Technische Universität Braunschweig

Ecoversity

Collaborative space for change

Contents

0. EXECUTIVE SUMMARY

As we come to understand the complexity of the great global challenges we face, we recognise that science needs to be increasingly collaborative. Scientific collaborations of the future will have to overcome long-established boundaries between disciplines and sectors, and become more equitable and inclusive to achieve comprehensive results. Academia, industry, policymakers and society must find co-designed future solutions and interventions to societal problems.

Recognising this need, TU Braunschweig has built strong internal structures to support collaborative research across its faculties and their broad range of disciplines. In its most recent strategic development plan, TU Braunschweig commits to go beyond traditional interdisciplinary work and interconnects its high-profile research, high-quality teaching, wide range of transfer activities, and supportive governance and administration activities in a comprehensive developmental model.

In this current proposal, we integrate these aims **into a collaborative scientific ecosystem approach, evolving our university into an internationally compatible Ecoversity:** we aim to transcend our internal disciplinary boundaries and integrate our regional partners into a joint research, teaching and transfer environment to achieve sustainable change. We will stimulate change by **establishing new, central management and targeted support structures.** We will enable **changemakers: a generation of scientists, staff and students** who are equipped to look beyond the borders of traditional disciplines and sectors and increasingly understand their work as transdisciplinary. Our ***Ecoversity*** will increase and create synergies between outstanding areas of expertise and enable changemakers to use the full potential of our ecosystem. Initially, we will explore this potential within **two innovative topic areas** to achieve high impact themed innovations: ***BrightBrain: illuminating the brain and the heart and ReSpace!: Connected Response-able Spaces for Sustainable Living.***

In times of multiple crises, we more than ever acknowledge the acute urgency of joining forces and – along with our regional, national and international partners – more deliberately exploiting the full potential of our scientific ecosystem, to **anticipate, research, teach, train for, and work on pressing seminal issues.**

1. SWOT ANALYSIS / SELF REPORT

Self Report

TU Braunschweig is located in one of the top five most research-intensive regions (based on the ratio of R&D expenditure to gross domestic product (GDP)) in Europe, a region characterised by a large number of high-performance research institutions, innovative companies, and a vital, committed civil society. As a university of technology, we actively seek dialogue with society and industry to sensibly co-create and accompany the impending transformation process. Over the past two decades, TU Braunschweig has purposely expanded and consolidated its cooperation with local and regional partners, creating an **entire network of robust mostly bilateral partnerships.**

As one of the nine leading Universities of Technology in Germany (the TU9 Alliance), as an active member in several prominent international associations and networks, and currently hosting two clusters of excellence, TU Braunschweig ranks as one of the best higher education institutions in Germany and Lower Saxony and is the most prominent research institution in the region. TU Braunschweig is among the top 40 universities with the highest DFG funding for 2017 to 2019 in Germany, having received €88.9 million.

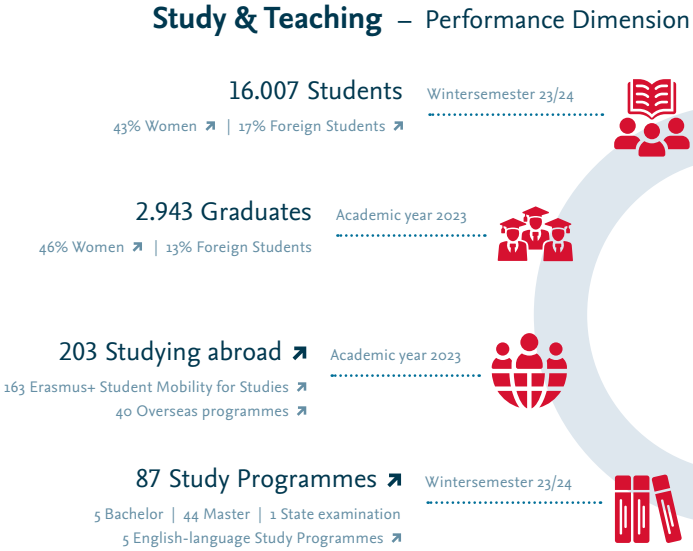


Fig. 1: Current figures on study & teaching

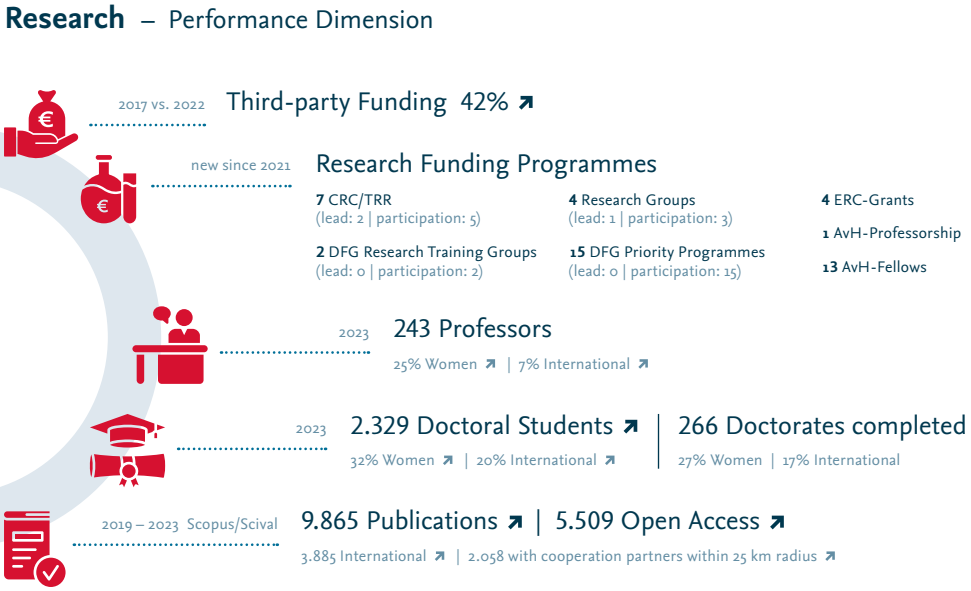


Fig. 2: Current figures on research

In the field of Civil Engineering and Architecture, DFG awards increased by 73 per cent compared to the last reporting period (2014-2016), from €6.2 million to €10.7 million (2017-2019), putting these departments in third place nationwide.

Our numerous state-funded research centres work hand in hand with non-university research institutions and other regional, national and international partners. They host outstanding, globally unique research infrastructures and form a strong basis for our four established **core research areas** focusing on “Future City”, “Metrology”, “Mobility”, and “Engineering for Health“. These research centres are an expression of our systematic efforts to stimulate interdisciplinary work across faculties in collaborative research groups and thus develop bold **innovations that will advance and transform technology and society.**

“Future City” involves researchers from all faculties who want to contribute to work focusing on integrated, multi-dimensional and multi-scalar development strategies, concepts and tools for sustainable future cities. The goal is to realise the potential of urbanisation and meet its complex demands by developing holistic concepts and solutions leading to efficient, environmentally friendly, healthy, social and green smart cities of the future. Collaborative Research Center Transregio 277 – Additive Manufacturing in Construction (AMC) in cooperation with TU Munich brings us closer to this goal by developing innovative approaches for efficient and sustainable digital construction and paves the way for TU Braunschweig to further strengthen its position as a leading research institution in this field.

In **“Metrology”**, researchers from all faculties develop new methods for precise measurements at the frontier of quantum technology and nanotechnology. Higher resolutions and accuracy open windows into new science and new applications. TU Braunschweig constitutes the technological cornerstone of the “German Metrology Triangle” together with the Physikalisch-Technische Bundesanstalt (PTB) in Braunschweig (the second-largest metrology institute worldwide) and the Leibniz University in Hannover. This alliance is the basis for a highly successful research field focused on quantum metrology and nanometrology, rich in labs and infrastructure for developing excellence with high international visibility, one example being the Cluster of Excellence QuantumFrontiers.

In **“Mobility”**, researchers and their teams from the social sciences, the life sciences, engineering, electrical engineering, and physics envision a seamless, multimodal system of individualised mobility and transportation covering automotive, aerospace and rail technologies. Interdisciplinary research is initialised and constructively conducted in the Aeronautics Research Centre Niedersachsen (NFL), Automotive Research Centre Niedersachsen (NFF), Battery LabFactory Braunschweig (BLB) and in the near future the Center for Circular Production of Next Batteries and Fuel Cells (CPC). The joint research projects focus on fundamental research as performed within the Cluster of Excellence SE²A “Sustainable and Energy-Efficient Aviation“, and by the Collaborative Research Centre Transregio 364 on “Synergies of Highly Integrated Transport Aircraft” as well as applied research with industrial partners and within EU projects.

“Engineering for Health” pursues the goals of understanding health, focused on research on infection mechanisms, and of maintaining health within our society by providing innovative customised active pharmaceutical ingredients and drug products as well as developing new processes and methods in drug production and testing. In this core research area, researchers and their teams from the fields of computer science, the life sciences, engineering and physics work on scientific approaches to make biological processes predictable and research into the cost-effective production of patient-specific drugs. One example of this collaborative cross-disciplinary approach is the project “Homeo-Hirn”, funded by the Ministry for Science and Culture of the State of Lower Saxony. At its heart are two research centres: the Braunschweig Integrated Centre of Systems Biology (BRICS) and the Center of Pharmaceutical Engineering (PVZ), with large networks including cooperation with the Helmholtz Centre for Infection Research (HZI).

Fig. 3: Strategic partnerships

These four established core research areas offer a reliable structure for **cross-faculty and interdisciplinary collaboration.** Similarly, the culture of collaboration in the region and the close working relationship between TU Braunschweig and TU9 university partners ensure that all groups and research teams mutually benefit from common large-scale research infrastructures. The established close cooperation with the region's high-level research organisations is pivotal for the joint success with TU Braunschweig's local partners:

- Helmholtz Centre for Infection Research (HZI) and German Aerospace Center (DLR),
- Leibniz Institutes: Georg Eckert Institute for International Textbook Research (GEI), and the German Collection of Microorganisms and Cell Cultures (DSMZ),
- Fraunhofer Institute for Surface Engineering and Thin Films (IST), Fraunhofer Institute for Wood Research (WKI) and Fraunhofer Center for Energy Storage and Systems (ZESS),
- Government institutions: Germany's National Metrology Institute (Physikalisch-Technische Bundesanstalt, PTB), agricultural Thünen Institute, and Julius Kühn Institute.

TU Braunschweig's University Development Concept 2030

Adopted in 2022, our **University Development Concept 2030** defines objectives and priorities for TU Braunschweig in a comprehensive approach to excellent science and higher education, including all dimensions of our performance and relevant cross-cutting themes. Our **vision** for TU Braunschweig is guided by our goal of **contributing to sustainable development in all dimensions of the university's performance.** We actively shape a sustainable social and ecological transformation.

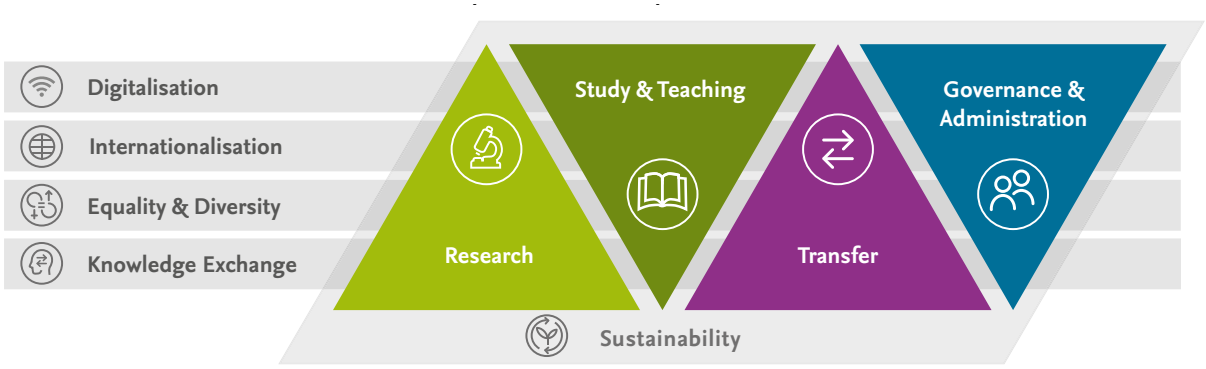


Fig. 4: University Development Concept 2030

The concept stipulates that in order to promote excellence in internationally compatible science, we need to define our priorities in all dimensions by systematically integrating strategically relevant cross-cutting themes. It also includes the goal to strengthen the strategic work we conduct with our regional partners to achieve greater synergies in our expertise and a higher visibility of our collaborative potential with our national and international partners. We will focus effectively on reinforcing and interlinking our support structures accordingly to support our members to achieve these goals. In 2021, the Scientific Commission of the State of Lower Saxony (Wissenschaftliche Kommission Niedersachsen – WKN) analysed the potential of the science system in Lower Saxony. Our initiative's intentions relate to the recommendations from this 2021 analysis of TU Braunschweig's potential and the German Science Council's 2019 feedback on TU Braunschweig's proposal for the excellence initiative. The following version of the SWOT analysis reflects the summarised contents of these reviews.

S

Two Clusters of Excellence and high level of excellence in basic and applied research.

Strong interdisciplinary and multidisciplinary research centres with close integration of non-university research institutions and other partner universities.

Outstanding research infrastructures in research centres.

Strategic systematic connections between multiple disciplines.

Strong joint appointments and junior research groups with excellent and internationally renowned non-university research institutions.

University-wide hybrid infrastructure and an innovative experimental test field for teachers (AI tools, teaching labs, MediaLab).

High culture of excellent teaching and learning.

Close strategic cooperation with industry, strong regional network (Siemens, Volkswagen etc.); Significant proportion of research at a higher TRL level in strong cooperation with industry.

Well-established technology transfer structures, e.g. Open Hybrid Lab Factory, Quantum Valley Lower Saxony Hightech Incubator.

High standard of management professionalism (strategy, leadership, project.

W

Number of strong Principle Investigators (PIs) for coordinated research projects; Proportion of female professorships.

Proportion of coordinated research projects (SFB, TRR, RTG, RTG, etc.) and individual projects; number of internationally visible, award-winning research prizes too low in relation to third-party funds.

Integration of humanities and social sciences into coordinated interdisciplinary research projects with national and international visibility.

Low amount of English teaching limits participation in formal (ERASMUS) and informal exchange programmes.

Lack of essential tools for increasing student's academic success.

International science communication and visibility.

High decentralized financial and administrative governance.

O

Relaunch of internal incentive systems for coordinated research projects (starter fundings).

Targeted expansion of high-profile expertise in the humanities and social sciences.

System accreditation enables more flexible adaptation of teaching programmes and consensus on teaching quality.

Newly set up transfer service structures aligned more closely with the needs of faculty members.

Newly founded strategic partnerships with UNAM, Tampere, Strathclyde and Rhode Island support internationalisation on all levels (research, teaching, administration and governance).

Establish interlocking support and service structures.

Clear understanding and wide acceptance of core brand characteristics.

T

Low, non-competitive state salary structure prevents recruitment of top-level professorships.

Low, non competitive basic state funding limits sustainable and long term development.

Declining basic state funding due to demographic change and 20% drop in the number of domestic students in the last 5 years.

Difficulties in introducing English-language bachelor's programmes: German-speaking first-year students deterred by increased proportion of English-language teaching conflicts with need to attract international students.

Start-up culture and legal framework for knowledge transfer not sufficiently developed in Lower Saxony.

Insufficient transparency, documentation and visibility of processes in the field of knowledge transfer.

Condition of infrastructure (buildings) noticeably hinders recruitment and institutional development.

Significant increase in basic equipment necessary to implement systemically relevant digitalization projects.

Fig. 5: SWOT Analysis

Research · Study & Teaching · Transfer · Governance & administration

2. STRATEGIC GOALS – CREATING AN ECOSYSTEM FOR CHANGEMAKERS

Breakthroughs in science are often achieved only through concerted collaborative effort. This will become even more evident in the future as research questions become more and more complex. Some of the most distinguished research institutions and higher education institutions worldwide (e.g. UC Davis, TU Eindhoven and Stanford HAI) have recently adjusted their structures to accommodate this need.

As an **Ecoversity,** TU Braunschweig will exploit its potential arising from establishing multilateral collaboration across the borders of our strong research areas and of our institution to become a **driving force for the development of the region and to create solutions to global challenges.** Experts (students, scientists and other members of various groups and institutions) from different fields will join as **changemaker** forces, to accelerate themed innovations with our partners, promoting community engagement, providing closer guidance to students, and encouraging diversity in participation. Our Ecoversity will focus on taking **collaboration with our partners to a whole new level, establishing a sustainable scientific ecosystem** in which changemakers can thrive and find solutions to urgent challenges. The ecosystem will focus not only on research but also on teaching, technology and knowledge transfer. We will improve visibility, perception and reflection of scientific evidence by the general public and enhance the way we communicate in the public sphere.

Our scientific ecosystem is an evolving multilateral structure comprising members of regional institutions whose relationships and interactions are supported and fuelled by targeted activities, support programmes and support structures.

Our Ecoversity will **transcend our current understanding of interdisciplinary work** and cooperation in our network and establish a culture of science in which changemakers utilise their diverse competencies and relationships to **co-create new ways** to serve science and academia. Members will **involve national and international partners in activities in all dimensions of our performance from the start:** we will focus on jointly developing strategies and innovative topics for **themed innovations.** Newly established expertise and **innovative measures of science communication will transform the visibility and understanding of our footprint within society.** By combining strengths we will also achieve an internationally compatible magnitude as a research region, and enhance our visibility and attractiveness for future changemakers on all levels. We will establish important structures and low-threshold measures at various institutional levels while simultaneously assessing, adjusting or dropping existing structures and measures accordingly. By addressing the potentials

of TU Braunschweig transforming into an Ecoversity, we are establishing a basis to make a targeted application to the Excellence Strategy (ExStra) for German Universities.

Our **vision** is to establish a vibrant scientific ecosystem with our partners in which knowledge and expertise can flow multi-directionally, nationally and transnationally between professional partners in science, society, commerce, industry and politics to create synergies and spark ideas for themed innovation for future solutions and interventions.

2.1 Strategic goal: accelerating innovation and boosting cutting-edge research by increasing synergies with strong institutional partners

Ecoversity will **consolidate and promote top-level research by further investing in strategic partnerships. We will form a strong basis with our regional partners on which to expand our activities nationally and internationally.** We will structurally expand our cooperation with other research and higher education institutions, non-university institutions, companies and civil society, and systematically add to a common research infrastructure to share valuable resources. Furthermore, we will focus on the expansion of strategic activities for German Research Foundation (DFG) and European Research Council (ERC) funding. We will also tap into the potential of the **humanities and social sciences** in particular and intensify international and interdisciplinary projects explicitly focussing on these fields of research.

2.2 Strategic goal: Attracting, empowering and retaining changemakers by strengthening support structures

Concurrently, we aim to **attract, empower** and **retain national and international talents as changemakers** who want to make a difference in tackling the compelling challenges of our times and support a transdisciplinary approach. In line with the results of our SWOT analysis, we will therefore expand our efforts to recruit talented staff and students and future changemakers on all levels. To enlarge our talent pool, we aim to tap into the abilities of underrepresented student groups in STEM subjects, in particular by providing suitable support for prospective, new, and current German and international students. We will increase our activities to recruit female and international personnel, and support **all** staff in finding collaborative solutions to tackle future challenges. Finally, we aim to provide attractive developmental opportunities for all our members as **changemakers** by offering them **novel support and vast opportunities for exchanging ideas** and networking within our national and international scientific ecosystem.

3. IMPLEMENTATION

In our **scientific ecosystem**, we will **accelerate themed innovation** and **attract, empower and retain changemakers** by systematically addressing the results of our SWOT analysis with **new or adopted measures.**

The starting point of our endeavour is our existing research network, cooperation among our excellence clusters, and well-established research and knowledge transfer infrastructure. Building on these strengths, in the next few years we will focus on the potential of **innovative, interdisciplinary topic areas to promote themed innovation.** This proposed initiative **"ECOVERSITY – Collaborative Space for Change"** leverages our potential by:

1. **Promoting themed innovation within our ecosystem and**
2. **enhancing changemaker potential by establishing strong support structures.**

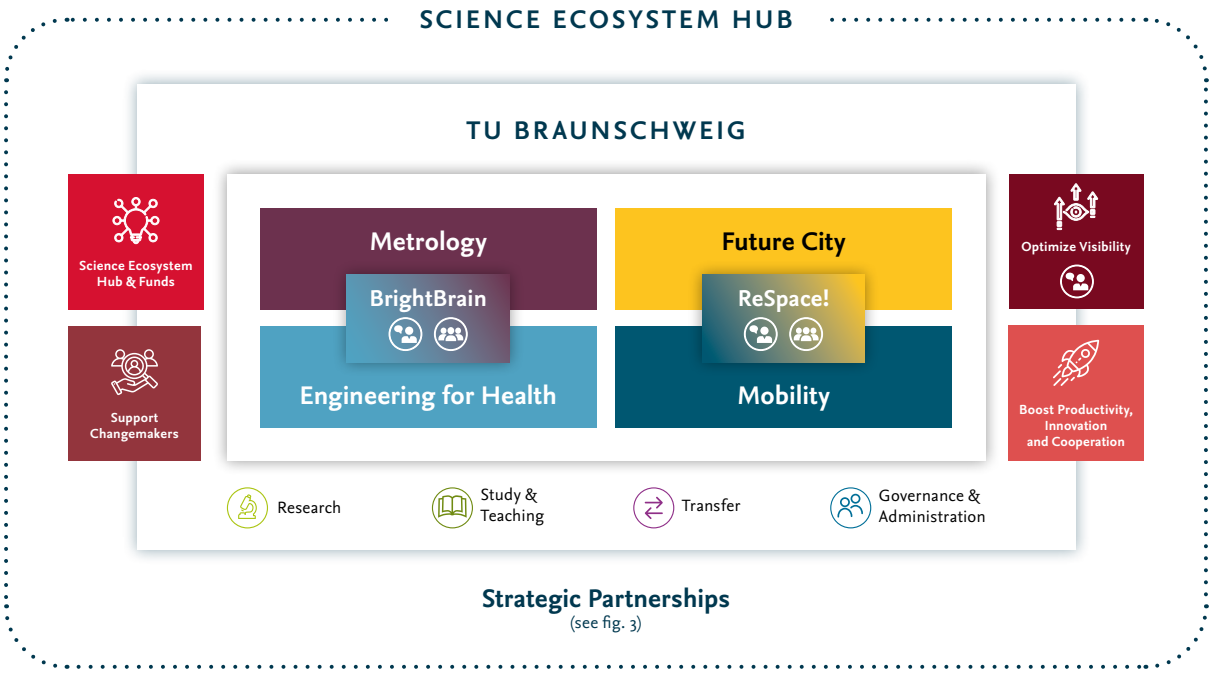


Fig. 6: Ecoversity structure

3.1 Promoting themed innovation within our ecosystem

When preparing this proposal, we carefully chose **two topic areas** in which we expect **seminal themed innovation based on their current strength and their innovative potential to implement our vision.** For each topic area, TU Braunschweig can leverage and focus its distinctive strengths in finding synergies between two of our four successfully established **core research areas** to foster solutions that tackle complex challenges. Based on the excellent work in our core research areas **"Metrology"** and **"Engineering for Health"**, the initiative ***BrightBrain: illuminating the brain and the heart*** was developed.

Our core research areas **“Future City”** and **“Mobility”** form the basis for the second topic, ***ReSpace!: Connected Response-able Spaces for Sustainable Living.*** By developing the innovative scientific potential of both topic areas, we will set a clear thematic focus, while at the same time initiating a **long-term cultural and institutional change by implementing sustainable structures.** Internationally recognized as future potentials, the two topic areas contribute to several missions of the **German government’s „Future Research and Innovation Strategy“,** published by the Federal Ministry of Education and Research (BMBF) in 2023. *“BrightBrain - illuminating the brain and the heart”* has a strong overlap with Mission 3 (Improving health for all). *ReSpace! Connected Response-able Spaces for Sustainable Living* contributes to the government’s Missions 1 (Enabling resource-efficient, competitive industry and sustainable mobility based on a circular economy), 2 (Advancing climate protection, climate adaptation, food security and biodiversity conservation), and 6 (Strengthening social resilience, diversity and cohesion). Both topic areas will be interlinked with the Science Communication Hub (Measure C.1) and the Science & Art Lab (Measure B.2) in order to systematically improve science communication skills as well as to engage in dialogue with society and provide impetus for reflection.

3.1.1 Topic area BrightBrain: illuminating the brain and the heart

“To measure is to know.” Generations of scientists have followed this strategy to push the frontiers of our knowledge. These frontiers have often been extended by the invention of improved, more precise measurement technologies based on novel technological developments. In the field of **biochemistry and biomedicine**, experiments with biological systems (a cell, a neuron, an organ) are particularly complex, since experiments have to be performed in an environment mimicking the natural in-vivo situation. In addition, similarly to quantum physics but for other reasons, objects change when in contact with the measurement probe, which increases complexity in data interpretation.

Modern microtechnology in combination with recent developments in microphotonics allows us to combine microfluidic chambers, micron-scale light emitters and sensors as well as photonic integrated circuits to control light at the nanoscale and perform compact experiments with minimum material consumption and minimum impact upon the object under observation. Key to this is the availability of silicon microtechnology for microfluidic chambers and microphotonic devices covering the whole range of wavelengths required to remotely sense biological values, up to those of blue and UV light. TU Braunschweig engineering has strong expertise in all these areas.

One critical – and highly relevant – field of biomedicine is research on **neurodegenerative diseases** and the development of new drugs and treatment concepts; others are stroke, heart disease, kidney failure and diabetes. One auspicious approach is the investigation of

e.g. neuronal tissue potentially combined with endothelial blood-brain-barrier tissue, pancreatic islets or heart organoids. Organoids, cell cultures and co-cultivations are an ideal testbed to develop new measurement technology and at the same time create new knowledge on pressing medical challenges of our aging societies. **Our initiative BrightBrain aims at developing concepts, methods and instruments to substantially push biomedical research by leveraging the enormous potential of the interdisciplinary expertise in life science and engineering** by including experts from the Faculties of Life Sciences (Prof. Martin Korte, Prof. Reinhard Köster, Prof. Melanie Brinkmann, Prof. Stephan Reichl, Prof. Heike Bunjes, Prof. Ingo Ott, Prof. Anett Schallmey, Prof. Theresia Stradal, Prof. Jomo Walla), of Mechanical Engineering, and of Electrical Engineering, Information Technology, Physics (Prof. Stefanie Kroker, Prof. Arno Kwade, Prof. Andreas Dietzel, Prof. Vadim Issakov, Prof. Iordania Constantinou, Prof. Daniel Prades, Prof. Andreas Waag). Research on neurodegenerative diseases will be an initial testbed.

Brief state of the art and challenge(s)

In view of the high potential, high societal impact and importance of research on neurodegenerative diseases, TU Braunschweig has already brought together experts from life sciences and engineering in initial collaborations. PIs from our interdisciplinary team, including colleagues from biomedical research (Korte, Köster, Brinkmann et al.) and from microengineering and microphotonics (Kroker, Dietzel, Waag, Prades et al.), demonstrated that cells can grow in a microfluidic chamber, and that sensor signals and high-resolution microscopic images can be captured. In addition, the group has demonstrated very efficient sensors for gas atmospheres above biological material (Prades), one of the most compact light sources for structured illumination at the nanoscale in combination with compact microscopy (Waag) and novel waveguiding and mirror components based on metamaterials for photonic integrated circuits (Kroker). A micro-LED array-based platform from TU Braunschweig has already been used for the spatio-temporal optogenetic control of various cardiac models.

However, the transition from first demonstrators to deep and widespread research in biomedicine still lies ahead. TU Braunschweig is in an excellent position for this endeavour, as it can take advantage of the close cooperation between groups from the life sciences and engineering, which have two strong networks with external research institutions. TU Braunschweig has strong links to the Helmholtz Centre for Infection Research, the Leibniz Institute DSMZ – German Collection of Microorganisms and Cell Cultures GmbH, Fraunhofer, Klinikum Braunschweig, the Center for Individualized Infection Medicine in Hannover, and Hannover Medical University. This microtechnology and microphotonics research is supported by a top-rate infrastructure and further benefits from collaborations with partners from two Clusters of Excellence, QuantumFrontiers and PhoenixD, as well as close collaboration with the

Physikalisch-Technische Bundesanstalt in Braunschweig, the second largest national metrology institute worldwide. TU Braunschweig's engineering department is a partner in the Cluster-4Future "QVLS iLabs", receiving flagship funding from the BMBF for setting up internationally visible groundbreaking research hubs in close collaboration with industry. These collaborative ventures include joint projects with industrial leaders in Germany such as ams OSRAM or Infineon, targeting topics such as the development of novel miniaturised light emitters, integrated photonics and the hybrid integration of microsystems, photonics, microelectronics and sensors. The required wavelength ranges require nitride semiconductor technology. In the Nitride Technology Center (NTC) at TU Braunschweig, highly relevant unique infrastructure and expertise is available for developing novel measurement technology for biomedical research. With the new Alexander von Humboldt professorship (Prof. Daniel Prades), which started in April 2024, TU Braunschweig has additionally strengthened its research area focusing on nanometrology and sensing.

The NTC consortium has already made key achievements in nitride technology over recent years, e.g. demonstrating 512x512 pixel microLED/CMOS arrays with unprecedented switching speed, or gas sensors with an energy consumption that is lower by a factor of 1,000. It provides a comprehensive technological basis for chip processing and hybrid integration including laser processing and micro-positioning, based on the existing collaboration of various groups running a clean-room infrastructure. Integrated photonics is developed both in silicon and nitride technology to address a wide range of wavelengths, from IR to UV.

The groups under Dietzel, Köster and Reichl at the BRICS/PVZ have been cooperating for over five years on the topics of on-chip test systems, focusing in particular on use in the preclinical phase of drug development, such as organ-on-chip, zebrafish-on-chip and biosensor testing. The NeuroExaminer was developed for whole brain light sheet microscopy combined with microfluidic neuronal stimulation of zebrafish larvae. In recent years, TU Braunschweig scientists from the three research centres LENA, BRICS and PVZ have already started establishing initial cross-disciplinary projects and programmes in an attempt to merge neuroscience with microengineering and nanoengineering, e.g. for the research group "Homeo-Hirn" (since 2021 with Korte as the speaker of the Homeo-Hirn research group, which paved the way for this BrightBrain consortium) and for the EFRE application "BioIng4H – Bioengineering For Health". Both consortia at TU Braunschweig have initiated close collaboration between microfluidic on-chip measurement technology, drug application, infection models, and neurobiological research.

Objectives

Our BrightBrain initiative aims to develop concepts, methods and instruments to substantially advance biomedical research by leveraging the enormous potential of the interdisciplinary expertise in the life sciences and engineering available at TU Braunschweig and its partners.

The key objective is to bring neuroscience, microtechnology and microphotonics together and form a nationally unique centre for metrology in the life sciences at TU Braunschweig in collaboration with our partners. BrightBrain will boost experimental possibilities and knowledge by making available new measurement instruments that enable precision experimentation in environments mimicking the natural situation of biological objects under study as closely as possible. The main objective of BrightBrain is to answer central questions around more efficient healthcare in societies with their rapidly growing challenges.

The more detailed objectives of BrightBrain can be summarised as follows:

- Develop novel chip systems compatible with biomimetically reproducible environments, at first for neuronal cells and neuronal tissue as a testbed. This will be expanded to other culture systems, e.g. immune cells, heart muscle cells and kidney cells, to name a few.
- Integrate sensor measurements and high-resolution imaging into novel chip systems, and develop AI methods for the efficient extraction of information.
- Answer questions about the homeostasis of neuronal tissue with highly repeatable and reproducible measurements based on the newly available measurement systems.
- Develop new concepts for the treatment of neurodegenerative diseases.

Resources

Implementing the BrightBrain concept with a high degree of international uniqueness and achieving excellence that qualifies us to lead large consortia, not only nationally (DFG SFB) but also internationally (EU-coordinated programmes), will require the following measures:

a) Changemaker professorships: The first changemaker professorship in **“Cellular metabolism in infection”** will be established as a pre-appointed successor to an existing full professorship. It will focus on precise, reproducible measurements of metabolic compounds in health and disease relating to pathogens and the immune response in the peripheral nervous system and the brain. Identifying biomarkers and their measurements (planned cooperation with the PTB, HZI and DSMZ; we have already started to implement new young investigator groups in this area, co-appointed as W1 professorships at TU).

A second changemaker professorship was established with Prof. Dr. Iordania Constantinou: **“Microfluidic systems for advanced tissue testing and biomedical diagnostics”.** Profile: micro- and nano-systems (based on Micro-Electro-Mechanical Systems – MEMS) for bio-mimetic cell cultivation and organ-on-chip systems allowing reproducible data to be acquired by integrating sensors and microelectronic interfaces.

A third changemaker professorship has already been established (since 04/2024); the Alexander von Humboldt Professorship held by Prof. Prades: **“Ubiquitous Metrology”** (already funded): reliable molecular sensing, and any other type of sensing for low amounts of

matter in an open environment, such as molecules, particulate matter/dust, microorganisms, complex biomolecules, etc.

All three changemaker professorships will be supported by a new joint professorship (with TUBS-Fraunhofer IST) on thin film and microtechnology process technology, focusing especially on the production of microfluidics. In this context, the Fraunhofer Attract funding programme is intended to give a young researcher with funding of up to €2.5m the opportunity to refine their own ideas in an application-oriented manner at the Fraunhofer IST in collaboration with BrightBrain. These scientists, together with the three changemaker professorships, will jointly build a unique synergetic triad combining neuroscience, microtechnology, and semiconductor technology. Prof. Prades is a member of the "Systems Metrology" advisory board at PTB, providing the ideal bridge to PTB's activities in metrology in the life sciences.

b) BrightBrain Research Group (PhD position for 8 PIs, 5 years): The research group focuses on the interdisciplinary development of modern microscopy, imaging and sensor technology, and the physical investigation of biological matter in engineered environments. This enables spatial and temporal scales to be precisely controlled and tissues to be accurately exposed to chemical stimuli (active compounds, such as blood/brain-barrier-crossing nanoparticle systems and organoids) and microorganism infections. The aim is to develop methods and in future to cooperate with industry partners and start-ups emerging from the research groups. The methods will allow a high degree of reproducibility that cannot yet be realised with commercially available instrumentation and that requires key innovations in the fields of biophotonics, chip systems (for pre-clinical testing of pharmaceuticals), organoids of different organs (e.g. heart and brain organoids), combined imaging, precision metabolomics, and microsensor systems. The already successfully established concept of tandem supervision from the "Homeo-Hirn" doctoral research group (PI from the life sciences + PI from engineering), as well as the mentoring of postdocs, will be an essential academic element.

We are setting up an international "BioChip"/ "Brain on Chips" **course programme** (Dietzel, Constantinou, Winkler) with the University of Tampere (discussions are even underway to expand this programme by bringing in KTU Stockholm and possibly other universities) and develop an **international master's programme** for "Bioelectronic Engineering" between FK2 and FK5 (Kowalsky, Köster, Korte & Jahn). The current master's programmes in biotechnology and biology will also incorporate BrightBrain topics and technical development as well as highly sophisticated analysis tools derived from AI applications. Together with HZI, we will establish a teaching offer called **"Bio-Entrepreneurship"** to foster cross-disciplinary education on translating biomedicine into industry applications and biotechnological start-ups.

Activities relating to **knowledge transfer, knowledge exchange and science communication** will be supported by central structures. BrightBrain PIs already have considerable experience in supporting spin-offs. The head of innovation at Sartorius AG, Prof. Dr. Oscar-Werner Reif, is a member of the scientific advisory board of the research priority programme "Engineering for Health". The spin-off initiative Minktec and MINDS was awarded the Lower Saxony Innovation Prize in 2019. Another successful example of tech transfer is QubeDot, which was founded in 2019. QubeDot was successful in the EIC Accelerator programme (funding probability less than 5%) and is the only start-up in Europe that has successfully passed all three stages of innovation funding for the European Innovation Council: EIC Pathfinder, EIC Transition and EIC Accelerator. QubeDot already has products on the market for biological testing. All these examples demonstrate the high innovation potential of this topic area, in both the life sciences and engineering. Furthermore, the BrightBrain PIs are closely interlinked with the science communication hub to systematically improve the science communication skills of their researchers of all ages, as well as to establish a research strategy for science communication on BrightBrain topics.

Other important PIs: Prof. Stefan Dübel (+successor), Prof. Karsten Hiller, Prof. Thekla Cordes (W1, junior researcher), Prof. Susanne Engelmann, Prof. Meinhard Schilling, Prof. Michael Meyer-Hermann, Prof. Thomas Deserno / Prof. Tim Kacprowski (AI in medicine), Prof. Dieter Jahn (+successor), Prof. Laura Steenpaß (DSMZ), Prof. Josef Penninger/Dr. Kristin Metzdorf (HZI Organoide), Dr Gavin O'Connor (PTB), Prof. Norbert Krug (Fraunhofer Institute for Toxicology and Experimental Medicine), Prof. Christoph Herrmann (Fraunhofer IST), Prof. Pasi Kallio (Univ. of Tampere), Prof. Jan Huisken (U Gö), Prof. André Bleich (MHH).

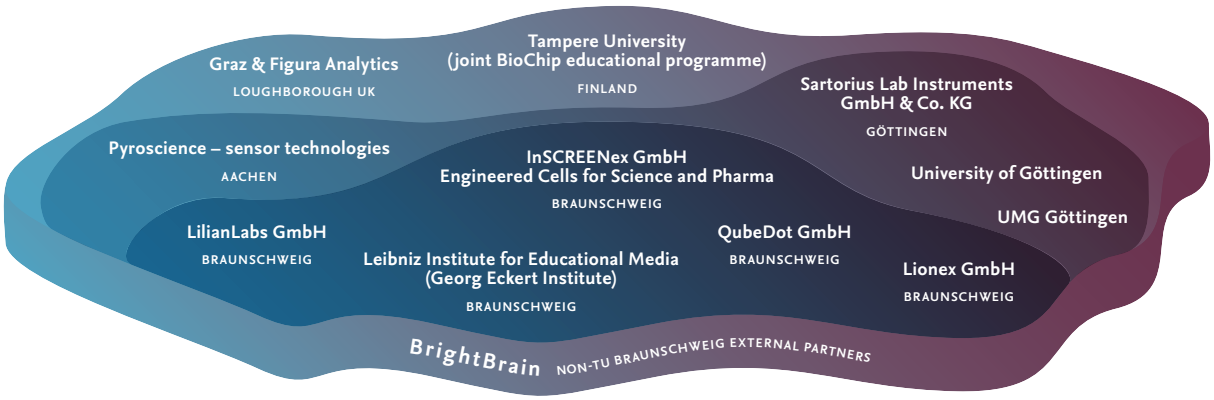


Fig. 7: BrightBrain: Non-TU Braunschweig external partners

3.1.2 Topic area ReSpace!: Connected Response-able Spaces for Sustainable Living

Climate change is forcing us to rethink how humanity's most important resource – space – is used, its characteristics and interconnections, and how it is perceived. With **ReSpace!** we foresee a transdisciplinary quantum leap where scientists, partners and spaces are connected

in living labs and through research to re-explore the potential of **three-dimensionality for spaces that are "response-able"** (a term combining "responsible" and "able to respond"). **Our aim is to create adaptive spaces that can respond to changing environmental conditions and resulting ethical challenges because they are based on responsible planning and decision-making.** ReSpace! consists of the transdisciplinary **Changemaker Research Group** and the new **Changemaker Professorship for Environmental Humanities.** ReSpace! will allow us to explore new, transformative research fields and methods providing the structural and scientific foundations for major collaborative research, international visibility and excellence.

Challenge(s)

The surface of Earth is a finite resource. Urbanisation has been based on extractivist human activities, transportation and the industrial production of goods, products, and infrastructures. This, in turn, has fostered climate change to an unforeseen extent – the largest single threat to current and future societies, especially urban societies. Historically, the needs of developing societies have been met by spreading out over an area, based on functional segregation and connected by two-dimensional forms of mobility. This "flat" mode of urbanisation has contributed to the depletion of soil, accelerated the loss of biodiversity and diminished access to fresh water worldwide. Today, the goods, materials and energy accumulated in cities and urban regions account for the largest share of anthropogenic resource depletion, while their spatial effects are outsourced. As cities and urban regions will continue to be home to most of the world population, they also remain nodal points of consumption for the resources most threatened by climate change. Clearly, climate change mitigation and adaptation have strong spatial, societal and social implications for cities and urban regions largely constrained by limited two-dimensional space. While many urban utopias of the past proposed incremental steps to solve social issues, climate change generally challenges inherited planning paradigms and prompts a new understanding of space, its utilisation, dynamics, adaptability, resilience, attributes, performance and interconnections. This ultimately challenges mankind's concept and perception of space, going beyond utopias. **The interlinked global dynamics of population growth, urbanisation and climate change strongly prompt us to rethink the three-dimensional potential of space and the interweaving of biotic and mineral spaces, looking beyond the "city/nature" dichotomy and beyond the two-dimensional surface. This also calls for equity, environmental justice and, more generally, the consideration of affective responses, such as emotions, values, meaning-making and "response-ability" from the research perspectives of environmental ethics, science and technology studies, global citizenship and citizen science.**

By introducing ReSpace! we plan to take a scientific leap in understanding the three-dimensional interconnectivities and potential utilisation of spaces to conceptualise "response-able"

solutions for sustainable living, infrastructures and products that enable the internalisation of climate change experiences. “Response-ability” thus refers to the ability of spaces – biotic and mineral – to a) cope with or respond to changing climatic conditions, b) to be responsibly planned, produced, executed, and governed, so as to c) provide interconnected justice and relational accountability, by understanding the networked, relational and affective nature of spaces. **We intend to draw attention to new types of sustainable configurations that encompass three-dimensional spatial components, take into account their interdependencies with other spaces and strive for equity with regard to inter-individual, demographic and temporal dimensions.** Sustainable (urban) development is a highly complex endeavour that requires holistic approaches. Therefore, we will cooperate intensely to bridge our disciplines – from engineering to environmental humanities – and engage with numerous partners. Together, we will explore living labs in the proximity of TU Braunschweig to explore these questions: **How can the third spatial dimension facilitate the necessary sustainable transition towards “response-able” spaces? What potential do different spaces and space types entail for the overall sustainable transformation and resilience of the urban–rural system? How can future requirements of sustainable living, infrastructures and mobility, blue-green-grey networks and production be spatially better integrated – potentially utilising three-dimensionality?** Based on this, we will jointly develop multi-disciplinary approaches to conceptualise “response-able” urban and rural spaces. We will describe pathways towards fully circular construction and to production that is not only climate-neutral, but also actively restores and replenishes ecosystems and resources. Think, for example, of an infrastructure for sustainable mobility that also provides a comfortable micro-climate in hot summers, produces food and energy and helps prevent flood disasters!

Objectives

In five years’ time, we plan to be leading experts with international visibility and a go-to competence centre for Lower Saxony stakeholders. We will be excellent in **comprehensively researching the topic of sustainable living spaces from technological, economic and social perspectives.** This will enable us to explore new, transformative research fields and methods that provide the structural and scientific foundations on which major collaborative projects such as a **DFG CRC** will be carried out. We therefore consider ReSpace! a unique opportunity to combine our creativity, methodologies, data and strategic competences through transdisciplinary research, teaching and action. We will harness this opportunity to conduct research in real-world environments (living labs) by strategically bridging our disciplines and connecting with other scientists and real-world actors to explore accountable and sustainable solutions for “response-able” spaces. Since our framework is based on **absolute sustainability goals** derived from ecological carrying capacities and stress limits for environmental sustainability, we will investigate real-world spaces to explore relational methods that overcome insularity.

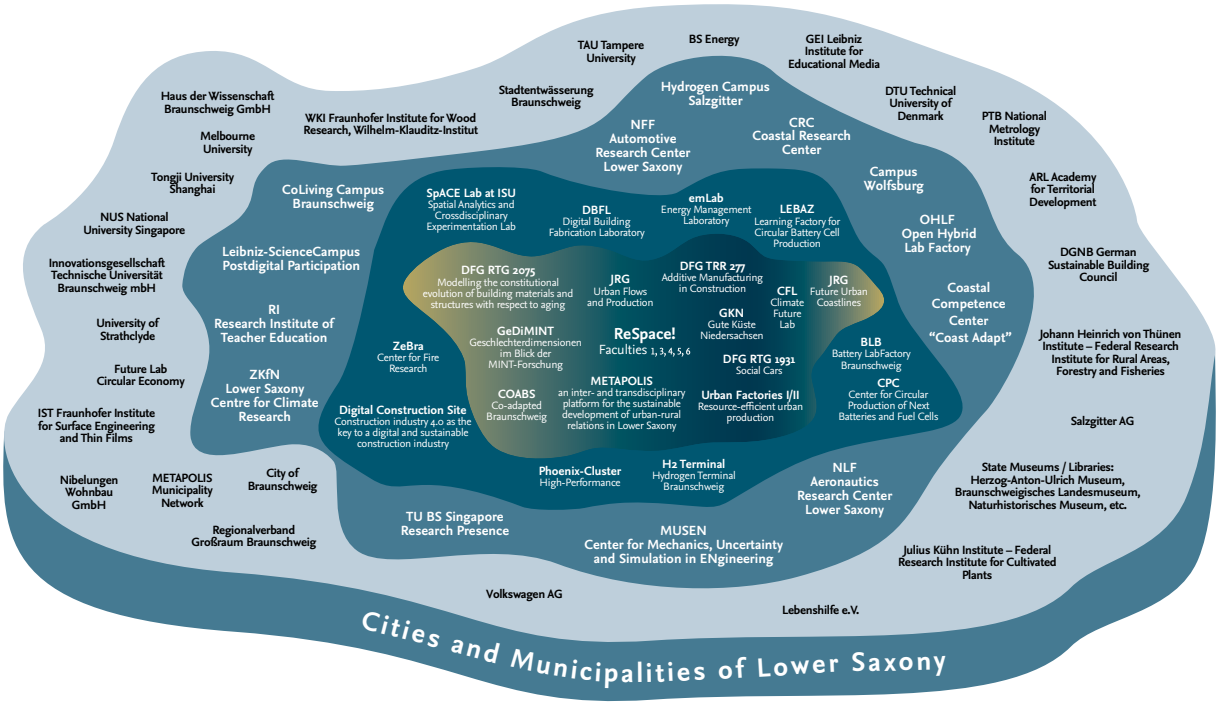


Fig. 8: ReSpace!: Collaboration Environment

At the heart of our ReSpace! research area are the interdisciplinary **ReSpace! Research Group and the new Changemaker Professorship for Environmental Humanities** at TU Braunschweig. This inner sphere of ReSpace! builds on our extensive, long-standing collaborative research in the two relevant core research areas **Future City** and **Mobility** (e.g. DFG TRR 277, DFG RTGs 1931 & 2075). The next sphere includes relevant research infrastructures at our university that have the potential to connect different PIs (e.g. Learning Factory, H2 Terminal, Battery LabFactory, Center for Circular Production of Next Batteries and Fuel Cells, Digital Construction Site). This is followed by a sphere encompassing regional and international collaborative research hubs (e.g. TU BS Singapore, Wolfsburg Campus, Salzgitter Hydrogen Campus) where different academic and real-world actors converge to exchange ideas, collaborate and drive innovation. Finally, the outer sphere comprises research partnerships as places of cooperation between researchers and various stakeholders, for instance from industry (e.g. VW, Salzgitter AG), planning entities and municipalities (e.g. Regionalverband Großraum BS), public institutions, utility providers, science communication and transfer, non-profit organisations and civil society. Since regions in Lower Saxony will face severe transformations as a result of climate change, we will pursue a "living lab" approach to connect all existing, planned and future research projects and initiatives, spaces, planning entities and actors to grow and harness our collaborative research. We will therefore systematically explore, refine or newly develop and test methods such as co-creation processes, design thinking, iterative prototyping, surveys, and focus groups, fostering trans- and multidisciplinary collaboration. The goal is a more comprehensive understanding of the real-world use

of spaces, based on challenges or contextual factors, enabling usage of diverse data types, encompassing qualitative feedback, quantitative measurements, and contextual observations. The specific Living Lab locations will be specified within the first year of the project.

Resources

a) Changemaker Professorship for Environmental Humanities: As a pre-appointed successor we will establish a Changemaker professorship for Environmental Humanities. This full professorship will enhance the impact of the humanities within the topic, and the appointed professor will take part in all of the key scientific endeavours of ReSpace! to ensure the lateral integration of the Environmental Humanities – which will be unique among Lower Saxony universities. By establishing this changemaker professorship, we are responding to the 2023 WKN Report on the Humanities and Social Sciences, which identified research into urban cultures, ethics and the history of urban design, as well as the cultural and meta-scientific analysis of sustainability discourses, as key sources of potential for research in the region. The environmental humanities are a rapidly evolving and innovative research field that is ideally suited to finding collaborative means of tackling the climate change challenges laid out above. It is becoming established globally in swiftly developing interdisciplinary research centres (e.g. US: CHE Wisconsin; SE: KTH Environmental Humanities Laboratory; GUEHL Gothenburg; ECOHUM, Mid Sweden University; DE: Rachel Carson Center, Munich; Environmental Humanities Center, Augsburg; MESH Cologne). The changemaker professorship is conceived as an accelerated successor appointment. It will be a cornerstone in developing our position in the environmental humanities and becoming a substantial node for augmenting the internationally visible natural sciences and engineering departments as an integral part of an institute of technology such as TU Braunschweig.

b) ReSpace! Research Group (RRG)

Fig. 9: ReSpace! Overall structure with high-impact RRG themes and respective PIs

PIs: Prof. Vanessa Carlow: Architecture, Urban Design and Planning; Prof. Harald Kloft & Prof. Norman Hack: Architecture, Construction Engineering; Prof. Stephan Weber: Urban Climate, Environmental Meteorology (FK3); Prof. Michael Kurrat: Energy systems (FK5) & Prof. Elisabeth Endres, Building Climatology and Energy of Architecture (FK3), Prof. Eckart Voigts & Prof. Franziska Neumann: Environmental Humanities (FK 6), Prof. Bernhard Friedrich: Sustainable Mobility (FK3) & Prof. Jürgen Pannek: Intermodal Transport and Logistics (FK4), Prof. Christoph Herrmann: Urban Production and Circular Economies (FK4), NN, Artificial Intelligence in Interactive Systems (FK1) & Prof. Henning Wessels: Scientific Machine Learning and Computational Modelling (FK3)

To address the complex challenges and opportunities of sustainable (urban) development through ReSpace!, our highly interdisciplinary **RRG** combines PIs from five faculties and 13 disciplines. Our diverse team includes excellent experienced and young PIs, many of whom are rooted in the TU Braunschweig's core research areas **Future City** and **Mobility**. Since its foundation in 2015, Future City has become a super agile and interdisciplinary group of approx. 60 PIs from various career levels and fields, including architecture, engineering, the environmental sciences, social and political science, the humanities, and data science. Partnering with "Mobility" we want to utilise the "Ecoversity" to level up our opportunities and increase our impact for joint transformative research in order to tackle the interrelated issues of urbanisation, mobility, production and climate change. We have jointly identified **nine interrelated high-impact themes** that are absolutely crucial to ReSpace! and will be gradually extended by acquiring additional research funding: **Urban Climate: Blue-Green-Grey** infrastructures have significant potential to foster local climate change adaptation and mitigation. We will investigate alterations to microclimate and energy exchange processes caused by their increased horizontal and spatial density. **Sustainable Spatialities, Space Types and Dynamics** creates systematic knowledge about the characteristics, properties, dependencies and interconnections between different space types along the urban–rural gradient to understand their interrelated, three-dimensional potential for the shift towards "response-able" spaces. Based on climate impact data, relevant use cases will be identified and new space categories for formal planning, planning guidelines and sustainable transformation paths will be proposed. Future **Sustainable Mobility and Logistic Systems** will include autonomous load units for goods and people capable of defining their own routes, using multiple transport modes and operating between different altitudes. We will investigate self-organisation and the integration of multimodal load units in buildings, hubs and production sites. **Advanced Materials and Construction** will explore new digital technologies in design, fabrication and monitoring to enable integrative and resilient construction and infrastructures. Circular construction and additive manufacturing technologies (some with digital twin control systems) will address future challenges in construction, combining automated processing, customised manufacturing, and material-efficient structural designs. **Circular and Regenerative Economies** will investigate future production within planetary

boundaries, requiring new decentralised production infrastructures that enable resources to be used in an eco-efficient, eco-effective manner in combination with renewable energies. Beyond technical and economic interactions, there will be a focus on human–nature relationships with a planetary boundaries mindset. **Resources and energy systems** will investigate and develop potential decentralised energy-saving measures achieved by optimising the use and spatial programming not just of existing and new structures and areas but also of their interaction with their surroundings. **Computational Modelling** will investigate "response-able" methods to support and evaluate the transformation of spaces using physics-based evidence. **Arts, Humanities, Equity and Ethics** will investigate the cross-cutting ethical dimensions of the three pillars of sustainability thinking and environmental spatiality: environmental, economic and social factors. It will focus on civic participation, knowledge production, emotions and attitudes, imaginaries and material culture. **Living Labs** will be used as a cross-disciplinary package facilitating the exchange and integration of ideas, concepts, data, models and results from the research themes described here.

Overall, our **RRG** is designed to allow the co-supervision of PhDs, share data and knowledge, and foster the co-evolution of methods to build the foundation for other large research initiatives, such as a DFG CRC. ReSpace! promotes research and **teaching** across faculties through joint lectures, retreats, summer schools and workshops. Together with our strategic partner universities and existing cooperation partners, we will also develop modules and programmes in line with the Global Citizenship Education/UNESCO BNE 2030 roadmap. We will continue our successful programmes in digital education, Global Teachers for a Sustainable Future (GTSF) and Erasmus+, and link them to the transdisciplinary master's programme "Culture of the Techno-Scientific World".

We will use our research infrastructures jointly to enhance students' competences and experiences. Our use cases are pivotal to **transferring** our activities, developing tailor-made modules for research priorities, expanding forward-looking methods (e.g. AI as a communication tool) and investigating participatory communication formats (e.g. citizen science, participatory design). We will also target GLAM partners (galleries, libraries, archives and museums). PhD students are trained early on in science communication (in cooperation with the science communication hub) and are actively involved in supporting the publication of our research results.

A fundamental consideration of **sex and gender in STEM** research is an absolute necessity for TU Braunschweig. Both topic areas and the respective researchers will cooperate with the BMBF-funded project GeDiMINT ("Geschlechterdimensionen im Blick der MINT-Forschung"). Coordinated by the Braunschweig Centre for Gender Studies, this project will help researchers give gender and sex a firm place in their research. For example, in the BrightBrain topic area, sex-specific differences (e.g. in terms of antibiotic resistance and profile of side effects of drugs) will be explicitly tackled in relation to the diverse cell system and in data analysis.

Both topics will be set up to achieve themed innovations emerging from synergies between research areas that are considered to have high potential on the basis of our existing expertise. They will provide a context in which to explore the impact of the centrally implemented support structures, which will gradually be made available to all members of TU Braunschweig within the funding period.

3.2. Enhancing ecosystem and changemaker potential by strengthening support structures

Through our Ecoversity initiative, at the heart of which is the vision of a strong scientific ecosystem, we are structurally underpinning the opportunities offered by our university's location in one of Europe's most research-intensive regions. Within our ecosystem, changemakers can develop ideas and work in innovative topic areas, starting with the two described here. To leverage the potential for innovation within our ecosystem and provide the basis for new processes, we will **create and establish novel incentives and structures** as well as **refining and extending proven ones.** In line with our strategic goals and with the results of our SWOT analysis, funds, support structures and measures, we will **a) support changemakers, b) boost productivity, innovation & cooperation, and c) optimize visibility.** The coordination of the measures will be supervised by a new **Science Ecosystem Hub.**

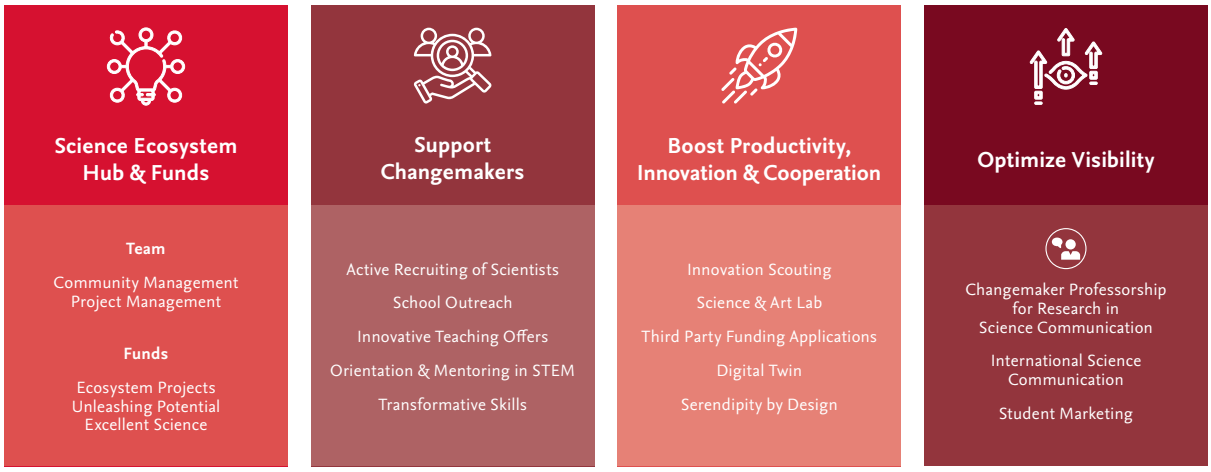


Fig. 10: Support structures

3.2.1 Science Ecosystem Hub & Funds

As an umbrella structure, we will establish a **Science Ecosystem Hub** to manage the project, coordinate the support measures and provide support in marketing, community management, relationship management, funding management, evaluation, and event planning. In future, other topic areas for themed innovation will also benefit from efficient support coordinated by the Ecosystem Hub. As corporate structure we will found an **association** to facilitate and boost the activities within Ecoversity. The Ecosystem Hub will assist the Scientific Advisory Board and the Selection Committee. The **Scientific Advisory Board (SAB)** will provide scientific quality assurance. It will consist of members of the TU Braunschweig Executive Board, external (some international) and internal top-class scientists, and regional representatives who will provide TU Braunschweig with expert guidance on issues relevant to university development by advising the Executive Board on thematic priorities in the scientific ecosystem to improve its performance. The **Selection Committee** will take decisions regarding funding programmes. It will include representatives from the SAB to ensure that important advice is taken into account. Once collaboration with a partner in the scientific ecosystem is formalised, an agreement will be signed describing the joint enterprise (e.g. shared research or fostering innovative education). The Hub can support the parties in such processes.

Our seed **funds** will provide incentives to promote cooperation and innovation in the ecosystem:

i. Seed funding for scientific ecosystem projects (e.g. targeted incentives for the development of international strategic cooperation in the ecosystem, knowledge transfer and teaching activities, student initiatives): Projects within the ecosystem that involve external partners can apply for seed funding. They must meet the criteria of interdisciplinarity and/or transdisciplinarity, involve members from different topic areas, and/or involve other actors from the scientific ecosystem. After a year, the team can apply for additional funding, competing with other projects. This ensures that a variety of new ideas are created and that those with impact are further promoted and developed.

ii. Seed funding for excellent science: A new programme for up to ten international **visiting professors** will be offered. The ReSpace! topic area will use this opportunity for stays by excellent, experienced researchers from abroad to foster scientific exchange, to build trust, and to create joint research results. To bring expertise from new frontiers to TU Braunschweig, BrightBrain will give PIs from the Global South access to high-end biomedical instruments and setups, actively recruit guest scientists for short and long-term stays, and support them for up to five years. **Doctoral scholarships** will provide funding for innovative joint research projects in cooperation with our international strategic partner universities. In addition to the PhD positions that are already planned, the topic areas will offer young scientists an

opportunity to join this research group through scholarships. Additional doctoral scholarships beyond the predefined research training group will enable us to hire researchers who display high potential and are interested in the topic areas. ReSpace! will use the scholarships to confer more intensively with scientists from Tampere University, Tongji University, the University of Strathclyde, and Singapore. Funds for an **International Female Scientist Programme** will increase our attractiveness for international female scientists. Participants will have the opportunity to write their thesis in this context, gain interesting insights into research practice and specialise in a possible future field of work during their studies. ReSpace! and BrightBrain will offer international female students and researchers the opportunity to participate in their activities during a stay in their research environment.

iii. Seed funding to unleash potential: This funding line enables the financing of projects, activities and initiatives to unleash potential in governance and amongst employees and bring the university closer to a level of excellence. Funds can, for instance, be used for talks or short-term activities such as specific training, e.g. for digitalisation, agile project management or intercultural skills. They can also be spent on coaching for organisational development, innovation and strategy workshops or keynote speeches by external experts.

3.2.2 Support measures

3.2.2.1 Support Changemakers

Changemakers know how and want to make a difference and accelerate international and interdisciplinary cooperation in research, teaching, administration, and knowledge transfer. In addition to the Changemaker Professorships and Research Groups in our topic areas we will implement the following measures to support changemakers:

Measure A.1: Actively recruiting scientists will increase our global and international presence and visibility in all dimensions of our performance by intensifying our active formal and informal, national and international activities to attract excellent scientists.

Measure A.2: School Outreach Innovative, e.g. game-based learning concepts, will introduce our topic areas to young citizens, improve our positive image among children, young people, their parents and teachers, and make us more attractive to prospective STEM students, channelling young talents into this area. ReSpace! will integrate tailor-made events and suitable concepts for science communication to raise children's interest to the absolute sustainability goals, urban challenges, and the idea of "response-able" spaces and infrastructures. As ambassadors for BrightBrain, bachelor's and master's students will give lectures at local schools and inform teachers about new technology. In particular, neuroscience is expected to attract female students.

Measure A.3: Regional & International Cooperative Teaching Offers We will improve our **teaching support** schemes designed to improve lecturers' ability to teach in English and work with international partners. **Cooperative entrepreneurship teaching** will accelerate start-up activity. Master's programmes offering teaching at the intersection of entrepreneurship, business, natural science and engineering science are to be set up with regional partners. At first, as a blueprint, a range of courses in Bio-Entrepreneurship will be developed as part of BrightBrain together with the Helmholtz Center for Infection Research (HZI).

Measure A.4: Orientation and mentoring in STEM

A.4.1 Orientation: In times of great challenges, when the significance of higher education is seen as dwindling, and student enrolment is declining at most universities – especially in engineering subjects – we plan to implement new ways to attract and empower students throughout and in the lead-up to their studies. We particularly want to address under-represented student groups, e.g. first-generation migrants, females and international students to diversify our student body and to exploit their full potential. To this end we plan to **establish a generic orientation programme in STEM at TU Braunschweig** across faculties, enabling newly enrolled students to switch between specific degree programmes through the defined recognition of their courses. During the first two semesters, we will provide special mentoring and – in close collaboration with the Chamber of Commerce and Industry – establish contacts to relevant industry in the region to provide practical experience in their field of interest. After the first year at the latest, students can then transfer to a specific subject.

A.4.2 Mentoring has a positive effect on academic success. We will firmly establish **mentoring programmes for students** at an early stage of their studies: Networking events will connect students with people from the two key topic areas to give them insights into innovative work within our scientific ecosystem. An intercultural training programme will bring together international and local students in intercultural tandem partnerships and enhance our attractiveness for all students. The intercultural partnership will offer an international experience for local students at their home university, motivating more students to study abroad through the ERASMUS programme. On a PhD level, we will also implement mentoring in the topic areas. To increase the number of graduates qualified for doctoral studies in research fields that contribute to sustainable living, ReSpace! scientists will invite students to participate in group coaching and mentoring programmes to explore their career prospects. In BrightBrain, all PhD students will be supervised and supported by at least two mentors from the Faculties of Life Sciences and Engineering and from their partners.

Measure A.5: Transformative Skills Programme Our Green Office will offer a transformative skills programme starting at the bachelor's level, creating tailored programmes for future changemakers. The creation of spaces for merging knowledge and transformative skills by

joint projects involving students and researchers at all levels increases the university's appeal in the long term. The GO will also implement a Certificate Programme to engage participants in the social, economic, and ecological aspects of sustainability. During international Summer Schools, master's students will gain insights into current and seminal research topics, and expand their professional network. ReSpace! will contribute to international Summer Schools researching into absolute sustainability goals, urban challenges, and the idea of "response-able" spaces and infrastructures. In BrightBrain such activities will also help build up synergies between Life Science and Engineering at student level, already.

3.2.2.2 Boost Productivity, Innovation & Cooperation

Formats and spaces for exchange to keep up with the constantly changing demands of our global environment, society, and the job market.

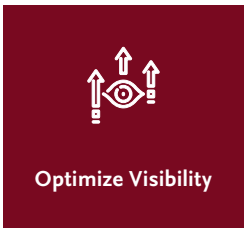
Measure B.1: Innovation Scouting Our scientific ecosystem will enable rapid access to networked expertise and innovation, improving the development of innovative and transfer-ready technologies, products and services. Through targeted scouting for innovations to tackle global challenges and professional support for innovators, combined with awareness-raising for entrepreneurship, we will substantially increase the implementation and protection of innovative ideas and inventions and, together with a cross-university start-up support organisation (to be set up in parallel), foster spin-offs. An innovation scout will accompany the newly established topic areas' activities, organising networking events and qualification schemes, exploring potential for business models, and accompanying entrepreneurs during the start-up process in association with the transfer service.

Measure B.2: Science & Art Lab promotes dialogue with society and provides impetus for reflecting on and evaluation of developments in science and technology, based on the conviction that complex social challenges can only be tackled by involving stakeholders from science, culture, business, politics and civil society. With this in mind, at the end of 2023, TU Braunschweig started to develop the Lab, which brings together science and art in their various forms of expression and media and places them in a dialogue, offering different approaches to research questions and a multidirectional exchange of ideas. Art, and specially developed art education formats, provide further levels of complexity and an innovative form of knowledge exchange. Through formats such as residencies, film programmes, exhibitions and talks, the Science & Art Lab will become an experimental field for innovation within the scientific ecosystem. Against this background, cooperation with the Braunschweig University of Art (HBK), the only art university in Lower Saxony, is fundamental for this project in order to combine the two universities' expertise at the interface of art and science. Both ReSpace! and BrightBrain provide abundant topics for dialogue about their methods, research questions, findings and interdisciplinary collaboration.

Measure B.3: Support for third-party funding applications will increase the number of applications by offering more intense coaching and guidance through the process. We plan to acquire coordinated DFG projects within the topic areas on the one hand and attract corresponding EU funds to TU Braunschweig as a basis for becoming a Cluster of Excellence on the other.

Measure B.4: Digitalization of Processes / Digital Twin is a new concept for an AI-supported service and knowledge ecosystem at TU Braunschweig that makes the handling of data and services more efficient, user-friendly, and up to date. The aim is to create an interoperable software ecosystem with role-specific access in which all data and services relevant to an individual are available and interact with each other consistently, essentially in real time. This requires the consistent mapping of all processes and the associated information and data flows between them. Freely available, pre-trained large language models are improved thanks to additional training with TU Braunschweig's own databases. This approach is particularly suitable for fostering the digital sovereignty of protected data areas. Digital Twin would essentially allow simplified-access administrative tasks relating to all aspects of research project management, business travel, international student and staff exchange, efficiently running offices, labs and meeting spaces, event organisation and many other tasks. Digital Twin will substantially improve the performance of the topic areas by a) providing a suitable platform for exchanging data and allocating resources among all partners in the scientific ecosystem with tailored access to data and services, b) reducing the effort needed for administrative purposes, and c) contributing to the sustainable use of material and immaterial resources in all dimensions of our performance.

Measure B.5: Serendipity By Design Our strategic goal is to attract changemakers to TU Braunschweig and establish a changemaker spirit within our scientific ecosystem. To spark new ideas, we will create windows of opportunity that can be individually adjusted and designed depending on spontaneous needs and the physical spaces available. Examples of these serendipitous spaces might include an open meeting hall for students and researchers to discuss a hot topic, a lab in which researchers regularly offer insights into their work or hands-on experiences, a room in which questions (e.g. on scientific, societal, or political topics, or specific questions regarding TU Braunschweig) can be collected orally or in written/digital form and others can offer their ideas and answers, or a stage on which spontaneous events can take place. In such spaces, people from the ecosystem and beyond can meet to create and develop ideas and thus drive innovation in all dimensions of the university's performance. By introducing these spaces, we will make targeted use of collective intelligence, enable the rapid development of topics in our ecosystem and create solutions for all issues affecting TU Braunschweig's performance.



3.2.2.3 Optimize Visibility ...*to promote innovation and attract talents*

Measure C.1: Changemaker Professorship for Research in Science Communication Promoting informed trust in science and technology is of enormous relevance, especially to support the acceptance of science and new or changing technologies. This is where the internationally flourishing field of science communication research comes in. It analyses the conditions for public trust in science and provides the necessary evidence to offer formats for dialogue-oriented communication with a broader public. To date, no university in Lower Saxony has provided structural support for this field of research. TU Braunschweig will address this by building an interdisciplinary Lower Saxon hub for science communication to (a) offset our university's weakness in systematically bringing science communication into focus (b) enhance the visibility of TU Braunschweig's research areas and in doing so (c) strengthen the research field and address the public. Accordingly, a new tenure-track professorship, is to be established (supported by Faculty 6 and in co-optation with the Institute for Communication Science at Faculty 1).

C.1.1 Strengthening and expanding excellent interdisciplinary research on science communication: Science communication research focusses on building trust in science, improving the visibility and perception of scientific evidence among the general public and enhancing the role of communicating scientists in the public sphere. This links in with other research areas, e.g. ethical aspects, questions around narratives, information technology issues, AI research and, in particular, the planned topic areas "BrightBrain" and "ReSpace!". Both areas address topics that rely heavily on building knowledge and awareness in the non-scientific public sphere and require the general public to grasp scientific facts, overcoming resistance to accepting behavioural change and to adjusting their attitudes and conduct accordingly; conversely and crucially, researchers and scientists need to build and expand their skills in communicating their scientific results.

C.1.2 Building evidence-based competences in science communication at TU Braunschweig The evidence-based training courses on science communication developed in Junior Research Group "fourC" will be consolidated and new modules customised to link in with the topic areas. The hub and the topic areas will collaborate to develop new topics.

C.1.3 Establishing networks and promoting the excellence of the Braunschweig research region in politics, business and society Networking in research (e.g. with the complementary Leibniz Research Centre for Science and Society, Hanover) and the TU's structural communication and outreach services, as well as cooperation with the HBK and the city of Braunschweig, will create excellence and professionalism in science communication, achieving high visibility and a major impact according to international benchmarks.

Measure C.2: International Science Communication To enhance TU Braunschweig's visibility as an Ecoversity among the international (scientific) community, we make use of the editorially independent, non-profit news release distribution service EurekAlert, which covers all fields of science, medicine and technology. Our public information officers (PIOs) share relevant news releases on peer-reviewed articles, knowledge and technology transfer, partnerships, awards and grants, etc. through this platform where more than 11,000 international journalists (including science journalists) are registered. By raising our profile among them, we increase the chances of the TU Braunschweig and its researchers being mentioned in international media outlets. This can help us find potential partners for research and business, as well as recruiting international talents.

Measure C.3: Student marketing (digitally and in person) inspires students to become changemakers by studying at our highly networked university with the opportunity to participate in activities in the innovative topic areas and profit sustainably from our scientific ecosystem.

4. EXPECTED IMPACT AND KEY INDICATORS

Through our Ecoversity initiative, at the heart of which is the vision of a strong scientific ecosystem, we are structurally underpinning the opportunities offered by our university's location in one of Europe's most research-intensive regions. The Ecoversity will strengthen national and international professional partnerships, leading to a visible contribution to global challenges. Our region will become more attractive to top scientists, top students and the best university administrators. The Ecoversity will promote the development of new ideas in the fields of research, knowledge transfer, teaching and administration. By enhancing opportunities for collaboration that boost new cutting-edge research, it will open up new co-creative spaces of various kinds for long-term interdisciplinary and transdisciplinary collaboration and enhance our international competitiveness. Knowledge and expertise will flow multidirectionally, nationally and transnationally. The targeted training of thousands of students to become graduates that are equipped to be changemakers will continue to impact society as a whole for decades. Our constant evaluation and adaptation to current trends and needs will ensure our success in the long run. We will measure this success using the following **key indicators.** The management of the Science Ecosystem Hub is responsible for monitoring the KPIs. It will collect relevant basic data to review the status of the KPI's achievement at the end of each project year. Subsequently, it will report the results to the Executive Board of TU Braunschweig and to the Scientific Advisory Board (SAB), for them to decide upon steps to be taken to adjust and improve the measures.

STRATEGIC GOAL #1

Accelerating innovation & boosting cutting-edge research by increasing synergies with strong institutional partners

KEY INDICATOR	OUTPUT	OUTCOME	IMPACT
Founding of an association to support the activities in the ecosystem	Networking, publications, events on the topics and across ecosystem partners	Increase regional, national and international visibility	Increasing number of solutions for global challenges
Systematically refining BrightBrain to apply to be an Excellence Cluster and honing ReSpace! to meet the requirements for applying to be a Collaborative Research Center (DFG criteria) by the end of the funding period	Topic areas established in terms of content, financing, structure, procedures and personnel, in accordance with DFG requirements. High-impact collaborative proposal (DFG CRC/TRR/Cluster) and publications in collaboration with partners	Topic areas are professionalised with a strong profile and visibility; regional scientific ecosystem is strengthened.	Researchers/scientists can make important contributions to relevant current research questions and challenges
Increasing number of publications on the ecosystem topics within funding period	Publications on the scientific ecosystem topics and across ecosystem partners.	Increased knowledge and national and/or international visibility; increasing attractiveness for top researchers and/or cooperation partners	Visible contributions to tackling major challenges; contributing expertise to solve major issues (e.g. for further research, policy advice)
Continuous increase in agreements on structured cooperation with ecosystem partners	Ensuring cooperation and collaboration in research, teaching, knowledge transfer and administration	Further professionalisation of cooperation in the scientific ecosystem between TU Braunschweig and non-university research institutions	Increasing the efficiency of the excellent scientific ecosystem

STRATEGIC GOAL #2

Attracting, empowering and retaining changemakers by strengthening support structures

KEY INDICATOR	OUTPUT	OUTCOME	IMPACT
Implementation of 1 summer school per topic area per year	Unique summer school courses that combine theoretical knowledge and practical experience in the topic areas	Strengthening/promoting national and international networking within the scientific and student communities of the topic areas; Increasing (international) visibility	Key topic and ambassadors around the world
Acquisition of 10 visiting professorships over the entire funding period	New national and international specialist expertise, experience and perspectives flow into research	Strengthening/promoting national and international networking; initiating new collaborations	Excellent scientists as ambassadors for the topic areas around the world
Active recruitment of excellent scientists for the two topic areas	Expanding and enhancing expertise in the topic areas	Increased competitiveness: larger research portfolio, broader range of courses offered by the newly recruited excellent scientists; further doctoral opportunities for young academics (supervision capacity, range of topics)	Strengthening our excellent scientific ecosystem and retaining excellent scientists in the region
Designing and introducing a new teaching programme in the field of Life Sciences and entrepreneurship together with HZI within the funding period	Unique joint teaching programme carried out by TU Braunschweig as a higher education institution and HZI as a non-university research institution	Arouse or strengthen interest in remaining in the scientific system and founding companies	Highly qualified graduates who can contribute expertise to major challenges and increase economic prosperity through start-ups