be intensified. To further develop **Aachen as a Fraunhofer Hub**, RWTH will, in selected cases, align its planning processes with the Fraunhofer directorate.

The **DWI – Leibniz Institute for Interactive Materials** is a prime example of the convergence paradigm. In 2014, it became a member of the Leibniz Association only after a rigorous evaluation process. Its uniqueness lies in the organizational framework and interdisciplinary research program, where the disciplines of biomacromolecular chemistry, biotechnology and chemical engineering converge. DWI has initiated a new infrastructure on the RWTH Aachen Campus called **fiT first-in-Translation**. This cooperation bet-

ween the University Hospital Aachen, the Center for Biohybrid Medical Systems CBMS and DWI tackles roadblocks in translating biomedical concepts into products. Together with the Leibniz Institute for Social Sciences, GESIS, Cologne, RWTH will establish a joint-professorship in the framework of the research activities in HumTec.

Aachen does not have any Max Planck Institutes on its premises. In the past, cooperation with Max Planck Institutes has been through Max Planck fellows. This cooperation will be intensified by the set-up of a Max Planck Research Group in the area of NMR-spectroscopy at the Aachen site. RWTH will provide a tenure track professorship for the group. The goal is to strengthen the cooperation between the MPI for Chemical Energy Conversion, Mülheim an der Ruhr, and the Profile Areas ECPE and MSE and the CoE FSC. RWTH will use a variety of funding instruments to develop JARA and expand cooperation with other extramural research institutions. These include ERS Project Funds and Strategy Funds. For example, (i) ERS funds (see measure M2) can be used to develop specific topics. Additionally, (ii) the Strategy Fund (see measure M10) can be used for structural development aimed at creating common infrastructure (Centers and joint research infrastructure). Finally, (iii) the Strategy Fund can also be used to recruit and develop both junior and senior level researchers. RWTH intends to utilize ERS and the Strategy Fund to fuel these endeavors.

Based on an already firm foundation of successful and synergistic cooperations and partnerships, the universities of Aachen, Bonn, Cologne, and Düsseldorf (ABCD) will ramp up their joint strategic planning activities to better coordinate their concerted actions by establishing the new **Rhineland University Alliance** (RUA) as a firm strategic and institutional/organizational basis for cooperation. Cooperations will address all performance and activity areas. The development of the RUA will be evaluated by external experts after four years.

In addition to the existing international partnerships and cooperations (see A.2.1.4, page 16), further strategic international partnerships are planned within the framework of the CoE or Profile Areas.

To support the fostering and further integration of JARA and other partnerships and the expansion of cooperations, RWTH intends to provide additional resources of € 1.22m p.a. Further funding will be provided by ERS and the Strategy Fund.

#### **Measure 10: “Tune Agile Governance”**

RWTH underwent a transformation process in the last decade. In addition to the willingness to change, an agile governance structure and the availability of flexible resources were key to realizing these developments. As stated in A.2.2.1, RWTH’s governance structures need to be able to adjust to changing requirements in order to turn uncer-

tainties into opportunities for the University (**ability to respond**). The University needs to maintain powerful decision making processes to retain its capacity for organizational renewal and guarantee sustainable structural development (**ability to renew**). It is very important that decision making processes enable the University to rapidly and effectively adapt to dynamic framework changes and to seize arising opportunities (**ability to react**). The University must be in a position to strengthen cooperations with non-university research organizations, build symbiotic partnerships both nationally and internationally and make use of the local research and innovation environment on Campus (**ability to cooperate**). RWTH aims to fine tune its governance processes and related instruments to establish a supportive environment for convergent research and to nurture the collective creativity of its staff.

### **Governance**

The **participatory character** of governance defines RWTH and is manifested in a spirit of collegiality where different groups of the University cooperate to achieve common goals. The **existing board structure** (see C.7.2) has been shown to be suitable in the past and will thus continue to exist without being supplemented by further entities. Nevertheless, the increasing need for cross-faculty planning and decision making demands additional governance processes. Structural questions need to be discussed, negotiated and consensus forged across the faculties and the rectorate. This is the responsibility of the new **Planning and Allocation Committee**. All deans and all members of the rectorate will be members of this committee. The Planning and Allocation Committee replaces the previous deans' meeting. In the future, the area of responsibilities of the new Planning and Allocation Committee will be significantly expanded compared to the deans' meeting and will include structural development strategies **across faculties** instead of only within faculties. The responsibility for the development of an overall strategy for RWTH and the final decisions regarding the structural development remain with the rectorate. The faculties remain responsible for the development and organization of research, teaching and studies in their respective area. The Planning and Allocation Committee will be supported by a renewed scientific **Strategy Board**. Using its scientific expertise, the Strategy Board will evaluate upcoming topics, work out recommendations and propose resolutions to the Planning and Allocation Committee. The composition of the Strategy Board will ensure that the University's interdisciplinary competence profile, strong ties with partner institutions and the ambition to promote young academic talent are adequately represented. The Strategy Board will be composed of both permanent and temporary members as well as internal and external experts with careful attention to diversity. Permanent members are the speakers of the CoEs, representatives from the Profile Areas, the FZJ and other extramural research institutions located on Aachen premises. The group of young advanced talents, organized within the Center for Young

Academics, will delegate one permanent representative to the Strategy Board. Temporary members will be invited by the Planning and Allocation Committee based on the specific topics to be dealt with. This broad participation will ensure sustainability and continuity of the board along with its ability to act flexibly. Regarding major developments and changes as well as to ensure broad acceptance and implementation of RWTH's strategy, a close exchange between the Planning and Allocation Committee and the senate is of great importance. In addition, the format of regular university-wide workshops will be continued in order to involve other key actors in the strategic development and to empower them to serve as ambassadors within the University.

### **Strategy Fund und ERS**

Major instruments supporting agile governance are the ERS funding scheme and the RWTH Strategy Fund. As ERS funding will stimulate new ideas and projects (measure M2, page 42), the Strategy Fund aims to reinforce new developments by initiating necessary structural changes. The rectorate will use the Strategy Fund to pursue the goals stated within the University's strategy and within this proposal. Allocation of the funds will be coordinated within the Planning and Allocation Committee. The faculties and Profile Areas have the right to submit proposals. After initial support by the Strategy Fund, development over the long term will be subject to the Planning and Allocation Committee and/or require appropriate external funding. It is already envisaged to finance the following structural enablers by the Strategy Fund:

- (a) joint infrastructure platforms,
- (b) interdisciplinary centers,
- (c) exploration of new organizational structures,
- (d) new professorship and early re-appointments.

(a) RWTH intends to **establish joint infrastructure platforms**. Financial support will be provided for qualified personnel and sustainable development of the infrastructure, including purchase of novel instruments. Strong incentives will be offered to PIs who are willing to incorporate their equipment into these platforms. Interdisciplinary users will be supported by professional management and competent instrument operators. The platforms will be operated according to the DFG rules for Core Facilities and will be registered in the DFG Research Infrastructure Portal Resources. After a initial three-year period, the funded facilities will be evaluated. Depending on the results and expert recommendations, the funding can be continued until the end of the entire funding period. To promote young academic talent and make access to joint infrastructure easier, RWTH will provide infrastructure vouchers for junior researchers.

As stated in the plans to strengthen life sciences, RWTH will build up a new joint infrastructure platform for life sciences (measure M1). Funding will not only focus on the de-

velopment of new joint platforms but will also support existing initiatives to reach a new level of infrastructure, service and participation. Support is foreseen for the Joint Nanofacility Physics/Electrical Engineering (fostering Profile Area MatSE and ICT) and the StrucMat Lab (fostering Profile Area MatSE) and will be decided based on the Strategy Fund allocation process.

The identification of further joint infrastructure initiatives is envisaged, the necessary funding for which will be provided by the RWTH Strategy Fund.

(b) The Strategy Fund will support the **establishment of new interdisciplinary centers** (measure M2). A new Center for Computational Life Science is planned, a JARA-BRAIN Center is already on the way.

(c) The Strategy Fund will be used to facilitate **reorganization processes** to increase the use of shared infrastructure and accelerate the integration of young academics.

(d) To initiate **rapid redirection of research topics or professorships**, RWTH will employ the Strategy Fund. The Fund will be used for reallocation processes and to help bridge budget gaps until necessary resources become available. The Fund will also be used to support important appointments, where appropriate in cooperation with several faculties, by providing additional resources on a temporary basis.

On average, RWTH will allocate € 3.1m p.a. to the Strategy Fund. At least € 1.2m p.a. will be used to set-up new or foster the development of existing joint infrastructure platforms. A minimum of € 0.4m p.a. is foreseen to pilot projects exploring new organizational arrangements of professorships.

### A.3.3. Governance and management structures

RWTH understands its governance (see C.7) as an **enabler of a prosperous development** based on its vision and values as well as the expectations from network partners and society. Guaranteeing responsiveness and the capacity for organizational renewal is key to the University's strategic development. This requires effective coordination, involvement and commitment of all parts of the University and its partners.

As described in the recommendations of the German Council of Science and Humanities<sup>11</sup>, coordination within universities can be characterized by **different modes of governance**: collegial self-organization, hierarchy, competition and negotiation. The governance model envisioned by RWTH comprises aspects of all of these elements. An effective balance between **collegial self-organization** and top-down monitoring and

<sup>11</sup> Empfehlungen zur Hochschulgovernance, WR, Drs. 7328-18.

directing (**hierarchy**) is in place. New ideas are initiated bottom-up through networks of PIs. Collegial self-organization in the institutes, faculties, centers and Profile Areas enables interdisciplinary research and convergence next to individual autonomy, creativity and freedom of disciplinary research. The foremost goal of ERS and the Strategy Fund is to facilitate and support these explorative processes and incubate them to a state where further implementation proceeds swiftly. Rectorate and faculties fulfill the formal hierarchical function of managing the processes of developing, organizing and implementing a research and teaching portfolio. The final responsibility for developing the overall strategy of RWTH and allocating resources lies with the rectorate. **Decisions** concerning appointments, structural development and allocation of resources such as ERS and the Strategy Fund are the result of **negotiations** between the faculties and rectorate. This novel responsibility takes place in the Planning and Allocation Committee.

ERS uses a **competitive** process to select new ideas and topics which are funded as relatively short-term projects. Long-term plans on the future development of the University will be prepared by the Planning and Allocation Committee. In these endeavors, the committee will rely on close communication and exchange **with the senate** and **advice of the Strategy Board** (measure M10). Since Profile Areas and CoEs inform the Planning and Allocation Committee on a regular basis, suggestions, plans and ideas based on their evolving roadmaps can be incorporated into the decision process. The success of the Institutional Strategy will be monitored (see A.3.4) and the conclusions drawn will be the foundation for adjusting the long-term plans.

On the organizational level, the decision making processes will benefit from robust administrative and scientific management structures both on a centralized level as well as on a decentralized level (faculties, Profile Areas, CoEs, centers). In regard to **sustainability**, the new Planning and Allocation Committee will ensure that necessary resources are identified and/or reallocated so that successful measures can continue to evolve in the long-run. Based on the current University Law (Hochschulgesetz), the universities of the State of NRW have far-reaching autonomy. The **present legal framework** provides all legal preconditions necessary for the implementation of RWTH's Institutional Strategy.

#### **A.3.4. Monitoring for quality assurance and success monitoring**

During the last two phases of the Excellence Initiative, RWTH has demonstrated its ability to efficiently implement the Institutional Strategy with all its proposed measures. The future measures described above will show **long-term effects** in the domains of research culture, people development and the institutional framework.

Regarding the **Research Culture**, the measures described will foster convergence within the Profile Areas and beyond. The scientific profile for life sciences and simulation and data sciences will be significantly sharpened by strengthening scientific bonds between medicine, engineering and natural sciences. This will lead to more research activities at the borders of disciplines and Profile Areas, substantiated by relevant projects, publications and an increased share of researchers integrated into the Profile Areas and utilizing them as breeding ground. New scientific networks will evolve from this process of convergence.

Regarding the **Development of People**, further diversification of academic staff and a growing ability to attract and retain promising talent will ensure RWTH's capabilities for the future. Advancements will be ensured by monitoring relevant numbers in gender, diversity and the balance of senior and junior academic staff as well as by evaluating processes to attract and welcome staff. The seamless integration of the scientific mindset into research oriented teaching will lead to intensified and personalized ways of learning. Strengthening transfer activities will help to radiate entrepreneurial spirit deep into the organization and early on into the student population. New communication formats will raise information and awareness in society and will accommodate political and societal trends and public debate.

With respect to shaping the **Institutional Framework**, intensifying cooperation with external partners will increase RWTH's potential to conduct outstanding research now and in the future. The effectiveness of formal network formation will be measured by the number of joint projects, joint appointments and personnel exchange, new joint structures as well as alignment of services. The governance of RWTH is robust enough to handle upcoming challenges, but flexibility enough to respond to and sustain new developments. The new governance approach will visibly increase synergies in and between the faculties and with partner institutions.

In the **overall perspective**, the interplay of the measures embedded in the three domains will strengthen RWTH's ability to tackle future research challenges by (i) creating an inner environment, that is suitable to act and renew and (ii) significantly raising and maintaining the international visibility and competitiveness of RWTH with respect to attracting the necessary resources and staff to reach our scientific goals.

The rectorate holds the overall responsibility for the implementation of the Institutional Strategy while the ten measures to implement the objectives will be led by the different pro-rectorates. The "AixInI"-Project-Team is responsible for coordinating the proposed measures in the involved University units, as well as for the overall activity- and finance-related reporting. The team will also collect all information necessary to monitor the quality assurance and success of the Institutional Strategy. Progress of implementation

will be monitored and evaluated in the Planning and Allocation Committee based on a review performed by the Strategy Board.

**Quality assurance and success monitoring** will be based on the principle of (i) planning, (ii) implementation, (iii) content-specific evaluation, and (iv) adjusting. This principle will be applied at all levels from the single ERS Seed Fund project up to the measures and the strategy as a whole. The success of the measures as well as their further improvement will be monitored by a suitable set of quantitative data and qualitative indicators. Results of the evaluation form the basis for feedback to the measures, adaption of activities and for decisions on further funding of measures or their termination, taken by the Planning and Allocation Committee. In case of far-reaching adaptations of measures, exchange with the senate and Board of Governors will ensure legitimation and a broad communication.

The Institutional Strategy mainly foresees the initiation of new interdisciplinary research networks and the development of networked structures. Quality and success can be measured by monitoring whether and to what extent these activities will be able to attract the resources necessary to consolidate them. Externally, this will be reflected by acquisition of peer-reviewed funding and attracting scientific talent. Internally, the organizational responsiveness and ability of RWTH to renew itself will be reflected in the choices made by the Planning and Allocation Committee regarding the redirection and reallocation of resources at its disposal.