TECHNICAL MEDICAL CENTRE POSITION PAPER

ENABLING SUSTAINABLE AND PERSONALISED HEALTH BY MEANS OF TECHNOLOGY

MARCH 2023

UNIVERSITY OF TWENTE. | TECHMED CENTRE

COLOPHON

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1. INTRODUCTION: THE UT - TECHNICAL MEDICAL CENTRE

The UT is one of the global leaders enabling sustainable and personalised health by means of technology. It obtained this position via one of its three institutes, the Technical Medical Centre (TechMed Centre). The TechMed Centre brings together all health(care) related activities of the UT from education, inter- and multidisciplinary research, shared infrastructures up to valorisation and partnerships. The The TechMed Centre's role within the university is to realise a societal impact on health, to coordinate and align all activities across the university and stimulate inter- and multidisciplinary collaboration. Furthermore, it facilitates the interaction between the inner and the outside world. New personalised health solutions are developed, improved and implemented. These solutions will on one hand reduce the healthcare burden regarding the current staffing challenges and costs, and at the same time increase the regional, national and international economic growth by facilitating the necessary breeding place for Medtech companies in the EU.

The University of Twente is a technical university located in Enschede, the Netherlands. The university has been placed in the top 200 universities in the world by multiple central ranking tables. In addition, the UT is often ranked the best technical university in The Netherlands by "Keuzegids Universiteiten", the most significant national university ranking on education[1]. The university also scores particularly strong in other rankings such as the Times Higher Education Impact Ranking where the UT was ranked first in 2022 in the world ranking on Industry, Innovation and Infrastructure (SDG9)[2]. The UT collaborates with Delft University of Technology, Eindhoven University of Technology and the Wageningen University and Research Centre under the umbrella of the 4TU alliance and is also a partner in the European Consortium of Innovative Universities (ECIU). The UT is a people-centred university of technology and aims to empower society through sustainable solutions.[3] The UT is a highly entrepreneurial university located in the region of Twente, closely positioned to and connected with the German border area. Its ecosystem supported by Novel-T has a strong track record in building and scaling hightech spin-off companies. The life sciences and health sector in the Twente region, including the powerful MedTech Twente cluster, is growing faster (32%) than the average Dutch growth in this sector (19%) over the past ten years .

The university has strong connections with industry, societal organisations, and many patient and healthcare organisations. The broad technological expertise, present at the University of Twente, together with the social, organisational, and

[1] Home - Keuzegids
[2] Impact Rankings 2022: industry, innovation, and infrastructure | Times Higher Education (THE)
[3] Twente Index, E.3012_Ontwikkeling_PrioritaireSectoren | Tableau Public / 2022

environmental knowledge gives UT the capability to address important scientific healthcare problems from a nano to a global scale. Supported by powerful and pioneering educational programs like Technical Medicine, Biomedical Engineering and Health Sciences, the UT educates many new talents that are needed to enable valuable innovations in healthcare.

This document describes the vision, mission and core strategy of the TechMed Centre. Furthermore, it provides an overview of the three core pillars of activities of the TechMed Centre, i.e. **1. education and training**, **2. research and development**, and **3. innovation and collaboration**. We end with an overview of the governance of the TechMed Centre, the support activities, and the (shared) infrastructure.

2. TRENDS & CHALLENGES IN HEALTHCARE

Healthcare worldwide has improved enormously. Life expectancy in Europe has increased by five years in the last 25 years. We are living longer, but we also live longer with chronic diseases, which has led to increasingly high healthcare costs. Due to this ageing population and expanding medical treatment options, the demand for healthcare has increased. This has resulted in an increase of the development and use of devices such as surgical instruments, medical equipment, e-Health, diagnostic tests and implants. Furthermore, we have an increasing shortage of healthcare workers. In addition, global environmental challenges appear to be a very important health threat of the 21st century. If these environmental changes and the use of resources and materials continue at the current pace, the foundations of good health are seriously jeopardized. Therefore, measures to combat climate change, loss of biodiversity and large-scale environmental pollution, deserve an even higher priority than is apparent from the current innovation activities in the healthcare domain. Our current healthcare systems, solutions, and practices, are not yet resilient enough to cope with the impending responsibilities, as the Covid-19 pandemic has amply demonstrated. We must therefore make even better use of our well-known innovative power to contribute to these societal challenges.

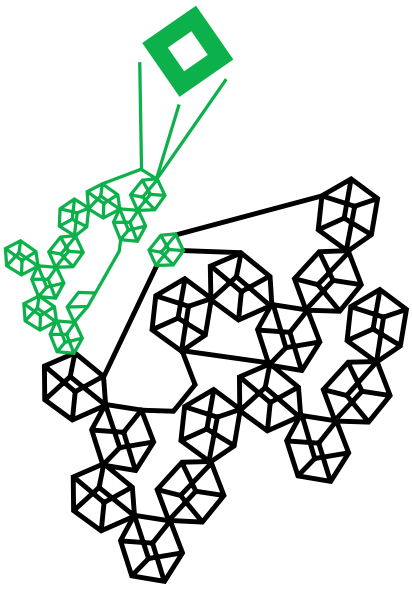
Healthcare has been known as a slowly moving domain with regards to innovation, but the Covid-19 pandemic, combined with the financial and staffing challenges in healthcare, led to an acceleration in the adoption of technology and digitization, which both have dramatically changed the healthcare landscape. However, technological innovations are only as valuable as their impact on people's lives, their environment and the involved healthcare professionals. That is why we need to identify the potential benefits and challenges of each innovation as early as possible to further steer the development, evaluation and implementation. Leveraging innovation wisely will benefit more patients, while making optimal use of the scarce financial and personnel resources and reducing the environmental footprint of healthcare.

The MedTech market

The total global medical technology industry's market size is approximating half a trillion U.S. dollars. In 2022 there were 34,000 medical technology companies in Europe of which 95% are Small and Medium Enterprises (SMEs). The European medical device market accounts for 27.3% of the world market representing a market size of € 150 billion after the USA. The largest European medical device markets are Germany (25.8%), France (14.3%), UK (10.4%), Italy (9%) and Netherlands (6.4%). The European medical device market has been growing on average by 4.8% per year and has exported € 6 billion more than it has imported in 2022.

Technologies as robotics, artificial intelligence, 3D printing, organs-on-chips, wearables, e-health, and imaging methods are already changing and will continue to change the way healthcare is delivered. Future developments could open new avenues for preventing, understanding, predicting and treating diseases that were unthinkable a few years ago. Furthermore, technology plays a major role in personalizing the healthcare system. For example, better instruments allow for a more accurate, individual diagnosis. Miniaturization allows us to develop sensors that monitor the patient's condition and disease progression, often out of the hospital in e-Health applications. Patient-derived stem cells in combination with organ-on-chip models can tackle patient to patient variations. Targeted drug delivery reduces the patient's burden and increases effectiveness in various chronic diseases. Robotic support systems enhance people's capacities and compensate for reduced functionality. 'Big data' techniques allow to include environmental aspects for even more personalised diagnosis and treatment.

Besides the potential benefits, a number of challenges have been identified that affect the implementation and upscaling of healthcare innovations. First, efficient use of innovations also requires changes in work processes. Innovations are too often incorporated as add-on into old processes rather than as a substitute. Second, limited acceptance of innovations by healthcare providers and regulators forms a barrier to implementation. The acceptance rate will be higher if users (e.g. patients & professionals) are involved in the development, evaluation and implementation of innovations. Training and education of students and employees is also an important precondition. Third, inter- and multidisciplinary collaboration is required for implementation and upscaling of innovations. Regional or (inter)national collaborations incorporating all relevant stakeholders, including end-users such as citizens/patients, contribute to implementing and scaling up innovations in an efficient and sustainable manner.



3. VISION AND MISSION

3.1 VISION

The TechMed Centre's vision is that
Development, evaluation, and appropriate implementation of technology will enable sustainable and personalised health for everyone

A good health and active societal participation are important for the perceived health and well-being of our citizens. In our vision, health is much more than the absence of diseases or disease symptoms as also stated by Huber: 'a state of complete physical, psychological and social well-being and not only the absence of disease'. (Bio)Medical technology can play an important role in addressing the current challenges that are affecting health as well as the healthcare system, resulting in impactful innovations that will enable a more sustainable and personalised health and healthcare.

Newly developed (bio)medical technologies and solutions will lead to sustainable innovations, only if they are developed, evaluated, and appropriately implemented. This means that the innovation has added value both from an environmental, business, staffing, organizational, (end-)user, patient, regulatory, quality and cost perspective.

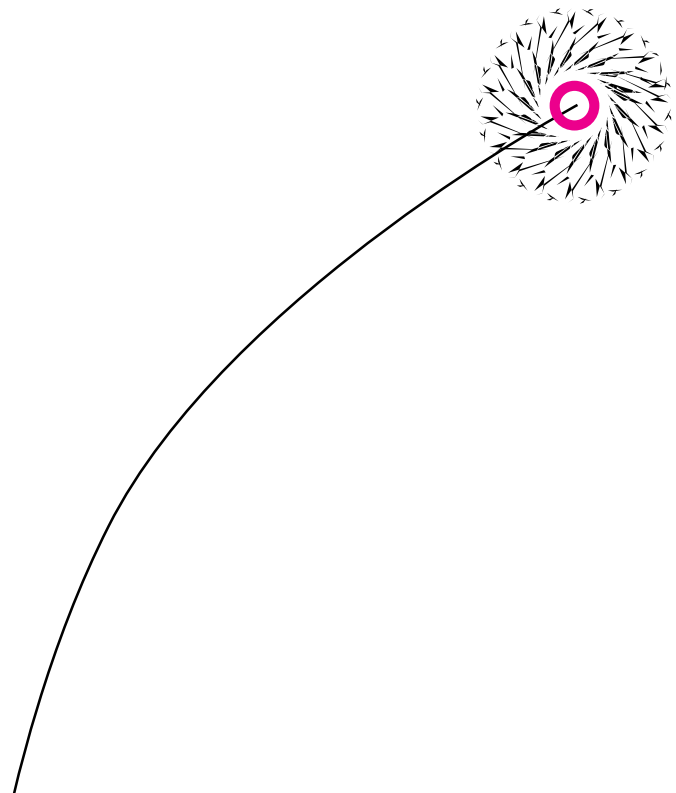
Some solutions may be technical or scientific, but sustainable innovation also includes organisation of the healthcare system, application of innovations, extensive testing of safety and efficacy of innovations, adoption of new technologies in the clinic or broader societal setting, and education and training of students, professionals and citizens on the use of these new solutions. Hence, to have an impact on society, all multi-dimensional aspects from idea to (clinical) implementation should be taken into account.

3.2 MISSION

The TechMed Centre's mission is to
Enable sustainable and personalised health by means of technology. We strive to be a globally leading Technical Medical Centre with a significant impact on society. We educate students and professionals, perform outstanding research and are strong innovators. We foster talent development, knowledge, products and services that are recognized for their positive impact on health. As innovation hub, we attract regional and (inter)national experts from both the healthcare, (bio)medical technology and governmental sectors, to collaborate on our shared goals in a flourishing innovation ecosystem.

The Technical Medical Centre of the University Twente is the first of its kind globally. It is a unique addition to the ecosystem of university hospitals and medical faculties ('university medical centres' in the Netherlands), initiated from a technical university by starting a pioneering educational program Technical Medicine in 2003. The technological expertise of our university, combined with healthcare research, education and innovation, in close collaboration with a network of clinical partners, further defines our unique proposition aiming at the development, evaluation, and implementation of (bio)medical technology in healthcare. It builds on a strong network of healthcare and industry partners, the unique educational programs of the UT, in combination with the solid fundament of research covering almost the entire spectrum of (bio)medical technology as well as the domain of health tech implementation sciences.

The TechMed Centre aims to inspire and stimulate the development of new solutions that have a positive sustainable impact in health and healthcare. Students and professionals are trained with a solid knowledge base and as individuals that work and think interdisciplinary, and analyse and solve problems in healthcare. Our alumni are known as confident and adaptive professionals, able to find new pathways, recognising and understanding new challenges, and designing new solutions.



4. STRATEGY

The TechMed Centre brings together all health(care) related activities of the UT, i.e. education, inter- and multidisciplinary research, shared infrastructures, business development, innovation and support services. **The Centre aims to act as the interface between the UT and our partners in the outside world** (Fig 1).

To enable sustainable and personalised health supported by technology, our strategy is to (i) focus on having impact on society, (ii) facilitate cross disciplinary and cross sectoral collaboration, and (iii) foster an integrated approach on education, research and innovation.

To achieve this, we:

1. Provide **Education & Training** via modern educational programs offered by the faculties with an engineering approach covering the healthcare value chain, and by addressing societal needs, delivering future professionals needed for innovation in health;
2. Perform interdisciplinary **Research** as to obtain relevant knowledge and to develop technology for health and well-being answering clinical and societal needs;
3. Stimulate **Innovation & Collaboration** by fostering partnerships within both the regional MedTech Twente and Euregio Ecosystem, societal organisations and TechMed healthcare network and the global hub-and-spoke network with (academic) medical centres, research institutions and the Medtech industry/

   SMEs, delivering new solutions and true impact in health & healthcare

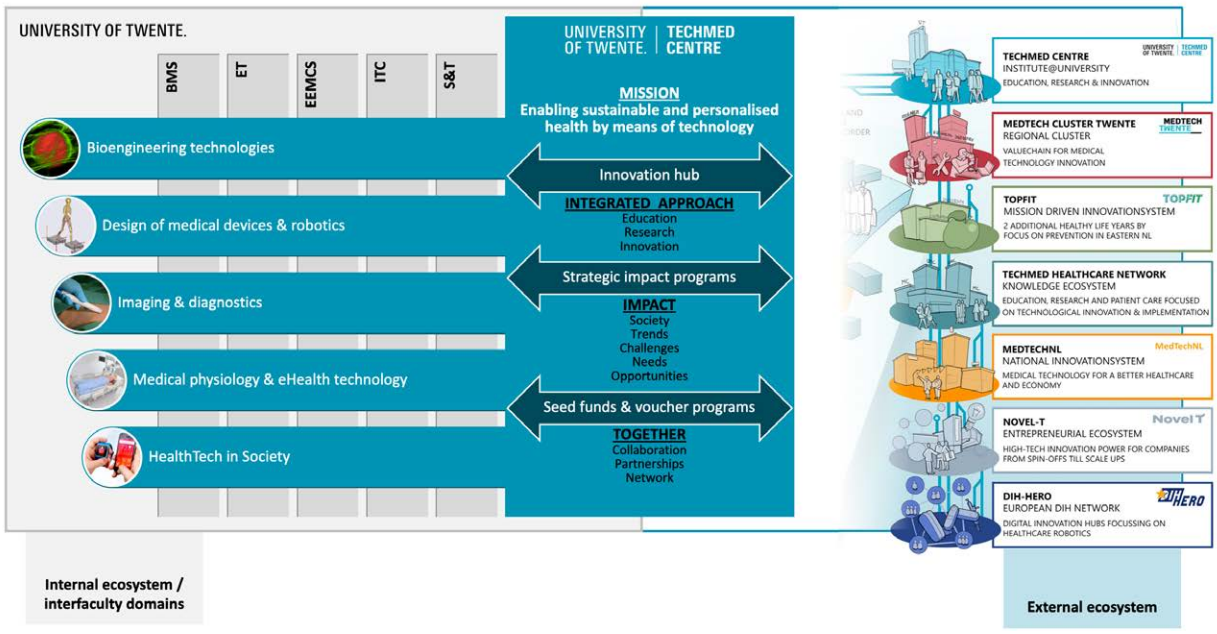


Figure 1. The TechMed Centre as interface between the internal and external ecosystems and its core strategic principles

4.1 CORE PRINCIPLES OF THE STRATEGY

4.1.1 FOCUS ON *IMPACT*: ADDRESSING SOCIETAL CHALLENGES WHERE UT CAN MAKE A DIFFERENCE

Since the founding of the UT in 1961, it has addressed economic and societal questions by means of a unique combination of technical and social sciences. The UT therefore was and is a thriving, entrepreneurial university that is known for its strengths in personalised healthcare technologies, smart manufacturing, advanced materials, digital technologies and its engineering capabilities to develop a resilient world.

In order to further contribute to the current societal challenges in healthcare, and enable our scientific staff to use their talents and drivers, we will invest in a way of working that (i) focusses on societal challenges that can be solved by means of science and engineering (ii) expands our entrepreneurial ambitions by acting as an engaged institution that connects with all relevant stakeholders to generate impact, and (iii) starts from the unmet needs rather than a supplier of knowledge that engineers solutions.

4.1.2 *TOGETHER* WE ACHIEVE MORE: BUILDING A STRONG TECHMED INNOVATION ECOSYSTEM

We believe in the power of collaboration as to create impact and bring valuable solutions to the regional, national and international healthcare systems. We aim to build long term relations and partnerships with relevant stakeholders that support our mission, and create a network of innovation ecosystems and partners. The TechMed Centre functions as a central innovation hub that connects these ecosystems.

4.1.3 *INTEGRATED* APPROACH: ALIGNMENT OF EDUCATION, RESEARCH AND INNOVATION

Each Dutch university has three core tasks: education, research and innovation/ valorisation. The TechMed Centre combines and aligns these three activities as much as possible. Educational programs strengthen the research domain and contribute to innovation and vice versa. Strategic partnerships cover all three tasks as much as possible and build upon shared roadmaps on research, innovation and education. The strategic shared infrastructure also facilitates all three core tasks.

4.2 STRATEGIC INSTRUMENTS TO BOOST IMPACT AND STIMULATE COLLABORATION

The TechMed Centre is responsible for the initiation, development, coordination and execution (together with the faculties and all involved research domains) of several strategic instruments such as impact programs and seed funds that together form a coherent Health Impact Portfolio funded by the central strategic budget of the University of Twente, the faculties, or external sources. The impact programs typically run 4 to 5 years and provide strategic impulses that boost the impact in a specific domain or application area across multiple faculties. The seed funds are an instrument to stimulate new valuable collaborations and have

proven to act as a multiplier towards larger grant applications (Fig 2). The way of working and prioritized programs and instruments are described in more detail in the implementation plan of the multi-annual strategy.

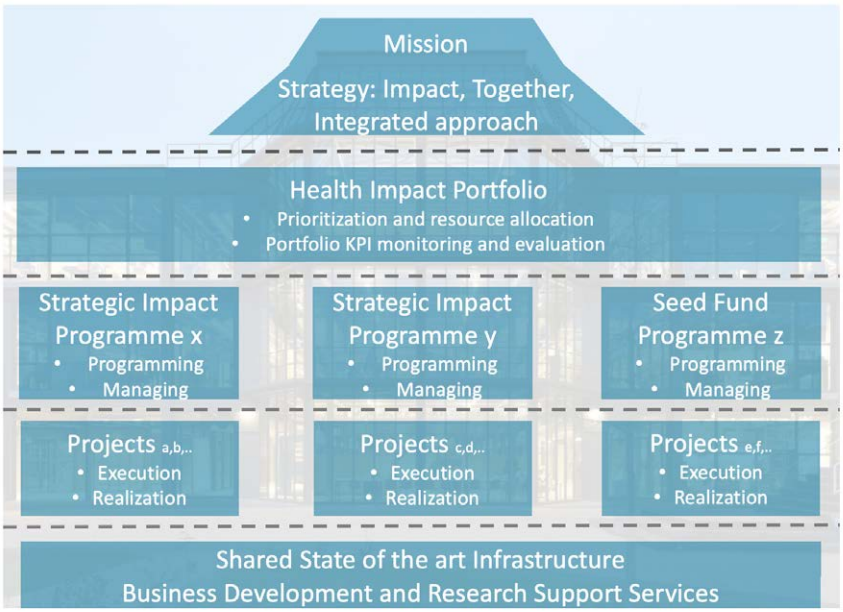


Figure 2. The TechMed Centre's portfolio of strategic instruments

As part of our Health Impact Portfolio, the TechMed Centre coordinates several strategic programs. Figure 3 provides an overview of the ongoing programs and new intended strategic impact programs.

The ongoing programs are Personalised eHealth Technology (ending in 2023), Stimulate HealthTech Implementation and Key Enabling Technologies for Personalised Medicine.

Strategic Program	2022	2023	2024	2025	2026	2027
Personalised eHealth Technology						
Stimulate HealthTech implementation						
KETs for Personalised Medicine						
MedTech for Staffing challenges						
Planetary & sustainable Health						
New programs, to be defined						

Figure 3. Strategic impact programs of the TechMed Centre

In 2023/2024 new programs will be launched that focus on i) innovative technology for sustainable (healthcare) staffing and ii) planetary health and a

more sustainable healthcare by reducing the environmental footprint of the healthcare system. We have built in the flexibility to start new programs in 2025/2026 on relevant societal themes.

Next to the impact programs, successful seedfunds as Pioneers in Healthcare with the regional topclinical hospitals MST, ZGT and DZ, the Saxion university of Applied Sciences and the Reggeborgh fund, and the TURBO grants with Radboudumc will be continued. These funds are regularly evaluated, and contribute to the realization of many new collaborations with an average success in attracting 5 times more future external funds than the initial investments.

For more detailed information about our strategic programs and seed funds, we refer to our website and the implementation plan of the multi-annual strategy.

4.3 OTHER STRATEGIC PRIORITIES FOR THE UPCOMING YEARS

Next to the core principles of the strategy and the strategic instruments of the impact portfolio, we will invest in de following strategic priorities for the upcoming years:

- International positioning & collaboration, e.g.
  - Continued partnering with Ircad/IHU Strasbourg and MGH Boston
  - 4-5 new international academic partnerships, such as with UKM Munster & German border area, Waterloo University, Tampere University / ECIU
- Talent Development, e.g.
  - Future proof bachelor and master programs
  - Invest in Life Long professional Learning / TechMed Academy
- Growing our impact via strategic partnerships with i) healthcare partners, ii) medtech industry and iii) societal partners, e.g.
  - Invest in account management, long term relations
  - Invest in impact growth opportunities, stronger partnerships and less boundaries between organisations
- Strategic Shared Infrastructure
  - State of the art physical and digital infrastructure for all research domains

5. EDUCATION & TRAINING

5.1 BSC & MSC PROGRAMS

With the core Bachelor's and Master's programs Health Sciences, Biomedical Engineering and Technical Medicine that are embedded in and provided by the Faculty of S&T, we are committed to training professionals who contribute to the TechMed Centre's vision: Development, evaluation, and appropriate implementation of technology to enable sustainable and personalised health for everyone. Each of these programmes has its own focus and collectively they cover the entire continuum: Biomedical Engineering students are trained to develop and design technological innovations for healthcare. Technical Medicine students focus on using this technology on individual patients and Health

Sciences students consider this development, implementation and evaluation of technology from multiple points of view (e.g. organisational).

As highly inter- and multidisciplinary programs, a broad range of disciplines across all faculties is contributing to these programs. In addition to the three core programs, multiple other UT programs contribute to the mission and goals of the TechMed Centre and its domains with tracks that focus on health such as the Master's of Business Administration, Mechanical Engineering, Industrial Design Engineering, Interaction Technology, Psychology, Public Administration and Public Management.

5.1.1 BIOMEDICAL ENGINEERING

The Biomedical Engineering program trains students in research, design and the development of innovative products and processes that will benefit the healthcare sector. Students learn to develop technical innovations that really contribute to better care. This multidisciplinary field combines engineering and life sciences, such as biology, nanotechnology, physics, electrical engineering, chemistry and mechanical engineering. The design of both the Bachelor and Master programs is closely linked to the research domains of the TechMed Centre. All biomedical research domains are represented in the bachelor's and during the master students specialize in the tracks:

- Bioengineering Technologies
- Imaging and in vitro Diagnostics
- Physiological Signals and Systems
- Biorobotics
- Medical Device Design

5.1.2 TECHNICAL MEDICINE

Technical Medicine offers a unique interdisciplinary program, linking medicine with technology and professional behavior to educate technical physicians to treat patients and to improve their patient's care by the use of technology. The technical physicians educated here are authorized by law to practice medicine because they have the right skills, a thorough understanding of the functioning of the human body, an equally thorough understanding of medical technology and of professional behavior. Combining this, they design and use new technology supported solutions for diagnosis and therapy in (individual) patient care. The first year of the Master's in Technical Medicine focuses on more in-depth technical and technical-medical courses as well as technical-medical skills like injections, surgical skills, endoscopic skills, etc. The second and the third year of the master's program have a practical focus, where students follow clinical rotations within a healthcare institution to become more competent in their clinical profession.

The master offers two tracks:

- Medical Imaging & Interventions
- Medical Sensing & Stimulation

5.1.3 HEALTH SCIENCES

The Health Sciences program of the University of Twente trains students to become an academic interdisciplinary Health & Technology professional who is capable of improving healthcare in a sustainable way through collaboration with various disciplines. The Health Scientist has a broad overview of health care and health systems and examines the quality of care and how health care can be improved from multiple perspectives (qualitative, ethical, legal, technological, financial, organisational). These different perspectives can be applied at different levels, such as the doctor-patient level, at the institution and organisation level and at the healthcare system/society level. The University of Twente trains health scientists to analyze, (re)design, implement and evaluate processes, systems and actions with a view to providing sustainable high-quality care. In doing so, the health scientist has specific knowledge in the field of health technology and, through a critical-analytical attitude and knowledge of the development and implementation process, can contribute to a responsible and successful introduction of new health technology in existing care. In the Master program the health scientist acquires more in-depth knowledge in Health Technology Assessment and Data Science and specializes in one of the three following tracks:

- Personalised Monitoring and Coaching
- Optimization of Healthcare Processes
- Innovation in Public Health

5.2 LIFE LONG LEARNING (LLL)

The LLL of the TechMed Centre is offered via the TechMed Academy, that aims to train health & technology professionals in a personalised way in the use and/or development of medical technology. Our personalised programs are based on a trainee's context and learning needs in which professionals learn to apply and/or develop new technology or methods both in predictable as well as unforeseen (new and untrained) situations empowering them to provide patient centric healthcare.

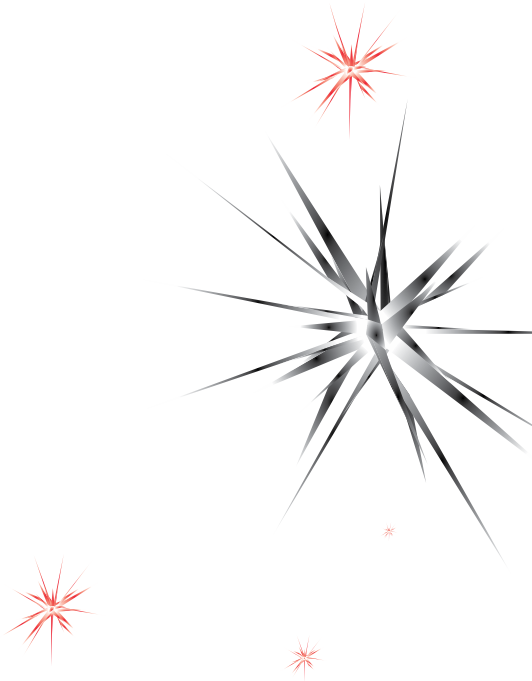
LLL is increasingly important, as technology is developing fast, and professionals need to keep up with the latest developments. We distinguish three types of TechMed Academy LLL activities:

1. Courses, provided under responsibility of the TechMed Centre/UT, with academic certificate for the participant after successfully passing the course.
2. Joint courses, often a co-production between an external partner (hospitals, professional organisations, industry) and UT. In some cases, the UT can provide an academic certificate, but only if it meets the academic quality standards of UT. Often the professional association of the partners have their own certificates.
3. External Courses from partners, facilitated by the TechMed Academy. The partner is responsible for the content and quality, and only uses the infrastructure.

We combine the expertise of the UT (and specifically the educational expertise on training in simulated areas, simulators or simulated patients) with the medical expertise of our end users, so every program is a true co-creation of the partners. Together with the client, our educational specialists and content experts, we aim to develop tailor-made solutions for the Healthcare and Life Science sector. The learning questions/needs, experience and background level of intended participants are always guiding the educational design process. The TechMed Simulation Centre provides a realistic environment both in-hospital (operating rooms, hybrid operating room, intensive care unit) and home setting (eHealth House) to suit the needs of the learner.

In our programs, we aim to train *adaptive* health & technology professionals who have an adequate knowledge of concepts and technologies, an adaptive and innovative way of working, and can use and/or develop technology to meet the needs of the individual patient even in untrained, unknown or uncertain situations. We educate these future adaptive health & technology professionals by integrating a specific pedagogical approach, consisting of four key elements:

1. *Self-Directed Learning* in which participants have autonomy and self-control over their own learning process, regarding individual learning goals and time and place independent learning.
2. *Stimulate Deliberate Practice*, by purposeful training incorporating powerful feedback and critical reflection.
3. Enhancing conceptual understanding of core concepts and theories resulting in a flexible *transfer to the workplace*.
4. *A continuous interaction* between curricular design and in-house research evaluating the learning outcomes (research-based educational design).



6 RESEARCH DOMAINS

The research of the TechMed Centre is highly inter- and multidisciplinary and organized in different interfaculty research domains (see Fig 4). The domains are responsible for outstanding research ensure our global position as frontrunner in multiple research areas. All domains perform both fundamental and applied research as translational research, including the 'reverse translation' of clinical insights and needs to the research labs. Researchers embedded in the 5 domains are working in all 5 faculties of the UT. The adjunct and full professors are part of the Discipline Counsel. The total number of researchers affiliated with our TechMed Centre is about 650. It should be noted that any research group or individual researcher that is willing to contribute to the goals of the TechMed Centre institute is welcome to join and participate in all our (research) activities.

Figure 4. Research domains

Within these interfaculty domains, scientists are working together on a joint (bio) medical technology, specific educational programs or mastertracks and using a shared R&D infrastructure. The domains are jointly positioned and all contribute within their specific research area to our ambition to develop, evaluate and implement technology that will enable sustainable and personalised health.

6.1 BIOENGINEERING TECHNOLOGIES

The researchers within the domain of bioengineering technologies perform both fundamental and applied research, aiming to develop innovative diagnostic and therapeutic strategies for patients. This aim is pursued through the application of state-of-the-art technologies at the interface of chemistry, (stem)cell and molecular biology, biomaterials and membrane science, microfluidics, microengineering and nanotechnology. The researchers in this domain also participate in education in the above-mentioned fields and aim to create a stimulating environment for research valorization leading to products and spin-off companies.

The research within this domain is multidisciplinary in nature and is applied in a broad range of applications. This spans from injectable hydrogels to battle osteoarthritis, to implantable bioartificial pancreas devices to help to treat type 1 diabetes and to organs-on-chips to test the safety and efficacy of new drugs and therapies and thereby reduce animal experiments.

Involved research groups	
• Applied Microfluidics for BioEngineering Research (EEMCS-AMBER) • Advanced Organ bioengineering and Therapeutics (S&T-AOT) • Applied Stem Cell Technologies (S&T-AST) • Bioelectronics (S&T-BE) • Bioelectric signaling and engineering (S&T-BioEE)	• Engineering Organ Support Technologies (ET-EOST) • Biomolecular NanoTechnology (S&T-BNT) • BIOS Lab-on-a-Chip (EEMCS-BIOS) • Developmental BioEngineering (S&T-DBE) • Mesoscale Chemical Systems (S&T-MCS) • Molecular NanoFabrication (S&T-MNF) • NanoBioPhysics (S&T-NBP)

6.2 DESIGN OF MEDICAL DEVICES & ROBOTICS

The researchers in the medical devices & robotics domain develop engineering solutions based on robotic technology to improve the diagnosis and treatment of widespread diseases in society.

The research in this domain focusses on scientific knowhow that is relevant for various diseases, such as cancer, cardiovascular diseases, stroke and mobility deficiencies, and to develop engineering solutions based on medical devices and robotic technology that can help to diagnose or treat those diseases. This will often go hand in hand with imaging technologies, which form integral part of the solution as it happens in robotic interventional radiology and image guided surgical treatment.

We see medical devices and robotics as a pervasive technology, which can revolutionize our society by addressing the challenges we face in healthcare. Medical devices and robotic solutions must co-exist and co-work with people to improve our way of living and well-being. That's why people-centered devices and robotics are our main focus. The interaction between people and devices needs to be both natural, easy to use and adaptable, from fully operated to fully autonomous. Such medical devices and robots have for example the potential to alleviate staffing challenges in healthcare by providing assistance to medical professionals and reducing the burden of certain tasks.

Involved research groups	
• Biomedical Device Design and Production technology (ET-BDDP) • Biomechatronics and Rehabilitation Technology (ET-BRT) • Engineering Organ Support Technologies (ET-EOST)	• Biomedical Signals and Systems (EEMCS-BSS) • Interaction Design (ET-IxD) • Neuromechanical Engineering (ET-NE) • Robotics and Mechatronics (EEMCS-RAM) • Surgical Robotics (ET-SR)

6.3 IMAGING & DIAGNOSTICS

The researchers in the imaging & diagnostics domain aim to revolutionize the entire medical trajectory from diagnosis to follow up. This will enable healthcare professionals to improve their care for patients by using accurate, quantitative and personalised imaging in screening, diagnosis and evaluation. It also improves their abilities to practice precision medicine.

Our research ranges from development to the assessment and implementation of new technologies and methods. Application areas include anatomic and functional imaging of vesicles, cells, tissues, vasculature and organs to diagnose and characterize disease and health. Our research groups focus on ultrasound, optical, photoacoustic, molecular, magnetic and nuclear imaging for precision medicine. Diagnostic imaging has been proven to lead to an improved diagnostic accuracy, earlier detection of diseases, improved patient outcomes, and personalised healthcare as imaging allows to tailor treatment plans to the individual need of each patient.

Involved research groups	
• Biomedical Photonic Imaging (S&T-BMPI) • Datamanagement & Biometrics (EEMCS-DMB) • Magnetic Detection & Imaging (S&T-MD&I) • Personalised Diagnostics and Therapeutics (S&T-PDT) • Mathematics of Imaging & AI (EEMCS-MIA) • Multiscale Modelling and Simulation (EEMCS-MMS)	• Multi-Modality Medical Imaging (S&T-M3I) • Physics of Fluids (S&T-POF) • Robotics and Mechatronics (EEMCS-RAM) • Molecular NanoFabrication (S&T-MNF) • Surgical Robotics (ET-SR)

6.4 MEDICAL PHYSIOLOGY & E-HEALTH TECHNOLOGY

Researchers within this domain aim to improve prevention, diagnostics, (remote) monitoring, therapy and management of the cardiovascular and respiratory system, neurological disorders and mental health with translational research at the interface of science, engineering and medicine. Where this domain

historically focused primarily on the hospital environment, it has expanded towards a focus where healthcare is in a transition towards the own living environment, with an aging population and increasing number of chronically ill patients.

The research groups consist of a multi-disciplinary team of technical and biomedical engineers, physicists, clinicians, biologists, mathematicians, cognitive neuroscientists and psychologists. There is close collaboration with several teaching hospitals, academic medical centres, homecare organizations and companies, both in the Netherlands and abroad. Many of the affiliated researchers also work in hospitals as (technical) physicians in various fields, like neurology and cardiology.

Particularly the remote monitoring provides several benefits and values for patients, including improved access to healthcare, increased convenience, better patient engagement, and improved outcomes. This technology is therefore becoming increasingly popular and is expected to continue to grow in importance.

Involved research groups	
• BIOS Lab-on-a-Chip (EEMCS-BIOS) • Biomechatronics and Rehabilitation Technology (ET-BRT) • Biomedical Signals and Systems (EEMCS-BSS) • Cardio-Respiratory Physiology (S&T-CRPH) • Clinical Neurophysiology (S&T-CNPH) • Datamanagement & Biometrics (EEMCS-DMB) • Engineering Fluid Dynamics (ET-EFD) • Engineering Organ Support Technologies (ET-EOST)	• Human Media Interaction (EEMCS-HMI) • Integrated Circuit Design (EEMCS-ICD) • Integrated Devices and Systems (EEMCS-IDS) • Mathematics of Imaging & AI (EEMCS-MIA) • Mathematics of Systems Theory (EEMCS-MAST) • Multiscale Modelling and Simulation (EEMCS-MMS) • Neuromechanical Engineering (ET-NE) • Psychology, Health & Technology (BMS-PGT)

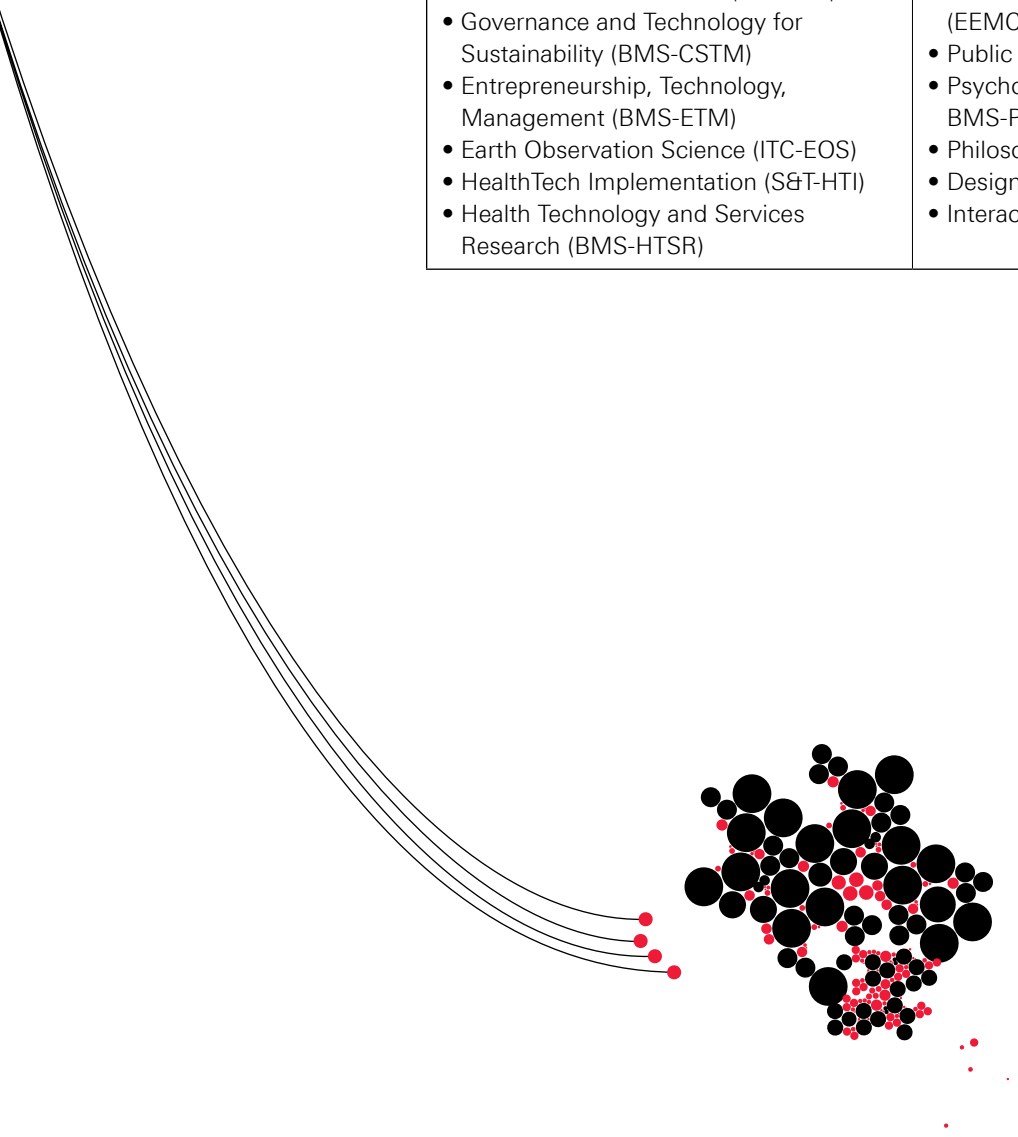
6.5 HEALTHTECH IN SOCIETY

The researchers in the healthtech in society domain use a cutting-edge and interdisciplinary approach to gain more insight into the conditions and mechanisms that make health technologies effective in daily practice. In close collaboration with designers of technology, patients, healthcare professionals, providers and managers, we contribute to the development, implementation and evaluation of value-based technologies that can be used in prevention, homecare and in (pre-) clinical settings. Improving healthcare by addressing the needs of patients and professionals and stimulating user engagement and social connectedness is main priorities in all our activities.

We address behavioral sciences and health economics, but also new forms of governance of integrated healthcare to implement technologies in an inclusive

and cost-effective way and optimize complex logistic healthcare challenges by operations research and management. To make this approach a success, we have strong ties with healthcare organizations including academic and regional hospitals, public health and home care institutions.
Healthtech provides significant value to society by improving access to healthcare, improving outcomes, reducing cost, providing health education, and accelerating research and development. As the field of healthtech continues to grow, it is likely that its impact on society will only become more significant.

Involved research groups	
• Cognition, Data and Education (BMS-CODE) • Communication Science (BMS-CS) • Governance and Technology for Sustainability (BMS-CSTM) • Entrepreneurship, Technology, Management (BMS-ETM) • Earth Observation Science (ITC-EOS) • HealthTech Implementation (S&T-HTI) • Health Technology and Services Research (BMS-HTSR)	• Industrial Engineering and Business Information Systems (BMS-IEBIS) • Mathematics of Operations Research (EEMCS-MOR) • Public Administration (BMS-PA) • Psychology, Health & Technology (BMS-BMS-PGT) • Philosophy (BMS-WIJSB) • Designlab (EEMCS-DESIGNLAB) • Interaction Design (ET-IxD)



7 INNOVATION & COLLABORATION

7.1 TECHMED INNOVATION HUB

As the connecting interface between the internal (UT) and external ecosystems, with a strong focus on innovation, the Technical Medical Centre is a leading Innovation Hub (Fig 5) that stimulates the development and implementation of technology as to further improve health and healthcare. To have a significant impact in healthcare and the MedTech industry, the TechMed Centre boosts innovation by connecting different stakeholders in our network and regional ecosystem, offering a wide diversity of services, stimulating new innovation projects with funds and voucher programs and by offering our extensive experience in Tech Transfer.

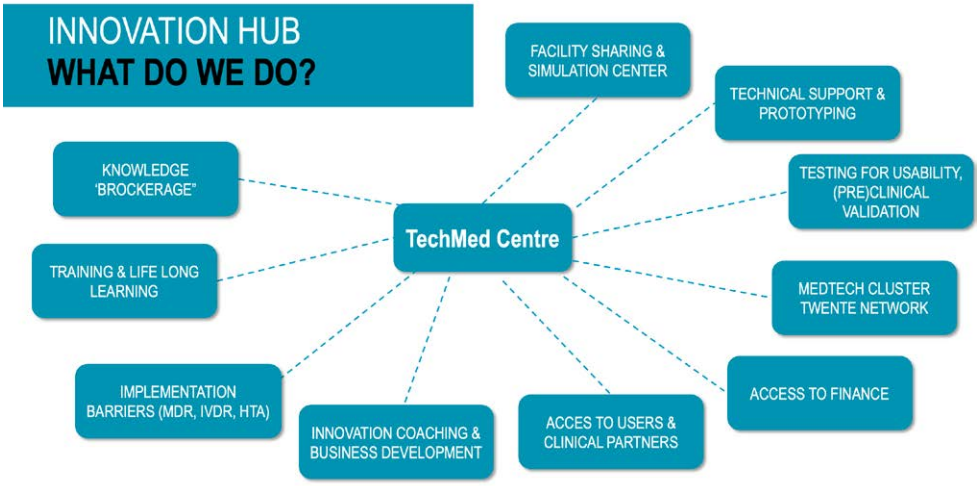


Figure 5. The TechMed innovation hub

Digital Innovation Hubs are in the core of the Digitizing European Industry (DEI) strategy and have a key role in the vision of the European Commission in programs such as Horizon Europe and Digital Europe. The TechMed innovation Hub is recognized as a 'fully operational' hub in the DIH-Catalogue on the Smart Specialisation Platform of the European Commission.

The TechMed Innovation Hub coordinates a big European project bringing together all DIH's in Robotics in Healthcare (DIH-HERO) and is connected to the eDIH Boost Robotics East Netherlands for the health application domain. This DIH position strengthens the European visibility and will create opportunities for domains such as Artificial Intelligence in Healthcare, and others.

7.2 INNOVATION APPROACH

We define innovation as the practical implementation of new knowledge, ideas, products or services that adds value and results in an improvement compared to the previous state.

Our approach to be known for our outstanding innovation, is to:

1. Ensure needs driven innovation (e.g. by Citizen Science & design methodologies, close involvement of patient, patient organisations and end users in our R&D and challenge-based student projects);
2. Build and sustain a strong valorisation funnel (scouting, screening, business development, in close collaboration with Novel-T);
3. Invest and elaborate on our innovation ecosystems and partnerships (healthcare, industry, society);
4. Tackle innovation barriers where possible, by providing discipline specific research support services (MDR, IVDR, animal & human subject research) for innovators;
5. Offer an innovative and state-of-the-art infrastructure for development, testing, (clinical) validation, and clinical implementation.

7.3 VALORISATION SUPPORT

The TechMed Centre and Novel-T are closely collaborating on valorisation support. The support consists of multiple instruments (Fig 6) across the development funnel as can be seen in the figure. New propositions are scouted continuously (both by digital surveys as interviews), screened in a structured way, and high potential propositions are actively supported by the business development team of Novel-T. This results in a steady (growing) number of annual patents (>10 per year) and spin offs (on average 4-5 per year, between

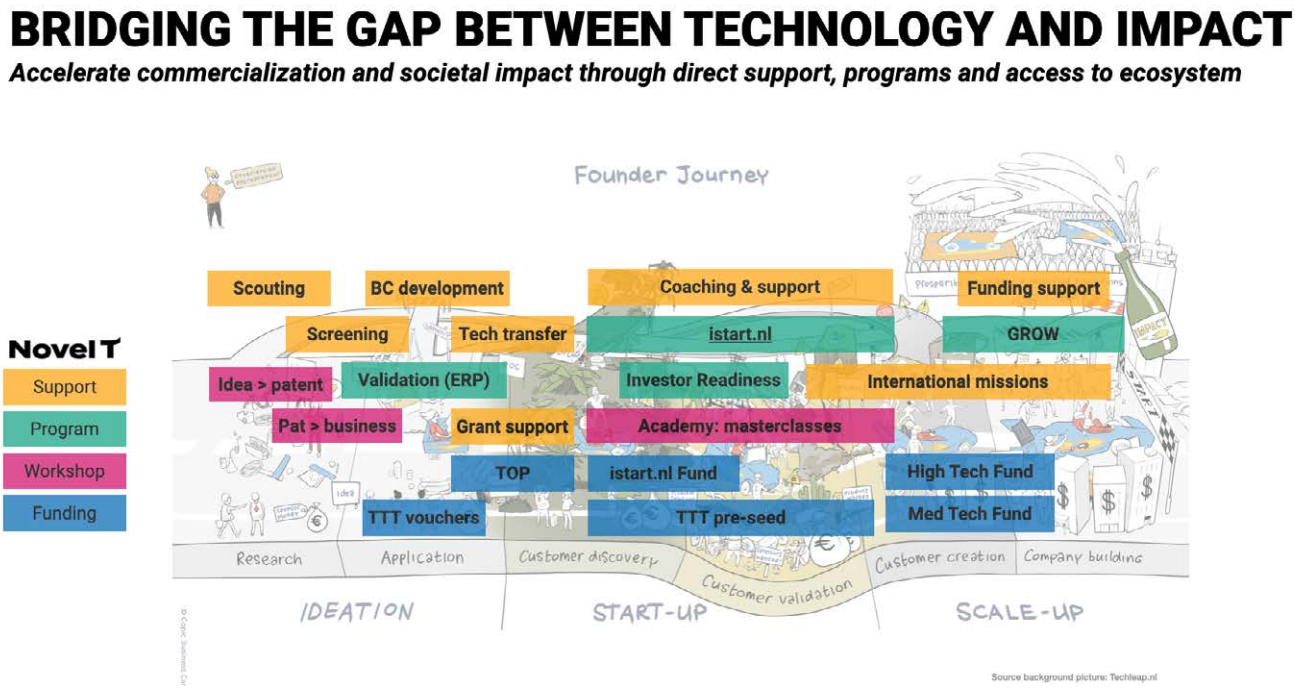


Figure 6. Novel-t's valorisation support instruments

50-75% of all UT spin offs are health related the last 3 years). The UT has been the most entrepreneurial university in the Netherlands over the last 10 years according to ScienceWorks/Elsevier.

7.4 TECHMED INNOVATION ECOSYSTEM

As a knowledge institute, the UT has a pivotal role in the Ecosystem of the region Twente and Eastern-NL (Gelderland + Overijssel). As innovation hub, the TechMed Centre stimulates collaboration and connectivity between multiple innovation ecosystems (Fig 7), ranging from the rapidly growing MedTech Cluster Twente, the national attempts for a MedTech consortium, to the strong TechMed healthcare network with multiple partnerships and a growing number of dual appointments of scientific staff. Collaboration with external partners is key for boosting innovation in healthcare. These partners vary from SMEs to MedTech corporates, from regional hospitals and other healthcare providers to University Medical Centres and international University Hospitals, from local to national governments, advisory boards and topsectors LSH &HTSM and from funding organizations and scientific societies to patient and societal organizations, and (groups of) citizens. These partners are our best ambassadors and they state that we always deliver what we have promised, and we are therefore known as a pleasant and very reliable collaborator.

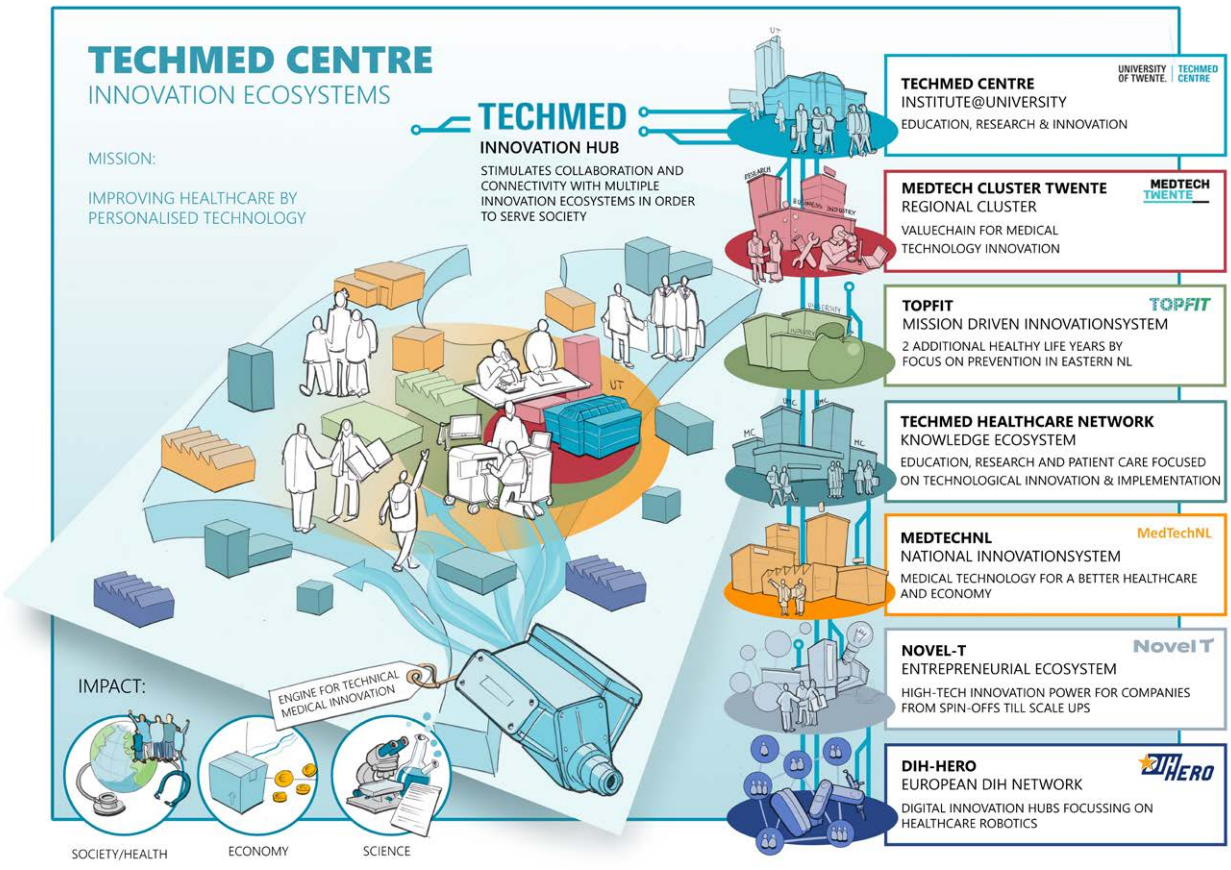


Figure 7. The TechMed Centre as innovation hub, connecting multiple innovation ecosystems

7.4.1 HEALTHCARE PARTNERSHIPS

The TechMed Centre has established relationships with all University Medical Centres and with several large hospitals and other healthcare organizations in The Netherlands (Fig 8). Collaboration within this clinical network is strongly supported by the numerous clinical internships of the Technical Medicine program. All internship projects are supervised by clinicians and scientific staff from the UT. In addition to this internship network, we have more than 40 dual scientific staff positions (including 17 clinical professors) with healthcare institutions, and formal research partnership are in place with Radboudumc, UMCG, MST, ZGT, Rijnstate and Isala and with Rehabilitation centre Roessingh. Next to that, there are (formalized) collaborations with more specialized hospitals, like centres for rehabilitation and the Dutch Cancer Institute and mental health organizations such as Dimence Groep. To stimulate new strategic collaborations and partnerships and to attract future funding for collaborative projects, the UT initiated several seed funds / voucher programs such as Pioneers in Healthcare (with MST, ZGT, Deventer Ziekenhuis, Saxion and Reggeborgh) and the TURBO grants (with Radboudumc). Particularly the strong collaboration with our partners in the region will enable us to have a significant impact on health.

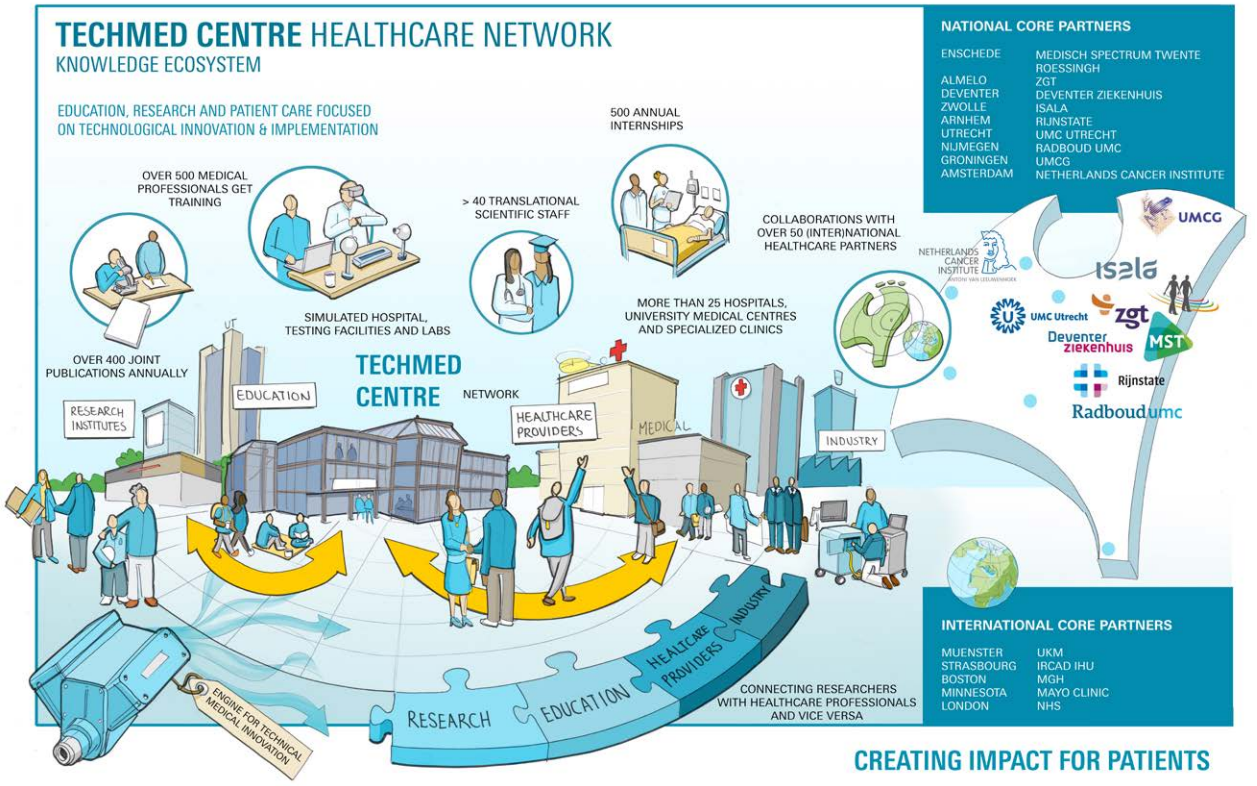


Figure 8. The TechMed Centre's healthcare ecosystem

7.4.2 INDUSTRY PARTNERSHIPS

Besides the collaboration with clinical sites, partnerships with medtech companies are crucial for bringing real solutions to the international healthcare

market and to grow our impact. The list of industrial partners is impressive and includes large to very large companies (e.g. Siemens Healthineers, Medtronic, GE, Philips, Terumo, Teledyne, Sonion) as well as many regional companies (e.g. Demcon, Baat, Hankamp, Panton, Holland Innovative, Movella, Unitron, UNeedle). As there is a strong focus on early stage medtech innovations, there is a strong network of numerous start-ups and SMEs, of which a lot originate from the University.

With some of the industry partners, broader collaboration agreements are in place, for example with Siemens Healthineers (education & research partnership). With others, letters of intent have been signed about setting up broader strategic collaborations (e.g. Medtronic, Ancora Health). In many other cases, collaborations are based on specific R&D projects, or the usage of shared facilities. A considerable growth potential is foreseen with regard to the industry partnerships (e.g. contract research, PPP funding).

7.4.3 OTHER PARTNERSHIPS

The regional ecosystem in Twente is recognized for its mindset and culture of collaboration. Although the region has 650.000 citizens, the number of organisations can be overseen and most of them have a strong focus on collaboration. Good examples are the strong interaction of the UT with the Saxion University of Applied Sciences and ROC van Twente, and the regional network of healthcare organizations, regional governments and innovators that joined forces on specific challenges within Vitaal Twente.

As we are living in a growing internationally oriented environment, the UT is proud of its international partnerships with renowned institutes such as the UKM Münster, Waterloo University, IRCAD/IHU in Strasbourg, the Wyss institute and the MGH hospital in Boston, and a wide range of strong research connection with top research groups at MIT, Yale, Sunnybrook, Kings College, ETH Zürich, Tampere University, etc. We aim to further build on our Euregional position near Germany and the already ongoing collaborations with among others the Munster region.

In addition, there are long term collaborations with patient organizations and with health care funds such as Reuma Nederland, who recognized the bioengineering groups of the TechMed Centre as ‘Research Centre of Excellence’.

Furthermore, the UT is involved in multiple consortia such as:

- TOPFIT, that focusses on innovations that contribute to the sustainable organisation and provision of healthcare, from the hospital to the personal living environment, in order to prevent diseases and disease burden.
- ICMS, that has the ambition to become a national research centre on movement sciences.
- hDMT, the Institute for human organ and Disease Model Technologies, with the mission to develop and qualify cell culture models that mimic healthy and diseased human tissues based on Organ-on-Chip technology, and to facilitate their valorisation and implementation.

8. THE TECHMED OFFICE – SUPPORT ACTIVITIES

The TechMed office supports the management of the TechMed Centre and the research domains in the execution of its tasks.

The TechMed office covers two main activities:

1. **TechMed Business Development**: improving impact by the development of programs and attracting additional funding, ecosystem development, finding the right partners, stimulating dissemination, marketing & communication.
2. **TechMed Research Support**: facilitating researchers across the university with specific research support activities for running research projects and supporting compliancy discussions in areas such as human subjects research, medical devices or in vitro diagnostics development and animal research.

8.1 TECHMED BUSINESS DEVELOPMENT SUPPORT

The TechMed business development activities aim to create and develop new opportunities that contribute to our mission and strategic goals. The core business development activities are:

- Supporting the development and execution of strategic programs and seed funds
- Funding support (in close collaboration with the SBD Grants Office)
  - o Funding strategy support: support the research by developing a funding strategy for research idea's, dreams, program lines or careers paths of talented individuals and consortia;
  - o Grant Support, especially on (i) specific health related calls and funding organizations, on (ii) consortium development, and on (iii) proposal development with a special focus on implementation and impact;
  - o Lobby & strategic influence, by a close contact with relevant national and international funding organisations.
- Business development partnerships
  - o Business partnerships & Tech Transfer (in close collaboration with Novel-T)
  - o Healthcare partnerships
  - o Societal partnerships & Citizen Science (in close collaboration with Design Lab)
- Organization of events (e.g. TechMed Event, Research Day, thematic events)
- Marketing & Communication related to the TechMed Centre (e.g. magazine, website, video's, news and media items)

8.2 TECHMED RESEARCH SUPPORT

In addition to the regular research support services offered by the UT's faculties and service departments, we provide specific research support. Hereby we facilitate researchers with respect to the procedures and documentation during the different phases of scientific research ensuring compliance with relevant guidelines and legislation. We invest in improving awareness of relevant guidelines and legislation amongst the research community, and provide workshops and training programs.

For the following topics, the TechMed Centre office is facilitating the entire UT:
- Human Subjects research / Medical Ethical Review Committee;
- Medical Device & IVD development, QA/RA expertise;
- Animal experiments.

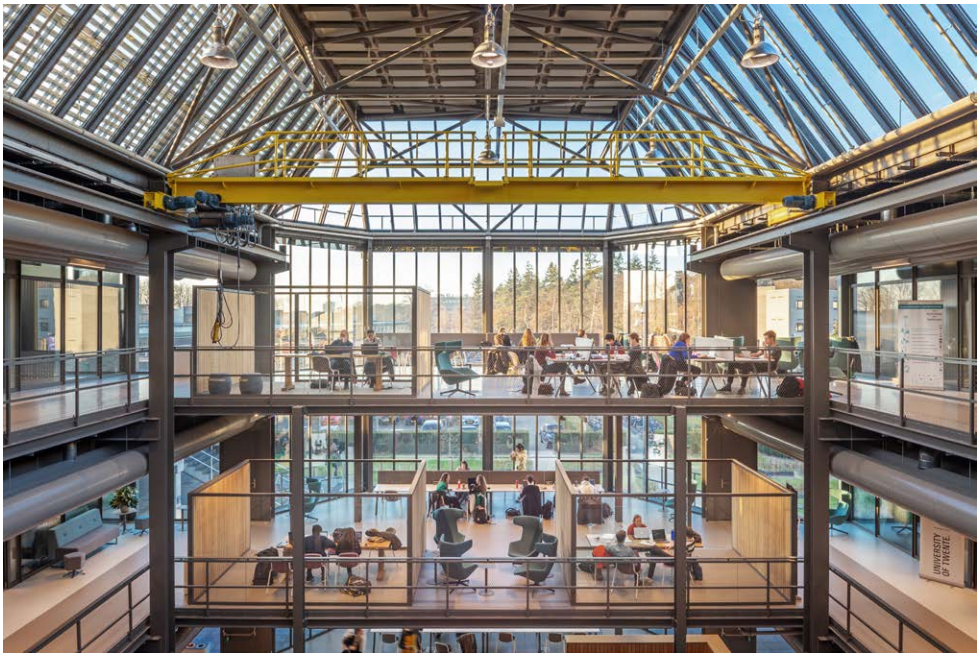


Figure 9. The TechMed Centres core building

9. TECHMED INFRASTRUCTURE

The TechMed Centre has more than 5000 m2 of unique infrastructure to facilitate its activities in education, research and innovation.

Infrastructure is managed by the TechMed Infra department. TechMed infrastructure includes the UT Animal Facility, the TechMed Simulation Centre with an e-Health house, hybrid OR, imaging labs and advanced simulation training labs, and ML1/ML2 bioengineering laboratories in the Zuidhorst building. Additionally, new strategic infra initiatives like the Bio Imaging Centre (BIC), the Organ on a Chip Centre and the Phantom Lab are actively supported in securing funding, lab space and the implementation of operations. About half of the infrastructure is directly managed by the TechMed Centre. The other part is managed by individual chairs or combinations of chairs within other faculties. The TechMed Centre does however also provide support and advice for those facilities and helps with the positioning and branding of the strategic labs.

Figure 10. Impression of the bioengineering labs

Figure 11. The wearable robotics lab

Our simulation infrastructure is uniquely positioned in between the fundamental research labs and the real-life clinical environment. This chain of labs is organized such that innovation funnels are created that will shorten the time to market of medical innovations, and allow short-cyclic innovation with earlier feasibility assessment opportunities. A great example of an innovation infrastructure chain is the imaging and image guided treatment infrastructure: from robotics and 3D printing labs, via simulated hybrid OR's and pre-clinical imaging labs at the UT, up to the MITEC clinical environment at the Radboudumc. All used for education, research and innovation activities.

The TechMed Centre actively promotes facility sharing. It encourages the collaborative usage of research labs and simulation facilities by different research groups within the university. It also stimulates the usage of facilities by external parties, e.g. hospitals for providing training programs, and startups up to the big medtech corporates for executing experiments. By opening up our facilities for external users, we also aim to inspire partnerships and our ecosystem, adding value to the TechMed Centre on the long run. Support is provided with respect to contracts and agreements with external users, and financial, administrative and legal processes will be optimized and standardized as much as possible. Additionally, the quality management procedures will facilitate integration of a third party's QMS with our facilities, enabling them to incorporate preclinical testing and validation into their development cycles.

Given the focus on collaboration, especially with clinical partners, reliable and secure data exchange between partners has become increasingly important. The relevant data infrastructure will be consolidated, together with the UT's LISA department, under the umbrella of TechMed Infra. This includes the existing XNAT PACS infrastructure. We also have secured integrated systems for exchanging physiological data and e-Health or remote monitoring data.

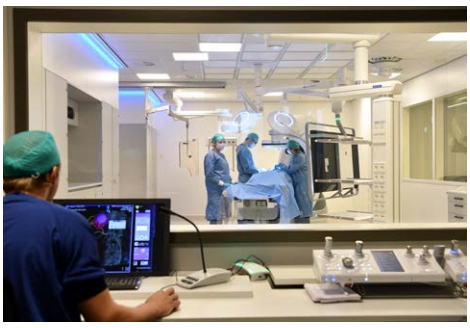


Figure 12. The simulated hybrid Operating Room

10. GOVERNANCE

We aim at a *lean-and-mean* governance of the TechMed Centre.

The TechMed Centre has a **Management Team** (MT) consisting of:

- Scientific Director representing the TechMed Centre institute
- Managing Director in charge of innovation & collaboration, business development, the TechMed office, TechMed infra and the business administration
- Director of Education representing the educational programs
- Medical Director representing the medical aspects and translational character of research and education & the core clinical partnerships
- Standard invitation: Chairman of TechMed discipline counsel

The MT meets every week. To ensure a solid embedding in the university structure, a representative of each faculty board is included in the extended MT of the TechMed Centre. This **extended MT** meets at least twice a year. In addition, regular bilateral meetings with (representatives of) faculty boards and the MT are planned based on actual needs and demands.

The Executive Board has given the Medical Director their mandate to approve research with human subjects that falls under the human related research law (in Dutch 'Wet Mensgebonden Onderzoek').

The TechMed Centre MT meets twice a year with the coordinators of each **research domain**. These meetings focus on defining the strategic plans and priorities and on information exchange between the institute and research domains.

The TechMed Centre has a **discipline council** that includes all professors (HL or UHD with promotion rights) of the TechMed Centre. The discipline council meets 5 times per year. The primary goal is to embed the educational and research programmes of the TechMed Centre in the participating faculties and to exchange information, good practices and concerns between the chair holders. It also serves as an advisory council to the MT.

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