FACULTY OF ELECTRICAL ENGINEERING,
MATHEMATICS AND COMPUTER SCIENCE

Research
SELF-EVALUATION
2017 - 2022
ELECTRICAL ENGINEERING

May 2024

UNIVERSITY OF TWENTE.


Kirsten Pondman,
Veni laureate in the AMBER group.


Harijot Singh Bindra,
Veni laureate in the ICD group.


Anastasia Lavrenko,
Veni laureate in the RS group.

Click on the images
to know more

RESEARCH SELF EVALUATION
Fullterm Review
2017-2022

ELECTRICAL ENGINEERING
UNIVERSITY OF TWENTE

May 2024

The electronic version of this document has direct links to references and, additionally, links to the list of references at the end of the document, e.g. [1], or to pages, figures or tables in this document itself. You can download the electronic version from:
https://VisitationEE.utwente.nl/EE-FT-2017-2022/pdf/FT-EE-2017-2022.pdf or by scanning the QR code:

Additional information is available at https://VisitationEE.utwente.nl/EE-FT-2017-2022/ [2],
or by scanning the QR-code:

This report has been compiled and partly written by Gijs Krijnen with input from Loes Segerink, Monique Tabak, Job van Amerongen, Jan Eijkel, Bram Nauta, Stefano Stramigioli, and important feedback from Peter Veltink, Séverine Le Gac, Jurriaan Schmitz, Cora Salm, Frank Leferink, Jan Buitenweg, Geert Heijenk, Jasper van Alten (S&P). Much of the data was provided by Anja Smit (EEMCS-HR), Rob Schepers (S&P, BI@UT), Ard Sprengers (EEMCS-BC) and Samuel Mok (UT-LISA). We highly appreciate the many discussions we had in preparation of the visit with our colleagues Jan Vleeshouwers and Rianne van Eerd at EE@TU/e.

This document was prepared in LaTeX in the overleaf.com environment, using the Carlito font.

Preface

In front of you is the research self-evaluation report 2017 – 2022 of the discipline Electrical Engineering of the University of Twente. Looking back we can safely conclude that a lot has happened during the assessment period.

The Dutch government has helped us to realise a significant investment in our staff, due to the Sector Plans. We pride ourselves that we have been able to use this opportunity to attract many talented junior scientists, boding for a successful future of our discipline. In the previous period we have also been able to rejuvenate some important leadership positions, safeguarding important research lines. Financially the discipline has been doing reasonably well, following the reorganisation of 2013–2014. The results of all these developments is that our staff has grown by no less than 46% in the reporting period.

Of course, all these developments would not mean much if we had no results to show. Reading this report you will conclude that we did obtain many results; prestigious grants, participation and leadership in big national and EU projects, new centres and a new educational programme, and continuing good scientific output.

That does not mean there are no critical notes to make. The COVID-19 pandemic, though showing how important electrical engineering in its many facets is in keeping the world turn around during a lock-down, has hampered our research and our education, clearly reflected in pass rates of our BSc, MSc and PhD students, especially the latter being a long-term concern.

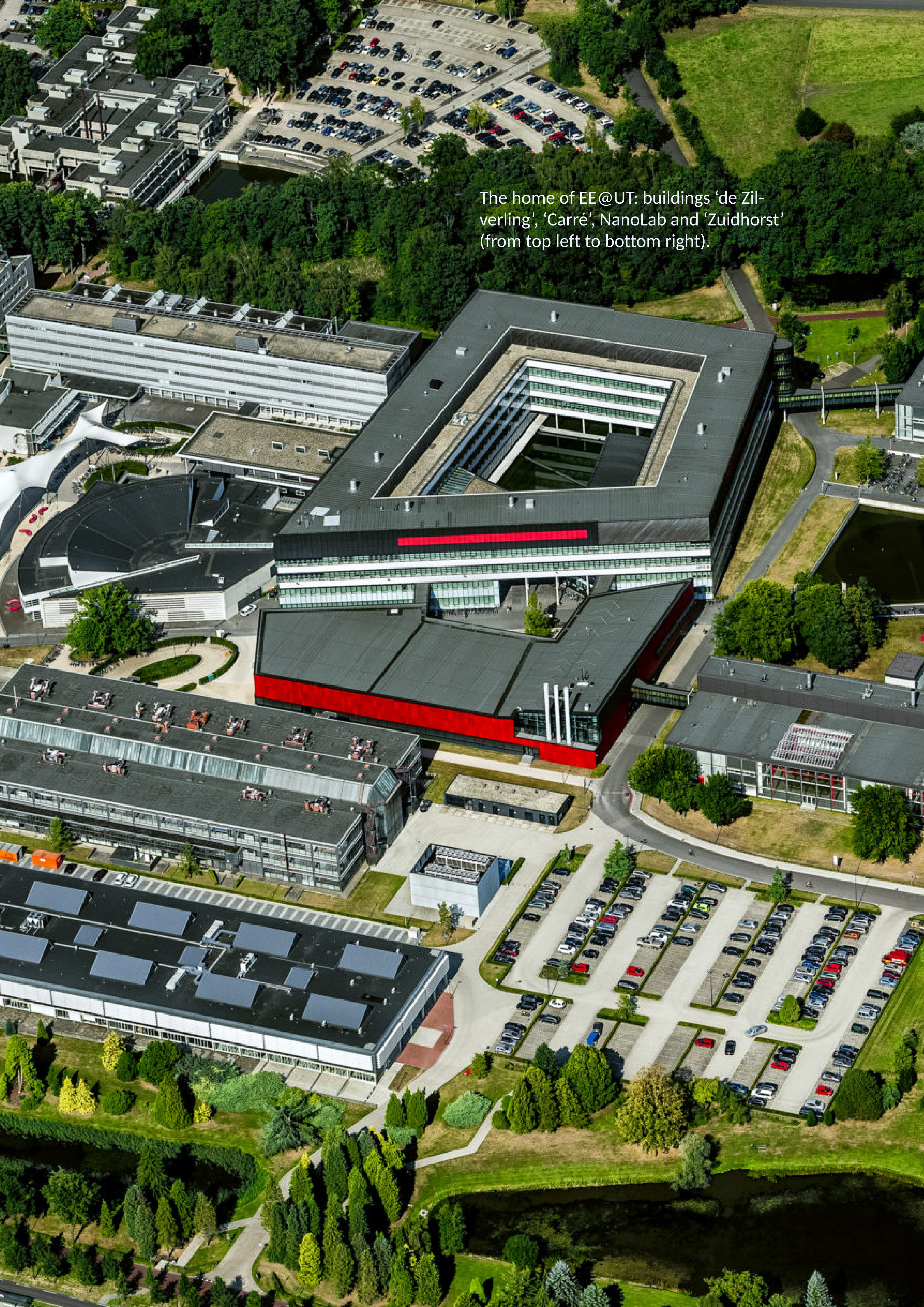
On a more critical note; we have seen a, at least perceived, increase of bureaucracy in which managerial or accounting checkmarks seem to prevail over delegated professional responsibility. Another concern not fundamentally dissolved is the influx of students in our BSc and MSc electrical engineering programmes. Although not really low in historical context, society can use many more electrical engineers than we currently educate. In this respect the internationalisation debates amongst politicians, and the way in which they scare off potential interested international students, is not helping us, on the contrary. On a positive note, the recently announced plans by the government to invest 1.4 B€ in the Dutch semiconductor industry, with a large share for education, will present new possibilities for EE in Twente, Delft and Eindhoven and clearly demonstrates EE's societal connection. Finally, we may not yet have found our most optimal, future proof, governance model. Something to keep working on.

All in all, looking at our current constitution, its large breadth, the quality and talent in our discipline and how well we are connected to society and societal challenges, we can be optimistic about the next 6 year of electrical engineering research and education at the University of Twente.

Hopefully, after reading this report, you can share both our concerns and optimism.

Prof. dr. ir. G.J.M. Krijnen
Chair of the EE discipline

Prof.dr. ir. Peter Veltink
Interim Dean EEMCS



The home of EE@UT: buildings ‘de Zilverling’, ‘Carré’, NanoLab and ‘Zuidhorst’ (from top left to bottom right).

Contents

Preface iii

Abbreviations and Acronyms vii

Joint note: Electrical Engineering in the Netherlands ix

1 Introduction 1
- 1.1 University of Twente and Electrical Engineering . . . 1
- 1.2 Governance . . . 3
- 1.3 Financing . . . 4
- 1.4 Ethics and scientific integrity . . . 5

2 Mission & strategy during assessment period 7
- 2.1 Vision . . . 7
- 2.2 Mission . . . 8
- 2.3 EE@UT in context . . . 8
- 2.4 Sectorplans . . . 9
- 2.5 Research lines and objectives in the assessment period . . . 10
- 2.6 Strategy over the assessment period . . . 11

3 Quality and relevance 15
- 3.1 Key Performance Indicators . . . 15
- 3.2 Evidence in terms of KPIs . . . 15

4 PhD policy and training 19
- 4.1 Training and Supervision . . . 19
- 4.2 Intake and Success Rates . . . 20

5 Working environment and personnel policies 21
- 5.1 Human Resources policy . . . 21
- 5.2 Recruitment . . . 21
- 5.3 Promotion . . . 21
- 5.4 Diversity . . . 22
- 5.5 Well-being . . . 23

6 Strategy for the next six years 25
- 6.1 SWOT . . . 25
- 6.2 Sectorplan Techniek II . . . 26
- 6.3 Developing strategic research fields . . . 27
- 6.4 Education and PhD policies . . . 28
- 6.5 Financial autonomy . . . 28
- 6.6 Personnel . . . 29
- 6.7 Benchmark Study . . . 29
- 6.8 Conclusion . . . 29

7 Summary 31

A Case Studies: Developments and Rejuvenation 32

B Key Publications 35

C Recommendations 2011-2016 Visitation EE@UT 36

D Supporting data KPIs 38

E Personnel 50

F Research Funding and Finances 53

G Education and PhDs 55

H Benchmark Project Plan **58**

I Organogram University of Twente **61**

Index **62**

References **64**

Abbreviations and Acronyms

	Groups in Electrical Engineering	Chair (2024)
AMBER	Applied Microfluidics for BioEngineering Research	prof. dr. ir. Séverine Le Gac
BIOS	Biomedical and Environmental Sensor Systems	prof. dr. ir. Loes Segerink
DMB (CVB)	Computer Vision and Biometrics CVB is part of the Data Management & Biometrics group	prof. dr. ir. Raymond Veldhuis & dr. ir. Luuk Spreeuwers
BSS	Biomedical Signals and Systems	prof. dr. ir. Monique Tabak prof. dr. ir. Jan Buitenweg
CAES	Computer Architecture for Embedded Systems	prof. dr. ir. Ana-Lucia Varbanescu
DACS	Design and Analysis of Communication Systems	prof. dr. ir. Geert Heijenk
ICD	Integrated Circuit Design	prof. dr. ir. Bram Nauta
IDS	Integrated Devices and Systems	prof. dr. Jurriaan Schmitz
NE	Nano Electronics	prof. dr. ir. Wilfred van der Wiel
PE	Power Electronics and Electromagnetic Compatibility	prof. dr. ir. Thiago Batista Soeiro
RAM	Robotics and Mechatronics	prof. dr. ir. Stefano Stramigioli
RS	Radio Systems	prof. dr. ir. André Kokkeler

	Research Institutes		
DSI	Digital Society Institute	MESA+	Institute for Nanotechnology
TechMed	Technical Medical Centre		

	Graduate Schools		
ASCI	Advanced School for Computing and Imaging	DISC	Dutch Institute of Systems and Control
IPA	Inst. for Programming research and Algorithmics	TGS	Twente Graduate School
SIKS	School for Information and Knowledge Systems		

	Other
4TU	Federation of the 4 Technical Universities in the Netherlands (Delft, Eindhoven, Twente & Wageningen)
AM	Applied Mathematics discipline of the EEMCS faculty
BMS	Faculty of Behavioural, Management and Social sciences
CMO	Commissie Mensgebonden Onderzoek
CS	Computer Science discipline of the EEMCS faculty
CNPH	Clinical NeuroPHysiology Group in Faculty of Science and Technology
CTW	Dutch for ET: Construerende Technische Wetenschappen
DC-EE	Discipline Council Electrical Engineering
EC	European Credit point
ECS	Ministry of Education, Culture and Science (Dutch: ministerie van Onderwijs, Cultuur en Wetenschappen)
EE	Electrical Engineering
EE@UT	Electrical Engineering Discipline of the EEMCS faculty at the University of Twente
EE@TU/e	Electrical Engineering Faculty of the Eindhoven University of Technology
EEMCS	Electrical Engineering, Mathematics and Computer Science faculty
EE-NL	Electrical Engineering Platform Nederland (Kamer Elektrotechniek)
ET	Engineering Technology faculty
FAIR	Findable, Accessible, Interoperable and Reusable
FTE	Full Time Equivalent
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual Property
HRM	Human Resource Management
KHMW	Koninklijke Hollandsche Maatschappij der Wetenschappen
KNAW	Koninklijke Nederlandse Academie van Wetenschappen
LOWI	Landelijk Orgaan Wetenschappelijke Integriteit / Netherlands Board on Research Integrity
MREC	Medical Research Ethics Committee
NGO	Non-Governmental organisation
NPU	Northwestern Polytechnical University, China
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
OA	Open Access
PD	PostDoc, postdoctoral position
PeHT	Personalised eHealth Technology
PhD	Doctor of Philosophy
PhDs	PhD students
RUMC	Radboud University Medical Centre
SCNU	South China Normal University, China
SPT	SectorPlan Techniek I and II (SPT-I and SPT-II)
TCS	Technical Computer Science
TGS	Twente Graduate School
TOP	Tijdelijke Ondernemers Plaats (Temporary Entrepreneurs' Location)
TSP	Training and Supervision Plan
TUD	Delft University of Technology
TU/e	Eindhoven University of Technology
UT	University of Twente
WMO	Wet Medisch-wetenschappelijk Onderzoek
WUR	Wageningen University and Research

Huge data center amidst windmills epitomising electrical engineering is in all facets of society.

Joint note:
Electrical Engineering in the Netherlands

The global landscape of electrical engineering

Electrical Engineering (EE) plays a key role in our society and global economy. It is directly connected to nine out of twelve potentially disruptive technologies listed by McKinsey [3] in 2013: the mobile internet, the internet of things, advanced robotics, autonomous and near-autonomous vehicles, next generation genomics, energy storage, 3D printing, advanced oil and gas exploration and recovery, renewable energy. Among the big societal challenges (energy transition and de-carbonisation, health, food-security, water quality, digital transition) [4] there are no solutions that can do without EE.

For example, since the previous EE research review (2011-2016) the energy transition (wind and solar power, electric cars) has gained momentum and, according to another McKinsey report [5], it is expected that increasing electrification and carbon-neutral power generation will be responsible for 44 % of CO_2 reduction between 2022 and 2050. As another example; during the recent COVID-19 pandemic the way we work has changed. Thanks to products directly related to EE working from home is well feasible and, now the pandemic is over, this continues to affect the work-private balance and reduces the need to travel. The societal dependence on electronics has grown to such proportions that the EU has decided in 2023 to invest 8.6 B€ , expecting to raise another private 13.7 B€ , in strengthening its semiconductor activities (European Chips Act, [6]).

EE has become increasingly intertwined with other disciplines like physics, material science, computer science, mechanical engineering, biomedical engineering and chemistry, blending in application areas such as energy, healthcare, mobility and transport, safety and security, vitality and sports.

Domain of EE

The *domain of EE* is best represented by a list of the IEEE professional societies and in more detail by their journals, transactions, letters and magazines. The Institute of Electrical and Electronics Engineers (IEEE) [7] is “the world’s largest technical professional society – promoting the development and application of electro-technology and allied sciences for the benefit of humanity, the advancement of the profession, and the well-being of its (450 000) members”. Obviously, no research programme can reasonably cover all these subareas in depth.

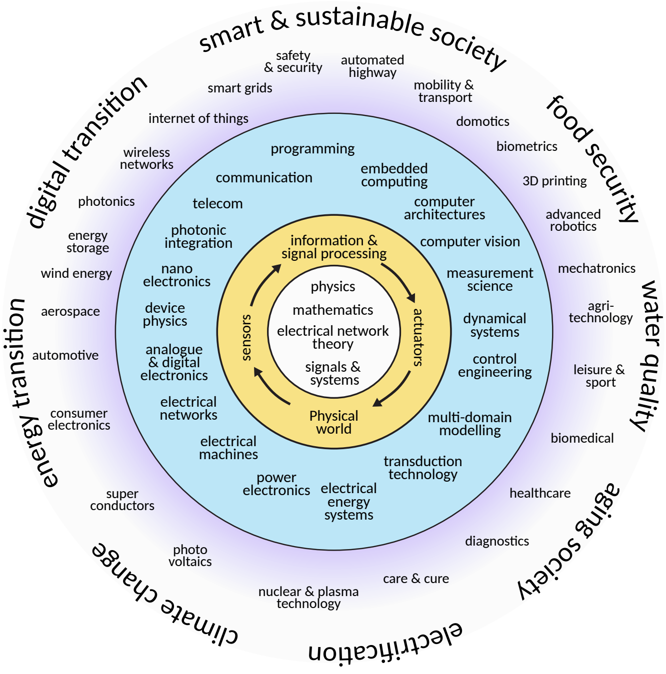


Figure 1
The domain of EE with some of the big societal challenges for which EE is indispensable.

Figure 1 illustrates the domain of EE at different levels of abstraction. The white centre of the figure indicates that EE builds on mathematics and physics, electrical network theory and signals & systems, while power, in the widest sense, including information transfer, is always related to the work of electrical engineers. The yellow circle indicates that EE is at the interface of the physical world, where (electrical) power and information processing (in electronics or software) play a role. The two worlds are coupled by sensors extracting information from the physical world and, after processing this information, converted back into the physical world by actuators. The blue circle represents some relevant EE disciplines needed for realising actual systems, while the topics outside the blue circle show (a selection of) application areas. Finally, the outermost circle shows some major societal challenges for which the various EE disciplines are thought to be indispensable.

EE in the Netherlands

EE@TU/e

EE@UT

Within the Netherlands historically there has been collaboration and focusing of the 3 EE departments: the EE department in Delft (EE@TUD) the EE faculty in Eindhoven (EE@TU/e) and the EE discipline at the UT (EE@UT). Part of this collaboration was by virtue of the 3TU.Federation, which, after the addition of Wageningen University & Research (WUR), turned into 4TU.Federation. For example, at the end of the 1980's each of the EE departments in the 3TU.Federation decided to focus on a specific technology area; TUD focused on semiconductor integration technology, TU/e on III/V semi-conductor photonics and UT at MEMS, micro- and nano-technology. When there were still 3 EE faculties, the so-called *E-kamer* met every half year. The delegations of each university consisted of the dean and the vice deans for research and education and strategic choices were discussed in an open atmosphere. However, after the introduction of the faculties EEMCS in Delft and Twente the E-kamer slowly disappeared from the agendas.

E-kamer

Reactions on general comments of the Review 2011-2016

Many of the comments of the committee, directed commonly to the 3 EE departments (TU/e, TUD and UT), stimulate us to develop plans in collaboration. The recommendations range from a “Roadmap for EE on a discipline level” to “doing a proper Benchmark together”. Most of these recommendations can be realised, or facilitated, by reviving the so-called “E-kamer” which met every half year to do exactly what was recommended by the committee. We do realise the importance of regular meetings of the discipline EE in the Netherlands. This e.g. became again clear during the formulation of the EE *Sector Plan Techniek - I* (SPT-I). Setting up this plan required good communication, agreements and common plans for stimulating focus points in the three EE departments as well as promoting EE in the Netherlands in general, also clear wishes of the Sectorplan Committee. Further, as a precursor to a revived E-kamer the EE disciplines of 3TU [8] have collaborated on a few subjects related to the 2017 - 2019 midterm research self-study report. Eventually in 2021, the 3 EE departments have set up an E-kamer new style, the ‘*Electrical Engineering Platform Netherlands*’ (EE-NL), or the ‘Raad voor Elektrotechniek’ (in Dutch). The formulated mission reads:

Sector Plan Techniek - I

Electrical Engineering
Platform Netherlands

1. Establishment of an EE community in the Netherlands to improve the visibility of EE and promote the notion of the importance of EE for relevant societal parties.
2. To contribute to societal challenges by common, 4TU-EE concerted actions to efficiently use and, when needed, acquire needed infrastructure.

Prospective activities are: to improve the visibility of EE in the Netherlands, to collaborate in and align common project proposals to improve success rates in larger project calls (NWO Zwaartekracht, Perspectief), to optimise (proposals for) infrastructure sharing and to collaborate in education with respect to content, influx and diversity of students.

Because the management structure at the 3 TUs is different, the composition of the platform is somewhat hybrid. A management team, including junior scientific staff, takes care of running regular activities, potentially supported by advisory parties. An executive committee of senior scientific staff helps to direct the management teams to pick up important questions and issues. Finally there is a board, of the deans of the 3 TU's, to oversee the overall functioning of EE-NL.

Since end 2021 regular meetings of EE-NL take place, NWO is supporting the platform, and the first EE-NL day (2023) has meanwhile been organised, it is fair to say that EE-NL has seen a bumpy start. It has been in search of a well defined organisation form for a while and is lacking recognition to be a discussion partner in national policy questions.

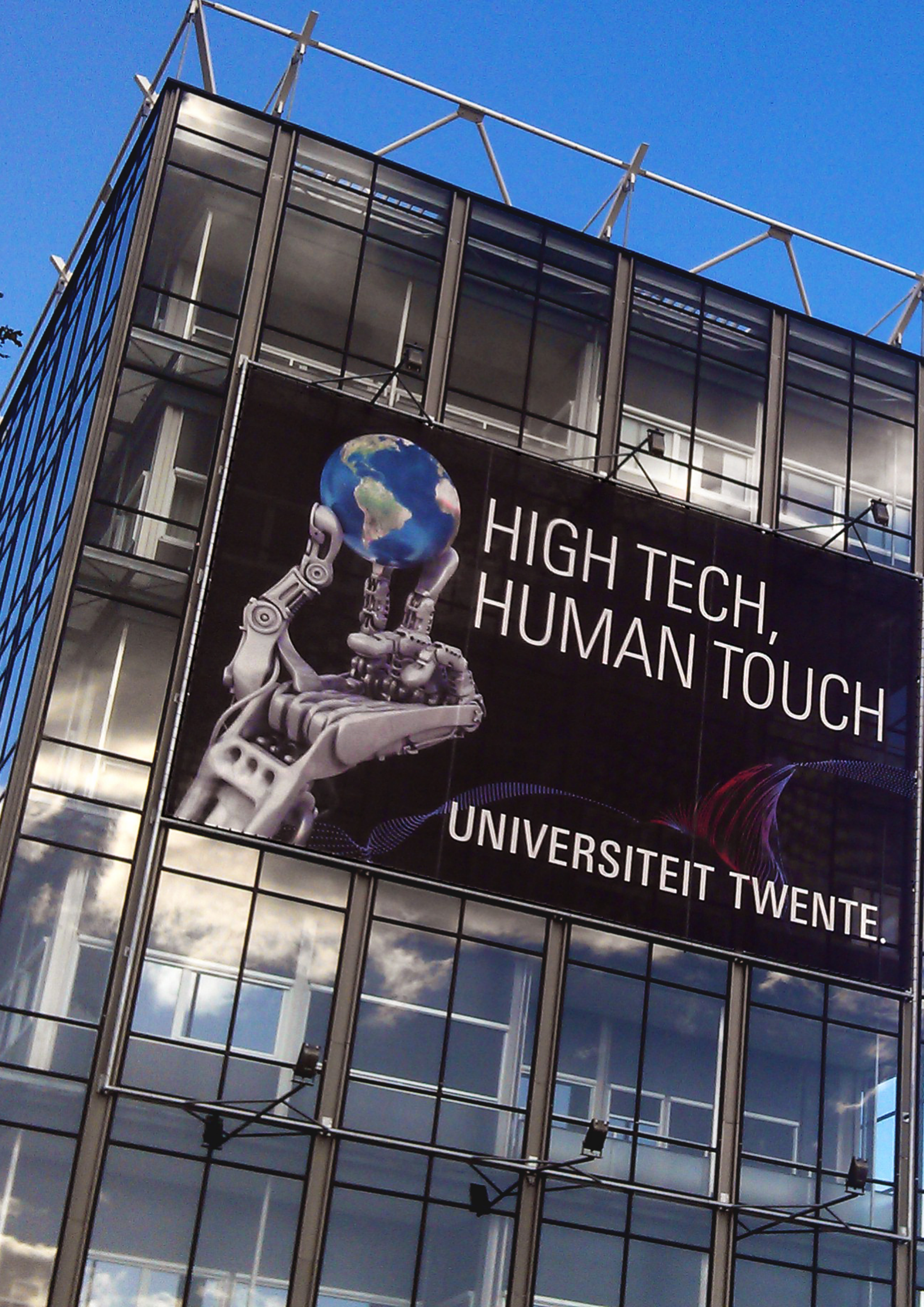
Looking ahead

Looking ahead means returning to the statement that started this Joint Note: Electrical Engineering plays a key role in our society and global economy.

Both the Eindhoven and the Twente Department of EE are aware of this role (and we know our colleagues in Delft are as well). We know that our responsibility regarding this role is to provide high quality research, high quality education, close collaboration and active participation on societal challenges. We expect the Dutch (and European) society to entrust us to do this, and provide a proper embedding for it. This includes effective governance, to allow the discipline to act in a dynamic context. And it includes investments in housing, infrastructure and attracting staff, which may seem expensive but which returns societal profit manifold.

Chiara Gabellieri (RAM) showing the FlyFlic (FLYing companion for Floating LItter Collection)) drone, the subject of her Marie Skłodowska-Curie Actions (MSCA) project [9].

Click on the image to know more


HIGH TECH, HUMAN TOUCH
UNIVERSITEIT TWENTE.

The self-evaluation starts with a brief presentation of the research unit. Main characteristics, important organisational features and changes over the past years are presented.

1

Introduction

1.1 University of Twente and Electrical Engineering

The University of Twente (UT) was founded in 1961 to innovate the manufacturing industry around Enschede [10]. EE was one of the first faculties established at the, then new, UT. The strength of the UT lies in the variety of collaborations between faculties, institutes and research groups. The UT is characterised by a well-knitted community with short links between colleagues over organisational boundaries (literally “at walking distance”). The motto of the university is “High Tech - Human Touch” expressing the two cores of the university: *Science, Technology, Engineering & Mathematics* (STEM) and *Social and Behavioural Sciences*. Core values of the UT, as expressed in its Shaping 2030 [11] mission document, are to be entrepreneurial, inclusive and open. In its own words

Science, Technology, Engineering & Mathematics

Social and Behavioural Sciences

> *The University of Twente is the ultimate people-first university of technology.*
> *We empower society through sustainable solutions.*

The UT has 3 research institutes, 5 faculties and it hosts numerous centres [12, 13] (see Appendix I). One of the 5 faculties is *Electrical Engineering, Mathematics and Computer Science (EEMCS)* in which the EE discipline resides [14]. EE@UT consist of 12 research groups of which 3 are both in the EE and CS disciplines, see Figure 1.1, a reflection of the continuity of the research over the discipline boundaries, e.g. embedded systems, distributed power networks and biometrics.

Electrical Engineering, Mathematics and Computer Science (EEMCS)

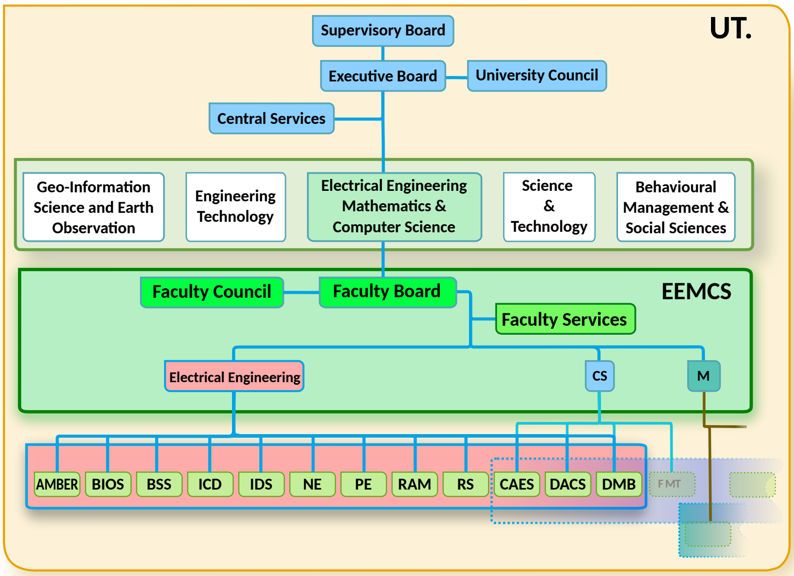


Figure 1.1
EE@UT embedding in the UT & EEMCS faculty.

See also Figure I.1

The EEMCS disciplines have a certain freedom to organise themselves, for example in the way they divide the nominal research funding from the faculty over the research groups, or how close or not they want to collaborate, share facilities, etc. As far as the research agenda is concerned the research groups, with their respective chairs, have a large autonomy. Different from the faculties or the UT, the discipline as such does not have a strategic multi-year plan. Consequently concerted actions on discipline level are mostly driven by special, and often incidental, funding instruments like the Sector Plans or Growthfund [15]. Larger developments are addressed on faculty or UT level when needed.

Furthermore the UT provides the embedding in terms of the various service departments, see Appendix I

The research in the EE discipline is broad; it ranges from micro-fabrication to robotics, from nano-electronics to smart grids, from sensors to eHealth, from chip design to embedded systems to Artificial Intelligence (AI), from electromagnetism to trusted and reliable networks. See Figure 1.2: the 12 EE groups are shown in a circle, illustrating how neighbouring groups seamlessly cover our selected fields in EE. EE@UT is right at the intersection of the three research institutes present at the UT, giving us a central and connecting role in our university research. Still, each of the 12 groups has its own signature, clearly recognisable inside the UT but also for societal partners outside. The connecting factor in all of this variety is a solid foundation in network theoretical and systems engineering approaches, characteristic for the EE domain, geared towards technology, devices and systems. The common EE BSc educational program is a solid basis to which all groups in EE contribute. It is our belief that EE is a corner-stone of modern society, e.g. as witnessed in the recent COVID-19 pandemic and the role EE technology plays in the resilience of the functioning of our society (communication, health, etc.). With the activities chosen by EE@UT, and with the means that we have at our disposal, we can optimally contribute to developments in society.

UT campus infrastructure

The *UT campus* infrastructure and the neighbouring Kennispark offers a.o. the Nanolab, the Design lab, the Techmed Centre, Novel-T, the Gallery and numerous companies, all of which strongly contribute to the fabric of EE@UT and offer many chances. In the DesignLab research and education (e.g. the BSc programme Creative Technology (CREATE) [16] and MSc programme Interaction Technology (IT)) combine in an environment that is open to society, both on the national and international level. The Nanolab infrastructure enables fundamental breakthroughs in micro- and nano-technology such as needed in organ-on-a-chip and neuro-morphic electronic research. The Techmed centre hosts numerous connections to healthcare such as the TOPFIT Citizenlab and brings together citizens, regional and national clinical institutions, healthcare professionals and companies. The Gallery, including its Novel-T [17] offices, offers an on-campus bridge between companies and researchers.

Novel-T

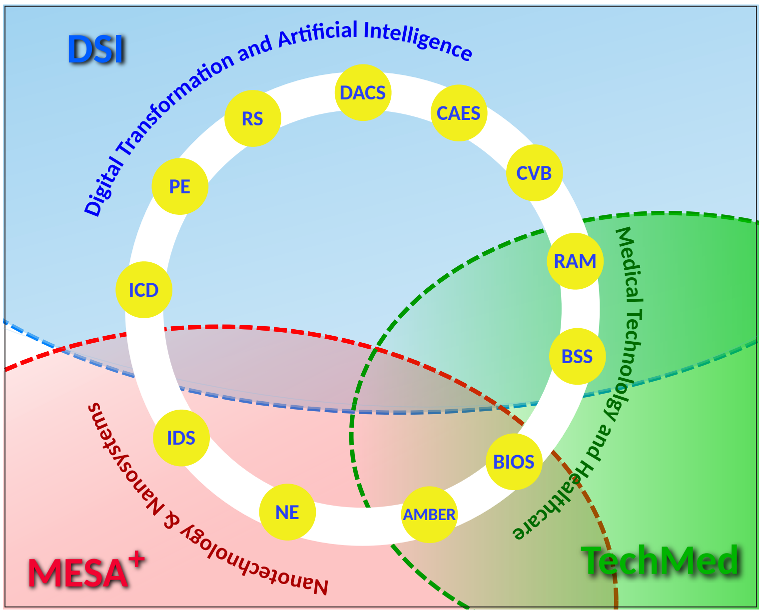


Figure 1.2 EE@UT connections to other disciplines via the institutes.

See page vii for the list of abbreviations

Research Institutes

HRM

In the research institutes the UT connects technology (high tech) to human behaviour and social relevance (human touch). Before 2017 research was organised through scientific institutes. It were the prerogatives of the institutes to develop strategic lines for research and govern over the research in the groups, whereas the faculties managed the human resource management (HRM) and educational programmes. However, this separation of responsibilities eventually turned out to be problematic. Therefore, in the reporting period (2017) this model was changed and research governance was transferred to the faculties with research institutes only coordinating interfaculty research. Due to the now larger range of governance of the faculties, less focused on research and not necessarily leading to strong collaboration within the discipline or faculty, research groups have become more autonomous regarding their research programmes. Given the previous situation there is a clear historical context of multidisciplinary cooperation and most research groups of EE@UT are participating in one or more research institute(s), together having presence in all 3 UT institutes.

The *Digital Society Institute* (DSI) [18] initiates and coordinates scientific research in technology that is essential for digitalisation, on methods and techniques for integrating digital technology in our environments, and in how we can come to intelligent, well-informed decision making.

> "We live and work in the exciting age of digital transformation. The UT's mission as a people-first university of technology places us in the crossfire of digital advancement and the disruption it can cause. As scientists and tech pioneers, our task is to drive digitalization. In close cooperation with all our stakeholders. Next to other institutes and faculties at the UT, these include business & industry, government, Non-Governamental Organisations (NGO's) and knowledge institutes. As a partner in regional, national and international ecosystems, we offer the knowledge, education and infrastructure for the development of successful solutions and products. In doing so, we focus on five themes: Data Science & AI, Smart Industry, eHealth, Robotics and Cyber Security. We boost innovation by delivering scientific knowledge for real-life solutions that have societal and economic relevance. Our research focuses on natural, societal and industrial challenges, which serve as starting points for our way to work and have one common denominator: digital technologies." [18].

DSI

(DMB, BSS, CAES, DACS, ICD, RS, PE, RAM)

DSI is the place where the UT connects its research on Artificial Intelligence and the digital world.

Description baed on institutes websites ([18], [19], [21])

The *Technical Medical Centre* (TechMed Centre) [19] is a leading innovation hub impacting healthcare by excellent research, innovation and educational programmes. It is equipped with state-of-the-art infrastructure, ranging from research labs, preclinical testbeds and simulated hospital environments.

> "Technology is a tool to enable sustainable and personalised healthcare. Not only for diagnosis and treatment but also for improving the quality of life and to stimulate independent living. We strive to have a significant impact on society, both by scientific excellence as well as by linking fundamental research to clinical applications, from the nano to the global scale. Ultimately, we bring our technology to the clinic or to the home environment. For this purpose, it is imperative to have close working relations with clinical and industrial partners [20]."

> "In our mission to impact society, we stimulate entrepreneurship and enable (new) companies to grow within our regional Novel-T [17] ecosystem. We collaborate with industry, hospitals, governments and insurance agencies on the development of new solutions for healthcare."

TechMed

(AMBER, BIOS, BSS, RAM)

For EE, TechMed offers access to clinical institutions and facilitates applications in real-world settings.

MESA$^+$ [21] is one of the world's leading research institutes on nanostructures, nanomaterials, nanosystems and nanodevices. Embracing a cross-disciplinary approach and benefiting from the NanoLab cleanroom that ranks among the very best on the globe, over 500 researchers deliver high quality, competitive and frequently ground-breaking research.

> "At MESA$^+$, we believe in realising grand solutions with the extremely small. We contribute to solving current and future societal challenges. We do this by using our fascination with the extremely small. We bring societal challenges inside and use our fascination to work on innovative and sustainable solutions. We focus on societal challenges in four application areas: Health, AgriFood & Water, Security, and Energy & Sustainability." [21].

> "MESA$^+$ actively seeks for collaboration with external partners providing an excellent setting for consortium formation. Next to our excellent scientists and facilities, we offer a strong regional ecosystem that creates the breeding ground to let ideas blossom and grow to relevant, successful solutions and businesses." [21].

MESA$^+$

(AMBER, BIOS, IDS, NE)

For EE, MESA$^+$ offers research on material, technologies and future electronic components, including sensors and actuators.

Organisation-wise, MESA$^+$, TechMed and DSI facilitate easy multidisciplinary cooperation across the boundaries of the faculties. This dynamic, interconnected and open-to-society atmosphere strongly benefits EE@UT. For the future, UT-wide plans exist to invest in integrated photonics together with Lionix International, in which EE will participate.

Open-to-society

1.2 Governance

As indicated in Figure 1.2 our research is carried out in the historical multidisciplinary context of the research institutes of the UT. The participants in the research institutes meet on a regular basis to discuss research related plans. A few times per year the chair holders and the faculty board of EEMCS meet during a dinner where topics important for EEMCS as a whole are discussed. Further the chair holders of the EE groups have their monthly *Discipline Council EE* (DC-EE) meetings.

Discipline Council EE

The matrix structure formed by faculties and institutes described above, in which the research groups

Matrix structure, see Appendix I

are on the cross-points, creates a research organisation with sufficient critical mass to be a major player in the Netherlands and Europe and stimulates multidisciplinary cooperation with groups outside EE and societal stakeholders. Most groups have regular contacts with their 4TU counterparts, e.g. through participation in PhD committees or through 4TU.Nirict [22]. Since 2021 the chair of the EE discipline also meets monthly with colleagues of TUD and TU/e in the EE-NL meetings.

The faculty, next to governance over personnel affairs and education, has governance over research as well but mostly limits this to financial, infrastructural, organisational and HR matters. Important topics such as personnel increase (and reduction), financial frameworks, etc. are governed by the faculty, desirably and usually, after requesting input from the three disciplines. In a limited volume, the faculty provides money for strategic research projects, e.g. when stimulating multi (EE-M-CS) disciplinary collaboration, see section 2.3. So, in effect, the research groups have a large autonomy in developing their own research programmes.

FB^+

The discipline acts as a collective of research groups active in EE. Its most important regular gathering is the monthly DC-EE meeting in which all chairs of the research groups (or their replacements) and the programme directors of the educational programmes (BSc EE, MSc EE, MSc Embedded Systems, MSc Systems & Control and MSc Robotics) participate. On the agenda are topics related to the educational programmes, research developments and UT and EEMCS organisational topics. The discipline chair organises these DC-EE meetings and collects points for further action, e.g. in the FB^+ (Faculty Board plus discipline chairs and heads of the service departments) meetings, EE-NL meetings, Sectorplan gatherings, or in more incidental interactions, e.g. with the executive board (EB) of the UT. Importantly, the discipline does not have its own governance, decisions in the DC-EE need to be consensus based and, most often, formalised by the FB. This, amongst other things, implies that the discipline chair cannot act swiftly and formally when circumstances ask for it. It also implies that, in formal matters, the discipline needs to be properly represented on FB level, i.e. by the (vice)dean(s). Given the breadth of the faculty, with 3 disciplines, this can be a challenging task.

bottom-up

open-to-collaboration

As a result of the organisational structure, de facto there is ample (academic) freedom for research chairs and their permanent scientific staff to develop their own scientific programmes. A freedom which is thoroughly and widely appreciated. Each research group brings its own research subjects, strengths and networks. In other words, EE@UT has a strong bottom-up organisational structure where personal quality, well chosen (societal) relevant subjects and opportunities determine its success to a large extent. In combination with the open-to-collaboration mindset found at the UT, it has shown to be very effective and successful. This environment provides freedom for our staff to develop in directions and towards roles that fit them well, not necessarily only vertically up the academic ladder, but also sideways. E.g. by choosing a career more dedicated to education. Or by developing niche research ahead of time before it gets more general attention. In fact our bottom-up organisation provides the fertile soil from which our diversity develops.

1.3 Financing

At the UT the lowest level of financial responsibility resides in the research chairs. At this level many of the expenses need to be balanced with the various forms of income. Income of the groups primarily consists of the so-called 1st-, 2nd- and 3rd tier money flows:

- 1st tier – *Direct funding* from the ministry of Education, Culture and Science (ECS) to the university
- 2nd tier – *Research grants*, obtained in competition from national funding agencies (NWO). In this tier project money only pays for additional costs directely related to the funded project but excluding any infrastructural costs and (most of the) salaries of permanent staff.
- 3rd tier – *Contract research* with industry and EU funded projects. Projects funded in this tier do pay for overheads and salaries of permanent staff.

Expenses include office rent, laboratory usage, salaries, ICT costs, contributions to faculty expenses such as financial and HRM services. Figure 1.3 shows how the various money streams reach the groups. All numbers relate to 2020 as a representative year. The budget of EE from the '1st tier' is 14.5 M€. Assuming that EE has an equal share in the central services of the UT, the contribution of EE to these central services is estimated to be 6.5 M€ or 31% of the total gross budget of EE. After subtracting the payments to educational support en services of EEMCS, 10.3 M€ goes to the groups (8.4 M€ related to education and research + 1.9 M€ 'earmarked'). The earmarked money consists of

1.4 M€ for the sectorplan positions, 300 k€ 'zwaartekracht' funding, plus 220 k€ for the Max Planck institute. In addition to the total net budget of 10.3 M€ of the first money flow, EE realises an income of 3.4 M€ from research funds (2nd tier) and 6.3 M€ from the EU and industry (3rd tier).

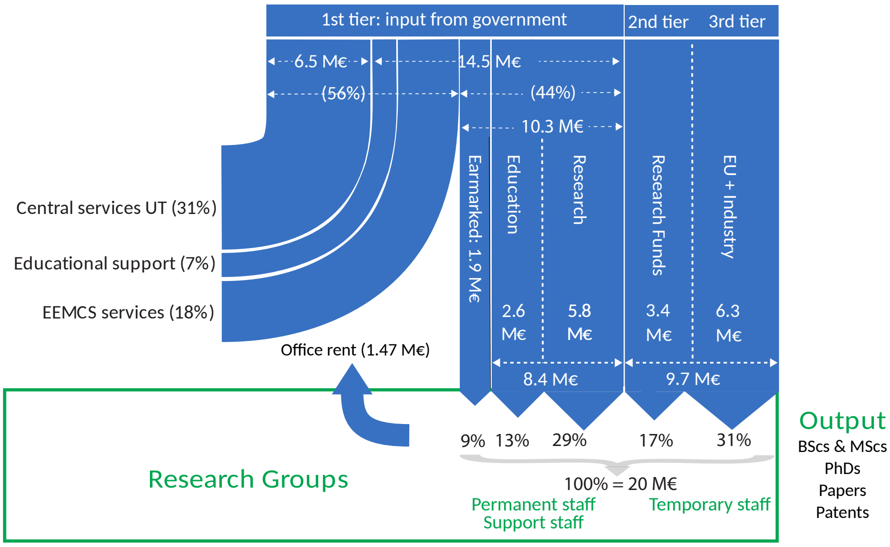


Figure 1.3
Financial Flows (2020 taken as representative year)

1.4 Ethics and scientific integrity

House of Integrity

The UT has established an integrated integrity programme, called 'House of Integrity' [23], to structure and organise various integrity policies, regulations and practices. This House of Integrity approach covers scientific, social and business integrity and holds for everyone who is part of the UT community: employees, students and those representing the UT. Obviously, EE@UT adheres to university-wide policies and procedures for ethics and scientific integrity.

Specifically, the UT subscribes to the guidelines for scientific integrity, as specified in the VSNU policies and procedures in the Netherlands Code of Conduct for Research Integrity [24]. The European code of conduct [25] and the Singapore statement on research integrity [26] are also relevant as well as the advice of the KNAW about correct citations [27]. All those involved with education and research bear responsibility regarding upholding scientific integrity as specified in the above-mentioned code of conduct.

The UT stimulates an environment within which responsible research practices are stimulated and warranted. It offers dedicated facilities such as ethics assessment of research and innovation, scientific integrity education for PhD candidates and research data management support. Other initiatives include the *MindLab* [28] and promotion of the *Dilemma Game* [29], both intended to stimulate discussions on various aspects of scientific integrity and ethics. In the Active Bystander Training [30] people are equipped to deal with all kinds of inacceptable behaviour and appropriate ways of acting.

MindLab
Dilemma Game

The UT website [31] on scientific integrity and the links provided there, explain in detail how the UT deals with issues concerning scientific integrity. The Executive Board of the UT established the *Scientific Integrity Complaints Procedure* in order to protect and guarantee scientific integrity. This procedure provides a system for reporting and dealing with possible violations of scientific integrity. This procedure is consistent with the national LOWI (National Body for Academic Integrity) regulations. The first point of contact is the university's confidential advisor for scientific integrity. Possible violations of scientific integrity as well as any follow-up steps can be discussed with this advisor in full confidence. Actual reports about (possible) violations of scientific integrity are dealt with by the appropriate committee [31]. The advice of the committee is sent to the Executive Board of the UT for further action as well as to the LOWI. The Executive Board determines its opinion on the complaint and takes appropriate measures.

Scientific Integrity Complaints Procedure

LOWI

Attention to scientific integrity is given on various levels. E.g. already in the first module of the EE curriculum, research integrity and avoiding plagiarism are taught. Further, explicit attention is given to scientific integrity during the BSc and MSc projects and in the supervision of PhD students. When writing their theses, all students are taught how to deal with quotations, citations and references. Moreover, all PhD and MSc theses of EE are checked for plagiarism, mainly using the UT license of *TurnItIn* [32] which includes previous UT reports in its database as well.

Plagiarism check

As for the use of (generative) AI in report writing the UT has formulated a policy [33], in line with policies as formulated e.g. by publishers such as Elsevier [34] and IEEE. Use of such tools is allowed but must be specified and the author of the report retains full responsibility of all written material.

The ethics protocol of the faculty of EEMCS

Medical Research

MREC

Research with human subjects must undergo a medical-ethical review if it falls under the *Medical Research* Involving Human Subjects Act (WMO). For the medical-ethical review the UT collaborates with an accredited Medical Research Ethics Committee (MREC), the Commissie Mensgebonden Onderzoek (CMO) Arnhem-Nijmegen (in Dutch), and support is offered by the UT Techmed centre.

University-wide research ethics policy

The UT has adopted a *university-wide research ethics policy* for the ethics assessment of research which does not fall under the WMO act. Ethical review is conducted and facilitated by 4 domain-specific ethical committees: Humanities and Social Sciences, Natural Sciences and Engineering Sciences, Geo-Information Sciences and Computer & Information Sciences. A web-based tool [35] is available to assist students and researchers to submit their research proposals to the relevant committees for approval. The committees consist of representatives of the groups in which this kind of research is actually performed. The groups involved have submitted certain ‘standard research’ topics in the protocol text, referring to comparable research that has been carried repeatedly previously. The full committee assesses the standard research topics once. A standard research proposal may be assessed in a fast-track procedure. This means that the committee member of the department is authorized to make a positive assessment of the ethical permissibility of the research proposal under consideration. If the member of the department is itself involved in the proposed research, however, the proposal must be submitted to the full committee.

Data policy

Open data

PURE

Open data and related research-data policies are gaining importance in academia. In 2017 a National Plan Open Science [36] was presented by all major Dutch research organisations. Already in 2015, an overall research-data management policy was established by the UT, and updated in 2018. In support of the Open Science transition, the UT policy statement Shaping 2030 [37] formulated that 100% Open Access publication is the aim to be reached already in 2023. Publications should preferably be immediate open access and, if necessary, after 6 months via the UT research information website *PURE* [38]. Tools such as the UT Open Access website [39] help researchers in this process. At the end of the assessment period about 90% of the publications of EE@UT were OA in some form (including green OA, see Figure D.2), getting near the target of 100% OA. Shaping 2030 also established FAIR [40] data as the new norm for UT researchers. The university-wide data-management policy serves as a starting point for tailored data policies of UT faculties, institutes, and research groups.

UT-wide RDM

To further the implementation of the research data management (RDM) policy, a *UT-wide RDM* project was started in 2019 [41]. Within this project a data steward was hired to provide direct practical support on RDM for EEMCS researchers. In 2021 the RDM project resulted in the start of a Digital Competence Center (UT-DCC) [42] at the UT, with funding from the Dutch Government. The goals for the UT-DCC are to make:

- the research (process): open, reproducible, and transparent
- publications Open Access
- research data FAIR: Findable, Accessible, Interoperable, Reusable (FAIR) [40]
- research easier, faster, and more efficient with state-of-the-art technology
- technological tools for (inter)national research cooperation more secure and user friendly.

FAIR

EEMCS

Twente Graduate School

In 2019 the faculty *EEMCS* formulated a tailored RDM policy, a refinement of the UT-wide policy. Several research groups have, or are in the process of formulating, further refinements in the form of practical guidelines and workflows for handling of research data. The guiding principles in all of these are scientific integrity and FAIR data. For PhDs a compulsory course on RDM is provided by the *Twente Graduate School*, see chapter 4.

In this chapter we describe our mission and the main strategic aims of the past six years. This description regards its contribution to scientific knowledge, as well as its contribution to society.

2

Mission & strategy during assessment period

2.1 Vision

The field of EE is the place where the physical world is probed, its information transduced into (the flow of) electrons, cast into the atomistic entity of the digital world - *the bit* - to be used to diagnose, perceive, understand, model the real physical world - *nature* - to eventually control processes, information flow et cetera. In short, the field of EE is the place where '*bits meet nature*'. In this context 'nature' is the real world we live in with physical activity and information. The virtual world of 'bits' represents information carried by electrical charges and waves in electrically engineered devices and systems.

Bits meet Nature

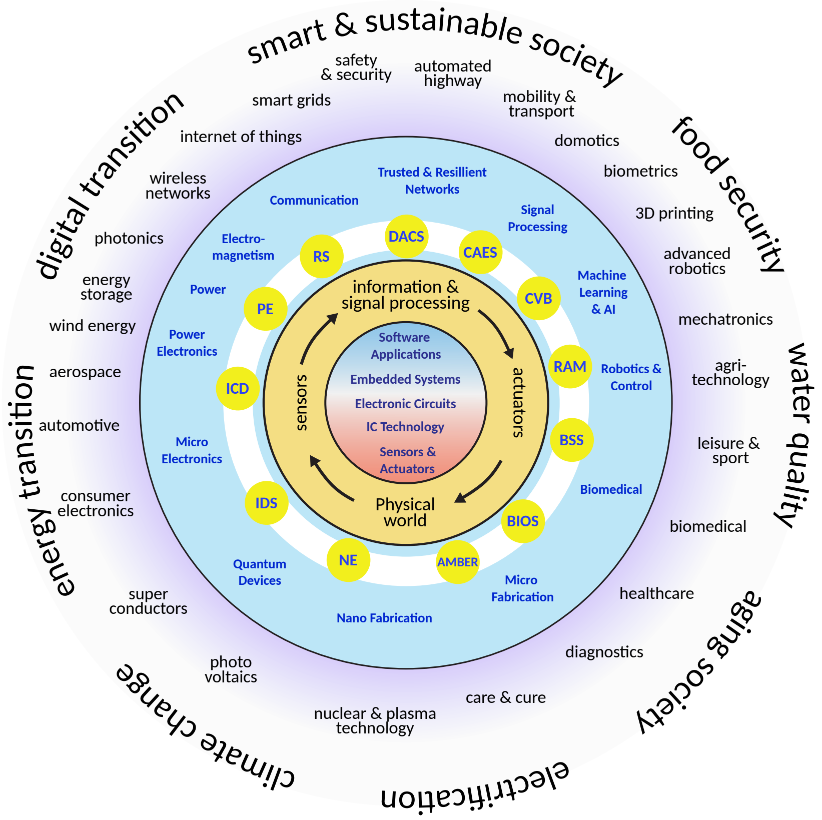


Figure 2.1
EE, where bits (information / software - light blue) meet nature (hardware, the physical world - pink)

Looking back in history at the profound changes in society that have been enabled by EE and given the grand challenges in e.g. ICT, healthcare, robotics, energy transition, transport, security, we see a central and leading role for the field of EE. In our vision our EE discipline exists in order

> to help establish a world in which the purpose of technology is to improve human life

2.2 Mission

EE is application oriented while it synergizes with many other domains, making EE a key enabler to address world-scale, societal challenges. Through our graduates, our research and industrial collaborations, we address technical problems from an EE perspective. It is our mission

> to research and develop innovative EE Systems Technologies to serve society by bridging the gap between physics and computer technology using a broad spectrum from deep theory to demonstrable prototyping, and to teach our students to become responsible scientists capable of taking leadership roles in technical and societal matters.

Embedded System

EE takes a central role in almost every modern digital system. Crucial in such a system is a computing core, which is built in integrated circuit technology, in which electronic circuits are processing analogue and digital information, resulting in a so called '*embedded system*'. Such a general computing system is illustrated in the core of Figure 2.1. In order to be able to meaningful connect the 'bits' in such a computing system to 'nature', sensors, actuators, and often feedback control systems and communication are required, together with dedicated software applications operating in synergy with the hardware. With our 12 research groups in EE, we cover key areas of such systems, as illustrated in Figure 2.1.

2.3 EE@UT in context

EE in Society

The field of EE forms a fast evolving and developing discipline. Worldwide it has a strong industrial base representing hundreds of billions of dollars in terms of sales, labour and investments. The latter can be on such extreme levels that academic players, like the EE discipline at the UT cannot even come close. However, at the UT, we are in a position to make conceptually new contributions to technology and societal applications and train our BSc, MSc and PhD students to become the excellent technological experts that society needs. We pride ourselves on the facilities we have; the various labs are well equipped for their respective purposes with clear examples e.g. the Nanolab and the Robotics lab. More importantly, we feel that our lab-settings and open scientific culture allow us to foster multi- and trans-disciplinary research and provide the academic freedom to develop methods of design, analysis and fabrication that are of high interest to both our big and small industrial partners. In the same vein we can facilitate pre-competitive research as well as address societally relevant research that does not have an industrial embedding (yet).

Role of the institutes

Where previously the institutes governed all research matters they now concentrated on facilitating and promoting collaboration between the research chairs, in order to maximise research opportunities and efficient use of shared infra-structure, and forming clear recognisable points of contact between the research groups and external parties, e.g. through newly founded centres (see page 12).

Groeifonds

The role of the research institutes has become more strategic. They are instrumental in bringing together groups around research foci and initiatives. E.g. they are actively involved in the granted '*Groeifonds*' proposals QDNL, with 150 M€ for NanoLabNL, AI (DSI) and the **NXT**GEN HighTech [45] programme (MESA$^+$, TechMed) .

Artificial Intelligence

DSI is active in bringing together the research activities in the domain of *Artificial Intelligence* (AI), forming one clear point of contact and promoting the UT as an important player in the AI field. The MESA$^+$ institute coordinates and promotes nano- and micro-technology at the UT, creates a community of UT researchers and stakeholders by common activities like the MESA$^+$ day, plays the the central role in the development and management of the Nanolab cleanroom infrastructure and ties this multi-million infrastructure with other labs in the Netherlands (NanolabNL) [43]. The TechMed center[19] initiates common research proposals, builds a community through extensive

TechMed events

health related events (the so-called *TechMed events*) and facilitates small grass-roots initiatives through concerted actions with the regional hospitals and educational institutes. Examples are the *Pioneers in Health Care* (PiHC) vouchers for combined technical–medical research for one year projects, and the *TURBO grants* [44] aimed at bootstrapping collaborative projects between the UT and Radboud UMC (RUMC) where UT researchers are challenged to develop new technology to be used in medical applications of interest to the RUMC researchers. The grants are meant to facilitate limited research projects of about 1 year, which results can underpin larger common research proposals. In 2019 TechMed has opened the *TechnoHal* where it provides modern spaces for research and education in the health domain (e.g. Biomedical Engineering and Technical Medicine programmes).

Pioneers in Health Care

TURBO grants

TechnoHal

EE as part of the faculty EEMCS

The three disciplines Electrical Engineering, Mathematics and Computer Science form the foundation of EEMCS and are also strongly intertwined. “EE transduces” input from the physical world to the electronic and digital domain and manipulates the data using algorithms designed in CS, depending on mathematics to formulate the models and make the decisions. The design and development of new electronics, e.g. on a neuro-morphic basis (EE), need the development of new mathematical tools (M). Secure and dependable communication systems need an integrated design of hardware (EE) and software (CS). In a comparable way, energy-efficient and reliable embedded systems can only be developed with concerted efforts in developing hardware and software.

Important matters such as research visitations take place on discipline level. The faculty therefore opts for a certain autonomy, whereby substantive choices can be made within the disciplines. The disciplines thus have the space to partly determine the distribution of research budgets. A good example of this are the recently-formulated ‘*sector plans*’ that have been designed by the disciplines themselves. The ambitions and investment agendas set out herein, form an important part of the disciplinary and faculty research agendas for the coming six years.

Sector plans

In 2019 the faculty decided to promote inter-disciplinary research between the disciplines by awarding so called *Theme-team initiatives*. These projects are run by EEMCS teams on the *four faculty themes*: 1) Human Centred Robotics, 2) Personalised Health, Wellbeing & Sports, 3) Data Science & AI, and 4) Energy Optimisation. Teams need to be composed of three junior staff members, one each from EE, Mathematics and Computer Science. The teams are responsible for developing the theme within the faculty. The grant provides the team members with three PhD students, embedded in the three disciplines and to be supervised by the three team members in cooperation. This instrument allows for agile reaction to new opportunities, while firmly anchoring the activities in the disciplines by the formation of teams. The more recent *Incentive Grants*, a by-product of the starting grants of the Sectorplans, see below, are organised likewise, however, they provide only the financial means for one PhD student.

Theme-team initiatives

four faculty themes

Incentive Grants

From 2021 to 2023, the three EEMCS disciplines received funding (0.6 M€ cumulative) from the faculty to support strategic activities to strengthen the discipline research. The EE discipline has decided to use this funding to establish a Systems Integration Lab EE (*SIL-EE*), a workshop for research and education in the discipline. Its purpose is to bring together more generic equipment that is not found in the specialised research group labs, with the intend to enable “quick and dirty” tests for students, student activity groups (Solar Boat, Green Team Twente, etc.) [46] and researchers, with the added possibility to foster small-scale cooperation with companies lacking such facilities.

SIL-EE

2.4 Sectorplans

Sectorplans are a Dutch government initiative to strengthen the foundations of research and academic eduation in a specific set of disciplines. The first *Sectorplan* (2007) covered the disciplines of Physics and Chemistry, *Sectorplan Techniek I* (SPT-I). In November 2017, the Ministry of Science and Education decided to engage in two follow-up *Sectorplans*, one which would cover four beta-disciplines and one, the SPT-I, to strengthen the cores of three engineering disciplines: EE, Mechanical Engineering and Civil Engineering. In 2022 *Sectorplan Techniek II* (SPT-II) was formulated and included (some parts of) the Dutch computer science fields as well [47]. In SPT-II 750 k€ /year is reserved for EE@UT. Initial hiring started in late 2022 and therefore SPT-II has had no influence in the period covered in this report, but does have an impact on our future strategies, see section 6.2.

Sectorplan Techniek I

Sectorplan Techniek II

Sectorbeeld

Sectorplan Committee

As a preparation for SPT-I, all pertaining universities were asked to describe their disciplines and research subjects, the way they were organised on National level, their cooperation and their outlook. The resulting document, the *Sectorbeeld* [48] (in Dutch), was the basis for the actual plans of the disciplines to strengthen their research and disciplinary basis. The plans, one for each university, detailed the research prospects up to the level of concrete necessary positions. They were evaluated by a special committee, the *Sectorplan Committee*, and approved by the Minister in June 2019.

To realise SPT-I, there is an associated structural budget for new permanent scientific staff, amounting to 17 M€ per year for the three selected technical disciplines. This allowed to appoint ≈100 Full Time Equivalent (FTE) new staff, distributed over the various faculties. By mid 2023, all vacancies at EE@UT [49] had been filled after lengthy hiring processes. This was partly due to significant salary differences, with respect to industry as well as neighbouring countries, as well as to the additional SPT-I aim to realize a serious shift in gender balance. Of course, the COVID-19 pandemic resulted in additional complications. The results, however, are very satisfactory with respect to the attracted talent (in part supported by solid starting packages), the newly started research activities and the increased available staff for education (improving the staff-to-student ratios).

Permanent positions

Tenure Track

Although the SPT-I positions are permanent in principle, the Ministry and the Sectorplan Committee evaluate progress on a regular (close to yearly) basis. These evaluations are supported by visits at the universities, to keep up with the developments and the research strengthening. After a site-visit in November 2024 they will come with a final report to the Minister and a recommendation whether to make the budgets and positions permanent. We like to mention here, that this is an unfortunate situation since it creates uncertainty for the coverage of the financial obligations that we have by offering the attracted staff permanent positions (rather than *Tenure Track* positions, see section 5.2).

2.5 Research lines and objectives in the assessment period

Starting at the core of EE, we have the following activities in various domains:

Microelectronics

Photovoltaics

The Nano Electronics (*NE*) group of *prof. Wilfred van der Wiel* focuses on disruptive new electronics, going beyond the boundaries of traditional disciplines. It plays a central role in the development of neuromorphic electronics. With this type of research, often done under cryogenic conditions we learn to better understand the fundamental behaviour of new materials and new structures.

The Integrated Devices and Systems (*IDS*) group of *prof. Jurriaan Schmitz* conducts research on materials and devices for upcoming generations of microelectronics, including integration and reliability aspects as well as on technology for photovoltaics. The program is conducted in close collaboration with semiconductor equipment industry and integrated circuit manufacturers.

The IC Design (*ICD*) group headed by *prof. Bram Nauta* focuses on the design of analogue and RF interfacing circuits with current main application in wireless communication. ICD uses industrially available IC technologies, enabling excellent transfer of know-how to industry. In 2022 the *ChipTech Twente* cluster was initiated from ICD, see section 6.3.

Electromagnetism

One part of our work on electromagnetism occurs in the Radio Systems (*RS*) group, headed by *prof. André Kokkeler*. The group focuses on antenna systems, radio propagation- and channel modelling, and signal processing. Another part takes place in the Power Electronics and Electromagnetic Compatibility (PE) group headed by *prof. Thiago Batista Soeiro*. The research in the PE group focuses on battery electronics, conducted and radiated electromagnetic interference, directed by *prof. Frank Leferink*, power-electronic packaging and on the physical layer of communication systems.

Communication

In addition to the research on reliable wireless communication in the RS group, the Design and Analysis of Communication Systems (*DACS*) group headed by *prof. Geert Heijenk* covers the design and analysis of responsible communication networks. It researches models, architectures, protocols, and algorithms for future networked systems, ensuring they provide the required functionality, performance, security, and resilience in a sustainable manner. The focus of this research is on two areas: network (Internet) security and wireless (e.g., 6G) networks.

Computers & embedded systems

The Computer Architecture for Embedded Systems (*CAES*) group, meanwhile headed by *prof. Ana-Lucia Varbanescu*, develops and applies techniques for high-performance, energy-efficient, real-time, and dependable computing systems. Applications powering this research vary from integrated circuits to smart grids, big-data and scientific computing.

Signal Processing & Imaging

Signal processing in our research is carried out in three groups. The first group is Computer Vision and Biometrics (CVB) headed by *dr. Luuk Spreeuwers*, who succeeded *prof. Raymond Veldhuis*, with research in machine learning for biometric recognition, including (forensic) fingerprint and face recognition, vascular pattern recognition, and research in privacy protected biometric recognition, and sensor development. The medical field is covered by *dr. Can Tan* who is part of the Robotics and Mechatronics (RAM) group. Here the focus is on medical imaging techniques and image-guided navigation in the body. The third group is the BSS group (see below under Biomedical).

Robotics, automation & control

The Robotics and Mechatronics (*RAM*) group, headed by *prof. Stefano Stramigioli* and a management team of early career researchers, is active on both fundamental and application-driven topics in the field of robotics. Modelling, dynamical systems, control, sensors, actuators, real-time (embedded) software, computer vision, and systems design are the research topics. The group develops novel fundamental paradigms and physically-based methodologies which are then translated from the lab into demonstrators and prototypes using, among others, the instrumentation, drone, medical robotics and general labs as well as extensive additive manufacturing facilities. The robot applications are mostly in healthcare, service and inspection and maintenance, including drones, robotics.

Biomedical

Biomedical work in EE@UT spans research from body-sized systems to micro- and nano-fluidics. The Biomedical Signals and Systems (*BSS*) group, meanwhile (2024) headed by *prof. Monique Tabak* and *prof. Jan Buitenweg*, who collectively succeeded *prof. Peter Veltink*, performs research (in a home or clinical setting) on smart sensing, selective actuation, neuromodulation and persuasive coaching technologies. Part of its research is in the strongly developing realm of eHealth. The *BIOS*-Lab on a chip-group, long time headed by *prof. Albert van den Berg* who now is succeeded by *prof. Loes Segerink*, pioneered micro- and nano-fluidics. The group bridges the gap between users from physical, chemical, medical and life-science fields and demonstrates the potential of 'Lab on a Chip' in biomedical and process industry, environmental applications and organs on chips. The *AMBER* group, led by *prof. Séverine Le Gac*, aims at the development of functional devices for pharmaceutical, biological and medical applications through the exploitation of microfluidic and organ-on-chip technologies.

Sensors & actuators

Besides the microfluidics work in the BIOS and AMBER groups, part of the IDS group, headed by *dr. Remco Wiegerink*, carries out research on micro- and nanomechanical devices and systems, with a focus on microfluidic handling systems and sensors for force, acceleration and fluid flow. In the field of embedded sensing, *prof. Gijs Krijnen* of the RAM group investigates fabrication, design and application of 3D-printed sensors integrated in robotic, prosthetic, and orthotic devices. Emphasis is on mechanical and biopotential (sEMG) sensing.

2.6 Strategy over the assessment period

New and discontinued groups

As described in section 2.4, SPT-I has provided a significant impulse to the EE domain in the Netherlands. As it was deliberately meant to strengthen research in the various engineering cores, EE@UT has made strategic choices with long-term impact. With 9 FTE from SPT-I for EE@UT, and with guaranteed financial coverage from the faculty for 3 years, we have started two new groups:

Power Electronics

1. New, since 2020, is the *Power Electronics & Electromagnetic Compatibility* (PE) group. The research focus of the group is on battery electronics, electromagnetic interference and power electronic packaging. The group was first spearheaded by the late prof. Braham Ferreira [50], who attracted two of the SPT-I candidates, and is now successfully lead by prof. Thiago Soeiro. One special theme of the program is small solar systems with battery storage to provide off-grid electric services to 3 billion people living in energy poverty [51], headed by Jelena Popovic [52], attracted to EE@UT in SPT-I. It is a challenging research field as it requires innovative and reliable technology and solutions need to be sustainable from a socio-economical point of view.

Radio Systems

2. The former Telecommunication Engineering group has been converted into the *Radio Systems* (RS) group. The research covers a wide range including designing physical layer for wireless communication systems, signal processing algorithms, radio propagation and channel modelling and antenna design. In addition to the theoretical components, its research also has practical aspects. That is why digital implementation of the signal processing algorithms, prototyping communication systems using Software Defined Radios, building and testing the designed antennas and practical channel measurements are also integral part of the research work in the Radio Systems group.

Integrated Devices and Systems (IDS)

Data Management & Biometrics (DMB)

In the previous report we expressed our intent to discontinue the Telecommunications Engineering group (TE). With the new RS and PE groups, where the latter also absorbed the EMC part of the previous TE group, indeed the TE group could be discontinued. Likewise the *Integrated Devices and Systems (IDS)* group was formed from the merger of the Micro Sensors and Systems (MSS) and Semiconductor (SC) groups into a favourably-sized new group. For the Biometric Pattern Recognition (BPR) group a comparably motivated merge with the group has been realised.

Cross disciplinary collaborations and new centres

One of the characteristics of EE, historically based on Kirchhoff's laws, is its aptness for analysing and synthesising complex electrical networks, but also systems that can be described in similar ways, e.g. micro-fluidic and mechatronic systems. It makes that EE approaches are readily applicable to many research and societal challenges. Therefore it should come as no surprise that many of the EE@UT groups participate in a variety of programmes, EU projects, consortia and centres.

BRAINS
QUANT

eCMC
OoCC

EDGE

Some centres have been founded and/or joined in the preceding assessment period. *BRAINS* (the Brain-inspired Nano Systems Centre) [53], the '*QUANT*' (the Centre for Quantum Nanotechnology Twente) [54] in which the Nano Electronics group plays a leading role, and the Solar Centre Twente[55] where the Integrated Devices and Systems group participates, were founded within MESA$^+$. Together with TechMed, the expertise Centre for Monitoring and Coaching (eCMC [56])*eCMC* and the '*Organ on Chip Centre Twente* (OoCC) [57]' (with important roles for AMBER and BIOS) were founded. The latter recently got an important impulse by a grant of over 3 M€ in the "NWO Research Infrastructure: national consortia" programme [58]. Also recently the *Edge* centre for networks, systems and intelligence was founded [59] (DACS, CAES, PS). These developments are indicative for a discipline that is primarily looking outwards, where it finds that its research is received with great interest and societal relevance.

Robotics Centre

Open UT culture

Recently the faculties EEMCS and Engineering Technology (ET) at the UT have jointly established the *Robotics Centre* [60] a robotics and AI centre that brings together researchers, companies and students in a highly synergistic environment. The open and dynamic research environment combines perfectly with two educational pearls of Twente, which are the recent bachelor study CREATE and the master study Technical Medicine. A master study Robotics, with an important contribution from EE, has kicked off in 2022, replacing the previous Systems & Control master. EE@UT sees this cooperative, connected and *open UT culture* as one of the cornerstones of its success.

Education

Design Lab

Research and education are strongly interwoven, not only by the bachelor and master assignments and student embedding in research groups, but also by the dynamic and multidisciplinary atmosphere that is created by several multi-disciplinary bachelor and master studies at the UT. Exceptionally for EE@UT is that 47% of our BSc educational income comes from programmes in faculties other than EEMCS and as much as 62% from educational programmes other than our "own EE BSc" programme, a clear indication that our EE field reaches far beyond the "traditional EE" programme. The bachelor study Creative Technology promotes an acute awareness for the impact of technological solutions, and always aims to contribute to society. This awareness contributes to the open mindset of the investigators at Twente, even more as it is supported by the infrastructure of the *Design Lab* [61]. The MSc Embedded Systems (EmSys) is another example of an EEMCS programme [62]. Similar contributions are given by the master studies Technical Medicine (TM) and BioMedical Engineering (BME), the Techmed Centre, and the bachelor study Advanced Technology. The new master Robotics and the Robotics Centre aim to contribute in a similar way to the robotics and artificial intelligence theme.

In Figure 2.2, left, we see that 1) the influx of students in the EE BSc and EE MSc programmes is rather fluctuating in the assessment period and 2) that international student influx is important for our EE BSc and MSc programmes with on average nearly 40% in the assessment period (and as high as up to 54% for the MSc influx in 2019). Figure 2.2, right, shows the sum of influx of students in the BSc and MSc programmes in EEMCS in which EE has a significant share (see Table G.2). Although the overall developments are comparable to the EE programmes, the fluctuations seem a bit reduced. In other words EE@UT's participation in multiple programmes in EEMCS (and other faculties) improves to some extent the stability of the educational activities and its associated income.

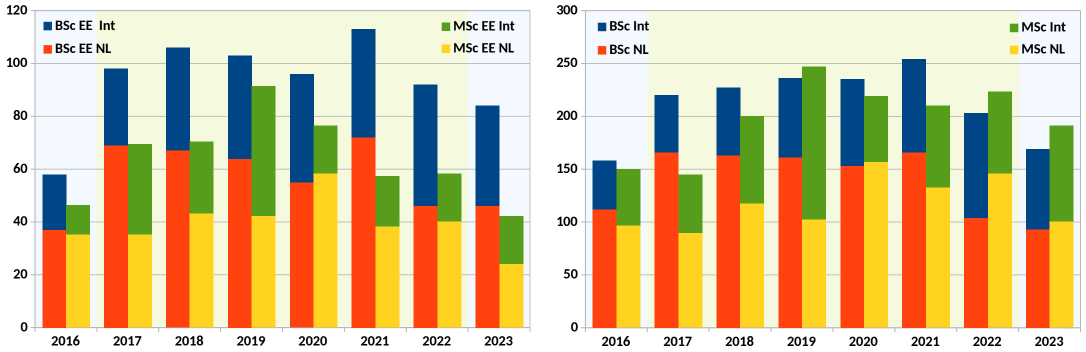


Figure 2.2
EE influx (left)

Total influx (right)

(See Table G.2)

Background colours are chosen such that yellow indicates the assessment period whereas the blue parts on the sides are included for context.

In the previous full term report we noted: "We would like to have 120 first year's Bachelor EE students and 65 Master EE influx before 2021." In 2019 we were able to realise a BSc influx of 103 + 18 premasters whereas the MSc influx was 91, both reasonably in line with our intentions and obligations to society. The 2020 pandemic has reduced student mobility severely and reduced student influx in 2020, especially for international MSc, but is more disruptive for 2021, especially for the MSc programme. We suspect that the Dutch internationalisation debate, important in popular politics, may be debit to the lower numbers of international influx in 2023. It is important to note that the ambition of EE@UT has recently been adjusted to grow to an influx of 200 BSc students serving both the societal need for electrical engineers as well as safeguarding the educational viability of the discipline.

Staff developments

In 2013 the EEMCS faculty had a reorganisation in which about 25% of the permanent staff was made redundant, leading to a reduction of the expenses, as intended. In the assessment period, courtesy of improved economics and the SectorPlans, for EE@UT there has been a significant 82% increase in the permanent scientific staff (FTE), a 9% increase in the support staff (FTE), while at the same time the temporary scientific staff increased by 33%, see Figure 2.3. The result is that the ratio of temporary to permanent scientific staff decreased from 2.9 to 2.1. In Figure 2.4 we see, as could be expected, that this correlates with an increase of the research funding, mostly from contract research (3rd tier), the research grants (2nd tier) virtually staying constant.

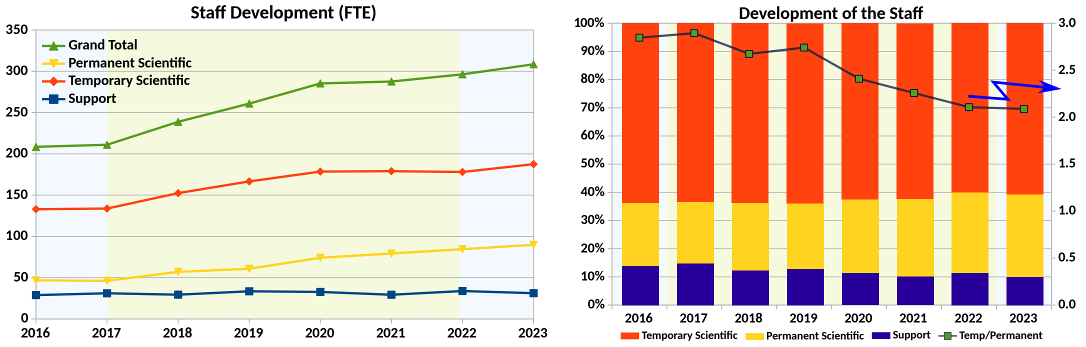


Figure 2.3
Left: development of the staff (in FTE).

Right: Staff in % (colour bars, left axis) and ratio temporary to permanent scientific staff (right axis).

(See Table E.1)

Finances

In Figure 2.4, left, we see that direct funding has grown by over 53% in the assessment period, a situation very much welcomed in the EE discipline. The increase can be mostly attributed to the various strategic investments on national level and correlates well with the increase of permanent faculty staff in EE, Figure 2.3, left. However, little of this direct funding ends up in actual new research (projects), except for the strategic programs as carried out by the EEMCS faculty and the recently introduced starter and incentive packages.

To a great extent our research depends on the 2nd and 3rd tier funding. In the full-term 2011–2016 self-study report we wrote under 'Research Vision': "We want to be successful in national funding schemes, as well as in the European Horizon 2020 programme and its successors". Figure 2.4, right, shows that from 2017 - 2022 the fraction direct funding has remained almost constant at about 60%, which is comforting to see and suggests a stable financial foundation for our activities. In the other 40% we see as shift to a larger fraction by contract research funding, predominantly EU projects and personal grants. This is a welcome development since research grants from 2nd tier funding have been felt to become increasingly competitive and for many research groups it has been a deliberate strategic choice to increasingly target EU funding and other 3rd tier research funding. This partly has to do with the financing of the *2nd tier funding* (e.g. NWO, FOM, ZonMw) which only covers additional cost but no overhead or hardly any salaries of permanent personnel. In combination with the approximately 10-12 k€ overhead cost per year per person, as imposed by the EEMCS faculty, it implies that this type of grants is financially less sustainable than contract research.

2nd tier funding

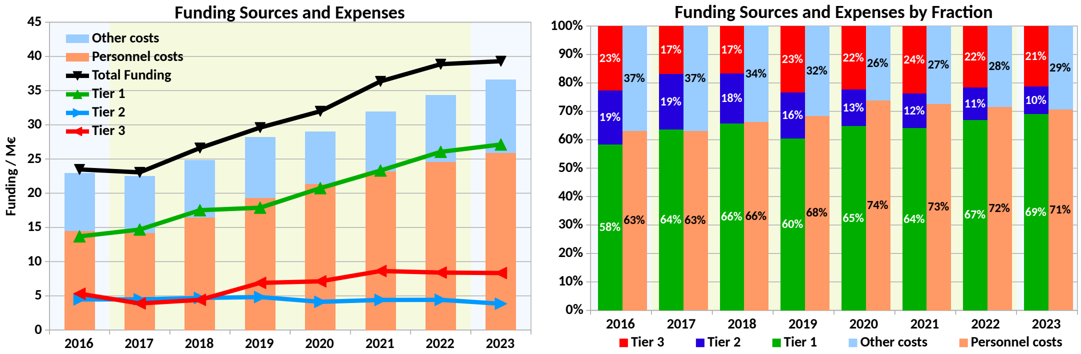


Figure 2.4
Left: Funding tiers (lines) and expenses (bars) (in M€)

Right: Same in %

(See Table F.1)

financial distribution model

To partly counter the situation in 2020/2021 EE@UT has made its own *financial distribution model* in which 2nd tier projects count in the weighing of the nominal research funds in the direct funding tier, see section 6.5. Though financial motives should never determine our choices for research subjects and we should be lead by academic interest only, we still like to plea for an improvement of the situation regarding 2nd tier funding. After all, it would be a shame when we would (have to) turn away from programmes provided by national funding agencies, solely because of financial motives.

research portfolio

viability

Whereas the figures above display the funding of our activities, they do not say so much about our *research portfolio*. The figures and tables in Appendix F show that over the assessment period the number of projects has effectively decreased by 70 whereas the value of the portfolio increased by 15.8 M€ . This means that on average the budget per project has increased (Figure F.3, right). This is consistent with the larger projects that we acquired, such as Advanced ERC grants, and Horizon 2020 projects. Note that we regard an increasing research portfolio as one indicator of our viability. At the same time we note that competition in project grant programmes seems to steadily increase; in some cases, e.g. EU calls like FET-open, chances boil down to a few percent only. For some talented researchers this may be sufficiently off-putting, and provoke disinterest in an academic career.

Rejuvenation: Loes Segerink and Mathieu Odijk, the next generation at the BIOS group after retirement of Albert van den Berg and Jan Eijkel.

We present and explain our KPIs (Key Performance Indices) for products, use and marks of recognition for both quality domains (research quality and relevance to society). Appendix A presents some highlights of our research in the form of Case studies. Appendix D presents underlying data for our KPIs

3

Quality and relevance

3.1 Key Performance Indicators

The key performance indicators (KPIs) have been chosen to reflect the values of the EE discipline. We aim for outstanding research in an open academic culture, collaborative, oriented on and inspired by society. In this fashion we remain relevant to society and vice versa. We strive our science to be open, though respecting the interests of societal partners like companies. Table 3.1 lists the resulting 6 KPIs.

Table 3.1 Key Performance Indicators

Quality domains

Assessment Dimensions

	Research quality	Relevance to society
Demonstrable products	**1. Research products for peers** a. Articles, conference contributions, PhD dissertations b. OA Datasets and software	**4. Research products for societal target groups** a. Sufficient, well-educated BSc, MSc and PhDs. b. Spin-off and start-up companies
Demonstrable use of products	**2. Use of research products by peers** a. References to our research	**5. Use of research products by societal groups** a. Technical products (designs, software, methods, and patents)
Demonstrable marks of recognition	**3. Marks of recognition from peers** a. Major awards and grants (ERC, Veni, Vidi, Vici, large research grants) b. Keynote Lectures c. Senior positions in research projects and related organisations	**6. Marks of recognition by societal groups/companies** a. Long-term research collaboration with industry b. Outreach to the general public

In the sections below we will give some context of our performance in terms of KPIs. The underlying data can be found in Appendix D and we will refer to the appropriate tables and graphs in that appendix.

3.2 Evidence in terms of KPIs

KPI 1a: Publications and Dissertations

The results of our research find their way to our peers in publications in high-quality journals and a number of selected conferences. Figure D.1 and Table D.2 show our output in the last 8 years. Figure D.1, left, indicates that the relative numbers of conference contributions and articles fluctuates somewhat over the years but is on average comparable. Note that both the ratio of temporary staff to permanent staff (Figure E.1, right) and the ratio of output to permanent staff (Figure D.1, right) diminish over the years. This is indicative of the fact that most of our research output comes from projects with temporary scientific staff..

Also PhD dissertations should be mentioned here. Table D.2 shows that on average ≈30 PhD theses per year are realised in the assessment period. In the years 2020 and 2021 the numbers fall clearly below this average where the COVID-19 pandemic is expected to form the main reason. In 2022 and 2023 a recovery seems recognisable with numbers closely to those before the pandemic.

Open Access

Of important note is our *Open Access* (OA) performance. Table D.3 and Figure D.2 show the OA fractions of our output. A few things are quite clear: 1) over the assessment period the overall fraction of our total OA has increased to up to 90% (2021). 2) Of all our OA, green only OA [39] forms a significant part of up to ≈50%. These numbers reflect that EE@UT is predominantly IEEE oriented. I.e. many of our publications are in leading journals published by IEEE, which is relatively slowly converging to open access (compared to EU based publishers). From the Horizon 2020 programme onwards the EU has been mandating OA for EU funded research [63] and many of the national funding organisation, like NWO, have done the same. This has pushed us somewhat in a split; our EE field draws us towards, often non OA, IEEE publications whereas the funding agencies push us towards the OA publishers.

Green OA

PURE

Green OA is the practice of putting author versions of publications in public OA repositories, often after a prescribed delay of 6 - 12 months, depending on publisher. Specific for the Netherlands, the Taverne amendment [64] has given Dutch authors of short scientific publications, (partly) funded by Dutch public funds, the right by law to put the publisher's version of their work in OA repositories after 6 months of publication. For the UT this is done in *PURE*. Looking at Figure D.2, 2022 and 2023, one can clearly see that the conversion from closed to green OA lags behind, masking to some extent the tendency of increasing OA publishing of EE@UT. As many of the EE@UT scientific staff are in editorial boards of IEEE publications, we will continu to put OA on the agenda of IEEE journals.

KPI 1b: OA Datasets and software

4TU.ResearchData

Zenodo

The use of OA repositories for datasets and software code is relatively new and not yet systematically tracked. Therefore, to get reliable numbers of these items is relatively cumbersome. The data presented in Table D.4 was collected manually from PURE [38]. It shows that there is a little increasing trend with respect to the number of published items per year. In the two repositories where most of our datasets are stored, *4TU.ResearchData* [65] and *Zenodo* [66], one can also see the number of downloads of the items, which are also given in Table D.4 for the time of writing.

KPI 2b: References to our output

Field-Weighted Citation Index

An important measure of the demonstrable use of products is what others do with our publications. Table D.5 gives an overview. An important metric is the *Field-Weighted Citation Index* (FWCI) [67]. This number quantifies, for a given group of publications, the average number of citations per output in that group relative to the overall average in the corresponding research field. A score above 1 indicates a better than average impact of the publications. From Table D.5 we see that we have a FWCI which is consistently above one and 1.2 on average for the assessment period. Other statistics indicate that 14.8% of our output is in the 10% best cited papers (field-weighted) and 33.8% of our papers are in the top 10% journals.

Table 3.2
Major Awards [72]

	<2017	2017	2018	2019	2020	2021	2022	2023
Veni	8				1	3	2	
Vidi	3						1	
Vici	2						1	
Simon Stevin Master	3							
Spinoza Prize	1							
Simon Stevin Prize								1
ERC Starting grant	2						1	1
ERC Advanced Grant	3		1	1				
IEEE Fellow Recognition	2			1	1			1
Honorary Prof. UT	2 (ongoing)							

KPI 3a: Major awards and grants

Table D.7, Table D.8 and Table D.8 shows the most important awards and expressions of recognition of the last six years, with a summary in Table 3.2. It indicates that our academic culture forms a healthy breeding ground to develop personal qualities and to compete for awards on the highest national and European levels. For example two ERC Advanced grants were awared in the assesment period; one by Bram Nauta, 'High risk, no gain' [68, 69] and one by Stefano Stramigioli 'PortWings' [70, 71]

KPI 3b: Keynote lectures

A list of keynote lectures is given in Table D.9. It turns out that this information is not systematically stored and therefore it is hard to claim completeness of this table. Nevertheless, the table shows a long list, reasonably distributed over our groups and over the years.

KPI 3b: Senior positions in research projects and related organisations

The staff of EE@UT is often asked and motivated to participate in organisations and positions where esteemed scientists can be of assistance. See Table D.10. Also in editorial roles and conference organisations you may find the EE@UT staff, see Table D.11.

KPI 4a: Sufficient, well educated MSc and PhDs[1]

The education of highly-qualified engineers is one of our main duties. Figure 2.2 already showed the influx of our BSc and MSc students. Figure 3.1, left, shows the number of students that leave our EE BSc and MSc programmes with a diploma. Though the numbers were increasing steadily up to 2021, 2022 and 2023 are rather low. We do think this may have to do with the pandemic during which many students may have experienced personal problems, got less motivated and may have chosen to take more time for their studies to be able to still experience the “student life”.

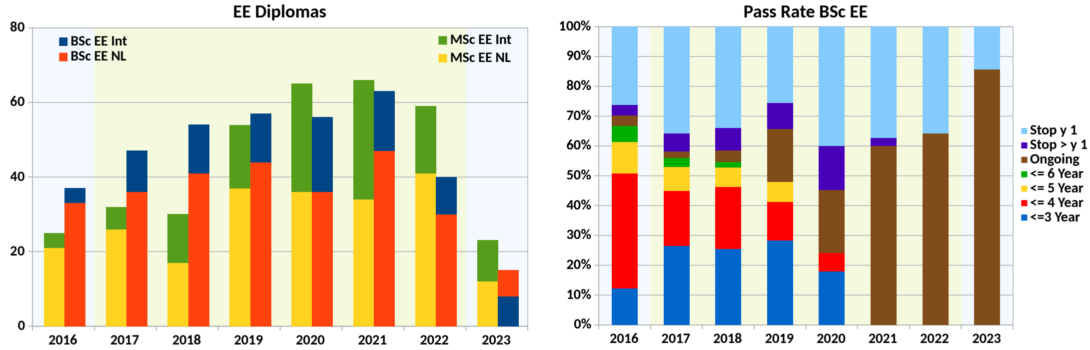


Figure 3.1
EE Diplomas (left)

Fractional pass rates relative to influx for BSc EE (right)

(Data from Table G.3)

Regarding the quality of our education we refer to the 2022 self-evaluation of the BSc and MSc EE studies [73] which has received favourable comments from the education visitation committee [74, 75]. Moreover, though not quantified, from our experience we find that most of our MSc students find jobs shortly after their graduation. From anecdotical evidence from 2019 we found that from 5 graduates, 3 had a job in 1 m, 1 in 3 m and 1 in 5 m. This may confirm that 1) there is a shortage of EE graduates and 2) our EE graduates bring qualities that are sought after by society.

Nevertheless, there remain two concerns; study pace is on the low side (<50% graduated after 4 years for BSc) and overall drop out is 30 - 40% for BSc, however, with most students leaving the programme in the first year (wrong choice or not able to attain the required level). For the MSc programme these numbers are somewhat better, see Figure G.4, right.

KPI 4b: Spin-off and start-up companies

Table D.12 gives a historical overview of enterprises that have started from EE@UT related research. From 1993 onwards, over 30 companies started up on the basis of research performed in EE@UT, mostly by the students themselves, many helped by the *Tijdelijke Ondernemers Plaatsen* (TOP, Temporary Entrepreneurial Posts)[76] arrangement which makes it relatively easy for start-ups to use the UT lab facilities and be near to the academic environment in which their know-how originated. A number kept their main base in the Kennispark Twente adjacent to the UT Campus, where some have strongly grown since they were established. Technology company Demcon, started in 1993, has a present size of 1100 employees. Technology transfer company 3T now has a size of 100 employees, and Micronit Microfluidics (1999), a spin-off of the micro-machining groups of EE, also 100 employees. Several other successful companies still present at the UT campus or the Kennispark have

Tijdelijke Ondernemers Plaatsen

---

[1] The PhD statistics are separately discussed in chapter 4.

been acquired by larger (foreign) companies, such as Xsens (140 employees, 2014 to Fairchild Semiconductor, recently became part of Movella), AXIOM IC (20 employees, to Teledyne-Dalsa in 2013) and the photonics and MEMS company Lionix (40 employees, for 75% acquired by Magic Micro in 2018). Of special note is the Athom as it was started by students from Creative Technology. It builds domotics solutions, such as the *Homey* [77], and presently has a size of ≈20 employees.

Homey

KPI 5a: Technical products

Table D.13 presents the list of technical products that have been developed in EE@UT over the assessment period. It ranges from software products to chip-designs, from measurement methods to prototype and demonstrator devices.

KPI 6a: Long-term research collaboration with industry

An indication of societal relevance is found in how our research is appreciated by companies. This can be for many reasons, e.g. because the knowledge we generated can be directly applied in products, or because these companies want to have a vanguard to what may come at the horizon in their field of business. Quite often this appreciation is cast into *long-term relationships* in which there can be an exchange of people (MSc and PhD students working with, or at the location of the partner, or accepting a job after graduation), ideas (by regular visits and progress meetings) and participation in projects (e.g. as user in an NWO-OTP project or by funding a PhD position). Table D.14 gives examples of such long-term collaborations.

long-term relationships

KPI 6b: Outreach to the general public

Table D.15 shows a list of outreach activities, ranging from radio interviews to lectures on popular festivals and from internet information to TV appearances. Clearly, the list is long as we find it extremely important that the general audience, and tax-payer, has insight in which research we do and why we do it.

Bettina Schwab from the Bio-Signals & Systems group has secured an ERC starting grant.

Click on the image to know more

This chapter presents our PhD policy as well as the success rates of the PhD candidates.

4

PhD policy and training

4.1 Training and Supervision

The training and mentoring of PhD candidates forms a crucial part of our scientific activities. We value intensive coaching of our PhD students, for example by having regular, e.g. bi-weekly, individual progress meetings, next to group meetings in which team forming and synergy are promoted. We aspire to educate and train the next generation of top scientists, for example by creating the proper environments for critical reflections and discussions, by giving our PhD students fitting responsibilities in their research projects and in education, through early attendance of conferences, and participation in specific programmes (e.g.*Our Future Leaders* [78]).

Our Future Leaders

Twente Graduate School (TGS)

All PhD candidates are enrolled in the *Twente Graduate School (TGS)* [79], established about a decade ago. The TGS gives a clear framework for our PhD policies; uniform procedures and rules applying for all PhD candidates of the UT. This involves:

- Central registration of all PhD candidates in the Hora Finita system (formerly ProDoc)
- PhD charter [80] defining responsibilities and prerogatives of PhD candidates and supervisors
- Qualifier with GO/NO-GO moment in the 1st year, followed by formal appointment of the promotor
- A 30 EC Training and Supervision Plan(T&SP)
- Forecast and drop-out registration
- A framework for data management

Hora Finita

Qalifier

Training and Supervision Plan (TSP)

The *Training and Supervision Plan (TSP)* [84] is obligatory for all PhDs and supervisors. The TSP has a strict format. It contains a summary of the research plan, the supervision plan and the educational programme to be followed by the PhD candidate. In principle this programme amounts to 30 ECs (European Credits), i.e. a six-month study load. It has a few mandatory courses [85] on bootstrapping PhD research, academic integrity, RDM and scientific writing whereas the rest is defined by the candidate and the supervisor, and needs approval from the Dean. This is delegated to the Director TGS, who can also approve exemptions up to 20 ECs. The educational programme contains courses offered by the university, national research schools or international programmes such as Summer Schools. The TSP further details the teaching obligations of the PhDs. Another part of the TSP describes the coaching of the PhDs: who the (intended) thesis supervisor of the PhD will be, who will act as daily supervisor(s) and how supervision is organised, e.g. the frequency of coaching meetings. At least one thesis supervisor and one daily supervisor must be appointed. The plan is first drawn up within three months after the start of the PhD candidate, and is periodically updated if necessary. A formal 'qualifier' towards the end of the first PhD year, aims to determine a conclusive assessment whether or not to proceed with the remainder of the PhD project. In this way we hope that under-qualifying PhD candidates leave the university without delay, both in their as the university's best interest.

Formal 'qualifier'

National research schools

Several groups participate in *national research schools* like *DISC* [81] (RAM), *ASCI* [82] (DACS, CAES), or *SIKS* [83] (DMB). These schools offer, among other things, summer schools and lectures, which can be

DISC
ASCI
SIKS

part of the TSP, but can also form independent educational programmes with own rules.

Research Data Management

Data management plan

Like all other PhD candidates at the UT, the PhDs of EE@UT take a mandatory course on Data Management, offered by the TGS. Data stewards function as trainers. Subjects in the course are: management of data for verification and reuse, the value of research data as scientific output of one's research, awareness of legal issues in the handling of research data and writing a data management plan (DMP). The knowledge from this training is used as a basis for the *data management plan* that every PhD student has to hand in, in the first year. The DMP has to be reviewed and monitored regularly, in line with planning and progress of the research project.

4.2 Intake and Success Rates

The influx and successful promotions of all EE PhD students, i.e. both those who are and those who are not employed by us, are given in Table 4.1. The number of promotions is systematically smaller, by on average 40%, than the number of starting PhDs. Also due to a slightly increasing influx of PhD students the population of active PhDs is almost monotonically increasing.

Table 4.1
PhD dynamics
Counted in FTE/year

starting year	2016	2017	2018	2019	2020	2021	2022	2023
Starting PhDs	44.4	35.7	58.9	51.1	56.8	52.8	50.7	59.4
Successful promotion	30.8	27.5	32.7	37.4	24.5	24.6	32.0	31.5
Active PhDs	182.5	184.4	205.6	202.9	224.6	244.8	255.6	272.0

More statistics about PhD dynamics and pass-rates can be found in Table G.1, which data is visualised in Figure 4.1. Overall, the success rate of PhD candidates in 4y + 3m is much lower than what we would like to see and topping at 32.3% for cohort 2018, increasing to about 60% for PhD durations of up to 6 years. The average PhD duration in this bracket is estimated to be 4y + 11m.

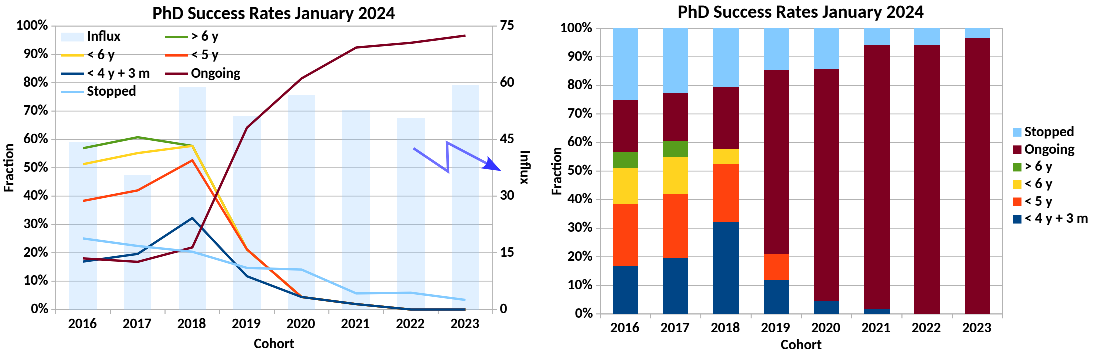


Figure 4.1
PhD influx and success rates as function of cohort.
(Data from Table G.1)

The COVID-19 pandemic played its role, e.g. by limited infra-access, see the strong decrease in <4y + 3m pass rate for cohorts 2019 and 2020. Some PhDs postponed their graduation in the hope to have a live defence, or their research was delayed because of limited lab access. The pandemic also had its mental impact and moreover asked additional effort for education. The faculty decided to support the PhDs that had to execute their research during the pandemic by 3m contract extensions. We also see some more factors explaining the slow progression of PhDs and high dropout rates:

- External PhD candidates (people with a job elsewhere) often only work part-time on their PhD.
- Mental and physical health issues make up for a delaying factor.
- There is a rather big drop-out rate, up to 25%, for several reasons: not all students pass their qualifier, (mental) health and well-being issues, external funding stops.
- There is a noticeable drop-out of external PhD candidates that have stipends. We have therefore become more restrictive accepting these students.
- Some PhDs get interesting job offers before finalising their thesis, jeopardising its completion.

This section discusses policies and accomplishments with respect to various aspects relating to academic culture within the unit. This includes diversity in terms of gender, nationality and age.

5

Working environment and personnel policies

5.1 Human Resources policy

EE adheres to the HR policies of the Faculty of EEMCS, which on their turn are primarily based on those of the UT. EEMCS wants to be a faculty where every employee has the opportunity to develop and use their talents in an optimal way, in line with *Shaping 2030* [11]. As a faculty, we choose to focus on talents of our employees, based on the conviction that each individual has unique talents. We have taken steps forward, but realise that improvements are possible and that development requires continuous attention.

Development

Shaping 2030

5.2 Recruitment

Recruitment is an important part of the HR policy within EE. When selecting new colleagues, we look at the talents of the applicants and how they fit into the team. Striving for more diverse teams is important to us. We are supported in this by HR. In addition some recruitment tools are used, such as Textio, an instrument that supports in writing vacancy texts, and tools for PhD candidate selection. Attention is also paid to the onboarding of new employees by arranging onboarding talks, in which, among other things, the possibilities within the UT in the field of training and coaching to support development are introduced. Additionally, new staff members are coupled to a buddy of comparable seniority. This person serves as a first point of contact when exploring the new working-environment; whom to turn to for certain questions, what are the peculiarities of the organisation? We no longer employ new talent, mostly assistant professors, on *Tenure Track* (TT) positions, unless mandatory, e.g. for some 4TU positions. Instead we offer them a regular permanent contract with the usual one year test period. The reason behind avoiding TT positions is that they put considerable pressure on the persons involved and that they lead to a tendency of shifting the balance in their personal and group related priorities, hampering a socially healthy working climate for all involved. I t is fair to say, though, that this policy is embraced by a large fraction of junior scientific staff, but not by all; some may perceive it as a reduction of their growth potential and speed to climb the academic ladder. Also, other faculties do not share the same preference, possibly leading to inequality.

Recruitment

Tenure Track

5.3 Promotion

Regarding a balanced age distribution, and in the context of the “recognition and rewards” policy [86] we actively monitor the quality of our *junior scientific staff*. This is not only done by the direct superior; all research chairs have regular consultations with HR, in which development and stimulation of development of employees are important subjects. Staff are invited to make a development plan to the next promotion. Promotions up to and including UHD1 are decided within the faculty, after advice from the discipline chair and educational program director to the dean. Promotions are less restricted than before, and can be biased towards research, education or management. To support the development of employee talents, the *9-grid tool* [87] has been introduced. In preparation for the annual performance appraisal, the research chair fills in the 9-grid with the potential and performance of each staff member. Subsequently, the chairholders of EE discuss the performance and potential of the staff with each other in wider context, especially because of the possible different perspectives. This way promising junior staff is identified in a timely manner and appropriate growth paths can be determined and supported.

Junior scientific staff

Talent

9-grid tool

On a side note, one of the insights evolving from these meetings is that the VSNU University job classification system (UFO) actually provides few growth possibilities for *technical support staff*.

Technical support staff

Certainly in current times of shortage of technical support personnel we look into tailor-made creative solutions on individual level to improve this situation. E.g. by hiring technical staff with an MSc or even PhD title, but without the desire to follow the path of independent prof. with associated (education, funding and managerial) obligations.

Teaching Excellence

Employees have a wide range of talent which we want to appreciate properly. That is why it is possible for employees wanting to spend more time and effort on education to grow into associate professors and full professors with focus on teaching. Because of the variety of teaching tasks due to the large number of educational programmes in which EE participates, this is interesting for a number of employees who are very involved in education and regularly experiment with educational innovations. Recently one associate professor within EE has been promoted to full professor with focus on education.

To prepare junior scientific staff better for their next career steps and relieve some management tasks of the research chairs, a few (larger) research groups have started to work with management teams. In these teams the managerial tasks are distributed such that also junior scientists get an opportunity to experience managerial work. Besides, it helps team-forming as more group members become aware of management challenges, provoking more shared responsibilities for the research groups. Further, other organisational tasks in educational or faculty committees form other possibilities to contribute, e.g. member of an examination board.

5.4 Diversity

Gender

Female professors

The goal of the faculty of EEMCS for 2025 is to employ 20% female full professors, 20% Associate and 35% Assistant professors. At present, for EE@UT these numbers are 16%, 17% and 39% by FTE, see Figure 5.1, left. However, the numbers are flattered: especially the BSS group has a large number of female permanent scientific staff whereas some other groups have few or no female staff.

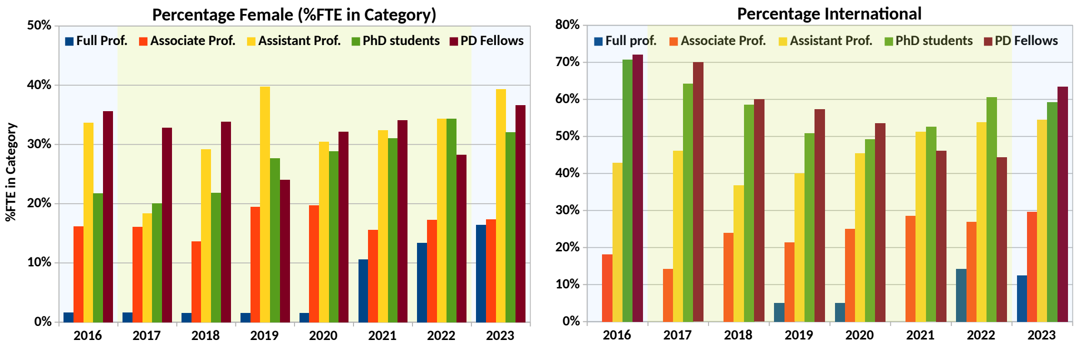
Figure 5.1

Staff diversity

Female (%FTE, left)

International (%App, right)

(based on Table E.2)



At the moment, the Faculty Board is in discussion with the Faculty Council to open up vacancies in the academic permanent staff to women first, e.g. for 1 month. At UT level the so-called Hypatia chairs are also meant to promote female professorships [88], but EE@UT has not yet profited from this programme. Such measures are necessary to catch up. But we also need to be realistic; the pool of female electrical engineers has been structurally smaller than the male counterpart. E.g. the historical fraction female students in our BSc EE programme is about 10%, somewhat lower, but not much different from our sister universities in the Netherlands (and likely other parts of west Europe). What is needed is change, in the entire educational chain from kindergarten to university the beauty and societal importance of science and technology needs to be communicated in order to better interest female talent for STEM careers.

EE@UT has participated in a pilot gender-scan in order to determine how we could become more attractive for female employees and students. This has resulted in a list of conclusions and recommendations, none being overwhelming by itself, but together forming a framework of how we can improve. This is a work in progress as many of the recommendations need to land on individual ground and induce appropriate awareness.

Given the age structure of full professors within EE (see Figure 5.2), opportunities are coming. The pool of female PhDs and Postdocs is also growing. In order to effectively use these opportunities for women, a number of measures have been taken, such as a diverse composition of selection committees and gender bias training. Furthermore, for female scientific staff there is a *Female Faculty Network* and a coaching programme at UT-level.

Female Faculty Network

Nationality

We find it important to be an international scientific community, which is also necessary to fulfil the needs of society for technological people. The percentage non-Dutch scientific staff, see Figure 5.1, right, has grown overall in the assessment period. Given the Dutch labour market for EE, this is not surprising. This growth, unfortunately, is opposed by political developments. At the moment, 3 research group chairs are non-Dutch and this may increase further in the future. Clearly, more attention will have to be paid to intercultural awareness than is currently the case.

Nationality

Age

The age distribution of EE (see Figure 5.2) is particularly skewed at the level of full professors. The average ages in 2022 were 54.3 year for Full, 39.3 years for associate and 39.3 years for assistant professors. This offers opportunities for women and also for younger staff members.

Age

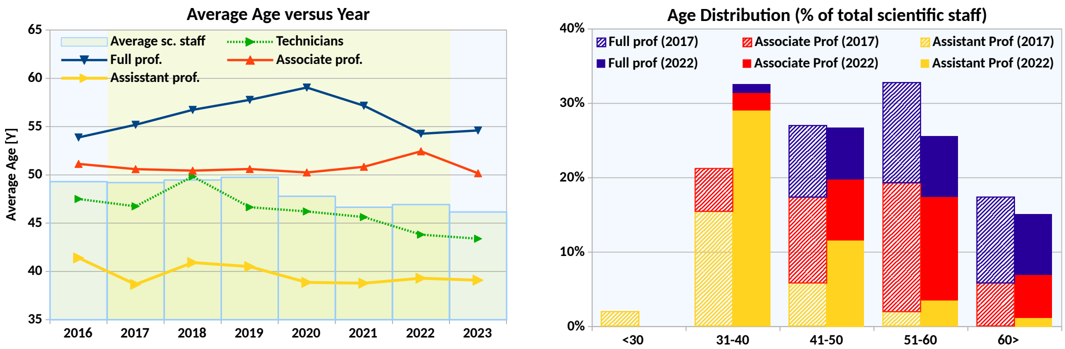


Figure 5.2 Left: Average age as function of year (Table E.3)

Right: Age distribution scientific staff 2017 & 2022

(Table E.3)

5.5 Well-being

Diversity, Equity & Integrity

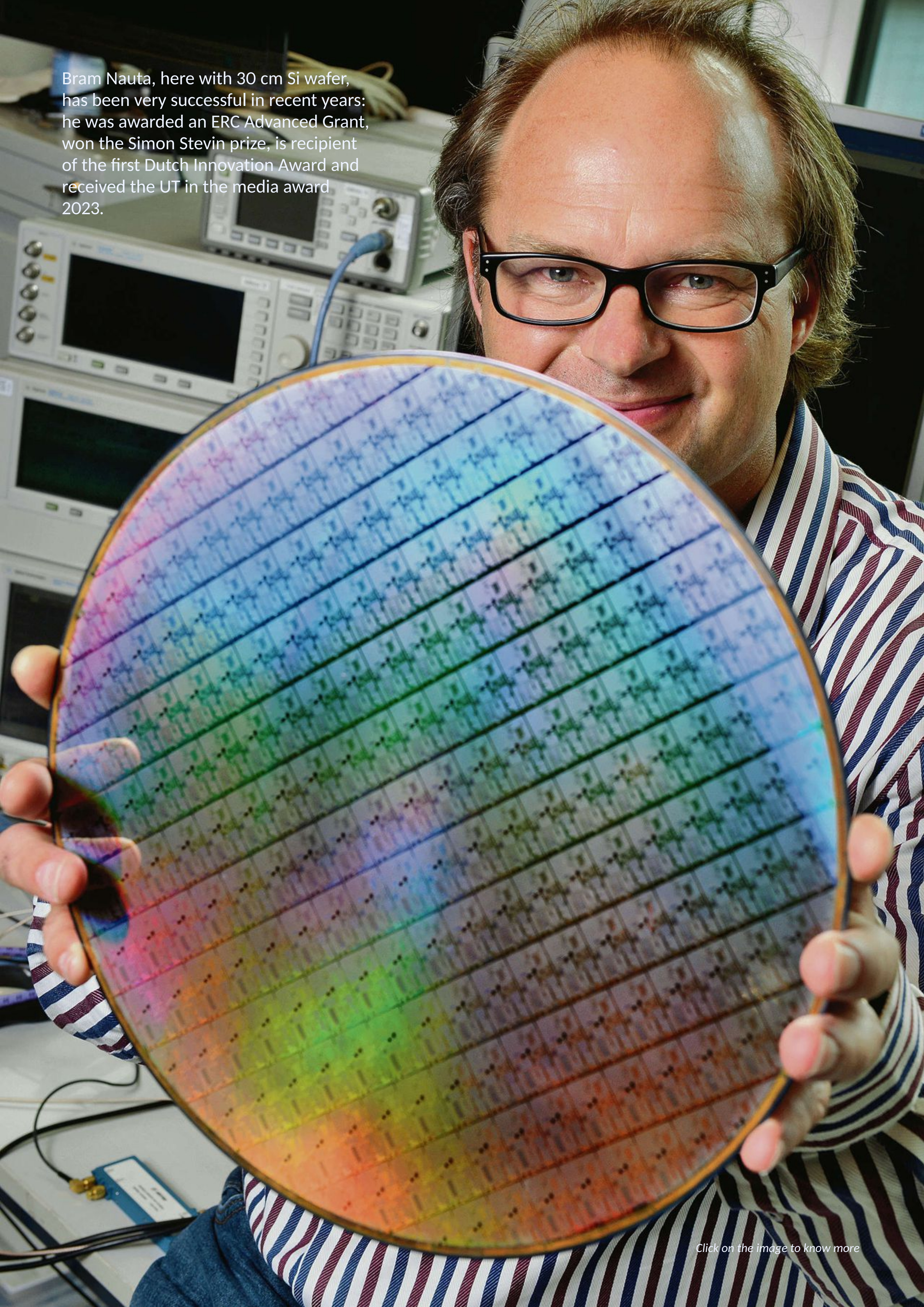
The EEMCS faculty board has expressed the wish to improve Diversity, Equity and Inclusion within our faculty and an informal EEMCS DE&I team was created to help facilitate this. A broader DE&I sounding board was put into life for input and feedback. General consensus within the DE&I team and DE&I sounding board is that there is insufficient knowledge and awareness within the faculty on how the faculty is faring with regard to DE&I. Therefore the focus for the coming time is on gathering data and feedback from employees on DE&I, to create awareness and to identify key areas for improvement. Some initial data on diversity (D&I November 2021) and more information were gathered via an anonymous survey and behavioural audit.

Recently a faculty-wide workshop on work-life balance was organised in which a few junior and senior staff acted as panel members, introduced various statements, which were subsequently open for discussion with and in the audience. The resulting 4 main take-aways were: 1) talk about well-being and work-life balance with your team, 2) block time to work for yourself, 3) be strict, specify your boundaries with others, and respect theirs, and, the most surprising one 4) accept the work is never done.

Work-pressure

More generally we see that our EE discipline forms no exception in terms of *work-pressure* and working hours as experienced in academics in the Netherlands. Especially increasing administrative duties seem to take their toll in efficiency and satisfaction of our work. Though this is a problem that should be addressed on NL scale, we feel that the size of our discipline and the open and the collegial atmosphere help in keeping things in bound. We value this aspect of our collaboration and feel that, together with our attractive infrastructure, it also helps us to interest new talents to come to Twente.

> *Why Twente? The people! Everybody helped me in getting the ERC, and were happy for me when I got it. Competition is constructive in Twente* (Remark during TT interview).



Bram Nauta, here with 30 cm Si wafer, has been very successful in recent years: he was awarded an ERC Advanced Grant, won the Simon Stevin prize, is recipient of the first Dutch Innovation Award and received the UT in the media award 2023.

Click on the image to know more

We reflect on the strategy needed for the future. We present a SWOT analysis, in which we analyse strengths, weaknesses, opportunities and threats. The strengths and weaknesses relate to the properties as well as the characteristics of the research unit. The SWOT analysis forms the basis of the strategic plans for the six years to come.

6

Strategy for the next six years

6.1 SWOT

During one of our strategy days we looked at our perceived Strengths, Weaknesses, Opportunities and Threats *SWOT*. We will discuss a few of them.

SWOT

We pride ourselves that we have a number of well regarded scientists among our staff. Some of them rather senior. But meanwhile a new, talented, generation has taken over in some of the groups (Table C.1). Another "wave of retirements" comes in 5 – 10 years, meaning that we need to scout for talented junior scientists, give them the space and time to grow and allow them to define their own research niches, networks and collaborations; the bottom-up process discussed in section 1.2.

Table 6.1 SWOT analysis, composed during a brainstorm session of the EE professors

	Strengths	Weaknesses
Internal organisation	• Internationally renown staff • Our strong teams support young talent • Strong cross-disciplinary cooperation within EE, EEMCS, institutes, UT • High vertical mobility of scientific staff • Attractive employer for top talent by offering clear grow paths, open atmosphere and location in attractive part of the country • Research relates very well to societal challenges • Societal mindset and intensive collaboration with societal stake holders including high-tech industry	• Retirements decrease coaching power for junior staff • Insufficient interaction to know each other's research • Complex management structure (departments, clusters, disciplines, faculties, institutes, centres) • Disjunct activities in embedded AI; limited visibility • Limited vertical and horizontal mobility technicians • PhD pass-rates and pass-times • Ethics & data management need to be more widely implemented and grow into the DNA of the organisation • Few female students • Strong international competition for female high potentials
	Opportunities	**Threats**
External context	• Huge potential for embedded AI / robotics, IOT, electrification, energy transition, health • Retirement of senior staff offers chance to rejuvenate, optimize research themes, bridge groups • Enabling MKBs in Twente region • New geo-economic developments like EU Chips Act • Airport Twente (Growth fund 'Luchtvaart', e.g. electric flight)	• Financial pressure due to inflation and changing laws • Uncertainty regarding financial coverage of SPT positions • Project funding possibilities lack staff increase • Maturing Si industry is leaving NL • Funding programmes seem to favour applied (i.e. biomedical) research over core technical research • Brainport, Randstad, more attractive for industry • Work pressure (funding competition, student-staff ratio, bureaucracy) • Input qualifications of student influx declining • Demographic developments

Considering the breadth of our discipline we expect to remain a rather diverse EE department, looking outside the discipline rather than inward, collaborating with a variety of UT, NL and EU partners, amongst others on important societal challenges. This will strengthen our research portfolio, providing chances for junior scientific staff members. But we also see increasing difficulty in securing funding for more fundamental EE research (e.g. in NWO OTP and Perspectief programmes), this now mostly being the subject of prestigious personal grants (Veni, Vidi, Vici and ERC). I.e. it becomes more difficult to have engineering science funding, which is still the breeding ground of EE@UT.

The breadth of our department also comes at the cost of a somewhat loose connection between the research chairs. They certainly form a collective, being anchored in a common scientific base. On the other hand the content-wise distances in the discipline, e.g. between nano-electronics and robotics, or chemical sensing and embedded systems, does not promote shared strategies and collaboration, other than merely in the shared educational programmes.

We have shown before that our research portfolio has increased over the assessment period. This confirms our viability. Nevertheless, at the time of writing (spring 2024) the financial situation of the UT, EEMCS and the research chairs has become somewhat worrisome, as with virtually all Dutch universities. Reasons for this development are the high inflation following the war in Ukraine, a new law in the Netherlands which requires employers to capitalise employees' unused leave hours and new regulations for hiring and paying student assistants. In effect, the uncertainty regarding continuation of the coverage of the SPT positions does not help either. As the government does not fully compensate the increased costs we are forced to have a much closer look at our expenses, especially since the financial set-backs fall in the 1st tier and therefore cannot be compensated by funds in 2nd and 3rd tier projects. A reminder that we need to stay vigilant about our finances.

One of the things that should not be untouched is bureaucracy. Over the last 4–6 years it seems that the bureaucratic load has increased. Not in the least due to the use of immature and often poorly implemented software tools, as well as rash decisions when implementing these tools. Staff members feel that procedures have expanded, often requiring unreasonable amounts of time for checks and balances that are no more than paper tigers. As an example permanent scientific staff has to sign off on presence of PhDs and PDs. However, in the open academic working climate, without a work-time registration system there is no possibility to responsibly sign off these hours. On the opposite side of the spectrum the financial software used, a few years after implementation, is still not suited to provide staff with overview of their project budgets, requiring inefficient (mail) conversations with the financial administration.

A final thought regarding the SWOT is that larger companies seem to prefer other parts of the country (especially Brainport area and randstad) where they may find more extensive eco-systems for their respective value chains. Though the UT has been a leader in the creation of economic activities, e.g. as measured in the number of spin-offs, it happens (more than) frequently that successful companies are acquired by larger ones and relocated outside the region (see the notes in Table D.12). Luckily the Netherlands is a small country and our relations with those companies do not necessarily need to suffer. The flip-side is that we remain attractive for talented academics given the favourable costs of housing and living in the eastern part of the Netherlands. Additionally the UT tries to make strong ties with other universities, e.g. the RUMC (health), WUR (agri & robotics), and Rijks Universiteit Groningen (RUG, health) and universities of applied science Windesheim (Zwolle) and Saxion (Enschede).

6.2 Sectorplan Techniek II

eHealth

In section 2.4 we already mentioned that the ministry of ECW has positively decided on the Sectorplan Techniek II (SPT-II) [47]. Plans as formulated by the various disciplines were tuned between the partners, TU/e, TUD and WUR. Since in SPT-II also the TCS departments in the Netherlands were involved, we teamed up with the CS discipline in EEMCS. Taking into account that SPT-I had focused on EE core areas, and that in SPT-II there is ample room to strengthen more applied research, we invested in a field which is in strong development and in which EE@UT and its partners have a strong position: *eHealth* (see the case study Table A). We formulated our plans in a vertical fashion, i.e. from integrated circuit design all the way up to AI for diagnostics and coaching. The 750 k€ per year was designated as shown in Table 6.2.

Table 6.2
Overview of SPT-II positions in eHealth

Position	Subject	group	realisation
UT9	Biomedical sensors for external or internat us	BIOS	1.0 FTE Ass. Prof.
UT10	Electronic circuit design for eHealth applications	ICD	1.0 FTE Ass. Prof.
UT11	Energy-efficient communication networks	DACS(1)	1.0 FTE Ass. Prof
UT12	Machine learning and AI for health diagnostics	DMB(2)	1.0 FTE Ass. Prof.
UT13	AI for mental health coaching	HMI(2)	1.0 FTE Ass. Prof.
UT14	System design for eHealth applications	BSS	1.0 FTE Ass. Prof. 0.5 FTE Full Prof.
(1)	One position shared between CS and EE		
(2)	Position at CS		

The eHealth activity is overseen by prof. Monique Tabac. We have started regular meetings with all participants in the SPT-II eHealth activity. The expectation is that bringing this large range of expertise in this eHealth activity, we will be in a good position to work on multi- and inter-disciplinary research questions and, therefore, likely more successful in (large) grant proposals.

6.3 Developing strategic research fields

New strategic research fields

Some strategic research fields that we will (further) develop are robotics, neuromorphic computing, artificial intelligence, and (e)health, organ-on-a-chip. In the context of an EE systems-approach, from a technological viewpoint we like to concentrate on vertical integration of photonics and electronics, with a firm industrial embedding to safeguard long-term application perspectives.

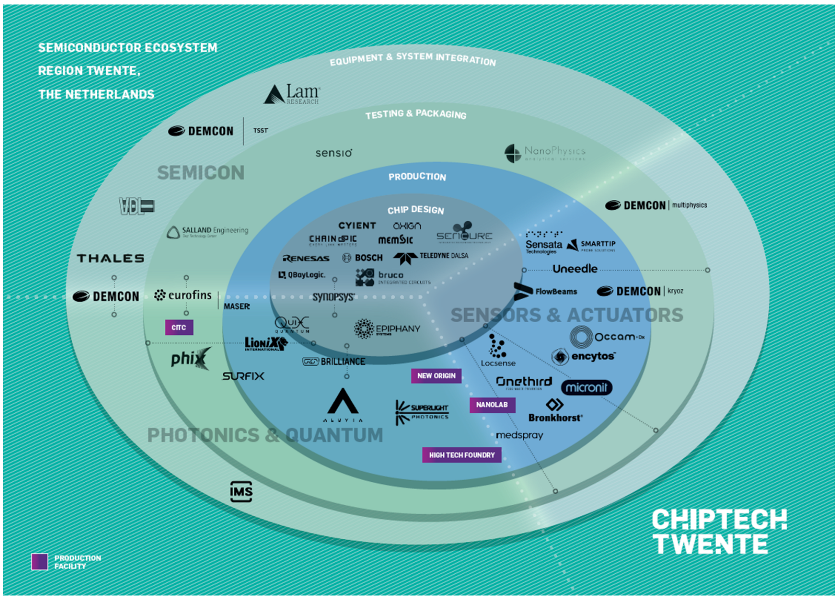


Figure 6.1 Overview of companies in the ChipTech Twente ecosystem

European Chips Act and ChipTech Twente

Beethoven programme

ChipTech Twente

Where in the SWOT of section 6.1 we put down as a threat that maturing Si industry is leaving the Netherlands, e.g. to south east Asia, it is good to mention that opposite developments are taking place as well. Of particular note are the EU's Chips Act [6], which is meant to make Europe less dependent on non-European actors in the electronics industry, and the *Beethoven programme* [89] to particularly support the semi-conductor industry in the Netherlands. At the UT prof. Bram Nauta [68] capitalises on these developments. By bringing together a number of companies, important (UT) infrastructure and intellectual power, a new *ChipTech Twente* cluster is built:

> "In Twente we can make an important contribution to the ambition of new generation chips. The breadth and combination of (enabling) technologies such as electronics, photonics and microfluidics is right here. We are ready for new challenges. Down to earth, up for anything! [90]"

By clustering these companies the idea is that new and existing companies may gravitate around Twente into a large eco-system that can provide (a large part of) the value-chain. It is important to note that, although the ChipTech Twente initiative is relatively new (2022) and large, the UT and EE@UT have been building (parts of) this eco-system over many years. The MESA$^+$NanoLab facility has played an important part in this process. It is a demonstration of how long-term collaboration between academia and industry can lead to societal developments with impact for the region. See also the case description in Appendix A on how such a centre could be established around EE@UT.

Robotics Centre and AI

Evidently, robotics is a multidisciplinary activity in which many research fields merge: mechanics, electronics, embedded systems, (human) physiology, machine learning, artificial intelligence, imaging, advanced fabrication (e.g. additive manufacturing), human media interaction, etc. It is widely expectated that: "Robotics and AI will shape the way we work, live, produce and operate in society".

At the UT research is done on many robotics related subjects, but spread over 2 faculties and 3 disciplines, physically and for the outside world also perceptionally, separated. Hence, we have formed the new *Twente Robotics Centre* with a focus on Robotics for Citizens and to show how Robotics can evolve for the Citizens of the future. With this new centre we will improve cross-fertilisation, be a recognisable player, a one stop interface to the 'external world', and attractive to industry and excellent researchers. We also push towards integrated housing. To this end the participating chairs from the EEMCS faculty (RAM, and the Human Media Interaction group) and the Engineering Technology faculty (Biomechanical Engineering and Precision Engineering groups) develop an integral strategy. The new centre is at the heart of an ecosystem, encompassing a vision which connects education to research, to valorisation in a uniquely attractive setting for researchers, students (Bsc,Msc,Phd), entrepreneurs and other stakeholders to catalyse each-others' strengths. As part of this strategy we recently developed a new MSc programme Robotics addressing the needs of, a.o. Medical, Inspection & Maintenance, Industrial (Agile Manufacturing & High-Tech Systems) and Agro-Food sector robotics. See Appendix A how the developments in the RAM group have helped to come to the Robotics Centre.

Twente Robotics Centre

6.4 Education and PhD policies

As mentioned in chapter 4 and chapter 3 pass-rates and average time to finish for BSc/MSc students and PhDs are longer than desirable. This aspect is closely monitored and acted upon by the educational programme directors and committees and is reported on in the periodic educational self-evaluation reports [74]. The other critical point is the influx of EE students. In historical perspective currently the influx is not low, could, however, be larger. As mentioned in chapter 2 the Dutch internationalisation debate is not very helpful in this respect. We will work within the UT frameworks on marketing and communication for student recruitment to make sure potential students can find us. At the same time we will keep lobbying for English taught BSc and MSc programmes, to deliver more international graduate to the labour market and make sure that our talented international staff can optimally contribute to the educational programmes. In EE-NL context we will explore possibilities for recruitment of increasing number of (female) students. Where possible we will profit from renewed interest in a strong EU semiconductor industry and according investments in education, specifically of engineers trained for jobs in this field (*Beethoven programme* [89]), in EE-NL context as well.

Beethoven programme

Following the financial impact of the capitalisation of leave hours, especially so for PhDs who seem to take less leave than staff on average, the BSS group reflected on PhD theses; "likely our quantitive expectations for PhD theses are on the high side, rather than the qualitative requirements".Taking into account that in some countries PhD thesis work takes 3, rather than the customary 4 years in the Netherlands, the question arose if we aren't expecting too much scientific output from our PhDs. Although neither TGS, nor EE@UT specifies a minimum number of papers or conference contributions, our implicit expectations may be too high. This insight has not yet been discussed on discipline or faculty level, clearly these are the sort of conversations that we need to have in the coming period.

6.5 Financial autonomy

Financial autonomy

A healthy financial policy with room for investments in new promising developments, sufficient personnel for all departmental tasks and fitting state of the art infrastructure forms the backbone for successful operation. The EE@UT has recently adapted a financial governance model, the idea behind it being to make financially not so interesting, but scientifically interesting projects 'more affordable'. Using a weighted sum of 2nd, 3rd and EU money flows, promotion premiums and education rewards over a 5 year period the non-normative part of the EE income is distributed over the groups. Simple rules for allotment of starting members and groups are in place to enable agile developments, focusing on research rather than financial commitment. Giving the current financial situation as described in section 6.1 it is expected that for the coming years we will have to limit our spending, using project funds for purchases and salaries in order to minimise the costs on 1st tier budget.

6.6 Personnel

Attracting new staff members is a top priority. A sizable part of our staff will retire in the coming 5-10 years. Also the technical support will suffer from this '*retirement wave*'. The junior sector plan positions and a number of tenure trackers in a number of cases can provide possible successors for the scientific staff, and attracting high-quality technicians is hard in the current market. Offering these technicians better growth possibilities in the organisation than the present ones, will be a helpful means for attracting them in the first place, but also for keeping them in the organisation. Furthermore, having some period of overlap with the leaving staff member is desirable.

Retirement wave

Diversity

Diversity and especially the gender balance needs constant attention. Traditionally in EE the number of female students is very low and as a result it is difficult to find female scientific and technical staff as well. This is especially true for the Netherlands. Finding new staff internationally contributes to the intercultural diversity. In chapter 5 we have indicated that the percentage of female scientific staff members is increasing but not yet at the target values of the faculty. To achieve this goal it will be necessary to fill 50% of all (coming) vacant positions with female staff. The faculty EEMCS is looking into improving its attractiveness for female academics, and considers possibilities to *prioritize female applications*. In general, female staff numbers will be on our strategic radar for the years to come.

Prioritize female applications

6.7 Benchmark Study

We have initiated a benchmark project with the Department of Electrical Engineering of Chalmers, in Sweden. However, it turned out to take much more time to 1) find the right people to bootstrap the benchmark with and 2) to find common available time-slots to do the initial phase of the benchmark study. Hence, we have not been able to conclude a complete benchmark study. Appendix H contains the project plan, which has currently proceeded to phase 2.

Nevertheless, we have had 3 online meetings with our colleagues Marianna Ivashina and Thomas Eriksson, in which we have been addressing highly interesting topics: governance, quality of PhD students and how to attract good PhDs, what do we expect from our PhDs and how do we coach and train them, dynamics of selection of research fields and how to attract funding, quality assessment of the EE units at Chalmers, scientific integrity, and social safety. As the SEP protocol does not require a benchmark study we have decided to not include intermediate results in our self-assessment reports. However, given the valuable initial online meetings, we have agreed to prolong our meetings as they will be very useful in the larger scheme of the quality assessment cycles.

6.8 Conclusion

We expect that in the coming years EE will be more important than ever. The *energy transition* is all about replacing fossil fuels by sustainable electrical energy, often leading to increased dynamics of supply and demand and requiring advanced solutions to guarantee proper provisioning. It also asks for a reduction of the power consumption of our electronic devices and machines (like e.g. has happened in LED lighting, portable and computing devices, electric car engines, domotic solutions for interior climate). Also in the field of energy storage, especially in *battery technology*, EE has an important role to play with respect to control and efficiency of the de/charging processes. The societal tendency to be online wherever and whenever we want and to connect all sorts of equipment (Internet of Things) is driving the impact of these technological developments even more. Electronic devices still continue to grow in numbers and capabilities. Opto-electronics will enhance electronic devices. Automation in the form of e.g. *robotics*; self driving cars and autonomous flying drones will become mature. In agriculture and livestock farming GPS, sensors and computer-systems are increasingly used to improve efficiency, animal welfare, quality control and increase production volume (precision agriculture). Medical technology is a growing field; advanced and pervasive sensing of vital indicators, diagnostics, organ-on-chip, tele-operating, e-health all are based on (enabling) technology from the EE domain.

Energy transition

Battery technology

Robotics

Precision agriculture

In short, society is counting on the EE discipline and its engineers to play their part in solving pressing societal problems. The demand for EE engineers only increases and there is work to be done, more than ever. At the UT we take on a set of these challenges consistent with the manpower, infrastructure and expertises that we have and expand where possible. The future for the EE discipline in general as well as for the EE department at the UT is bright!

Roland van Rijswijk - Deij
Recipient KHMW Kees Schouwhamer Immink Prize.
Recipient IEEE TCI Rising Star Award.
Vidi Laureate in the DACS group.

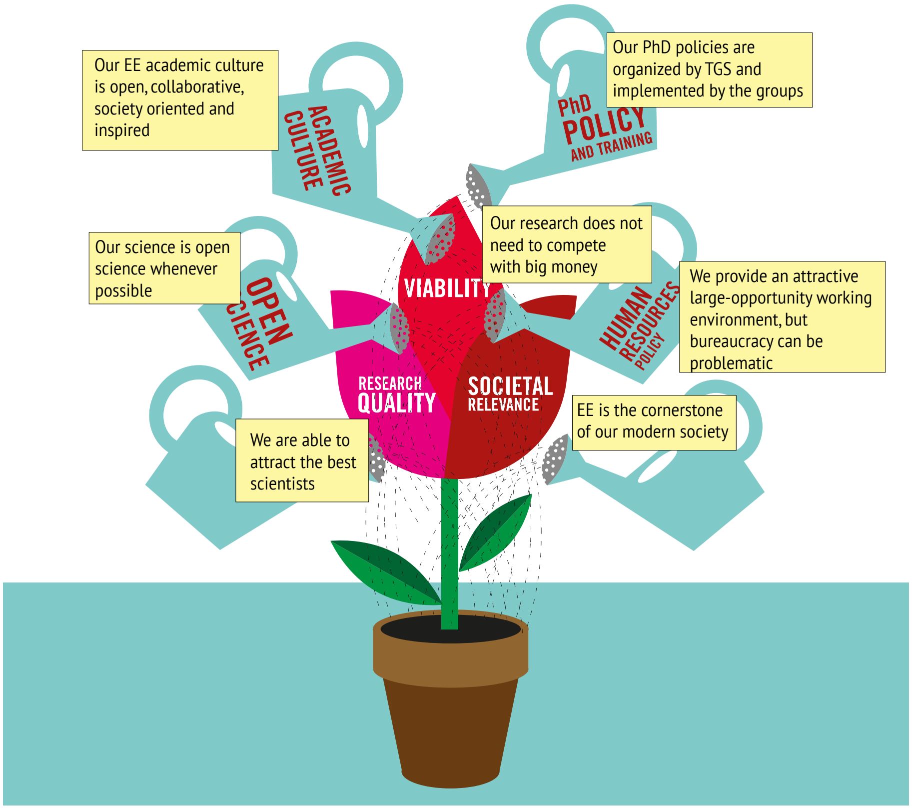
Click on the image to know more

The self-evaluation document is complemented with a one-page summary.

7

Summary

The front page of the SEP protocol 2021-2027 [1] shows the items, which should be addressed in this report. Figure 7.1 summarises how we see this for EE@UT, by adding some yellow notes. The DC-EE decided on these statements, which each concern central elements for the SEP protocol.



Our EE academic culture is open, collaborative, society oriented and inspired

Our PhD policies are organized by TGS and implemented by the groups

Our science is open science whenever possible

Our research does not need to compete with big money

We provide an attractive large-opportunity working environment, but bureaucracy can be problematic

EE is the cornerstone of our modern society

We are able to attract the best scientists

Figure 7.1
Viability, Research Quality and Societal Relevance

EE is a thriving research area. The societal importance of the EE field and its viability, in general, are beyond any doubt. Looking back at the past decade of EE@UT, we observe that the discipline has strongly recovered from the 2013 reorganisation both personnel-wise and financially. EE@UT boasts strong research teams with internationally renown staff, with excellent connections to high-tech industry. The development of the discipline has recently been spurred by the strong investments in the three core areas of EE (the white center in Figure 1) by SPT-I and in eHealth in SPT-II. In the future we see many chances in the area of robotics, health, energy and artificial intelligence, with strong ongoing initiatives in the applied areas of robotics, embedded AI, neuro-morphic computing, organ-on-a-chip and eHealth (the blue outer circle in Figure 1). Several issues will need attention in the coming years: the retirement of several senior staff, which offers both an opportunity and a challenge; the attraction of more female students and staff; relieving the administrative burden for the research staff and generally decreasing the working pressure to create more space for creativity. And we should not neglect the financial uncertainties in the Dutch academic landscape caused by inflation, law-changes, uncertainty of the sector plan financial coverage, and declining student numbers in the face of the internationalisation debate. However, the excellent infrastructure of the UT campus and the societal and open mindset of EE@UT and the UT in general will undoubtedly help addressing these issues.

Case studies are a part of the self-evaluation report.
They may play a crucial role, since case studies are
excellent instruments to function as both illustrations
and robust supporting elements of the self-evaluation

A

Case Studies: Developments and Rejuvenation

Robotics in the EE@UT programme

RAM
Stefano Stramigioli

The group Robotics and Mechatronics *(RAM)* stems from the group Control Engineering (CE) which and is managed by prof. Stramigioli since September 2011. The CE group was active in Control and Mechatronics, counted approximatively 6 scientific staff, 2 technicians, less than 10 PhD students and it had relatively few connections at the European and international level. Prof. Stramigioli [70] invested in the acquisition of a number of European projects which financially contributed to the growth of the group. Currently the chair has 19 people in the scientific staff, 6 technicians and there are 22 PhD students and 4 PostDocs active.

euRobotics

DIH-Hero

An important part of this growth and success has been the investment in networking at the European and international level: Prof. Stramigioli, after other positions, has been serving as Vice President for research of *euRobotics* [91], the European Robotics organisation which was the partner for many years of the European Commission for the creation and management of the SPARC program, a 2.8 B€ program on robotics for Europe, the biggest Civil Robotics Program Worldwide [92]. Prof. Stramigioli also served multiple times as Vice President for the IEEE Robotics and Automation Society, the biggest scientific Robotics association in the world. Thanks to such involvements, it was only natural to shape the group toward robotics and change its name to its current name: RAM. Another aspect of the success was the good contact with industry which brought many projects and IP generation and spin offs like ControlLab [93], still active after 24 years and a new business called Machned Medical Robotics [94] which has acquired already 4 M€ of investment and is in the phase of going to an investment for 40 M€ . Supported by a strong CV and capable group, Prof. Stramigioli also led the acquisition of the *Digital Innovation Hub for Health Robotics* (DIH Hero) and at the same time acquired an ERC Advanced Grant (PortWings) and is planning to submit an ERC synergy proposal. Such projects have given great international exposure to RAM and the UT, have attracted talented young researchers and have stimulated group members to focus on ERC project and EU project submissions, some of which are now currently under review.

Overall Prof. Stramigioli's leadership has contributed to the creation of a successful, internationally recognised group. But the thing Prof. Stramigioli is the most proud of is the group dynamics which he managed to establish, based on the importance and well being of each and every member of the chair and the open discussion atmosphere independent of hierarchical structure.

Old White Men

Albert van den Berg
BIOS
Organ-on-chip

Since 2000, prof. Albert van den Berg is the figurehead of the BIOS Lab on a Chip group. In this role he successfully initiated different research lines. In 2003 he started his research combining cell biology with microfluidic devices, that gradually evolves in a pioneering role in organ-on-chip research. His innovative and multidisciplinary work is remarked by the field, as indicated by several honors and awards such as the Simon Stevin award, Spinoza prize (2009) and member of the Royal Dutch Academy (KNAW). Recently, he made the switch to microfluidic systems for sustainability purposes.

Due to his appointment as scientific director of MIRA (2014-2018) and later the MESA$^+$research institute (2018-2024) his involvement in the daily activities of his research group reduced and prof. Jan Eijkel took over the role as chair of the research group. This change was accompanied by a smooth transition in the management of the group from a more traditional research group to a team-based approach. Additionally, it gave also the junior scientific staff members the opportunity to develop themselves further in the academic field, without being thrown in the deep. However, young researchers of BIOS are not only educated to fulfil academic leadership roles; others end up in industry and in spin-off companies.

Jan Eijkel

Team-based

After the retirement of Jan Eijkel in 2022, Loes Segerink became the chair of the group, and she continues the team-based approach. With the retirement of Albert van den Berg in sight (September 2024), the group will lose its figurehead who received both the ERC Advanced and NWO Zwaartekracht twice. In anticipation of this retirement, in the last years, the responsibilities and opportunities were gradually given to the younger generation, who is happy and confident that they can continue the pioneering research as started by Albert van den Berg. By keeping the network, existing collaborations, and lab facilities in combination with a team of diverse junior scientists, a smooth transition is ongoing.

Smooth transition

This clearly shows how old white men are of value for the younger generation; by giving them opportunities to grow and take over responsibilities, while being around to give support and advice if needed.

From graduates to ChipTech Twente

During the past decade, a local ecosystem has been developed around the Integrated Circuit Design Group of EE@UT. Attracted by a steady outflow of high-quality talent, nine analog/RF chip design companies are active in the university's region, see Table D.12.

Local eco-system

Chip design

In 2007, Axiom IC started as a spin-off company of the ICD group and was later acquired by Teledyne Dalsa. Its digital audio activities lead to the spin-off of another company, Axign (now Monolithic Power Systems). A few years ago, Ansem (now Cyient) and ItoM (now Bosch) also opened design centers in Twente, where the vicinity of the ICD group motivated this decision. Together with these and other companies like Bruco, Renesas, Chain IC, Sencure, and MEMSIC, the ICD group is at the heart of a flourishing mixed-signal IC design ecosystem where many of our graduates find jobs in the vicinity, and where we collaborate intensively in research projects and internships.

Spin-off

ICD at the heart

In 2022, the ChipTech Twente [90] initiative was created to bring together the analog/RF chip design industries and other companies working on chip-related products, like sensors, actuators, and chip-machine builders. Focus points are (1) electronic chip design, (2) heterogeneous integration, and (3) realization of a heterogeneous fab. The initiative has drawn national and international attention and has put Twente on the map for businesses. The importance of the activities in ChipTech Twente is likely to increase further in light of the European Union's ambition of achieving strategic autonomy in key technologies (as set out, for example, in the European Chips Act [6]).

Analog/RF

Heterogenous Fab

Personalised eHealth technology

Why personalised eHealth? Personalised eHealth is essential to help solve challenges we are facing in our healthcare system, specifically for people with chronic conditions. Personalised eHealth moves beyond traditional one-size-fits-all approaches towards a patient-centred approach. Benefits will arise from prevention of disease progression, earlier treatment, and reduced healthcare utilisation.

PeHT

eHealth as a research programme. In 2018, the UT started the strategic research programme "Personalized eHealth technology" (PeHT), lead by *prof. Hermie Hermens*, from 2023 by *prof. Monique Tabak*. The mission is to use advances in technology to create innovative personalized eHealth services contributing to sustainable healthcare. The PeHT programme facilitated cross-disciplinarity by coordinating *strong*, *university-wide collaborations*, covering the translational chain from technological development towards sustainable implementation in daily care.

Sustainable Healthcare

Revolving PostDocs

eHealth house

A strong community. PeHT was defined for a period of 5 years with 10 UT groups, labs and facilities from the different faculties with different areas of expertise and application topics involved. PeHT was coordinated from the BSS group (EEMCS), embedded in TechMed, and with strong ties to DSI. Besides the professors from the supervisory board, from each group one or more junior to mid-term career staff were involved in the PeHT community, to facilitate communication and collaborations between the groups. Several post-doc positions were created to increase the scientific focus and to assist in the programme. The *revolving Postdoc concept* supported the postdocs to attract project funding to support and fund their future career at the UT. This was successful, as they were able to attract several (large) funds (e.g. a Veni grant for Annemieke Witteveen), and many continued their career as assistant professors. Another key outcome of the PeHT programme is the creation of the living lab facility "the eHealth house", which is a state-of-the-art living lab available for our research community, educational programmes, and partners.

Acquisition Machine

Multidisciplinary science & innovation. eHealth technology requires multidisciplinary effort: sensing, analysis, decision making, and feedback; as well as other research domains like design, health technology assessment or implementation. PeHT defined *five key research lines* needed to deliver successful personalised eHealth solutions. To facilitate new initiatives and gather funding, the *acquisition machine* presented a new, interdisciplinary way of developing collaborative research proposals in an effective and joyful way. It resulted in many multidisciplinary projects, in the shared believe that only by such multidisciplinary collaborations sustainable eHealth solutions are created. Within PeHT over 23 research projects were granted with an estimated total project budget of ≈75 M€ . It gave the UT a strong research portfolio from small to large-scale projects (incl. Gravitation and Horizon), as well as state-of-the-art innovations towards market uptake (like Diameter [95]).

Structural collaboration

PhDs in residence

eCMC

Long term structural partnerships and network. A key outcome of the PeHT programme is the sustainable and structural collaboration with key partners within our network of hospitals and companies. This is underlined by structural collaboration agreements (e.g. ZGT, Ancora Health), shared (research) initiatives, and mutual and dual UT - hospital appointments, e.g. of clinical professors. This guarantees we are not solely technology - focused but also healthcare - challenge driven, enforcing the role of society (patients, healthcare) as key player in the success of eHealth technologies. UT education on eHealth was impacted by taking eHealth technology education to daily practice and vice versa. This is done by means of challenge-based education, and by PhDs in residence, which have a primary appointment in a hospital, helping to directly valorise knowledge. A major outcome of the PeHT programme is that the UT, with all its partners, is recognised as national key player in Personalised eHealth Technology. This is underlined by the involvement and solid acquisition record in large initiatives on strategic level and large-scale research and innovation projects; Caretech, ICMS, Topfit, or Health Holland Missie teams. One of the insights from PeHT is that there is a need for an umbrella organisation that bundles and transfers the broad knowledge & services from and within the network to support them in in fast forwarding eHealth innovation to daily care. The expertise Centre for Monitoring and Coaching (eCMC) [56] – creates the open door to society and facilitates impact beyond the end of the programme.

Collaboration with impact

The future of eHealth at UT. Joined efforts and increased collaboration between PeHT partners have resulted in a vivid sustainable community that lives beyond the end of the program. The impact of PeHT does not extinguish; on the contrary the volume and quality of activities are larger and better than ever as underlined by the present substantial portfolio of large, long-lasting projects and in which UT has a clear niche role. The addition of new staff members in eHealth, funded by the recent SPTII funding, and by the facility "the eHealth house" strongly further emphasises that personalised eHealth technology has become one of our competitive highlights. Together with a new generation of (upcoming) professors from various disciplines (e.g. *prof. Tabak*, *prof. Koffijberg*, *dr. Kelders*, *dr. van Keulen*), UT is giving a fresh impulse to our position as a university in the field of eHealth. UT has a clear MedTech profile for eHealth technology and a unique asset: *well established inter-disciplinary collaboration that impacts healthcare and society*.

B

Key Publications

1. T. Hartman, B. ten Have, N. Moonen and F. Leferink, *How to Earn Money with an EMI Problem: Static Energy Meters Running Backwards*, 2021 IEEE International Joint EMC/SI/PI and EMC Europe Symposium, Raleigh, NC, USA, 2021, pp. 788-793

   This work is relevant to society as it addresses a critical issue regarding the increasing use of non-linear appliances in households. This may affect the Energy Meters outputs on energy efficiency and billing accuracy, leading to energy consumer mistrust and loss of confidence in their energy bills. Due to financial implications for consumers this work paves the way for policy and regulation change.

2. B. Boom, A. Bertolini, E. Hennes, R. Brookhuis, R. Wiegerink, J. Van Den Brand, M. Beker, A. Oner, D. Van Wees, *Nano-G accelerometer using geometric anti-springs*, 2017, Proc. of the IEEE International Conference on Micro Electro Mechanical Systems (MEMS), art. no. 7863332, pp. 33 - 36

   An accelerometer was designed and realised, with the final goal to construct an array of highly sensitive seismometers around the gravitational wave experiment Virgo. To that purpose, a novel approach allowed for world record low noise performance, leading to a best-in-class sensitivity below 2 ng/$\sqrt{\text{Hz}}$. The accelerometer is now commercially available from Innoseis Sensor Technologies BV.

3. B. Venzac, S. Deng, Z. Mahmoud, A. Lenferink, A. Costa, F. Bray, C. Otto, C. Rolando, S. Le Gac, *PDMS curing inhibition on 3D printed-molds: Why? And, how to avoid it?*, Analytical Chemistry, 2021, 93, 19, 7180–7187.

   3D printing techniques are becoming ubiquitous in many fields, including the fabrication of microfluidic devices. The most appropriate 3D printing approach to create "small" structures is SLA (stereolithography). Yet, the formulation of the SLA resins is very complex and a common problem encountered with these materials is the release of unknown chemicals. These leachates can interfere with processes conducted in microfluidic devices and compromise the viability of biological materials introduced in these devices. In this paper, we have systematically studied 16 commercial resins, proposed post-treatment approaches to prevent leaching from happening and elucidated mechanisms at play during leaching and post-treatments.

4. J. Reenalda, E. Maartens, L. Homan, J. Buurke. *Continuous three dimensional analysis of running mechanics during a marathon by means of inertial magnetic measurement units to objectify changes in running mechanics*, 2016, Journal of biomechanics 49 (14), 3362-3367

   This publication is illustrative for many other works from the BSS group, which covers the full range from fundamental proof of principle on combined multi-sensor observation and system identification techniques to new concept development and validation in real-life situations associated with societal challenges on health and human performance, like sports and sport-related injuries.

5. C. Hesselman, P. Grosso, R. Holz, F. Kuipers, J. Xue, M. Jonker, J. de Ruiter, A. Sperotto, R.van Rijswijk-Deij, G. Moura, A. Pras, 2020 and C. de Laat, *A responsible internet to increase trust in the digital world*. Journal of Network and Systems Management, 28, pp.882-922.

   This is a key publication in the Internet community, introducing a new paradigm for future design and management thinking regarding the Internet. Based on the ideas described in this paper, a large national project NWO-NWA (2 M€), with UT as lead partner, including TUE, UvA TUDelft, Waag society, KPN, SIDN Labs, and NLnet Labs, collaborating with a large number of partners worldwide has been initiated.

This appendix presents the reactions on the recommendations of the visitation committee of the previous 2011- 2016 assessment.

C

Recommendations 2011-2016 Visitation EE@UT

Recommendations of the assessment committee (in italic) of the previous full-term visitation [96] with responses and developments:

A dialogue on strategy between the research groups planning their future and the leadership of the respective Domains seems ...... highly desirable.

Future Leadership

We have been organising yearly strategy days (so called "Heidagen" in Dutch) on which a common strategy has been discussed. Given the governance of the discipline, as well as the successes of the research groups in attracting funds in collaborations outside EE@UT, the restrictions of many funding schemes (limiting the number of people from one institute that can work together on one project) a common research strategy has been hardly feasible nor felt apropriate.

The Committee advises an evaluation of the newly proposed method of governance after a period of at most a year.

Theme Teams projects

After the governance change from the research institutes to the faculty the influence of the higher management on the research directions of the research groups has decreased. Strategic faculty funds have been used to incentivise research groups to engage in multi-disciplinary research, i.e. crossing the disciplinary boundaries of the 3 EEMCS disciplines in the earlier mentioned Theme Teams projects, related to focal points of the faculty. These projects are well appreciated but do, however, only form a small part of the entire EE@UT port-folio of research projects. As the EEMCS faculty has kept the normative research budget model constant for quite some years, and mostly refrained from steering research activities by financial means (except for PE and RS), the research groups have used this freedom to do what they are good at: securing research interest and funding in the 2nd and 3rd tiers (see section 1.3) on the basis of their expertise, quality and academic and societal partners. Nevertheless, the new multi-annual strategy plan of the faculty also addresses research strategy and priorities at the faculty level, involving all three disciplines.

Increase the fraction of contract research in your port-folio.

Contract research

The ratio of contract research volume in the 3rd tier to research volume in the 2nd tier has increased from about 84% in 2017 to about 233% in 2022. This is certainly high compared to our sister disciplines where the ratios are 83% for CS and 95% for AM (2023 numbers).

Rejuvenation of the leadership in the groups

New top figures

Following the establishment of the RS and PE groups, as well as the (evolving) changes in leadership in various groups (see Table C.1), top figures in the various groups are now much younger (see the cases provided in Appendix A). Overall, by attracting many young researchers (and technicians) in the last years, we think we have ample talented staff to safeguard future scientific quality and leadership.

Table C.1
Some noteworthy leadership rejuvenation

Group	Previous members	New members
BIOS	Albert van den Berg, Jan Eijkel, Wouter Olthuis	Loes Segerink, Mathieu Odijk, Serge Put
BSS	Hermie Hermens, Peter Veltink	Monique Tabak, Jan Buitenweg
CAES	Gerard Smit, Hans Kerkhoff	Ana-Lucia Varbanescu, Marco Ottavi
RAM	Kees Slump, Ferdi van der Heijden	Can Ozan Tan, Kenan Niu

Greater diversity and better gender-balance

More female staff

Since the previous full-term assessment there has been a significant staff addition, not in the least due to SPT-I and II, increasing age-, and cultural- diversity and improving gender balance. With reference to Table E.2 and Figure E.2, in all function categories, except for associate professors which fraction remained almost constant, the percentage female scientific personnel has increased between 2017 and 2022. By appointments the percentage of female full professor more than doubled from 6% to 13%, whereas the fraction of female assistant professors increased from 29% to 41%.

Good attendance of conferences and valuation of conference contributions
From the analysis of our scientific output, Table D.2 and Figure D.1, we see that the ratio of conference contributions to journal articles fluctuates somewhat over the years between 70% and 100% showing a nice balance in our journal output and conference contributions. Note that climate change considerations cause us to attend conferences less, especially where intercontinental flight is involved.

Conference attendance on par

Actions by the faculty to improve the (timely) success rate of PhD students
Within the Twente Graduate School (TGS) it is now obligatory that each PhD student has a second supervisor, which can be helpful in conflicts. Figure 2.3 showed that the ratio of temporary scientific staff to permanent scientific staff was reduced by 28% which, everything else being equal, means that permanent staff should have more time for coaching. However, there are too many unknowns (e.g. required time for teaching and administrative tasks) to draw this conclusion but nevertheless it is a development in the right direction. Further, potential improvement of PhD success rate is highly muddled by the COVID-19 pandemic which has had rather adverse effects on average PhD duration.

More coaching

Strengthen the efforts for regular coordinated actions for the common area of EE
As described before, the 3 EE departments in the NL have created the “Raad voor Elektrotechniek” (EE-NL) but are still somewhat struggling to find the appropriate form and gain momentum.

EE-NL

Leadership transfer at the
Biomedical-Signals & Systems group

Click on the image to know more

D

Supporting data KPIs

This appendix provides the data for the our discusion on the Key Performance Indicators (KPIs) as included in chapter 3.

Table D.1
Key Performance Indicators

	Quality domains	
Assessment Dimensions	Research quality	Relevance to society
Demonstrable products	**1. Research products for peers** a. Articles, conference contributions, PhD dissertations b. OA Datasets and software	**4. Research products for societal target groups** a. Sufficient, well-educated BSc, MSc and PhDs. b. Spin-off and start-up companies
Demonstrable use of products	**2. Use of research products by peers** a. References to our research	**5. Use of research products by societal groups** a. Technical products (designs, software, methods, and patents)
Demonstrable marks of recognition	**3. Marks of recognition from peers** a. Major awards and grants (ERC, Veni, Vidi, Vici, large research grants) b. Keynote Lectures c. Senior positions in research projects and related organisations	**6. Marks of recognition by societal groups/companies** a. Long-term research collaboration with industry b. Outreach to the general public

KPI 1a: Publications

Table D.2 shows the publications of EE@UT, distributed over the various output types.

Table D.2
Various types of output versus year of publication

(Data from PURE [38])

	2016	2017	2018	2019	2020	2021	2022	2023
Refereed (journal) articles	188	183	211	197	255	253	231	208
Non-refereed articles	3	0	3	3	4	3	2	1
Book chapters	8	14	8	7	7	20	15	8
Books	1	1	1	2	2	0	0	0
PhD theses	32	27	32	37	24	26	32	33
Refereed conference papers	160	143	178	191	185	176	180	178
Non-refereed conference papers	20	9	11	11	4	2	3	1
Professional publications	11	12	15	11	24	27	14	14
Publications aimed at the general public	1	0	0	1	0	3	4	3
Other research output	20	9	41	50	15	46	28	27
Patents	6	3	8	4	1	1	0	0
Total publications	444	398	500	510	520	556	509	473

Figure D.1 (left) indicates that the relative numbers of conference contributions and articles fluctuates somewhat over the years but is on average comparable. Note that both the ratio of temporary staff to permanent staff (Figure E.1, right) and the ratio of output to permanent staff (Figure D.1, right) diminish over the years. Possible explanations are that the permanent staff seldom finds time to write their own papers and strongly depends on the PhD students and postdoctoral fellows to generate new scientific results and corresponding output.

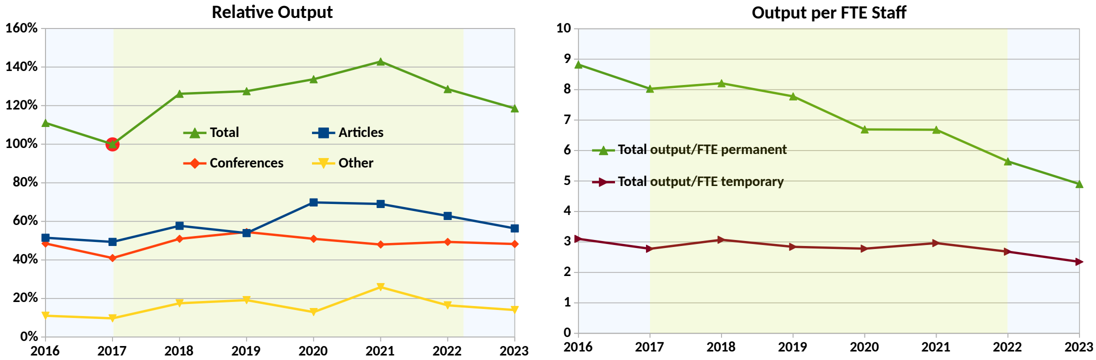


Figure D.1

Publications normalised to total output 2017 (left).

Output per permanent and temporary scientific FTE (right).

(See Table D.2 and Table E.1)

Table D.3
Various types of OA output versus year of publication

(Data from Open Alex [97]) and Pure [38])

	2016	2017	2018	2019	2020	2021	2022	2023
Gold(1)	12%	14%	15%	14%	15%	20%	18%	15%
Gold Hybrid	8%	12%	13%	17%	17%	21%	15%	15%
Bronze	4%	5%	5%	5%	7%	4%	7%	10%
Green only(2)	51%	47%	41%	43%	50%	45%	42%	16%
Total	75%	78%	75%	79%	89%	90%	83%	55%
Found as green (3)	63%	66%	65%	69%	78%	75%	67%	21%
Closed	25%	22%	25%	21%	11%	10%	17%	45%

(1) For definition of OA colours see e.g. [98, 99]
(2) Found as green but excluding gold, gold hybrid and bronze
(3) Found as green including gold, gold hybrid and bronze

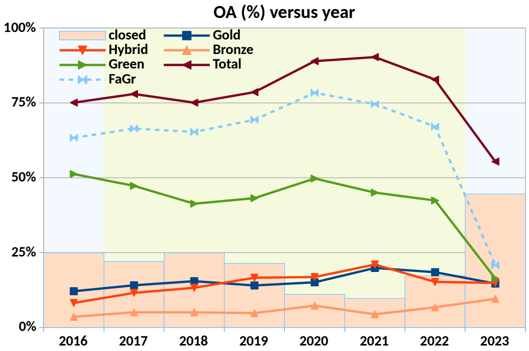
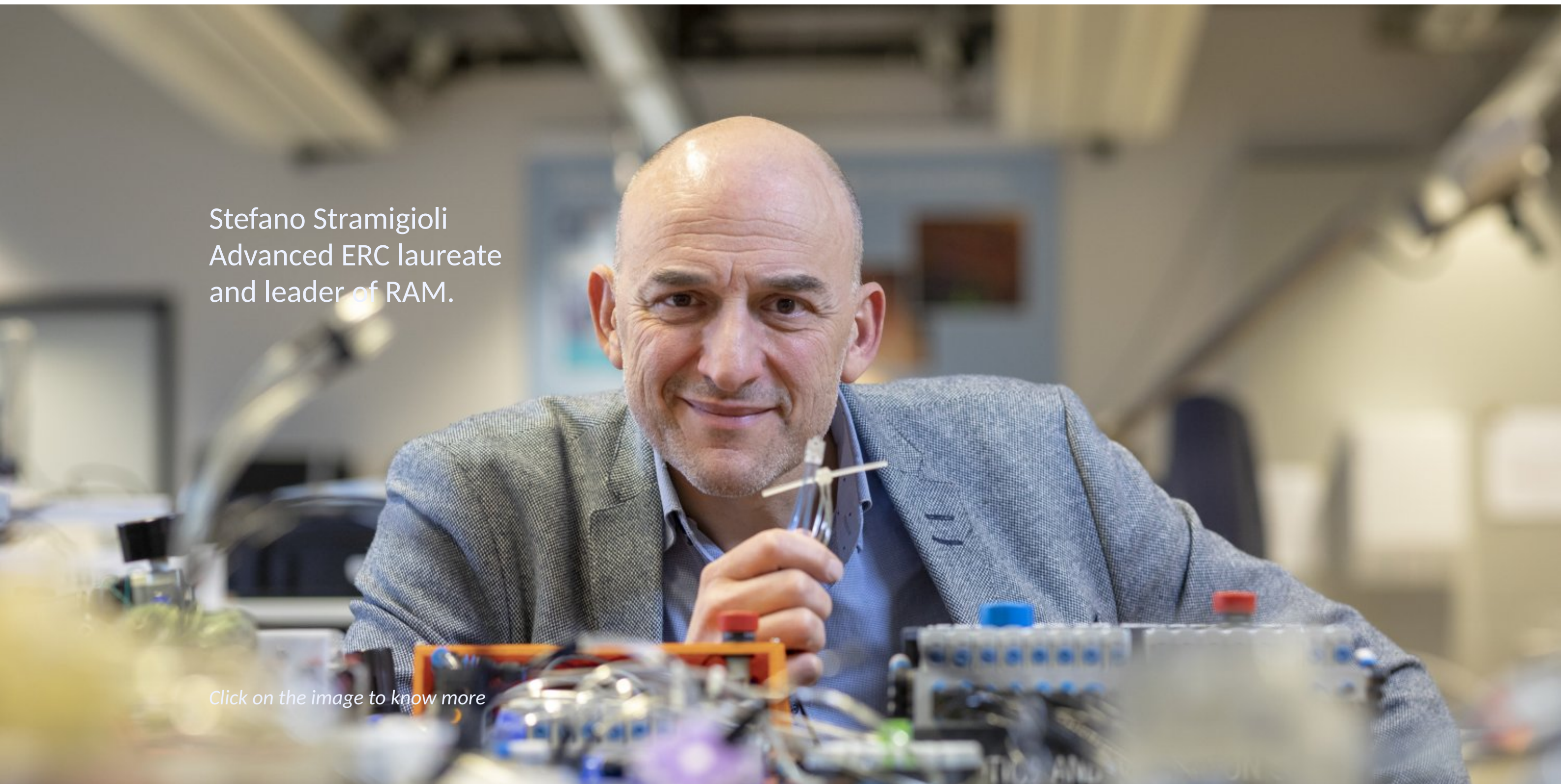


Figure D.2

Fractional Open Access publications.

(Based on Table D.3)



Stefano Stramigioli
Advanced ERC laureate
and leader of RAM.

Click on the image to know more

KPI 1b: Open data-sets and software code

Table D.4 Open datasets & software code

Year	Author	Title	Dow-loads
2015	Roland van Rijswijk-Deij	OpenINTEL, ongoing measurement data of Internet DNS data. 67 publications, based on the data up to 2023	
2017	Benneker, A. et. al	Desalination by Electrodialysis Using a Stack of Patterned Ion-Selective Hydrogels on a Microfluidic Device	355
2018	Benneker, A. et. al	Enhanced ion transport using geometrically structured charge selective iinterfaces	238
2020	Schwarz, A. et. al	Kinematics of reach-to-grasp and displacement after stroke	106
2020	Apriyanti, D. et. al	Orchid Flowers Dataset	1183
2020	Dolmans, T., et. al	Perceived Mental Workload Detection using Multimodal Physiological Data - Deep Learning, GitHub Linked	639
2021	Thammasan, N. et. al	Data underlying the publication “Exploring the Brain Activity Related to Missing Penalty Kicks: An fNIRS Study”.	3331
2021	Thammasan, N. et. al	Data underlying the publication “Detecting Fear of Heights Response to a Virtual Reality Environment Using Functional Near-Infrared Spectroscopy”	2607
2021	Mauritz, R., et. al	Source code for “Autoencoder-based cleaning in probabilistic databases”	27
2021	Dijkshoorn, A. et. al	Model Code of Anisotropic Electrical Conduction in Layered 3D-Prints with Fused Deposition Modeling	162
2022	Heredia Deba, S. et. al.	Data underlying the publication: Photocatalytic ceramic membrane: Effect of the illumination intensity and distribution	262
2022	Zandbergen, M. et. al	Dataset used for manuscript: Drift-Free 3D Orientation and Displacement (DFOD) estimation for quasi-cyclical movements using one inertial measurement unit: Application to running	584
2022	Schouten, M. et. al	Inductive 3D printer XY calibration GUI	110
2022	Schouten, M. et. al	Summation of currents electromagnetic solver	94
2022	Schouten, M. et. al	Automated xy calibration for 3D printers using a scanner	125
2023	Schouten, M. et. al	TiePieLCR Hardware	1
2023	Wouda, F. et. al	Data and software underlying the publication: Foot progression angle estimation using a single foot-worn inertial sensor	51
2023	Oprel, J. et. al	Models and Optimization Tools for a Novel 3D Printed Capacitive Shear Stress Sensor	986
2023	Zandbergen, N., et al.	QuestionMark	10
2023	Schouten, M. et. al	TiePieLCR GUI	1
2023	Schouten, M. et. al	1-dof setup	27
2024	Dijkshoorn, A. et. al	Model Code Modelling, Characterisation and Visualization of Anisotropic Electrical Behaviour in Cuboids of Fused-Deposition-Modelling 3D Prints	

KPI 2a: References to our work

Table D.5
Some output metrics

(Based on output in Table D.2)

	2016	2017	2018	2019	2020	2021	2022	2023	Average
Citations per Publication	17.9	17.4	15.6	13.3	12.0	9.8	4.3	1.0	12.3
Field-Weighted Citation Index(1)	1.1	1.3	1.1	1.2	1.1	1.2	1.3	1.2	1.2
Output in Top 10% Citation Percentiles (field-weighted, %)(1)	16.9%	14.9%	11.3%	17.5%	12.4%	14.2%	16.0%	16.1%	14.8%
Publications in Top Journal Percentiles (top 10% by CiteScore Percentile)	35.4%	31.5%	35.8%	28.9%	36.6%	39.1%	27.9%	35.3%	33.8%
(1)	Determined for the mix of articles, reviews and conference contributions								

KPI 3a: Major awards and grants

Table D.6
Major Awards

	<2017	2017	2018	2019	2020	2021	2022	2023
Veni	8				1	3	2	
Vidi	3						1	
Vici	2						1	
Simon Stevin Master	3							
Spinoza Prize	1							
Simon Stevin Prize								1
ERC Starting grant	2						1	1
ERC Advanced Grant	3		1	1				
IEEE Fellow Recognition	2			1	1			1
Honorary Prof. UT	2 (ongoing)							

Table D.7 Marks of recognition from peers: personal grants, prizes and appointments

Group	Year	Recognition	Budget
AMBER	2022	Kirsten Pondman, VENI, Circulating tumor cells: together we triumph, divided we fall	280 k€
BIOS	2017	Albert van den Berg, Consultant Professor at NPU, Xian, China	
	2018	Albert van den Berg, Visiting professor at EPFL Lausanne (CH)	
		Albert van den Berg: Chairman Nano4Society (before: NanoNextNL)	
		Albert van den Berg: co-founder EUROOCS (EuropeanOrgan on Chip Society)	
		Albert van den Berg and Jan Eijkel: visiting prof at SCNU and NPU (China)	
		Albert van den Berg 4th ERC Proof of Concept grant Organ on Chip research	
		Princes Maxima centrum/UT/Tobias Sybesma foundation (cancer research), collaboration	>5 temporary acad. FTE
	2022	Dr Tim Segers, ERC Starting grant: Diagnostics by listening to bubble echoes (MICOMAUS)	1.5 M€
		Nienke van Dongen, NCKF Spotlight award	
	2023	Ruben Kolkman, Rubicon award	
BSS	2017	De Diameter	50 k€
	2018	Annemieke Witteveen, best thesis in oncology of 2018/2019 of the Netherlands and Belgium	
	2020	Annemieke Witteveen: NWO-ZonMW Veni	250 k€
	2022	Annemieke Witteveen, Royal Academy of Science (KNAW) Early Career Award for innovative and original research	
	2023	Bettina Schwab, ERC Starting grant: Desynchronizing weak cortical fields during deep brain simulation	1.5 M€
	2023	Annemieke Witteveen, Henk Stassen Award for connecting medical and technical sciences (2023)	
		Annemieke Witteveen, nominated for the New Scientist Science Talent Prize	
CAES	2019	Baver Ozceylan, Boudewijn R. Haverkort, Maurits de Graaf, Marco E. T. Gerards, The Harvey Rosten Award for Excellence	
	2022	Kuan-Husn Chen, Promotion by SIGDA at “Who is who”	
DACS	2017	Hans van den Berg: Arne Jensen Lifetime Achievement Award, ITC	
	2018	Roland van Rijswijk-Deij et al., Dutch Data Prize for OpenINTEL	
	2019	Anna Sperotto 2019 rising stars in computer networking and communications	
	2020	Roland van Rijswijk-Deij: KHMW Kees Schouwhamer Immink Prize	
		Roland van Rijswijk-Deij: IEEE TCI Rising Star Award	
		Aiko Pras: Research Coordinator Concordia Cybersecurity Competence Network	
	2022	Roland van Rijswijk-Deij, VIDI, Towards a systematic holistic approach for re-engineering a quantum-safe internet	800 k€
ICD	2017	Bram Nauta, Fellow of the Royal Netherlands Academy of Arts and Sciences (KNAW)	
	2019	Bram Nauta, EU Horizon 2020 ERC Advanced Grant: HIGH RISK NO GAIN	2.475 M€
	2020	Eric Klumperink, IEEE Fellow	
	2022	Hariot Bindra, VENI, Creating electronics for making sensors work without batteries	280 k€
	2023	Bram Nauta	
		Simon Stevin Prize	1.5 M€
		IEEE International Solid-State Circuits Conference Author-Recognition Award for its first 70 years, as a top 10 contributor	
		Bram Nauta, recipient of the inaugural “Dutch Innovation Award”	
IDS	2022	Lis Nanver, guest researcher at Aalborg University, Denmark (from 2015 onwards).	
NE	2021	Hans-Christian Ruiz, VENI, Efficient AI with material-based neural network	280 k€
	2022	Floris Zwanenburg, VICI, Single-atom quantum coherence	1.5 M€
PE	2014>	Gert Rietveld, member of the CIPM, the governance board of the international bureau of weights and measures (BIPM)	
	2017	Frank Leferink “UT in Media Prize 2017”. The trigger article has been downloaded 4869, but it is not OA. The UT website had highest number of visitors on one day ever.	
	2018	Frank Leferink:Vice-Chair EMC Europe conferences	
	2019	Frank Leferink: IEEE fellow	
		Frank Leferink: re-appointed Honorary professor EMC, University of Nottingham, UK	
	2020	Frank Leferink: appointed Ambassador Chair KU Leuven, Belgium	
	2021	Jelena Popović, Vice-Chair of Empower a Billion Lives with the IEEE PELS society	
		Tom Hartman recipient of the 2021 President Memorial Award of the IEEE EMC society	
	2023	Best IEEE Transactions on Electromagnetic Compatibility Paper Award, Tom Hartman et al.,“Susceptibility of Static Energy Meters Due to Amplifier Clipping Caused by a Rogowski Coil”	
	2023	Jelena Popović Global Chair of Empower a Billion Lives with the IEEE PELS society	
RAM	2018	Stefano Stramigioli ERC Advanced grant Portwings	2.8 M€
		ReElection of Stefano Stramigioli as Vice President Research euRobotics [91]	
		Stefano Stramigioli: member KHMW	
	2020	Stramigioli: Incoming Vice President IEEE Robotics and Automation MAB	
	2022	Stefano Stramigioli, ERC Proof-of-Concept: Printing Electro-Tomography	150 k€
		Antonio Franchi double affiliation with Sapienza University of Rome, Rome, Italy	
		Sihao Sun, VENI, “Accurate Aerial Robotic Manipulation under Uncertainties”	280 k€
		Chiara Gabellieri, Marie Skłodowska-Curie Actions FlyFlic (MSCA ID: 101059875)	187 k€
	2023	Antonio Franchi IEEE Fellow	
RS	2020	Yang Miao, Marie Skłodowska-Curie Actions H2020 Individual Fellow	
	2022	Anastasia Lavrenko, VENI, Beyond bugging - wireless sensing and monitoring with harmonic radar	280 k€

Table D.8 Overview of project acquisition > 200 k€ (continued on next page)

Group	Year	Project	Budget
AMBER	2017	Séverine Le Gac, co-PI Interreg Elasto-Tweezers	
	2019	Séverine Le Gac, TKI-LSH HOOCS	430 k€
	2020	Séverine Le Gac, TKI-LSH QoroNano	231 k€
	2021	Séverine Le Gac, co-PI TKI-LSH/ZonMw MOMENTUM 1.0	
		Séverine Le Gac, PI OTP FibOoC	
	2022	Séverine Le Gac, Groeifonds NL, NXTGEN Hightech	203 k€
		Séverine Le Gac, PI NWO-M2 LivMetOoC	
		Séverine Le Gac, co-PI ATTRACT 2 Unicorn-Dx	
		Séverine Le Gac, co-PI OoC-Dev (with BIOS)	
BIOS	2017	PI en co-PI zwaartekracht proposal NOCI	19.2 M€, UT 3.5 M€
	2018	PI, Grant from 'stichting de Weijerhorst', cancer research	1.8 M€ (+0.46 M€ TKI)
		MCEC 2nd phase: 12 M€, UT 2.2 M€	
	2019	PI H2020 Electromed	550 k€
	2020	Keygene	450 k€
		Perspectief Smart OOC	2.2 M€, UT 500 k€
		co-PI EU H2020 Digipredict	4 M€, UT 800 k€
	2022	Groeifonds NL, NXTGEN Hightech	1.6 M€
		Ligalli financing	1.1 M€
		Continuation NOCI (NWO zwaartekracht)	
		NWA NanoEspresso	8.1 M€ , UT 425 k€
	2023	NWO/KWF 4WWW	1.1 M€ , UT 400 k€
		NWA Criminal Investigation Dx, co-PI	4.5 M€ , UT 330 k€
		NWO Research Infrastructure Organ-on-Chip Development Center	
		PI EU Horizon RealCare	11 M€ , UT 1.6 M€
		EIC Transition grant 3DCardiacHTS – River Biomedics [100]	
	2024	EIC Transition grant δypha – Sync Biosystems [101]	
BSS	2017	EU (coordination) - COUCH	545 k€
	2018	WO-ZonMW - E-manager	340 k€
		U-EFRO - PROMPT	400k €
		Geriatrie Heupfractuur	225 k€
	2019	NWO-Commit2Data (coordination) - EDIC	543 k€
		TKI - Personalized AP	412 k€
		U - Phara-on	490 k€
		Topfit Citizenlab	249 k€
	2020	Jan Buitenweg: TKI project Nocitune	580 k€
		WO - Perfect Fit	335 k€
		NWO-TTW - PARTNR	650 k€
		NWO-cross-over - INTENSE	287 k€
		FRO - INSTANT	258 k€
CAES	2017	STW: ULPT: Ultra-low power transponders for vulnerable road side users	434 k€
		STW: APSN-CAES Autonomous parking sensor networks	214 k€
		STW: ARM Autonomous roadside monitoring	426 k€
		STW: UT 5G Upconverting transmitters for 5g power efficiency in digital and analogue	286 k€
		Penta Project Hades	1.3 M€, UT 613 k€
	2018	NWO: EDLP Efficient deep learning platforms	218 k€
		Energy projects, collaboration with MOR and/or BMS:	
	2019	- OP-OOST EFRO "Vliegwieltechnologie voor energieopslag in microgrids"	2.6 M€, UT 250 k€
		- NWO Cybersecurity Project ISOLATE	250 k€
	2020	- H2020 Project SERENE	805 k€
		- H2020 Project SUSTENANCE	700 k€
		- RVO TKI FAIRPLAY	1.2 M€, UT 220 k€
		- RVO DEI+ Buurtbatterij in de Weverij	452 k€
	2021	NWO Perspective MEGAMIND (2021 - 2025)	262 k€
	2022	2020 TRISTAN (Together for RISC-V Technology and Applications)	509 k€
	2023	H2020 GraphMassivizer (2023-2026, 1PhD+1PD)	378 k€
DACS	2018	Concordia (EU Horizon 2020)	16 M€, UT 500 k€
		MADDVIPR	252 k€
	2020	UPINk	264 k€
		Intersect (NWO NWA ORC)	8 M€, UT 744 k€
		MASCOT	440 k€
	2021	CATRIN	786 k€
	2023	NWO Perspectief Xcarcity?	577 k€
	2023	IPCEI Modular Integrated Sustainable Data Centers	2.3 M€
	2023	Growthfund 6G Future Network Services - phase 1	320 k€

Table D.8 Overview of project acquisition > 200 k€ (continued)

Group	Year	Project	Budget
DMB	2018	State of the art of Morphing Detection	1.2 M€, UT 202 k€
	2020	MC-ITN PriMa, UT coordinator	14 aio's, 3.83 M€
	2020	EU image Manipulation Attack Resolving Solutions	6,5 M€, UT 450 k€
ICD	2017	STW: APSN-ICD Autonomous parking sensor networks	214 k€
		STW: UT 5G Upconverting transmitters for 5g power efficiency in digital and analogue	325 k€
		Agentschap NL: Varsities 1	313 k€
		Agentschap NL: Varsities 2	313 k€
	2019	EU Horizon 2020: HIGH RISK NO GAIN	2.475 M€
ICD/IDS	2018	4.TU project Plantenna	960 k€
IDS	2017	Interreg: XTC ID Extreme temperatuur chip radio frequentie identificatie technologie	322 k€
	2018	NWO: EX3VAGAND Energy efficient electron GaN devices	270 k€
		Agentschap NL: HAVALDAR High added value atomic layer deposition apparatus and recipes	697 k€
	2019	NWO: Synoptic optics	372 k€
NE	2017	NWS Startimpuls	400 k€
	2018	FLAG-ERA	800 k€
	2019	NWO Vrij Programma	3 M€ , UT 400 k€
		FETOPEN coordinator	3.1 M€ , UT 900 k€
	2020	ENW Groot: Higher Order Topological Nano Devices (HOTNANO)	2.2 MEUR, UT 1.2 M€
		FET FLAG	14.5 M€ , UT 400 k€
PE	2017	EMPIR (H2020) MeterEMI	313.6 k€
	2018	MSCA (H2020) SCENT, UT coordinator	1.02 M€ (of € 2.26 M€)
		MSCA (H2020) PETER	495 k€
	2019	MSCA (H2020) ETOPIA, UT coordinator	795 k€ (of 3 M€)
		Shenzhen-Twente Power Electronics	3 M€
	2020	STEPs	246 k€
		MSCA(H2020) ETERNITY	315 k€
		MSCA(H2020) ETUT, UT coordinator	1.24 M€ (of 3.16 M€)
		MSCA belongs with ERC to Pillar1: Excellence Science, of the EU. applications: 7% success rate	
		NWO ANRGI, UT coordinator	690 k€
	2021	B-POWER	576 k€
	2021	AMBIFALENT	332 k€
	2022	TEXAS INSTRUM. II 150k€	
	2022	Groeifonds NL, Aviation	2 M€
	2023	PowerizeD	609 k€
		SEANERGETIC	288 k€
		Maritime Batteries	304 k€
		NWO Pathways	315 k€
RAM	2017	Softpro EU	380 k€
	2018	Wearable Robotics	236 k€
		4TU Soft Robotics	277 k€
	2019	EU DIH-HERO, UT Coordinator	16 M€, UT 1.7 M€
		EU WEAFING: Wearable electroactive fabrics	UT: 294 k€
		EU RIMA, Robotics for infrastructure and maintenance	UT 346 k€
		EU H2020 AerialCore	750 k€
		NWO Perspectief programme FlexCraft	
	2022	NWO OTP "FIT-UP"	248 k€
RS	2019	STW Analog Approximate Accelerators	1.2 M€
	2020	EU H2020, Integrated Telematics for Next Generation 5G Vehicular Communications	488 k€
	2022	STW 3D-ComS - Towards-6G mmWave NanoCell: 3D Base Station for Joint Communication and Sensing	902k€
		4TU HTSF Green Sensors (June 22)	612 k€

KPI 3b: Keynote lectures

Table D.9 Keynotes

Group	Year	Keynote
AMBER	2016	Séverine Le Gac, Keynote @ MicroTAS, “Drug Screening On 3D Tumor Spheroids”
	2016	Séverine Le Gac, “Drug Screening on 3D tumor spheroids”, Keynote, MicroTAS conference
	2018	Séverine Le Gac, “From microfluidic technology to organ-on-a-chip platforms: new opportunities to develop physiologically relevant in vitro models”, Keynote, MicroNanoFluidics
	2019	Séverine Le Gac, “Organ-on-a-chip platforms for nanomedicine screening and assisted reproductive technologies”, Keynote, SMILS - Swedish Microfluidics in Life Sciences,
	2022	Séverine Le Gac, “Organ-on-chip models for assisted reproduction”, Keynote, MicroTAS, in-person and virtual
	2022	Séverine Le Gac, Keynote @ MicroTAS, “Organ-On-Chip Models For Assisted Reproduction”
	2023	Séverine Le Gac, “Organ-on-chip models for biological and medical applications”, Plenary lecture, MicroTAS conference
	2023	Séverine Le Gac, “Organ-on-a-chip platforms for biological and medical applications”, Keynote , SMILS - Swedish Microfluidics in Life Sciences
BIOS	2023	Loes Segerink, Plenary lecture @ Eurosensors“Technological challenges in organ on chips”
	2023	Loes Segerink, presentation at the “Gala van de Wetenschap”
CAES	2019	Hans Kerkhof, ITC-Asia 2019, “Highly Dependable Many-Processor Systems-on-Chips for Cars”
	2023	Kuan-Hsun Chen, Keynote @ CTHPC 2023, “Good Old Trees along with Emerging Memories”
	2024	Kuan-Hsun Chen: Invited Presentation @ DATE 2024 Special Session “Sustainable Computing”: “Timely vs. In Time: A perspective in real-time systems”
DACS	2016	Aiko Pras: Keynote presentation at IEEE/IFIP Network Operations and Management Symposium
	2016	Geert Heijenk: Invited presentation at IEEE Vehicular Technology Society Workshop on Wireless Vehicular Communications, Halmstad
	2018	Aiko Pras: Keynote ACM SIGCOMM 2018 Workshop on Traffic Measurements for Cybersecurity
	2019	Geert Heijenk: Keynote presentation at the 17th International Conference on Wired/Wireless Internet Communications (IFIP WWIC)
	2019	Geert Heijenk: Keynote presentation at IEEE Wireless Days, Manchester
	2022	Ralph Holz, Keynote at CompSys 2022
	2022	Suzan Bayhan, Invited presentation IEEE HPSR 2022 “Leveraging Machine Learning for Spectrum Sharing in Wireless Networks”
ICD	2021	Bram Nauta MS & RFIC 2021 keynote “Transceiver Roadmap for 2035 and Beyond”
IDS	2018	J. Schmitz. “Microchip innovations after the era of transistor miniaturization”, MASER symposium, Enschede 2018-11-22.
	2022	J. Schmitz, “Reliability in the era of the energy transition, ARES2022 (reliability symposium ASML), Veldhoven.
PE	2016	Frank Leferink, Keynote speaker Asia-Pacific EMC Conference
	2020	Bram Ferreira, Keynote Power Electronics and Energy Storage Event “Surfing the opportunity that the Energy Transition Wave Wil Bring about for Fledgling power electronic based enterprises”
	2021	Jelana Popović, 21st International Symposium on POWER ELECTRONICS Ee2021, “Energy Access – challenges and opportunities for the power electronics community”
	2021	Gert Rietveld, “Connecting renewables to the electricity grid – measurements supporting the Energy Transition”, keynote 2021 NSERC CREATE TOP-SET workshop, Ottawa, Canada,
	2021	Gert Rietveld and Helko van den Brom, “Impact of power electronics on static electricity meters”, Keynote FHI Power Electronics event
	2022	Jelena Popović Invited as a keynote speaker and panellist at Delft Global Energy Access Ideation Event
	2022	Jelana Popović, IEEE Applied Power Electronics Conference, “Energy Access: Challenges, Opportunities, & our Contributions”
	2023	Gert Rietveld, “From advanced metering to digital substations: an overview of smart grid measurement challenges”, Keynote 2023 SMAGRIMET conference, Cavtat, Croatia
	2023	Thiago Soeiro, Keynote Power Electronics and Energy Storage Event “Opportunity and Challenges for the Dutch industry in the Electrification of Transport in Maritime and Aerospace”
RAM	2018	Stefano Stramigioli, TUM Robotics Symposium “Energy Aware Robotics and Port-Based thinking”
	2020	Stefano Stramigioli, Keynote at Workshop on flapping flight UCLouvain
	2021	Stefano Stramigioli, 7th IFAC Workshop LHMNC21 “Birds, Fluids and Interaction”
	2021	Stefano Stramigioli, Plenary at Lagrangian and Hamiltonian Methods for Nonlinear Control - 7th LHMNC 2021
	2021	Gijs Krijnen, “3D Printing of Physical Sensors for Robotic & Medical Applications”, Flexible Electronics & Printed Sensors conference, online
	2022	Jan Broenink, Invited speaker at “175 years KIvI symposium: Engineering Continuous Transition”
	2023	Chiara Gabellieri, Invited Talk at DroneDays 2023, Zagreb, Croatia. “Present and Future of Aerial manipulation with single and multiple aerial robots”
	2023	Antonio Franchi & Chiara Gabellieri, Invited talk ICRA 2023 Workshop on Energy Efficient Aerial Robotics Systems, london, UK. “Optimally control the tradeoff between manoeuvrability and power consumption in morphing omnidirectional multirotors”
	2023	Giulio Dagnino, Invited talk at ICRA workshop, “Vision-Based Sensing in Endovascular Robotics”, London, UK

KPI 3c: Senior positions in research related organisations

Table D.10
Overview of senior positions in research related organisations

Group	Period	Position
AMBER	2018	Séverine Le Gac: Member of the board of directors of the Chemical & Biological Microsystems Society
	2021 – 2023	Séverine Le Gac: Vice-president of the board of directors of the Chemical & Biological Microsystems Society
	2023 – present	Séverine Le Gac: President of the board of directors of the Chemical & Biological Microsystems Society
BIOS	2014 – 2018	Albert van den Berg, Scientific Director of MIRA - Institute for Biomedical Technology and Technical Medicine
	2016 – 2024	Albert van den Berg, Member of the Raad van Toezicht of MST hospital, Enschede
	2017 – 2023	Albert van den Berg, Chairman section Technical Sciences of the KNAW
	2017 – present	Albert van den Berg, co-PI of 10 yr. Zwaartekracht programme Netherlands Organ on Chip Initiative (NOCI)
	2020	Albert van den Berg, Chairman of Section Applied Sciences of the KNAW
		Albert van den Berg member of the KHMW
		Albert van den Berg and Jan Eijkel: members of Max Planck Center Twente
	2018 – 2022	Scientific (co)-Director of MESA$^+$ Institute for Nanotechnology
	2021 – present	Tim Segers, Board member "Acoustofluidics Society"
	2022 – present	Albert van den Berg, Member of Swiss engineering academy
	2023 – present	Tim Segers, Member of the Young Academy Twente (YAT)
	2023	Albert van den Berg, Quartermaster Climate Centre, University of Twente
	Present	Albert van den Berg:
		- Chairman Nano4Society foundation
		- Scientific advisory board Wyss Institute at Harvard
		- Scientific Advisory board Waterloo Institute for Nanotechnology (Canada)
		- Scientific advisory board ETH Basel BSSE
		- Co-founder of European Organ on Chip Society (EUROoCS)
BSS	2016 – 2022	Jan Buitenweg, board member of the IMDI NeuroControl consortium
	2019 – 2024	Monique Tabak & Hermie Hermens & Annemieke Witteveen, UT Leader / Coordinator Health and Wellbeing track, Digital Society reseach program (VSNU/UNL)
	2020	Monique Tabak, Senior programme committee member IEEE conference ICHI 2020
	2022 – present	Annemieke Witteveen, member Young Academy Twente
	2022 – current	Jan Buitenweg Senior Teaching Fellow and member Comenius Network
	2022 – present	Monique Tabak, Member of the Health Holland national mission team 2
	2023 – present	Monique Tabak, board member Caretech (former IMDIs Sprintt and NeuroControl)
CAES	Ongoing	Marco Ottavi, Associate Professor University of Rome Tor Vergata
	2022 – present	Ana-Lucia Varbanescu, co-chair of IPN FGSN SIG
	2021 – present	Ana-Lucia Varbanescu, EU expert (reviewer) in various panels
	2023 – present	Ana-Lucia Varbanescu, co-chair of IPN EDI Working Group
	2023 – present	Ana-Lucia Varbanescu, FWO (Belgium) expert in the "SBWT5B - Informatics and data communication" panel
		Ana-Lucia Varbanescu – member of IEEE EPCC ICT working group
DACS	2009 - present	Geert Heijenk, steering committee member IEEE Vehicular Networking Conference
	2021 - present	Geert Heijenk, board member ASCI (Advanced School for Computing and Imaging)
	2022 - present	Roland van Rijswijk-Deij, steering committee Traffic Measurements and Analysis conference
	2023 - present	Cristian Hesselman, member Dutch National Cyber Security Council
	2023 - present	Suzan Bayhan, scientific co-director 4TU NIRICT
	- present	Cristian Hesselman, chair supervisory board NLNet Labs
	- present	Anna Sperotto, steering committee member Network traffic Measurement and analysis Conference
DMB	2015-present	Raymond Veldhuis, Chairman of EAB (European Association of Biometrics) Advisory Council
	2015-present	Raymond Veldhuis, Chairman of EAB (European Association of Biometrics) Academia Special Interest Group
	2016-2021	Luuk Spreeuwers, Chairman of IEEE Benelux Chapter on Signal Processing
	2016-2021	Raymond Veldhuis, Treasurer of WIC (Werkgemeenschap voor Informatie- en Communicatietheorie)
	2021-present	Luuk Spreeuwers, Treasurer of WIC (Werkgemeenschap voor Informatie- en Communicatietheorie)
ICD	2010 – 2021	Bram Nauta, Member advisory board State Key Lab, University of Macau
	2012 – present	Bram Nauta, Member advisory board INESC-ID institute, Technical University of Lisbon, Portugal
	2016 –2017	Bram Nauta, Vice President IEEE Solid-State Circuits Society
	2018 – 2020	Bram Nauta, President IEEE Solid-State Circuits Society (10.000+ members)
		Bram Nauta, Member Technical Advisory Board, IEEE (oversees all technical activities inside IEEE)
	2019 – present	Bram Nauta, Board Member Tyndall National Institute, Ireland
	2022 – present	Bram Nauta, Co-Founded the "Chiptech Twente" initiative (to strengthen local eco-system)
	2024 – present	Mark Oude Alink, After previous officer positions: chair of the Joint MTT/AP Chapter IEEE Benelux Section
IDS	All years	Joost Lötters, Member Board of Experts, Nat. Measurement Standards (Dutch ministry of economic affairs)
	2012 – present	Jurriaan Schmitz, Scientific Advisory Committee, Elsevier Solid State Electronics journal
	2016 – 2021	Lis Nanver, Member of expert panel Strategic Basic Research for Res. Foundation Flanders (FWO), Belgium
	2020 – present	Lis Nanver, Scientific Advisory Committee, Elsevier Solid State Electronics journal
	2021	Lis Nanver, Expert Evaluator for the Res. Ass. Exercise, for Royal Institute of Technology (KTH), Sweden.
PE	2017-2022	Frank Leferink, member of the Board of Directors of the IEEE EMC Society
	2018-2021	Frank Leferink, Vice-Chair EMC Europe International Steering Committee
	2023	Thiago Soeiro, member of Advisory Board of PCIM Europe
	2023 - present	Frank Leferink, Vice-President Conferences of the IEEE EMC Society 2023-now
RAM	2015-2023	Stefano Stramigioli, Vice president Research eu-Robotics
	2022 - present	Gijs Krijnen, Management team EE-NL
	2023	Stefano Stramigioli, Vice president Robotics Research ADRA
	2022-2023	Stefano Stramigioli, Vice president MAP IEEE RAS
	2023	Giulio Dagnino, Expert reviewer for the European Commission – HORIZON 2023
	2023 - present	Giulio Dagnino, Research Advisor on Robotic Surgery for the Dept. Surgical Sc., Univ. Turin, Italy
	Ongoing	Françoise Siepel, Lead euRobotics TG Healthcare

Table D.11 Overview of editorial positions and conference organisation

Group	Period	Position
AMBER	2019	Séverine Le Gac: Conference chair of NanoBioTech Montreux
	2017	Séverine Le Gac: IEEE-IEDM conference. Chair of the sub-committeeSensors, Microsystems & BioMEMS & Member of the IEEE-IEDM conference executive committee
	2020	Séverine Le Gac: Conference chair of MicroTAS 2020 together with Prog. Hang Lu (online)
BIOS	– present	Albert van den Berg, Editorial board member Nature Microsystems & Nanoengineering
	– present	Loes Segerink: associate editor Sensors and Actuators A
BSS	2019	Annemieke Witteveen, co-organizer conference 'Mind your data: privacy and legal matters in eHealth' (VSNU)
CAES	2023	Ana-Lucia Varbanescu – program co-chair for CCGrid'23, HiPC 2022, ISC-HPC 2021, workshop co-chair PACT'23, ICPE'21, tutorial co-chair SC'32, track chair SC'23, steering committee ASCI CompSys.
	2024	Kuan-Hsun Chen, Co-Chair for 18th annual workshop on Operating Systems Platforms for Embedded Real-Time applications
DACS	2019	Anna Sperotto, Roland van Rijswijk-Deij, Cristian Hesselman, General chairs ACM Internet Measurement Conference (IMC 2019)
	2021	Geert Heijenk, General chair IFIP IoT 2021
	2022	Anna Sperotto, Roland van Rijswijk-Deij, general chair Network Traffic MEasurement and Analysis Conference (TMA 2022)
	– present	Anna Sperotto, Area Editor for the ACM SIGCOMM Computer Communications Review (CCR)
	– present	Anna Sperotto, Associate Editor for the Journal of Network and Systems Management (JNSM)
	– present	Anna Sperotto, Associate Editor for the International Journal of Network Management (IJNM)
ICD	2018 – present	Mark Oude Alink, Technical Program Committee (TPC) of the Custom Integrated Circuits Conference (CICC)
	2020 & 2021	Mark Oude Alink, Guest Editor for the CICC 2020 and 2021 Special Issues in the Journal of Solid-State Circuits
	2021 – present	Ronan van der Zee, TPC-member in the European Solid-State Electronics Research Conference (ESSERC)
	2022 – present	Bram Nauta, Member core team annual workshop series AACD (Advances in Analog Circuit Design)
		Mark Oude Alink, Associate Editor for IEEE Solid-State Circuits Letters
	2021 – 2023	Harijot Sing Bindra, Associate Editor IEEE Transactions on Circuits and systems, part 1
	2023 – present	Mark Oude Alink, TPC-member in the RF/mmWave subcommittee of the European Solid-State Electronics Research Conference (ESSERC)
	2024 – present	Harijot Sing Bindra, TPC-member in the European Solid-State Electronics Research Conference (ESSERC)
	2024	Ronan van der zee, Guest Editor IEEE Journal of Solid-State Circuits, special issue on ESSCIRC 2023
IDS	All years	Cora Salm, Steering Committee and TPC member, ESREF conference
	2012 – 2017	Jurriaan Schmitz, Associate Editor for IEEE Electron Device Letters
	2012 – present	Jurriaan Schmitz, Scientific Advisory Committee, Elsevier Solid State Electronics journal
	2016 – 2022	Lis Nanver, Editor for IEEE Electron Device Letters
	2016 – 2017	Cora Salm, TPC member, IEEE IEDM conference
	2018 – 2019	Jurriaan Schmitz, TPC member, IEEE IRPS conference
	2018 – 2022	Jurriaan Schmitz, Associate Editor for MDPI Sensors
	2020 – present	Lis Nanver, Scientific Advisory Committee, Elsevier Solid State Electronics journal
	review period	Jurriaan Schmitz, TPC member, ESSDERC conference
	review period	Ray Hueting, TPC member, ESSDERC conference
	review period	Alexey Kovalgin, TPC member, IEEE ICMTS conference
	review period	Alexey Kovalgin, International Board member, EuroCVD conference
	review period	Alexey Kovalgin, co-organizer of Symposium 9 "Thin-Film processing", ICAE conference, South Korea
	review period	Cora Salm, Steering Committee and TPC member, ESREF conference
	review period	Joost Lötters, Chair, MFHS conference
	review period	Remco Wiegerink, TPC member, MFHS conference
PE	2008-2019	Ray Hueting, TPC-member (track 3: modelling and simulation) and chairman of the ESSDERC conference
	2018	Frank Leferink, Chair EMC Europe - Amsterdam
	2018 – present	Jelena Popović, Associate Editor, IEEE Transactions on Power Electronics
	2021	Frank Leferink, Technical Program Chair Asia-Pacific EMC Symposium - Bali
	2021 – 2023	Ray Hueting, TPC-member (Power and Energy Devices) and chairman of IEEE International Electron Devices Technology and Materials (EDTM) conference (2021- 2023)
	2022	Frank Leferink, Technical Program Chair IEEE EMC+SIPI Symposium - Spokane WA USA
RAM	2017 – present	Gijs Krijnen, Associate editor IEEE Sensors Journal
	2016	Gijs Krijnen, Guest Editor Special Issue on Selected Papers From the IEEE SENSORS 2015 Conference
	2020	Gijs Krijnen, Technical Programme Chair IEEE SENSORS conference 2020, Rotterdam (online)
	2021	Gijs Krijnen, Technical Programme Chair IEEE SENSORS conference 2021, Sydney (online)
	2021	Gijs Krijnen, Topical editor Special Issue IEEE Sensors Journal dedicated to the 2020 IEEE Sensors Conference
	2023 – present	Chiara Gabellieri, Associate Editor, IEEE RA-L
	2023 – present	Giulio Dagnino, Associate Editor, Surgical Robotics, IEEE Transactions on Medical Robotics and Bionics (IEEE TMRB)

KPI 4a: Well-educated Masters and PhDs

See Appendix G for data on education and PhDs.

KPI 4b: Spin-offs and start-up companies

Table D.12
Historical overview spinoffs

Year	Company	Group	Remark
1993	Demcon	CE (RAM)	
1994	3T		
1995	Controllab Products	CE (RAM)	
1998	Microflown	TST	
1999	Micronit Microfluidics	TST + BIOS	
2000	Xsens(1)	BSS	Now part of Movella
2001	Imotec	CE (RAM)	
2001	Lionix International	IOMS	
2002	Blue4Green	BIOS	
2005	Recore Systems	CADTES (CAESS)	
2006	Medimate	TST + BIOS	
2007	Mobihealth	BSS	
2007	AXIOM IC(2)	ICD	Acquired by Teledyne-Dalsa in 2013
2009	SATRAX(3)	TE (RS)	Now part of Lionix
2009	Bibix	CAES	
2011	NociTRACK(4)	BSS	Does no longer exist
2012	Clear Flight Solutions(5)	RAM	Now renamed The DroneBird Company
2012	MyLife Technologies	BIOS	
2013	StructWeb(6)	DB (DMB)	Does no longer exist
2014	Athom (Homey)	EEMCS (CREATE)	
2014	Axign(7)	ICD	Acquired by Monolithic Power Systems
2015	LocSense	BIOS	
2015	Telerevalidatie.nl	BSS	
2016	Characell(8)	BIOS	Does no longer exist
2016	20Face	DMB	
2016	Westpulse	CAES	
2016	QBayLogic	CAES	
2016	InnovationSprint	BSS	
2016	ANSEM(9)	ICD	Now part of Cyent
2017	Nanomed Dx(10)	BIOS	Now Qurin
2019	Occam.dx(11)	NE+AMBER	Changed the name from Ecens to Occam·dx
2020	MachNet Medical Robotics B.V.	RAM	
2020	Semirtec	NE	

Floris Zwanenburg giving a lecture for laymen at the Mañana festival.

KPI 5a: Technical products

Table D.13 Technical products and projects with industry

Group	Year	Technical products or project with industry	
BSS		Bert-Jan van Beijnum (Ambition project): BSS proposed and validated algorithms for assessing spatio-temporal and balance parameters during gait using 3 IMU's: A demonstrator product has been developed by 2M Engineering based on these algorithms	
CAES	2017	HADES Hierarchy aware and secure embedded test infrastructure for dependability and performance enhancement of integrated systems	
	2023	Probabilistic Data Structures For Secure And Reliable RISC-V Processor co-sponsored by ESA and Technolution	
DACS	-	OpenINTEL DNS Measurement Platform (measures over 50% of entire Internet DNS name space), and measurement data	
	-	DDoS Clearing House	
	-	(models of) protocols for vehicular networking	
	-	enhancements to Secure DNS	
	-	models/algorithms for mobile network management	
ICD	2019	Arbitrary digital clock	400 k€
		ULP building blocks	400 k€
		5G RF Ttransceiver integration	400 k€
	2017	DOWNCONVERTER 2: Low power rf downconverter receiver frontend 2	300 k€
		ICARUS Increased collection of energy by advanced solar harvesters on roof mounted solar panels	65 k€
IDS	2019	Postmortem analysis of solar cells	120 k€
		Gas monitor module for respiratory devices	439 k€
	2018	NEXTGENSCT Next generation surface channel technology	615 k€
RAM	2020	Various generation of 3D printed motors for MRI safe, robotic biopsy	
	2022	In-situ 3d print quality observations	
RS	2023	Donation of equipment by Rijksinspectie Digitale Infrastructuur (RDI)	

KPI 6a: Long-term research collaboration with industry

Table D.14
Long-term research funding

Group	Long-term research collaboration
BSS	In cash contributions by Inreda (67.7 k€:
	TKI-Connecting Industries Personalized AP project (granted in 2019):
	Part-time staff positions by societal organisations:
	0.2 FTE prof. dr. Jaap Buurke: financed by Roessingh Research and Development
	0.2 FTE prof. dr. Goos Laverman: financed by ZGT
	0.2 FTE prof. dr. Han Hegeman: financed by ZGT
CAES	Marco Ottavi, MoU Between ESA and EEMCS (2024-01-12)
	Guest Researcher Gerard Rauwerda (Technolution)
	Guest Lecturer Albert Molderink (NieuweStroom)
DACS	part-time staff positions (0.2 fte) paid by other organisations
	TNO, SIDN Labs, NCSC, Nedap, Northwave
IDS	0.2 fte (prof. Joost Lötters) paid by Bronkhorst
RAM	i-Botics programme with TNO
	Ultimaker participation and sponsoring in OTP projects, joining biweekly progress meetings
	Leon Abelmann, 0.2 FTE paid by KIST-Europe (2015 - 2022)

KPI 6b: Outreach to the general public

Table D.15 Outreach activities

Person	Date	Activity
Wilfred van der Wiel	Feb 2016	Studium Generale Universiteit Twente
Floris Zwanenburg	July 2016	Zwarte Cross festival performance
Gijs Krijnen	2016	Coach of a local First Lego League team
Frank Leferink	2016	Articles about lightning and Intentional EMI (with Stefan van de Beek, PhD candidate) in UT Nieuws, Tubantia, Technisch Weekblad
Frank Leferink	2017	worldwide coverage with 100s newspaper articles, television, socials media on Smart Meters. Interviews for many news channels, like NOS, RTL, WDR, but also Australia, Chile. Life BBC4 radio interview. The trigger article has been downloaded 4869, but it is not OA. The UT website had highest number of visitors on one day ever.
Loes Segerink	2017-06-16	“Alcohol beter dan medicijn, de bloed-hersen barrière”, Manana manana, Vorden
Loes Segerink	2017-Jul	“Op zoek naar dé zaadcel”, Zwarte cross, Lichtenvoorde
Loes Segerink	2017-11-01	“Zwanger met chip”, invited talk for the Universiteit van Nederland
Wilfred van der Wiel	Jan 2018	Qua art Qua science Enschede
Wilfred van der Wiel	May 2018	Gogbot Café Enschede
Floris Zwanenburg	Jun 2018	Manana Manana festival performance
Floris Zwanenburg	Jul 2018	Zwarte Cross festival performance
Loes Segerink	2018-05-23	Talkshow voor de toekomst”, Tivoli
Loes Segerink	2018-06-15	“Kanker vaststellen door te plassen”, Manana manana
Loes Segerink	2018-07-13	“Hersenonderzoek op chip, alcohol beter dan medicijn?” Zwarte cross
Frank Leferink	2018	5g in Volkskrant and Tubantia (full page 4), and use of mobile phones in planes.
PE group	2019 - Ongoing	Multiple Erasmus+ Talks/Workshops, Indonesia ITB, Egypt, Ukraine.
Floris Zwanenburg	Jun 2019	Manana Manana festival performance
Wilfred van der Wiel	Sep 2019	Studium Generale TU/e Eindhoven
Loes Segerink	2019-06-15	“Zwanger met chips”, Manana manana
Loes Segerink	2019-07-19	“Zwanger met chips”, Zwarte cross
Loes Segerink	2019-12-15	“Hoe meet je de kleinste bewegingen”, MuseumJeugdUniversiteit, Museumfabriek Enschede
Frank Leferink	2019	5G in newspapers(2 pages in Reformatorisch Dagblad), and life interview on BNR Nieuwsradio
Luuk Spreeuwers	2019-06-17	in de Tijd, Belgian newspaper: U wordt Herkend
Loes Segerink	2019	Universiteit Twente, Moeder de wetenschapper
Loes Segerink	2019	Ditta op den Dries, Ik krijg energie van samenwerken
Frank Leferink	2020-2022	Several interviews about smart meters, mercury in CFL, 5G and lightning in national newspapers (Volkskrant, Trouw, RTL, AD, Hart van Nederland)
Roland van Rijswijk-Deij	2020	Internet security concepts in ’Universiteit van Nederland’ videos
Loes Segerink	2020-02-06	Is er een dokter in de zaal, RTL4
Loes Segerink	2020-08-04	Karlijn Meinders, Een urinetest voor kanker, BNR radio
Loes Segerink	2020	Tobias Sybesma foundation, De zoektocht naar een succesvolle behandeling voor hersenstamkanker
Wilfred van der Wiel	Jun 2021	Artikel Trouw - Het ideaal ligt in de armen van de octopus
Floris Zwanenburg	Sep 2021	NPO Radio 1 interview Dr Kelder & co and podcast
André Kokkeler	2021-05-21	Interview RTV Oost Publiekplein
Gert Rietveld	2021-08-10	Klokhuis TV show with Haptamu de Hoop on “Standaard Maten”
Gerwin Hoogsteen	2022-01-27	Live appearance on regional TV (Oost NL) on PV inverters and grid congestion. Bij Oost | Vandaag - RTV Oost Tied to this is also an article: “Steeds grotere problemen op het stroomnet; Universiteit Twente werkt aan oplossingen”
DACS group	2022	*feature article in I/O Magazine*
Pieter-Tjerk de Boer	2022	Coverage by national and international media (including NY Times) of WebSDR allowing to listen into unencrypted radio transmissions of Russian Troops in Ukraine.
Luuk Spreeuwers	2022-01-11	in TV program BNN-VARA: Reference man in de Technologie
Wilfred van der Wiel	Jan 2022	NPO Radio 1 interview Dr Kelder & co and podcast
Wilfred van der Wiel	Feb 2022	Science Café Enschede
Wilfred van der Wiel	Apr 2022	Dutch Innovation Days Enschede
Floris Zwanenburg	Jun 2022	Manana Manana festival performance
Wilfred van der Wiel	Oct 2022	Lecture Royal Institution London (40k views)
Gerwin Hoogsteen	2023-01-27	Article in Volkskrant on grid congestion problems. “Op het overbelaste stroomnetwerk werd de zekering een tikkende tijdbom” | de Volkskrant
Tom Hartman	2023	Invited Exemplary Transactions Paper Presentation 2023 IEEE EMC + SIPI Conference.
Tom Hartman	Ongoing	Multiple “EMC on Tours” at different Universities of applied sciences (HAN, Fontys, HVA).
Meike Nauta	2023-03-31	on NPO Radio 1: De Nacht van ...
Wilfred van der Wiel	Mar 2024	iCANX lecture 15000 people audience
Lavrenko	2023-07-24	interview and story in Featured Scientists of UT Research: Using radio waves to track wildlife

E

Personnel

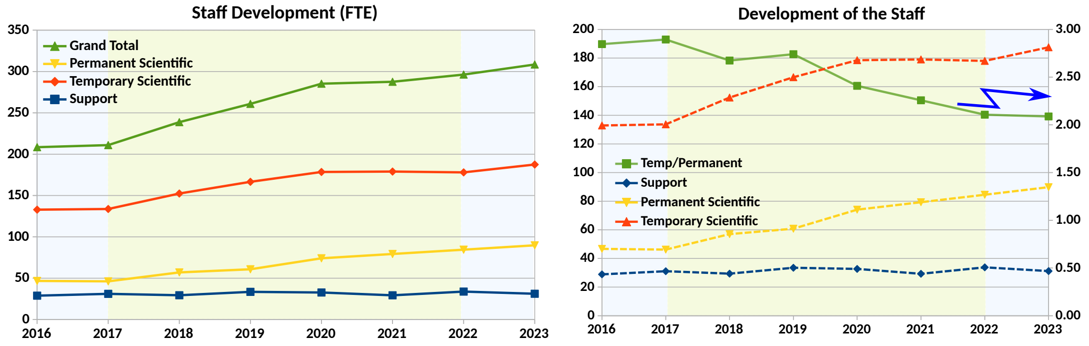
Personnel Constitution

Table E.1 Staff in FTEs and Appointments (SEP prescribed table E2)

	2016		2017		2018		2019		2020		2021		2022		2023	
	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#	FTE	#
Total staff	208.4	233	210.8	233	238.8	259	260.9	283	285.3	312	287.8	324	296.4	330	308.6	340
Full Prof.	12.9	17	12.7	18	13.7	19	13.7	20	13.7	20	11.4	18	14.9	21	17.9	24
Associate Prof.	19.8	22	19.3	21	22.9	25	25.4	28	24.3	28	25.0	28	24.0	26	24.2	27
Assistant Prof.	12.2	15	10.9	13	16.6	19	17.2	20	29.7	33	34.7	39	35.8	39	40.0	44
Teacher	1.8	2	3.3	4	3.8	4	4.5	6	6.4	8	7.4	11	8.7	13	7.5	11
Other Scientific											0.8	2	1.1	3	0.2	1
Permanent Scientific	46.7	56	46.2	56	57	67	60.8	74	74.1	89	79.3	98	84.5	102	89.8	107
PhD-student(1)	96.6	99	96.4	98	114.6	116	116.2	118	127.8	130	133.7	137	134.8	137	149.5	152
Eng. Doctorate	2.0	2	2.0	2	2.0	2					1.0	1	3.0	3	2.0	2
PD fellow	34.3	43	35.3	40	35.8	40	50.4	54	50.7	56	44.3	52	40.2	45	36.0	41
Temporary Scientific	132.9	144	133.7	140	152.4	158	166.6	172	178.5	186	179.0	190	178	185	187.5	195
Technicians	19.1	21	21.3	25	18.5	20	20.8	22	20.4	22	16.7	20	21.0	25	18.1	22
ICT support	2.0	2	2.0	2	2.4	3	4.0	4	4.0	4	4.4	5	4.9	6	4.0	4
Secretaries	7.8	10	7.8	10	8.3	10	7.5	9	8.1	10	8.0	10	7.0	10	6.9	9
Support staff	28.9	33	31.1	37	29.4	34	33.5	37	32.7	37	29.4	36	33.9	43	31.2	38

(1) Only PhDs employed by EE@UT, i.e. excluding external PhDs or those which have independent funding.

Figure E.1



Development of the staff (FTE) over the years (left).

Ratio of temporary to permanent staff (right).

(based on the data of Table E.1)

Figure E.1 (right) shows that both the temporary and the permanent staff have significantly increased over the assessment period, the latter not in the least due to the sector plans. However, the ratio of temporary staff to permanent staff has decreased from 2.85 to 2.11.

Diversity of research staff: Gender, Nationality and Age

Table E.2 Staff gender and nationality break down (appointments)

	2016				2017				2018				2019			
	Female		Male		Female		Male		Female		Male		Female		Male	
	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.
Full prof	1		16		1		17		1		18		1		18	1
Associate prof	1	3	17	1	2	2	16	1	2	2	17	4	4	2	18	4
Assistant prof	1	3	7	3		2	7	4	1	4	11	3	2	5	10	3
Teacher	1		1		1		1	2	1		2	1	1		4	1
Other Scientific																
Permanent Scientific	4	6	41	4	4	4	41	7	5	6	48	8	8	7	50	9
PhD candidates	7	15	22	55	6	14	29	49	11	14	37	54	17	16	41	44
Eng. Doctorate				2		1		1		1		1				
PD Fellow	4	10	8	21	6	7	6	21	6	8	10	16	5	8	18	23
Temporary Scientific	11	25	30	78	12	22	35	71	17	23	47	71	22	24	59	67

	2020				2021				2022				2023			
	Female		Male		Female		Male		Female		Male		Female		Male	
	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.	NL	Int.
Full prof	1		18	1	2		16		1	1	17	2	2	1	19	2
Associate prof	4	2	17	5	3	2	17	6	3	2	16	5	3	2	16	6
Assistant prof	4	6	14	9	5	8	14	12	6	8	12	13	6	12	14	12
Teacher	2	1	3	2	3	1	4	3	4	1	5	3	5	2	2	2
Other Scientific							2				3				1	
Permanent Scientific	11	9	52	17	13	11	53	21	14	12	53	23	16	17	52	22
PhD candidates	18	20	48	44	17	26	48	46	16	32	38	51	17	32	45	58
Eng. Doctorate							1		1		1	1	1			1
PD Fellow	11	8	15	22	13	4	15	20	7	5	18	15	4	10	11	16
Temporary Scientific	29	28	63	66	30	30	64	66	24	37	57	67	22	42	56	75

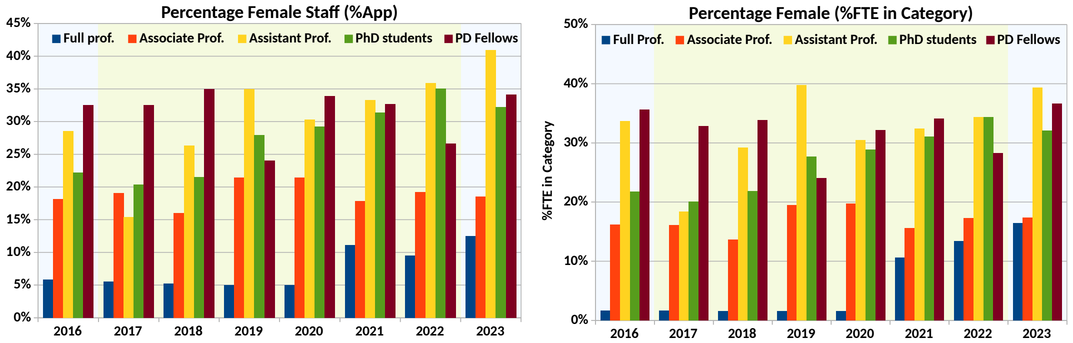


Figure E.2

Scientific staff diversity

% Female (by App, left)

% Female (by FTE, right)

(based on Table E.2)

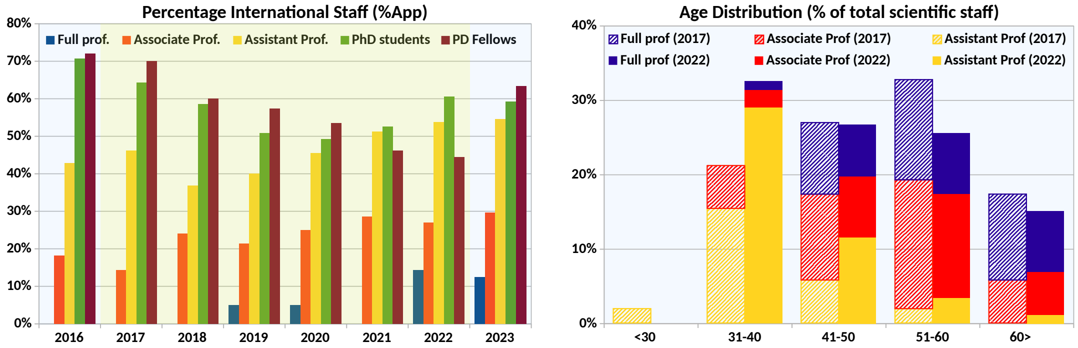


Figure E.3
International scientific staff (%App, left) (Table E.1) Age

distribution scientific staff (%App, 2022, right) (Table E.3)

	Year	21-30	31-40	41-50	51-60	>60	Total
Full professor	2017			5	7	6	18
	2022		1	6	7	7	21
Associate professor	2017		3	6	9	3	21
	2022		2	7	12	5	26
Assistant professor	2017	1	8	3	1		13
	2022		25	10	3	1	39
Total Scientific staff	2017	1	11	14	17	9	52
	2022		28	23	22	13	86

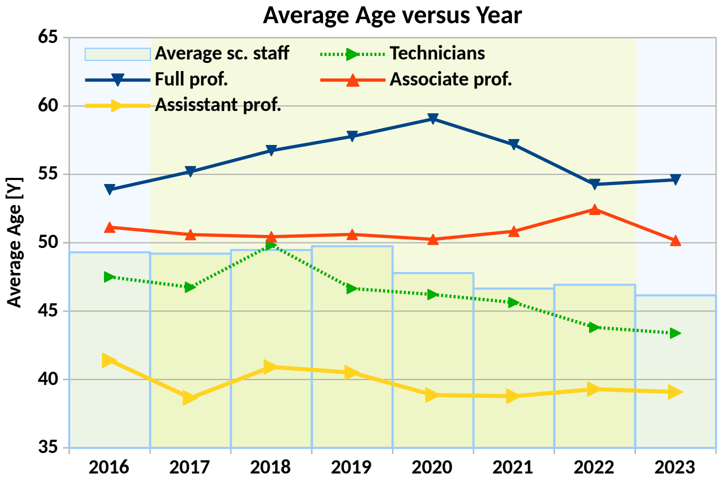
Table E.3
Age distribution scientific staff (2022)

Table E.4
Average age of permanent scientific staff, average of all scientific staff average age of technicians

	2016	2017	2018	2019	2020	2021	2022	2023
Full professor	53.9	55.2	56.7	57.8	59.1	57.2	54.3	54.6
Associate professor	51.1	50.6	50.4	50.6	50.3	50.8	52.4	50.2
Assistant professors	41.4	38.7	40.9	40.5	38.9	38.8	39.3	39.1
Average Sc. Staff	49.3	49.2	49.5	49.7	47.8	46.6	46.9	46.2
Technicians	47.5	46.7	49.8	46.7	46.2	45.6	43.8	43.4

Figure E.4
Average age versus year

(from Table E.4)




Floris Zwanenburg
Vici laureate in the NE group.

Click on the image to know more

F

Research Funding and Finances

This appendix gives an overview of the various forms of income to EE@UT. The 3 funding tiers are distinguished and numbers have been obtained by summation of the numbers of the 12 current research (and their preceding) groups.

Table F.1 Funding (according to tiers) and expenditures (SEP prescribed table E3)

	2016		2017		2018		2019		2020		2021		2022		2023	
Funding	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Direct funding (1)	13.7	58%	14.7	64%	17.5	66%	17.9	60%	20.7	65%	23.3	64%	26.1	67%	27.1	69%
Research grants (2)	4.5	19%	4.5	19%	4.7	18%	4.8	16%	4.1	13%	4.4	12%	4.4	11%	3.8	10%
Contract research (3)	5.3	23%	3.9	17%	4.4	17%	6.9	23%	7.1	22%	8.6	24%	8.4	22%	8.3	21%
Total funding	23.5	100%	23.1	100%	26.6	100%	29.6	100%	32.0	100%	36.4	100%	38.9	100%	39.3	100%
Spending	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%	M€	%
Personnel costs	14.5	63%	14.2	63%	16.4	66%	19.3	68%	21.4	74%	23.2	73%	24.6	72%	25.9	71%
Other costs	8.5	37%	8.3	37%	8.4	34%	8.9	32%	7.6	26%	8.7	27%	9.8	28%	10.7	29%
Total expenditure	22.9	100%	22.5	100%	24.8	100%	28.2	100%	29.0	100%	31.9	100%	34.3	100%	36.6	100%

Notes:

(1) Tier 1: Direct funding (basic funding / netto lump-sum budget for research and education)

(2) Tier 2: Research grants obtained in national scientific competition (e.g. grants from NWO and the Royal Academy)

(3) Tier 3: Research contracts for specific research projects obtained from external organisations, such as industry, government ministries, European organisations and charitable organisations

Note that the numbers in above table are based on how the various costs are covered by the various funding tiers. However, the acquisition of budget by research proposals is given in Table F.2. The figures below give graphical representations of the data of Table F.1.

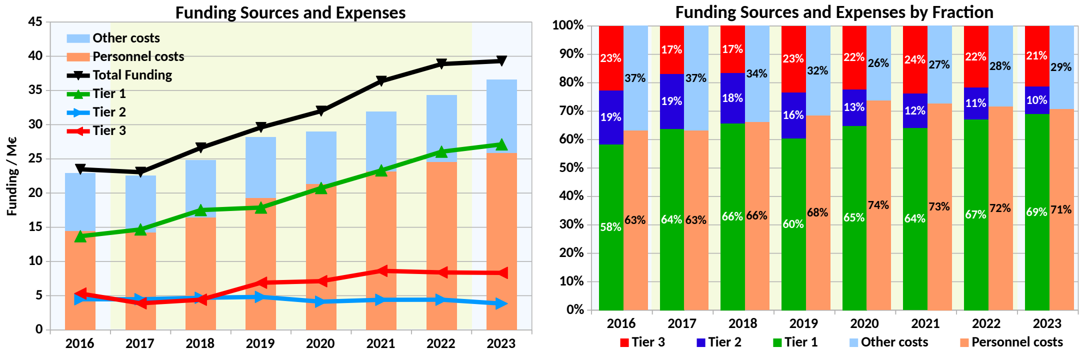


Figure F.1
Funding & Spending (in M€ , left)

Funding & Spending (%, right)

(Data from Table F.1)

Table F.2 shows how our portfolio changes over time and distinguishes the various funding tiers.

Table F.2 Change in portfolio over time

	2016				2017				2018				2019				2020				2021				2022				2023			
	Started		Ended		Started		Ended		Started		Ended		Started		Ended		Started		Ended		Started		Ended		Started		Ended		Started		Ended	
	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€	#	M€
2nd Tier	25	3.7	31	4.0	30	5.4	24	3.1	21	4.2	16	2.3	17	3.4	27	4.6	26	7.1	39	6.2	15	4.6	28	3.6	16	4.1	32	5.1	20	9.4	35	6.3
3rd Tier (EU)	4	1.9	12	4.1	3	1.1	9	5.3	6	3.5	6	2.2	18	9.7	4	1.4	12	4.9	8	4.0	7	2.4	6	2.0	12	5.2	8	1.5	10	6.6	17	9.9
3rd Tier (other)	20	2.7	18	3.0	22	3.7	27	5.7	19	5.9	16	2.5	17	3.7	14	1.5	7	1.1	12	1.7	9	2.2	20	3.5	22	5.9	22	6.0	18	6.9	15	3.8
Sum All Tiers	49	8.3	61	11.1	55	10.2	60	14.1	46	13.6	38	7.0	52	16.8	45	7.4	45	13.0	59	11.9	31	9.2	54	9.0	50	15.1	62	12.5	48	22.8	67	20.0
	#		M€		#		M€		#		M€		#		M€		#		M€		#		M€		#		M€		#		M€	
Overall effect:	**-12**		**-2.89**		**-5**		**-3.92**		**8**		**6.62**		**7**		**9.34**		**-14**		**1.11**		**-23**		**0.14**		**-12**		**2.62**		**-19**		**2.81**	

The figures below visualise the data from Table F.2 for easier interpretation. Note that over the period of 8 years the number of projects has effectively decreased by 70 whereas the value of the portfolio increased by 15.8 M€ . This means that on average the budget per project has increased (Figure F.3, right).

Figure F.2
Δ projects (left)

Δ portfolio
(in M€ , right)

(Data from Table F.2)

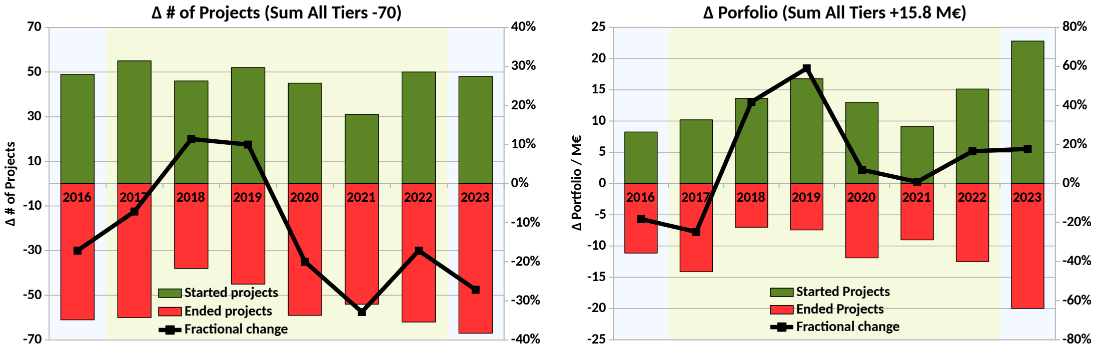
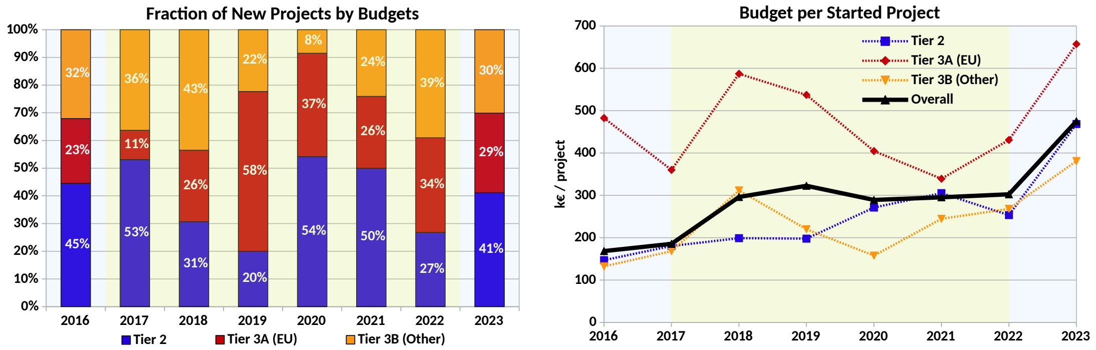


Figure F.3
Fractional distribution of new projects (left)

Budget per project
(in k€ , right)

(Data from Table F.2)



G

Education and PhDs

This appendix gives an overview of the PhD statistics with respect to influx, success rate and thesis duration, as well as information regarding the educational programmes.

Table G.1 PhD success rates(1). Data from Hora Finita (SEP prescribed table E4)

Enrollment(2)				Cumulative success rates: PhD candidates graduating within											
Cohort	Male	Female	Total	4 years + 3 months		5 years		6 years		Start 2024		Ongoing		Discontinued	
	FTE	FTE	FTE	FTE	%	FTE	%	FTE	%	FTE	%	#	%	FTE	%
2016	32.4	12.0	44.4	7.5	16.9%	17.0	38.3%	22.8	51.3%	25.3	56.9%	8.0	18.0%	11.1	25.1%
2017	24.0	11.7	35.7	7.0	19.6%	15.0	42.0%	19.7	55.2%	21.7	60.8%	6.0	16.8%	8.0	22.4%
2018	34.4	24.5	58.9	19.0	32.3%	31.0	52.6%	34.0	57.7%	34.0	57.7%	12.9	21.9%	12.0	20.4%
2019	31.8	19.3	51.1	6.0	11.7%	10.8	21.2%	10.8	21.2%	10.8	21.2%	32.8	64.2%	7.5	14.7%
2020	41.0	15.8	56.8	2.5	4.4%	2.5	4.4%	2.5	4.4%	2.5	4.4%	46.3	81.5%	8.0	14.1%
2021	38.0	14.8	52.8	1.0	1.9%	1.0	1.9%	1.0	1.9%	1.0	1.9%	48.8	92.4%	3.0	5.7%
2022	36.7	14.0	50.7									47.7	94.1%	3.0	5.9%
2023	42.5	16.9	59.4									57.4	96.6%	2.0	3.4%
Total	280.7	129.13	409.9	43		77.3		90.8		95.3		260.0	63.4%	54.6	13.3%

(1) All PhDs in Hora Finita, i.e. including external PhDs or those which have independent funding. Not identical to Table E.1
(2) The numbers given are in terms of FTE and account for part time working, shared, and part of the year working PhDs.

A more insightful representation is found in the figures below. Figure G.1, left, shows the cumulative success rates after 4 years and 3 months, 5 years, 6 years and after more than 6 years. The bars in blue give the influx of PhD students in each year. Figure G.1, right, shows the non cumulative numbers as fraction of the entire cohort.

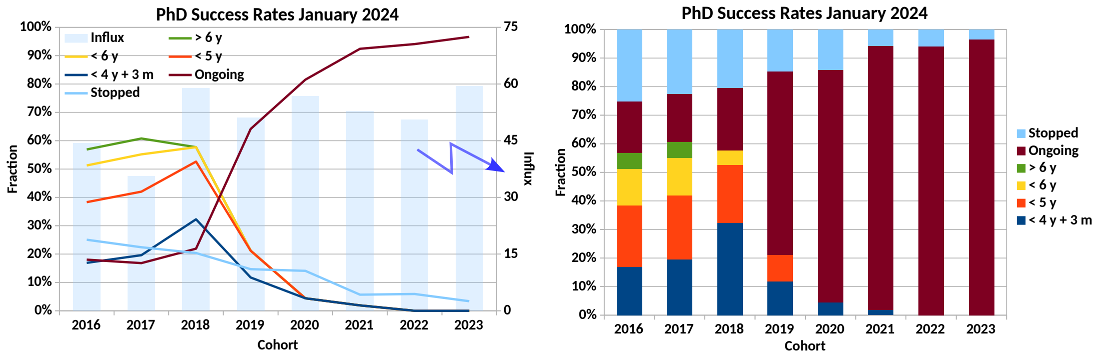


Figure G.1
PhD influx and success rates as function of cohort.
(Data from Table G.1)

Table G.2 shows the influx numbers for EEMCS study programmes in which EE@UT is strongly involved. Next to EEMCS programmes, EE@UT strongly participates in programmes of the Science and Technology faculty: BSc programmes Technische Geneeskunde, Biomedical Engineering, Advanced Technology and the MSc programmes Biomedical Engineering, Nanotechnology, Technical Medicine. As an indication: for 2024 the educational contributions (based on T-2 efforts) from non EEMCS BSc programmes is 47% of the educational BSc income. This is without the effort that EE@UT delivers in the UT's honours programmes.

Table G.2 Student influx in the various educational programmes

	2016		2017		2018		2019		2020		2021		2022		2023	
	NL	Int	NL	Int	NL	Int	NL	Int	NL	Int	NL	Int	NL	Int	NL	Int
BSc Electrical Engineering	37	21	69	29	67	39	64	39	55	41	72	41	46	46	46	38
BSc Creative Technology	75	25	97	25	96	25	97	36	98	41	94	47	58	53	47	38
Total	112	46	166	54	163	64	161	75	153	82	166	88	104	99	93	76
Total	**158**		**220**		**227**		**236**		**235**		**254**		**203**		**169**	
MSc Electrical Engineering	35	11	35	34	43	27	42	49	58	18	38	19	40	18	24	18
MSc Systems & Control	13	11	12		17	21	13	26	13	11	10	12	2	5		
MSc Robotics													42	13	35	27
MSc Interaction Technology	24	19	22	7	37	24	32	42	54	25	63	36	35	27	25	33
MSc Embedded Systems	24	12	20	14	20	10	15	27	31	8	21	10	26	14	16	12
Total	96	53	89	55	117	82	102	144	156	62	132	77	145	77	100	90
Total	**149**		**144**		**199**		**246**		**218**		**209**		**222**		**190**	

In Figure G.2 we see that 1) the influx of students in the EE BSc and EE MSc programmes is fluctuating without clear tendencies in the assessment period and 2) that international student influx is important for our EE BSc and MSc programmes with on average nearly 40% in the assessment period (and as high as up to 54% for the MSc influx in 2019).

Figure G.2
EE influx (left)

Total influx (right)

(Data from Table G.2)

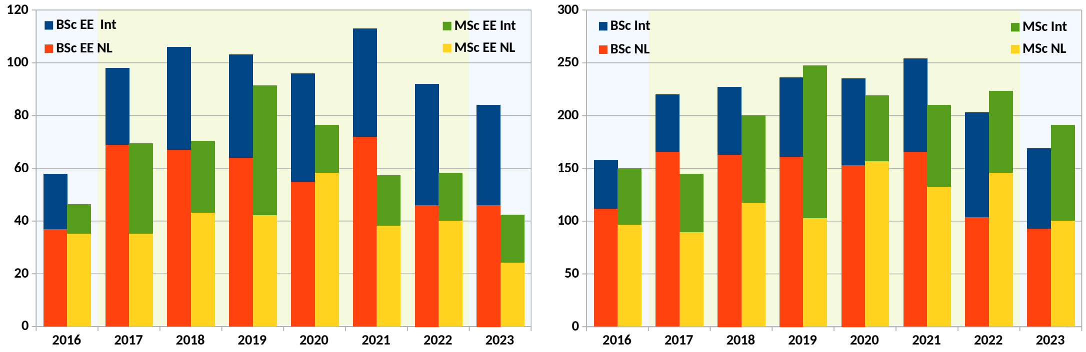


Figure G.3
EE Diplomas

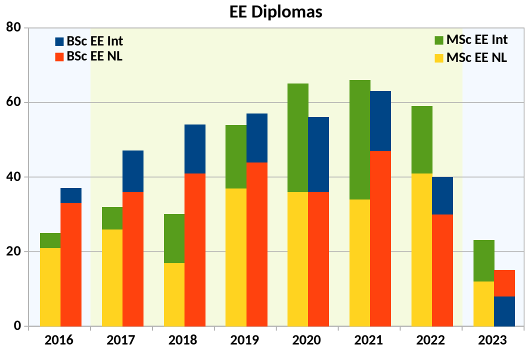


Table G.3
Student pass rates in the EE BSc and MSc programmes

Pass rates EE BSc Programme

	2016	2017	2018	2019	2020	2021	2022	2023
Total registrations	57	98	106	102	95	110	92	84
Stopped ≤1 year	15	35	36	26	38	41	33	12
Total re-enrolments	42	63	70	76	57	69	59	72
Pass in ≤3 Year	7	26	27	29	17			
Pass in ≤4 Year	29	44	49	42	23			
Pass in ≤5 Year	35	52	56	49	23			
Pass in ≤6 Year	38	55	58	49	23			
Total graduates (incl. current year)	38	55	58	49	23			
Ongoing	2	2	4	18	20	66	59	72
Stopped > year 1	2	6	8	9	14	3		

Pass rates EE MSc Programme

	2016	2017	2018	2019	2020	2021	2022	2023
Total registrations	45	68	69	89	74	57	57	42
Pass in ≤1 Year		1		2				
Pass in ≤2 Year	7	4	7	17	7	5		
Pass in ≤3 Year	23	32	43	59	42	15		
Pass in ≤4 Year	38	45	49	76	45	15		
Pass in >4 Year	3	3	5		0			
Total graduates (incl. current year)	41	48	54	76	45	15		
Ongoing	1	3	7	9	19	33	51	40
Stopped	3	17	8	4	10	9	6	2

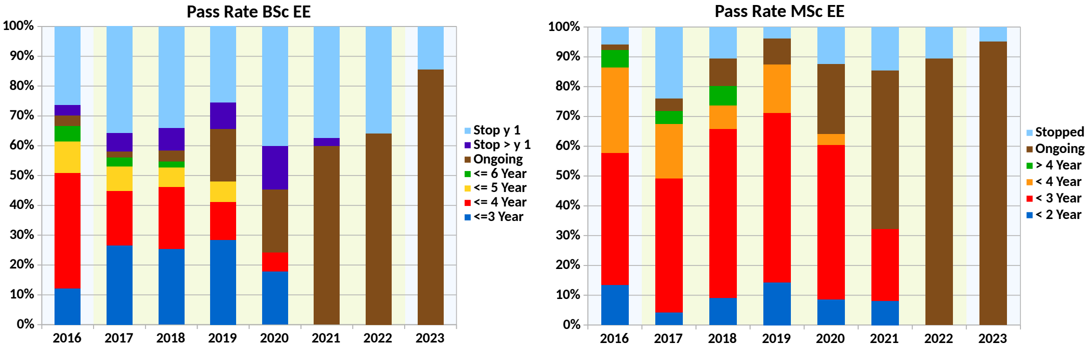


Figure G.4
EE Pass-rate

Total influx (right)

(Data from Table G.3)

Jan Broenink, quartermaster and first educational director of the MSc Robotics programme, started in 2022.

Click on the image to know more

H

Benchmark Project Plan

Role of a benchmark in research evaluation

SEP 2021 – 2027 (p.19):

> *The self-evaluation takes the overall shape of a coherent narrative argument . . . . This narrative argument is . . . supported by factual evidence . . . . The choice of indicators accordingly depends on the exact argument for which they should provide evidence. . . . Other sources of robust data may include benchmarking against peer research units . . . .*

A benchmark in this context is not a comparison to a de facto standard, leading to plusses and minuses on various aspects of academic research. It is a comparison to a peer organization, followed by an analysis of the observed differences, resulting in an evaluation of our way of working. A benchmark provides evidence for the narrative of the self- evaluation.

In 2019, we visited RWTH Aachen as a limited benchmark, which was a pragmatic choice: sufficiently close for a visit, sufficiently similar with respect to conducted research. The Committee found this benchmark "inconclusive and incomplete: aside of identifying structural similarities, such as the research Domains and the research matrix structure of faculties and interfaculty centers, no best practices on the scientific or technological choices between the respective Dutch Domains and the corresponding Domains at RWTH are addressed in detail."

Topics for a benchmark

A more valuable benchmark would focus on substantiation of topics that we wish to present in the self-evaluation:

a. Quality assurance of academic research (one of the two primary processes, next to education):
   1. What is 'quality' in the perception of our peer?
   2. What does our peer do to assure and enhance research quality? (At several levels of the organization.)
   3. What indicators do they use?

b. Is societal relevance an aspect that receives attention? If so, what does our peer consider to be societally relevant, and how does that shape their activities? How do long-term research targets relate to societal relevance?

c. How does our peer retain viability?
   1. How is the research funded? What is the role of government? What other funding sources are relevant?
   2. What laws and regulations affect the research? What laws are supportive, what laws are not?
   3. How does our peer attract staff? How do they make sure they are an attractive employer?
   4. How to attract students?

d. PhDs: How does our peer embed, supervise, organize and fund doctorate trajectories? What role do they have in the organisation? What quantitative data might be relevant?

e. Open Science: What are our peer's views on public availability of research data andresults? What is the context? How do they implement their views?

f. Gender balance and diversity: does our peer try to match the composition of the staff and student community to reflect the variety of the society it is part of? If so, what are the motives and how does that happen; what are concrete activities undertaken? (Cf. TU/e Irène Curie program). If not, how does this issue resound societally and how does the peer respond to that?
g. Scientific integrity: we assume our peer recognizes the possibility of compromising scientific work. What does he do to prevent that, and if it happens, to correct that?
h. Staff Development: how does our peer ensure the quality of staff? How do they address their continued need for development? Are there tenure tracks? How do scientific careers vary and how do these variations match individual talents?
i. Social safety, cooperation, developing talent, etc.: what are our peer's views on the optimal research community? What aspects are considered most important? How does the peer safeguard a safe working environment?
j. Does our peer formulate a general research strategy? If so, why and how? What topics receive attention? What is urgent, what are long-term issues, what context is important, and why? Is there external requirement (or demand) for a research strategy?
k. Are there strategic topics which are important to our peer but not covered by the above questions?

Strengthening contacts with the peer institution is not a benchmark target but can be a welcome side-effect. Of course, we are offering to return the favor we are asking. The benchmark is not targeting group level activities and comparison, because that is not the level of the SEP Research Evaluation. So the list above does not explicitly address the "best practices on the scientific or technological choices" mentioned by the previous Assessment Committee. We think concrete choices on subjects to research should be made by individuals or small teams, but of course these take responsibility to connect to the larger whole implied by the list, for example addressing societal relevance and the academic task of combining research and education.

Choosing a peer

We choose a peer according to a couple of criteria:

- The organisation must be involved in academic research [and education] in the discipline of Electrical Engineering; it is not necessary to cover exactly what the Dutch faculties address, but there must be sufficient common ground.
- The organisation will differ from the Dutch faculties of Electrical Engineering, but the difference must not be so large that all comparisons reduce to base dissimilarities which cannot be overcome. (For example: if funding of research is mainly private, it is much more difficult to find comparable considerations at both sides from which lessons can be learned.)
- It helps if there is frequent collaboration with the peer, having resulted in a set of contacts that can be used to collect concrete information and examples. Checking these criteria, we propose to contact the department of Electrical Engineering at Chalmers University of Technology in Gothenburg, Sweden, for the benchmark.

Benchmark outline

We propose to compose the benchmark as follows:

- Invitation: obtain formal support from peer, with one main contact. There are costs associated with the benchmark, but perhaps paying our peers for their time can be avoided.
- Desk research: find documents and information on peer with respect to research evaluation topics. Formulate preliminary analysis and raw evaluation conclusions and questions. Iterate with our contact on topics which cannot be found on-line.
- Online interviews with peer staff and PhD-students; probably in three phases: first verify our analysis with a small group of peers. Reformulate before addressing a larger set of staff members on various levels. Summarize interviews, verify with interviewed staff & check for remaining aspects which need detailing. Discuss these with the initial peer group.

- A visit is valuable for topics which are too difficult to address in on-line meetings. We may need a workshop on, for example, cultural differences. Perhaps a workshop can be organized together with a conference visit.
- Write a benchmark analysis text for the self-study. Ask our peer for checks and comments.
- We will of course welcome a return visit.

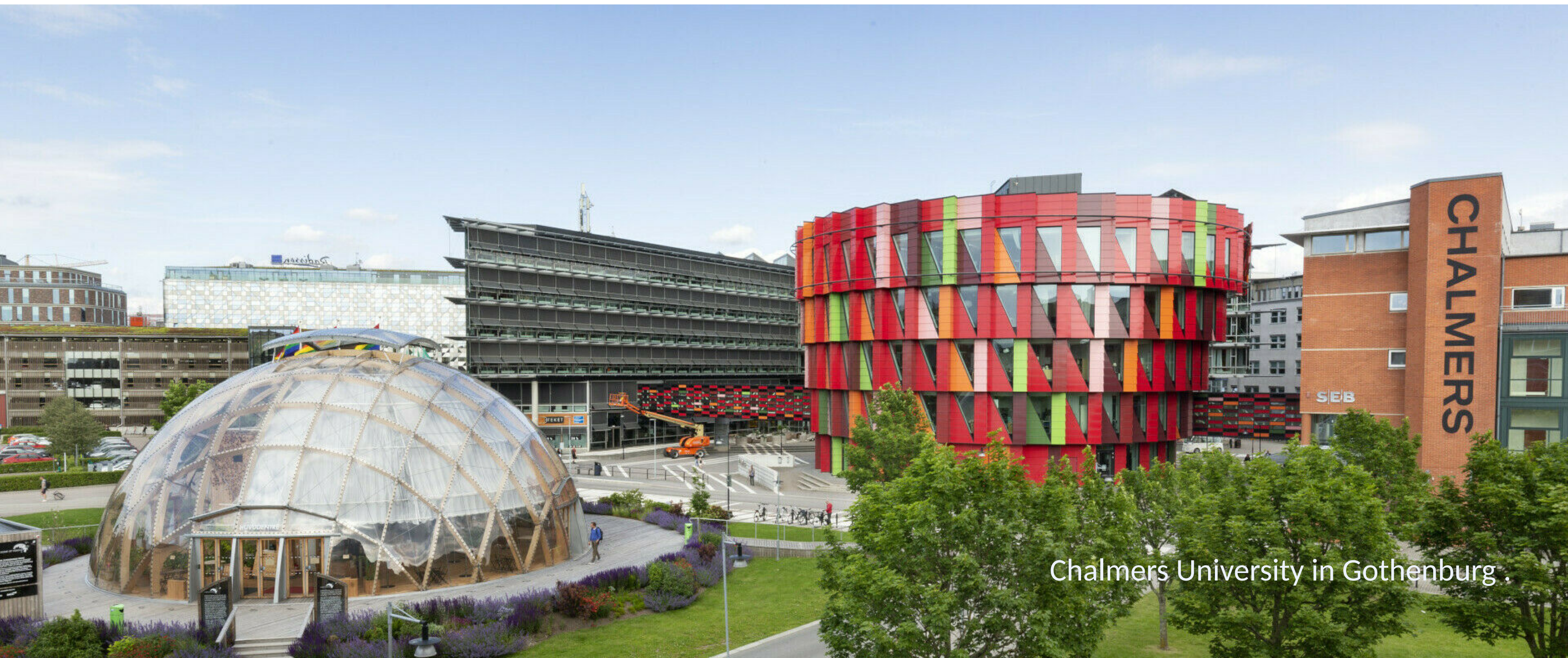
Estimated costs

If we do not count invested time, costs will be made for the physical visit only. If we compose the visiting panel by the self-study writing team, the EE-NL members and an additional PhD- student, the group will be 2 (UT & TUE; TUD organises its own benchmark) times 6 or 7 people. Estimating a 2-day visit, the budget will be: per person panel

Table H.1
Estimated costs benchmark study

	per person	entire panel
Traveling to Stockholm and back	300 €	4200 €
Hotel rooms	300 €	4200 €
Food & drinks	150 €	2100 €
Total		10500 €

If we sponsor a return visit, a similar budget will be needed.



Chalmers University in Gothenburg .

Organogram University of Twente

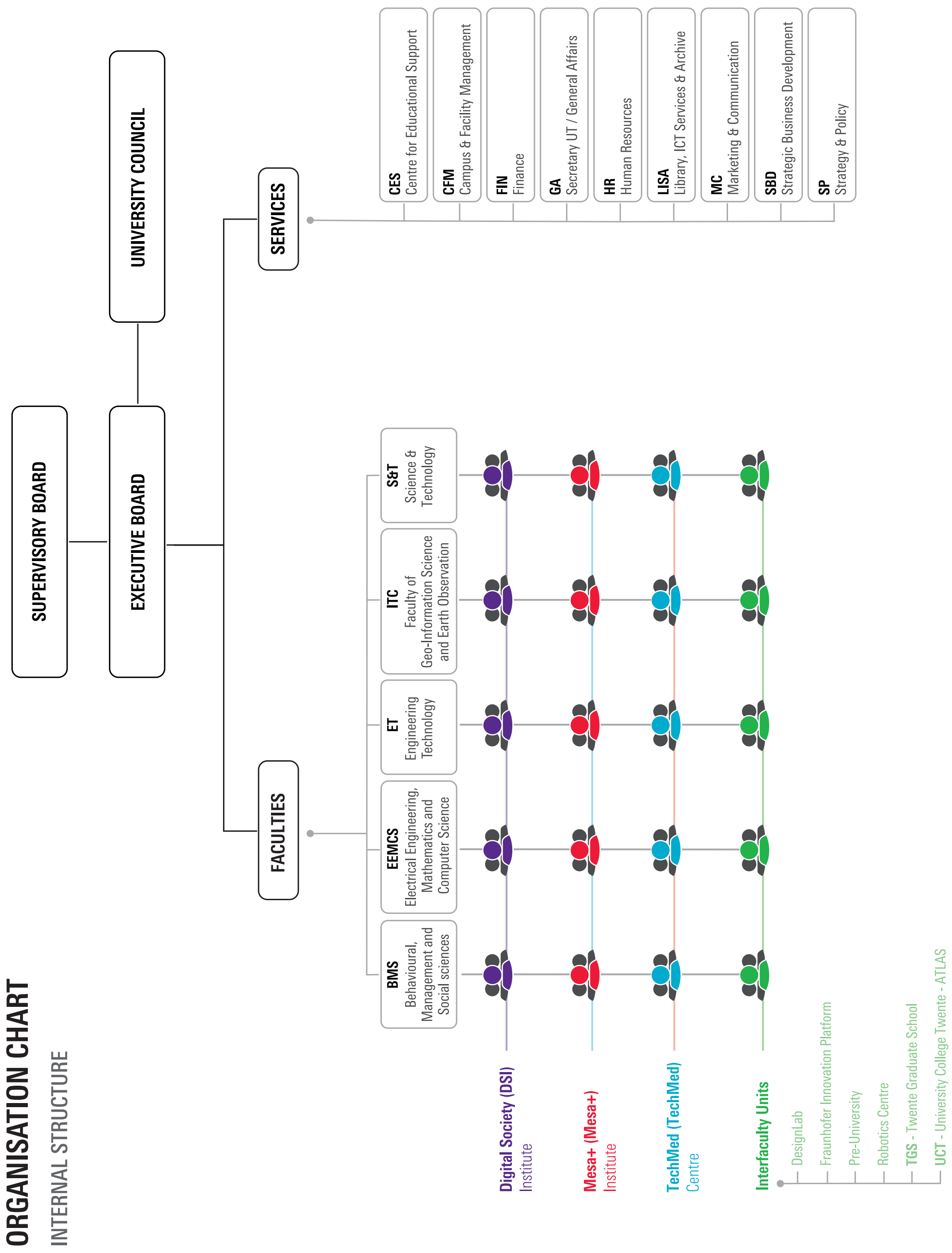


Figure I.1
Organogram of the UT

Index

1st tier flow, 4
2nd tier flow, 4
2nd tier funding, 14
3rd tier flow, 4
4TU.Federation, x
4TU.ResearchData, 16
9-grid tool, 21

AMBER, 3, 11
Artificial Intelligence, 6, 8
ASCI, 19

Batista Soeiro, Thiago, 10
Battery technology, 29
Beethoven programme, 27, 28
Berg, Albert van den, 11, 32
Bindra, Harijot Singh, i
BIOS, 3, 11
Bits meet Nature, 7
BRAINS, 12
BSS, 3, 11, 22
Buitenweg, Jan, 11

CAES, 3, 10
ChipTech Twente, 27, 33
Confidential advisor for scientific integrity, 5
Contract research, 4
CVB, 11

DACS, 3, 10
Data management plan, 20
Design Lab, 12
Digital Innovation Hub for Health Robotics: DIH-Hero, 32
Digital Society Institute, 3
Dilemma Game, 5
Direct funding, 4
DISC, 19
Discipline Council EE, 3
DMB, 3
    Data Management & Biometrics, 12
Domain of EE, ix
DSI, 3

E-kamer, x
eCMC, 12
Edge, 12
TU/e, x
UT, x
EEMCS, 6
eHealth, 26
Eijkel, Jan, 33
Electrical Engineering Platform Netherlands, x
Electrical Engineering, Mathematics and Computer Science (EEMCS), 1
Embedded System, 8
Energy transition, 29
European Chips Act, 27, 33
eurRobotics, 32

FB^{+}, 4
Female Faculty Network, 23
Female professors, 22
Field-Weighted Citation Index, 16
financial distribution model, 14
Formal qualifier, 19
four faculty themes, 9

Gac, Séverine le, 11
Green OA, 16
Groeifonds, 8

Heijenk, Geert, 10
Homey, 18
Hora Finita, 19
House of Integrity, 5
HRM, 2

ICD, 3, 10
IDS, 3, 10
Incentive Grants, 9
Institutes
    DSI, 3
    MESA^{+}, 3
    TechMed, 3
Integrated Devices and Systems (IDS), 12
inter-disciplinary research, 9

Junior scientific staff, 21
Junior scientists, 33

Kokkeler, André, 10
Krijnen, Gijs, 11

Lavrenko, Anastasia, i
Leferink, Frank, 10
long-term relationships, 18
LOWI, 5

Matrix structure, 3
Medical Research, 6
MESA^{+}, 3
MindLab, 5
ministry of Education, Culture and Science, 4
MREC, 6

National research schools, 19
Nauta, Bram, 10, 16
NE, 3, 10
NWO, OTP, 25

OoCC, 12
Open Access, 15
Open data, 6
Open UT culture, 12
OpenAlex, 39
Opportunities, 25
Our Future Leaders, 19

PE, 3
PeHT, 33
Personalised eHealth Technology, 33
Photovoltaics, 10
Pioneers in Health Care, 9
Pondman, Kirsten, i
PortWings, 32

Power Electronics & EMC, 11
Prioritize female applications, 29
PURE, 6, 16, 38

Qualifier, 19
QUANT, 12

Radio Systems, 11
RAM, 3, 11, 32
Research grants, 4
research portfolio, 14
Retirement wave, 29
Robotics, 29
Robotics Centre, 12
RS, 3, 10
RUMC
    Radboud University Medical Centre, 9

Schmitz, Jurriaan, 10
Schwab, Bettina, 18
Science, Technology, Engineering & Mathematics, 1
Scientific Integrity Complaints Procedure, 5
Sector Plan Techniek - I, x
Sector Plans, 1, 9, 13
Sectorbeeld, 10
Sectorplan Committee, 10
Sectorplan Techniek I, 9
Sectorplan Techniek II, 9, 26
Segerink, Loes, 11, 33
Shaping 2030, 21
SIKS, 19
SIL-EE, 9
Social and Behavioural Sciences, 1
Spreeuwers, Luuk, 11
SPT-II, 26
STEM, 1
Stramigioli, Stefano, 11, 16, 32
Strengths, 25
SWOT, 25

Tabak, Monique, 11
Tan, Can, 11
TechMed, 3
TechMed events, 8
Technical support staff, 21
TechnoHal, 9
Tenure Track, 10, 21
Theme Teams projects, 36
Theme-team initiatives, 9
Threats, 25
Tijdelijke Ondernemers Plaatsen , 17
Training and Supervision Plan (TSP), 19
TURBO grants, 9
TurnItIn, 6
Twente Graduate School, 6, 19
Twente Robotics Centre, 28

University-wide research ethics policy, 6
UT
    campus, 2
    University of Twente, 1
UT-wide RDM, 6

Varbanescu, Ana-Lucia, 10
Veldhuis, Raymond, 11
Veltink, Peter, 11
Vision, 7

Weaknesses, 25
Wiegerink. Remko, 11
Wiel, Wilfred van der, 10
Work-pressure, 23
WUR
    Wageningen University & Research, x

Zenodo, 16

References

[1] SEP protocol 2021-2027
https://www.universiteitenvannederland.nl/files/publications/SEP_2021-2027.pdf

[2] Accompanying web site
https://VisitationEE.utwente.nl/EE-FT-2017-2022/

Joint Note

[3] McKinsey: disruptive technologies
http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/disruptive-technologies

[4] The UN 2030 Agenda for Sustainable Development
https://sdgs.un.org/goals

[5] McKinsey: Global energy perspective
https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2023-industrial-electrification-outlook

[6] European Chips Act - Questions and Answers
https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3087

[7] IEEE
https://www.ieee.org/societies_communities/societies/index.html

[8] 4TU Federation
https://www.4tu.nl/

[9] Flying companion for floating litter collection
https://cordis.europa.eu/project/id/101059875

Introduction

[10] University of Twente: history
https://www.utwente.nl/en/organisation/about/history/

[11] Shaping 2030: our mission
https://www.utwente.nl/en/organisation/about/shaping2030/mission/

[12] University of Twente organisation overview
https://www.utwente.nl/en/organisation/

[13] UT centres of expertise
https://www.utwente.nl/en/research/vision/centres-of-expertise/

[14] Research in EEMCS (Electrical Engineering, Mathematics and Computer Science)
https://www.utwente.nl/en/eemcs/research/

[15] Nationaal Groeifonds
https://www.nationaalgroeifonds.nl/

[16] Bachelor programme Creative Technology
https://www.utwente.nl/en/create/

[17] Accelerate Impact with Innovation
https://novelt.com/en/

[18] DSI
https://www.utwente.nl/en/digital-society/

[19] TechMed
https://www.utwente.nl/en/techmed/

[20] Enabling Sustainable and Personalised Health by Means of Technology
https://www.utwente.nl/en/techmed/about/

[21] MESA+
https://www.utwente.nl/en/mesaplus/about/

[22] 4TU's Netherlands Institute on Research on ICT
https://www.4tu.nl/nirict/

[23] UT House of integrity
https://www.utwente.nl/en/organisation/about/integrity/

[24] Netherlands Code of Conduct for Research Integrity
https://www.universiteitenvannederland.nl/files/publications/Netherlands%20Code%20of%20Conduct%20for%20Research%20Integrity%202018.pdf

[25] European code of conduct
https://allea.org/code-of-conduct/

[26] Singapore statement on research integrity
https://www.wcrif.org/downloads/main-website/singapore-statements/223-singpore-statement-a4size

[27] KNAW Advice on correctly citing
https://www.knaw.nl/publicaties/correct-citeren

[28] Mindlab: a theatre performance that gets at the heart of the science community
https://www.utwente.nl/en/mindlab/

[29] Dilemma Game
https://www.eur.nl/en/about-eur/policy-and-regulations/integrity/research-integrity/dilemma-game

[30] Integrity: Active bystander training
https://www.utwente.nl/en/courses/1178419/integrity-active-bystander-training/

[31] UT web page on scientific integrity
https://www.utwente.nl/en/organisation/about/integrity/scientific-integrity/

[32] TurnItIn: Empower students to do their best, original work
https://www.turnitin.com/

[33] Use of AI in Education at the University of Twente
https://www.utwente.nl/.utwente_base/ws2016/download.shtml?f=uRnBbrXtGq5q6W2ouxATTpRP_yr0agD1MR2Ve6kV9p1JxBEYlt8gDaiRW4hlqVIlDq2HcucWVRYBwyChKhb7Tw

[34] The use of generative AI and AI-assisted technologies in writing for elsevier
https://www.elsevier.com/about/policies-and-standards/the-use-of-generative-ai-and-ai-assisted-technologies-in-writing-for-elsevier

[35] UT: Ethical Review
https://ethicalreview.utsp.utwente.nl/index.html

[36] Open Science NL
https://www.openscience.nl/en

[37] Shaping 2030
https://VisitationEE.utwente.nl/EE-FT-2017-2022/pdf/Shaping2030.pdf

[38] UT research information
https://research.utwente.nl

[39] UT Open Access website
https://www.utwente.nl/en/service-portal/university-library/publication-archiving/open-access

[40] FAIR data/software
https://www.go-fair.org/

[41] UT Research Data Management
https://www.utwente.nl/en/service-portal/university-library/research-data-management

[42] UT Digital Comptence Center
https://www.utwente.nl/en/dcc/#support-expertise-network-for-ut-researchers

Mission & strategy during assessment period

[43] NanonlabNL: nanotechnology at your fingertips
https://nanolabnl.nl/

[44] Twente University RadBoudumc Opportunities (TURBO) program
https://www.utwente.nl/en/techmed/innovation/funds-vouchers/turbo/

[45] The next generation high tech equipment, for our future generations
https://nxtgenhightech.nl/en/

[46] Student Organisations (some dedicated solely to sustainability)
https://www.utwente.nl/en/education/bachelor/studentlife/next-to-your-study/student-teams/

[47] Nationale Commissie Sectroplannen (in Dutch)
https://www.nlsectorplannen.nl/bestanden-techniek-ii

[48] Een nieuw fundament: Sectorbeeld voor de technische wetenschappen, November 2018
https://VisitationEE.utwente.nl/EE-FT-2017-2022/pdf/SectorbeeldTechniek.pdf

[49] Sector Plan Techniek, EE@UT
https://www.utwente.nl/en/et/research/sector-plan/electrical-engineering/

[50] In Memoriam: Braham Ferreira
https://www.utwente.nl/en/eemcs/news/2021/5/1062139/in-memoriam-braham-ferreira

[51] Empower a billion lives
https://empowerabillionlives.org/

[52] Jelena Popovic
https://www.utwente.nl/en/et/research/sector-plan/sectorplan-stories/Popovic/

[53] Center for Brain-Inspired Nano Systems
https://www.utwente.nl/en/mesaplus/research/centres-of-expertise/brains/

[54] Centre for Quantum Nanotechnology Twente
https://www.utwente.nl/en/mesaplus/research/centres-of-expertise/quant/

[55] Solar Centre Twente
https://www.utwente.nl/en/mesaplus/research/centres-of-expertise/solar/

[56] Centre for Monitoring and Coaching
https://www.utwente.nl/nieuws/2015/9/422075/opening-centre-for-monitoring-and-coaching

[57] Organ-on-Chip Centre Twente
https://www.utwente.nl/en/mesaplus/research/centres-of-expertise/oocct/

[58] Over 3M€ for Organ-on-Chip Development
https://www.utwente.nl/en/techmed/news/2023/5/940479/over-3-million-for-organ-on-chip-development

[59] Edge: The Centre for Networked Systems and Intelligence
https://www.utwente.nl/en/edge/about/

[60] Robotics Centre University of Twente
https://www.utwente.nl/en/robotics/

[61] Designlab University of Twente
https://www.utwente.nl/en/designlab/

[62] Master Embedded Systems
https://www.utwente.nl/en/education/master/programmes/embedded-systems/

Quality and relevance

[63] Factsheet Open Access in EU Horizon 2020 programmes
https://research-and-innovation.ec.europa.eu/document/download/15c0bc24-53da-4879-a561-de43599ed702_en?filename=ec_rtd_open-data-h2020.pdf

[64] Taverne Amendment
https://www.openaccess.nl/en/in-the-netherlands/you-share-we-take-care

[65] 4TU.ResearchData
https://data.4tu.nl/

[66] Zenodo: Passionate about Open Science!
https://zenodo.org/

[67] Field Weighted Citation Index
https://www.wiley.com/en-us/network/publishing/research-publishing/editors/what-is-field-weighted-citation-impact

[68] Bram Nauta designs chips for today and tomorrow
https://www.utwente.nl/en/research/researchers/featured-scientists/nauta/

[69] ERC project High Risk, No Gain
https://www.utwente.nl/en/news/2019/3/57233/erc-advanced-grant-for-arjen-hoekstra-bram-nauta-and-andrew-skidmore#profdrir-bram-nauta-high-risk-no-gain

[70] Stefano Stramigioli leads creation of new systems in the fields of Robotics and AI
https://www.utwente.nl/en/research/researchers/featured-scientists/stramigioli/

[71] ERC project Portwings
https://www.utwente.nl/en/news/2024/3/1420848/breakthrough-in-understanding-robotic-bird

[72] UT Awards & grants
https://www.utwente.nl/en/research/researchers/awards

[73] Assessment BSc and MSc Electrical Engineering
https://visitationee.utwente.nl/OW2022/index.php?c1=559181562023

[74] NVAO BSc EE@UT assessment
https://publicaties.nvao.net/prd/AV-1818_20230628_Rapport_University%20of%20Twente%20Bachelor%20Electrical%20Engineering%20Report.pdf

[75] NVAO MSc EE@UT assessment
https://publicaties.nvao.net/prd/AV-1819_20230628_Rapport_University%20of%20Twente%20Master%20Electrical%20Engineering%20Report.pdf

[76] UT TOP Programme
https://www.utwente.nl/en/alumni/inspiring-alumni/ut-canon/stories/top-rogramme/

[77] Homey
https://homey.app/en-gb/

PhD Policy and training

[78] Our Future Leaders
https://recesscollege.org/programmes/our-future-leaders

[79] Twente Graduate School
https://www.utwente.nl/en/education/tgs/

[80] Twente PhD Charter
https://www.utwente.nl/en/education/tgs/currentcandidates/phd/downloads/phd-charter-english.pdf

[81] The Dutch Institute of Systems and Control
`https://disc.tudelft.nl/about/`

[82] Advanced School for Computing and Imaging
`https://asci.school/about/`

[83] Netherlands Research School for Information and Knowledge Systems (SIKS)
`http://www.siks.nl`

[84] Training and supervision plan
`https://www.utwente.nl/en/education/tgs/currentcandidates/hora-finita/phd/research_phase/training-and-supervision-plan/`

[85] Doctoral Education guidelines
`https://www.utwente.nl/en/education/tgs/currentcandidates/phd/downloads/doctoral-education-guidelines.pdf`

Working environment and personnel policies

[86] NWO: Recognition and Rewards
`https://www.nwo.nl/en/recognition-and-rewards`

[87] 9 Box Grid: A Practitioner's Guide
`https://www.aihr.com/blog/9-box-grid/`

[88] University of Twente introduces Hypatia chairs for female professors
`https://www.utwente.nl/en/news/2018/7/260065/university-of-twente-introduces-hypatia-chairs-for-female-professors#hypatia-chairs`

Strategy for the next six years

[89] Dutch cabinet planning to invest heavily in semiconductor industry needs
`https://nltimes.nl/2024/03/25/cabinet-close-eu14-billion-plan-keep-asml-nxp-eindhoven-end-30-ruling-cuts`

[90] ChipTech Twente
`https://chiptechtwente.com/en/`

Appendices

[91] euRobotics portal
`https://www.robotics-portal.eu/`

[92] euRobotics: About SPARC
`https://eu-robotics.net/about-sparc/`

[93] ControlLab: From Simulation to Real Innovation
`https://www.controllab.nl/`

[94] Machnet Medical Robotics
`https://machnet-robotics.com/`

[95] Diameter: An app for diabetics
`https://www.utwente.nl/en/techmed/research/domains/medical-physiology/diameter/`

[96] Assessment Committee Report on Research in Electrical Enginering, March 2018
`https://VisitationEE.utwente.nl/EE-FT-2017-2022/pdf/Assessment%20Committee%20Report%20on%20Research%20in%20EE%202011-2016.pdf`

[97] OpenAlex, Search and analyze the world's research.
`https://openalex.org/`

[98] Open Access colours: green, gold, diamond, hybrid and more
`https://onderzoektips.ugent.be/en/tips/00000461/`

[99] Open Access: A State of the Art
`http://book.openingscience.org.s3-website-eu-west-1.amazonaws.com/tools/open_access_state_of_the_art.html`

[100] About 3DCardiacHTS
`https://3dcardiachts.eu/about/`

[101] Sync Biosystems secures 2.5M€ to validate technology with international end users
`https://syncbiosystems.com/sync-biosystems-secures-e2-5m-to-validate-technology-with-international-end-users/`

UNIVERSITY OF TWENTE.

Department of Electrical Engineering
Faculty of Electrical Engineering, Mathematics and Computer Science
University of Twente
P.O. Box 217
7500 AE Enschede
Netherlands