4TU.Federation

Annual Report 2022

April 2023

TU Delft Delft University of Technology
TU/e Eindhoven University of Technology
University of Twente.
Wageningen University & Research
4TU.

Report on activities

Foreword

With over 18,000 staff, 65,000 students and a multitude of alumni who occupy important positions in various companies and organisations, the Netherlands' four technical universities are a key driving force behind technological innovation in the Netherlands, supporting the transitions that our country must undergo.

The impact of our work was underscored very neatly in a recent research report published by BIGGAR Economics. This UK-based agency calculated that the '4TUs' generated no less than €9 in gross added value for the Dutch economy for every €1 of public funds invested. This is a finding that we at the 4TU.Federation take particular pride in, and also that motivates us to achieve a truly lasting impact.

This motivation goes far beyond creating economic value, as the stories told as part of the Insightful Innovators series show. This series, which tells the stories behind our enterprising students and their ambition to make the world a better place, provides a wonderful and inspiring glimpse into the world of science, education and commercial knowledge transfer.

Connection, representation and innovation are the key values on which we, the federation of technical universities in the Netherlands, base our role and contribution. These values do not stand in isolation, but are fundamentally linked. A perfect illustration of this is our *High Tech for a Sustainable Future* research programme. This is a capacity-building programme through which we are not only attracting and connecting the best scientific talent to tackle the challenges that we face as a society, but also giving a tangible form to innovation in education and research.

This annual report will present other such examples of successful partnership and cooperation.

In March 2022, I took over from Louise Fresco in her role as the previous chair of the 4TU.Federation. I would like to thank her for helping us to achieve our current position as universities of technology. At the same time, I would like to thank everybody else who has, in any way and however large or small, contributed to achieving our shared ambitions for a successful 2022.

Vinod Subramaniam
Chair of the 4TU.Federation (since March 2022)
Chair of the Executive Board, University of Twente

1 General & Executive Boards

General Board	Tim van der Hagen, Rob Mudde, Marien van der Meer (TU Delft) Robert-Jan Smits, Frank Baaijens, Nicole Ummelen (TU/e) Vinod Subramaniam (chair since 8 March 2022), Tom Veldkamp, Machteld Roos (UT) Louise Fresco (chair until 8 March 2022) / Sjoukje Heimovaara, Arthur Mol, Rens Buchwaldt (WUR)
Executive Board	Vinod Subramaniam (chair since 8 March 2022), Tim van der Hagen, Louise Fresco (chair until 8 March 2022) / Sjoukje Heimovaara
Support	Lotte Melenhorst/Birgit van Driel (TU Delft), Renee Westenbrink (TU/e), Dieuwertje ten Brinke (UT) Pieter Munster/Eva Verschoor (WUR)
4TU	Marjolein Dohmen-Janssen, Linda Baljeu

The General Board (GB) met twice (physically), and the Executive Board (EB) met five times – once in person. The EB also held an online meeting with a delegation from the participation bodies of the four TUs.

New chair and new representative from WUR

At the meeting of the GB held on 8 March 2022, having completed her second term as chair of WUR in June 2022, Louise Fresco (chair of WUR) handed over the chairmanship of the 4TU.Federation to Vinod Subramaniam (chair of UT). As the chair of WUR, Fresco worked hard to ensure that Wageningen joined the federation, and as a result, the 3TU.Federation became the 4TU.Federation in 2016. 4TU is very grateful to Fresco for all her hard work and inspiration. She was succeeded by Sjoukje Heimovaara on 1 July 2022, who therefore also took on the role of representative of WUR in the EB and member of the GB of 4TU.

Political developments

The policy agenda for the new incoming government (the coalition agreement) was published at the end of 2021, and the fourth cabinet of Mark Rutte took office on 10 January 2022. The new coalition agreement included a substantial investment in higher education, including €200 million per year for sector plans and €300 million per year for start-up and incentive grants. 4TU has worked hard to ensure that a substantial share of the sector plans budget is used to support technology, and starting in 2023 €40 million per year will be spent on this area.
Through frequent meetings of the delegation of deans for technology and their support staff (consisting of the deans and scientific staff from 24 faculties at the four universities of technology plus the University of Groningen (RUG)), progress was made on the Sector Plan for Technology II, a draft of which was finished at the end of 2022, in order to present to the National Sector Plans Committee in 2023. 4TU played a coordinating role in this process, and the many years of cooperation through the federation proved invaluable.

Research into the economic impact of 4TU

The 4TU board believes it is important to show people that the Netherlands' four technical universities are indispensable to our society. They are making an essential contribution to achieving the Sustainable Development Goals (SDGs) and to meeting the societal challenges and transitions that are required in the Netherlands and worldwide. Economic impact is one part of this broad societal impact, and this is why 4TU commissioned a UK-based research agency to measure the economic impact of the four universities. The total annual economic impact of the four TUs combined is estimated at €12.7 billion in gross added value, and 102,740 jobs. This impact is generated through the effects of education, research and commercial knowledge transfer, and the economic effects of our work as universities. For every €1 of public money invested, the four institutes create no less than €9 in gross added value for the Dutch economy. Just over half of this stems from targeted activities, demonstrating that the important role that our universities play in the economy goes far beyond just their role as large organisations.

'Drivers of Technology' and the 'Techrede' event

Following previous successful events, in September the 'Drivers of Technology' (*Aanjagers van Technologie*) held the Techrede 2022 at the Floriade in Almere. With a focus on the near future and how to speed up technology transitions, a group of ambitious and socially committed students from the four universities of technology worked on creating social impact. At the Techrede event, these 'Drivers of Technology' explained the activities they have been engaging in over the past year, and appealed to politicians to take concrete action. The State Secretary for Infrastructure and Water Management, Vivianne Heijnen, watched the Techrede with the students in a green mobile cinema, and praised the idea of including 'the voice of the future' in the debate on societal challenges and driving technological innovation as a useful and necessary addition.

Key figures

The tables below show the number of full-time professors and associate professors in the period 2011-2021. The increase in academic staff that has taken place since about 2018 to 2019 is clearly visible. This was due to the Sector Plan for Technology I (2019) and the Sector Plan for Science Education (2020), as well as a structural focus on recruiting more female academic staff.

Number of academic staff (FTE) (professors, associate professors, assistant professors) in m/f, 2011-2021

MALE	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	21/20	21/11
TUD	754	734	726	731	735	744	757	775	787	832	868	4.34%	15.15%
TUE	453	447	438	435	432	454	444	440	451	452	461	2.12%	1.85%
UT	467	452	434	421	417	418	423	435	460	498	519	4.35%	11.22%
WU	397	408	408	405	405	390	391	385	387	408	419	2.65%	5.58%
FEMALE	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	21/20	21/11
TUD	139	146	161	167	178	185	196	215	233	286	320	11.78%	130.05%
TUE	65	58	73	81	98	108	114	120	132	165	174	5.45%	168.00%
UT	121	118	117	114	115	119	127	145	151	175	205	16.85%	69.13%
WU	115	121	123	132	144	152	162	170	189	211	237	11.98%	105.78%
4TU % female	18%	18%	19%	20%	21%	22%	23%	24%	25%	28%	29%		

Source: WOPI, reference date 31 December

2 Research Board

Board	Arthur Mol (WUR, chair) Tim van der Hagen (TUD), Frank Baaijens (TU/e), Tom Veldkamp (UT)
Support	Pieter Munster (WUR, secretary), Birgit van Driel (TUD), Rianne Pas (TU/e), Jasper van Alten/Dieuwertje ten Brinke (UT)
4TU	Marjolein Dohmen-Janssen, Linda Baljeu

In 2022, the Research Board consisted of the research portfolio holders from the Executive Boards of the four technical universities. 4TU.Research is responsible for shaping and overseeing cooperation and planning by the universities of technology in the field of research.

High Tech for a Sustainable Future

The 4TU.Federation is giving a major boost to research into sustainable technology through its theme of 'High Tech for a Sustainable Future' (HTSF). This is a thematic capacity-building programme aimed at attracting new scientific talent and finding solutions to the major challenges that our society faces.

There was a second call for research proposals in 2022, which resulted in four new large-scale projects concerning personalised healthcare (RECENTRE), reducing heat in cities (HERITAGE), developing green biodegradable sensors (Green sensors) and a future-proof food system (REDESIGN). These programmes will launch in the first half of 2023 and will be staffed by tenure trackers aided by support staff such as PhD candidates and postdocs.

In 2018, our own resources were made available for five thematic programmes within the first HTSF call: DeSIRE, Plantenna, Precision Medicine, Pride & Prejudice and Soft Robotics. The start of the new HTSF programme means that these partnerships became a structural part of the universities. An update on each individual programme is provided in section 17.

NIRICT and HTM partner with University of Groningen

It was agreed in 2022 that the 4TU.Centres HTM and NIRICT would cooperate substantively with their counterparts at the University of Groningen (RUG). Given the RUG's expertise in the fields in which these centres are active, this creates clear added value. This means full membership for the RUG, with representatives joining the management team and contributing to the coordination budget of these centres.

4TU.ResearchData

The consortium agreement between the individual institutes regarding 4TU.ResearchData expired in 2022 but has been extended until December 2025.

Foundation for the History of Technology (*Stichting Historie der Techniek*)

In 2022, the board of 4TU.Research aligned the annually available budget for the Foundation for the History of Technology with the centres under the 4TU banner.

Exchange of opinions regarding the coalition agreement

In the year 2022, the research board was a place to discuss and coordinate action regarding the consequences of the coalition agreement (entitled 'Looking out for each other, looking ahead to the future') for research at the universities of technology. Relevant themes included the sector plans, the National Growth Fund and the start-up and incentive grants.

Academy of Engineering

4TU.Research welcomes the establishment of an Academy of Engineering in the Netherlands, and in 2022 took steps to make a positive contribution to this by bringing the relevant parties together.

NWO–AES

The arrival of a new director at NWO-AES was a good time to strengthen ties with NWO. Both the NWO-AES director Luuk Klomp and NWO director Marcel Levi visited the Research Board Committee. The position of the technical sciences in the wider Dutch research landscape was discussed at the meetings and in a letter from the Research Board, which was the reason for addressing various aspects of this subject in consultation with the NWO.

Key figures

Number of PhD defences at 4TU, 2012-2022

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/12
4TU	973	1,064	1,145	1,130	1,182	1,063	1,161	1,230	1,083	1,200	1,132	-6%	+16%
TUD	303	353	371	357	395	359	368	400	374	432	394	-9%	+30%
TUE	245	218	243	234	224	212	264	290	244	268	225	-16%	-8%
UT	196	220	244	234	267	197	243	247	184	206	193	-6%	-2%
WU	229	273	287	305	296	295	286	293	281	294	320	+9%	+40%

Number of 4TU PhD candidates, 2012-2022

M	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/12
TUD	1,854	1,871	1,881	1,913	1,959	1,995	2021	1,983	2,038	2,067	2,140	+4%	+15%
TUE	851	886	925	969	1,028	1,072	1,070	1,063	1,105	1,130	1,336	+18%	+57%
UT	831	784	784	783	756	751	699	648	798	843	834	-1%	0%
WU	994	963	962	953	938	933	912	922	1,026	1,073	1,097	+2%	+10%
F													
TUD	713	730	744	739	751	771	795	828	890	936	1,006	+7%	+41%
TUE	308	324	355	398	415	462	494	509	541	557	660*	+18%	+114%
UT	421	409	420	452	436	442	429	383	456	499	512	+3%	+22%
WU	965	992	941	943	929	938	955	1,014	1,170	1,224	1,292	+6%	+34%
4TU	6,937	6,959	7,012	7,150	7,212	7,364	7,375	7,350	8,018	8,329	8,877	+7%	+38%

Source: WOPI (reference date: 31 December)

**TU/e: 2 gender-neutral PhD candidates have been added under F*

Prizes

The prizes listed below were awarded during the 2022 reporting year. It is not the names of the grants that is important here, but the year in which they were awarded. For example, the Vici 2021 was awarded in July 2022 and is therefore included in this annual report.

Innovation incentive scheme	ERC
Veni 2021: awarded in 04/2022[1]	Starting 2021: awarded in 11/2022 Advanced 2021: awarded in 04/2022 Consolidator 2021: awarded in 03/2022
Veni 2021: awarded in 07/2022	
Veni 2021: awarded in 03/2022	

TUD	**Veni 2021** K. Bastiaans B. Cattoor J.L.C. Cremer S. Du E. Greplova J.B. van Grunsven K. Kirchner R.M. de Kruijff K. Lahabi K.M. Lompe S. Muraro M.F. Russ T. Sinnige C.A. Urzua Torres Y. Vardar Y. Wang **Vidi 2021** K. Batselier S. Conesa-Boj J.W. Haverkort M.J. Heiligers A. Katsifodimos K. Stankova A. Viré M. Wiertlewski (HTSF) **Vici 2021** G.A. Steele M.C. Veraar	**Starting 2021** J. Alonso-Mora F. Avallone C. Cottineau I. Langella S. Weingartner (HTSF) **Advanced 2021** C. Bisagni **Consolidator 2021** A. Caviglia A. Endo D. Tam	WUR	**Veni 2021** M. Diender J.E. Dykstra M.A. de Haas S. Hobbis J.J.E. van Hooff R. Huisman A. Kuhn B. van der Meer M.J. Zwetsloot **Vidi 2021** G.J. Amador (HTSF) G.R. Biesbroek A. van der Ent J.J. Fros I.T. Luijkx M.H. Medema S.R.M. Vialet-Chabrand **Vici 2021** E.H Poelman L.C.P.M. de Smet	**Starting 2021** - **Advanced 2020** - **Consolidator 2020** -
TU/e	**Veni 2021** P. Cosar C.W. Oh M. Rücker A.H. Schrotenboer F. van der Sommen **Vidi 2021** A. Abiad Monge E. Bosco S. Loerakker	**Starting 2021** F. Grisoni M. Schoukens R. van Sloun **Advanced 2021** H. Kuipers W. Mulder **Consolidator 2021** F. Alkemade	UT	**Veni 2021** A. Betken E. Hendriks F. Kalloor Joseph T. Kamperman A. Lavrenko L.I.M. Lenferink K.M. Pondman H.C. Ruiz Euler **Vidi 2021**	**Starting 2022** S. Kelders G. Lajoinie (HTSF) T. Segers **Advanced 2021** - **Consolidator 2021** D. Marpaung

[1]Due to the coronavirus pandemic and a security hack, Veni 2021 was awarded partly in December 2021 and partly in April 2022. This tables includes all recipients.

	R. van der Meel **Vici 2021** -			J.A. Faria Albanese R. Rietbroek **Vici 2021** K. Broersen	

3 Education Board

Board	Rob Mudde (TUD, chair), Frank Baaijens (TU/e), Tom Veldkamp (UT), Arthur Mol (WUR)
Support	Barbara Marx (TUD, secretary), Lilian Halsema (TU/e), Lisette Woud/Chris Rouwenhorst (UT), Eva Verschoor (WUR)
4TU	Marjolein Dohmen-Janssen, Linda Baljeu

In 2022, the Education Board consisted of the education portfolio holders of the Executive Boards of the technical universities. The committee is responsible for planning and cooperation between the universities in the field of education, as well as supervision.

Centre for Engineering Education (CEE)

The four technical universities are working together to improve engineering education through the CEE. The centre gathers and develops evidence-based knowledge and regularly informs and advises the board of 4TU.Education regarding trends and innovations in the education sector. The effectiveness of the innovation within the four institutes is monitored and analysed continuously by the CEE. The four technical universities also exchange expertise and experiences.
In 2022, the CEE updated the board regarding 'ethics in education', with the central goal being to provide society with responsible engineers. There was also a request for more focus on the recognition of education in staff career paths. The board committee has instructed the CEE, together with the Recognition & Reward working groups, to provide advice on how to speed up the implementation of the Recognition & Reward policy (with an emphasis on education) across the universities.

Student numbers in technology and engineering

The subject of 'new students joining engineering and technology education' featured prominently on the agenda in 2022. Various surveys and studies indicate that the number of students joining degree programmes in engineering and technology is lower than expected, when compared with the total number of incoming students. The Education Board Committee expressed its concern about this and instructed the 4TU.VO platform to carry out an analysis of existing research and initiatives in order to try to identify the causes and to turn the tide.
The platform indicates that in 2023, activities to raise the profile of engineering and technology in secondary education will be scaled up. It has also been concluded that new activities are needed specifically for lower secondary education, *before* pupils choose a profile.

Quality assurance in EngD programmes

Quality assurance for the EngD programmes was scrutinised in 2022. An EngD Quality Assurance Committee was asked for its advice for this purpose. The Committee concluded that quality assurance in relation to educational programmes is increasingly taking place at the institute level. Its advice is to develop a standard evaluation protocol that is tailored to EngD programmes. The Stan Ackermans Institute has been invited to do this.

Progress on 4TU projects in the Sector Plan for Science and Technology Education

Following the recommendation of the Van Rijn Committee, in 2019 the Ministry of Education, Culture and Science asked 4TU to draft a Sector Plan for Education in Science and Technology, together with the relevant faculties of the general universities, higher professional education, student organisations and the business community. This plan focuses on seven joint projects, with concrete planning initiated after the summer of 2020.
The board was also updated regularly on the progress of all projects during 2022. Two meetings were organised by the 4TU office in 2022, when the project leaders were able to provide an update on

progress in their project. The midterm report on these projects was completed by the end of 2022. The final recommendation will be presented to the Ministry of Education, Culture and Science at the beginning of 2023. Information on the latest progress can be found at https://www4tu.nl/onderwijs/sectorplan-betatechniek/

Key figures

The significant increase in the number of students during the period 2012-2022 is illustrated by the figures below.

Number of registered students m/f, NL/international

Student population of 4TU, 2012-2022, all students (main enrolment as of 1 October)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/09
TUD	17,874	19,148	20,034	21,469	22,199	23,325	24,507	24,961	26,028	26,670	26,620	0%	61%
TUE	7,762	8,377	9,209	10,116	10,764	11,372	11,969	12,237	12,873	12,796	12,816	0%	76%
UT	9,314	9,315	9,263	9,082	9,396	9,921	10,665	11,404	12,219	12,609	12,194	-3%	43%
WU	7,491	8,302	9,032	9,720	10,697	11,446	11,946	12,280	12,896	13,056	12,994	0%	128%
4TU	42,441	45,142	47,538	50,387	53,056	56,064	59,087	60,882	64,016	65,127	64,624	-1%	70%
M	29,280	30,967	32,363	34,025	35,290	36,983	38,681	39,529	41,243	41,739	41,283	0%	
F	13,161	14,175	15,175	16,362	17,766	19,081	20,406	21,353	22,773	23,392	23,341	0%	122%

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/12
INT	6,839	7,246	7,688	8,726	9,895	10,905	12,209	13,154	14,191	15,742	16,967	8%	254%
NL	35,602	37,896	39,850	41,661	43,161	45,159	46,878	47,728	49,825	49,389	47,657	-4%	894%

Number of incoming BSc students m/f, NL/international

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/09
TUD	2,756	3,057	3,125	3,274	3,353	3,641	4,094	3,783	3,943	3,859	3,708	-4%	158%
TUE	1,729	1,967	2,144	2,276	2,396	2,616	2,338	2,296	2,535	2,258	2,363	5%	199%
UT	1,780	1,792	1,814	1,691	2,060	2,113	2,335	2,631	2,755	2,840	2,195	-23%	197%
WU	1,181	1,457	1,484	1,521	1,655	1,713	1,711	1,620	1,734	1,544	1,463	-5%	180%
4TU	7,446	8,273	8,567	8,762	9,459	10,083	10,478	10,330	10,967	10,501	9,729	-7%	45%
M	5,092	5,657	5,793	5,956	6,149	6,725	6,869	6,664	7,056	6,884	6,396	-7%	34%
F	2,354	2,616	2,774	2,806	3,310	3,358	3,609	3,666	3,911	3,617	3,325	-8%	72%

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/09
INT	725	741	768	805	1,158	1,307	1,875	2,070	2,269	2,843	2,731	-4%	469%
NL	6,721	7,532	7,799	7,957	8,301	8,776	8,603	8,260	8,698	7,658	6,998	-9%	12%

Source: 1CHO

Key figures

The tables below show that the number of Master's students at the four universities of technology has increased over the past decade.

Incoming + transfer MSc m/f, NL/international

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/09
TUD	2,089	2,327	2,519	2,207	2,882	3,393	3,500	3,459	4,107	4,162	3,835	-8%	182%
TUE	717	887	976	655	1,117	1,180	1,264	1,373	1,633	1,599	1,311	-19%	165%
UT	847	688	667	471	1,072	1,122	1,117	1,195	1,284	1,308	1,941	-10%	76%
WU	1,325	1,310	1,300	1,228	1,676	1,750	1,765	2,035	2,053	2,128	1,173	-9%	118%
4TU	4,978	5,212	5,462	4,561	6,747	7,445	7,622	8,062	9,077	9,197	8,278	-11%	127%
M	3,170	3,243	3,516	2,893	4,131	4,577	4,666	4,858	5,558	5,591	5,000	-9%	170%
F	1,808	1,969	1,946	1,668	2,616	2,868	2,956	3,204	3,519	3,606	3,276	-10%	142%

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	22/21	22/09
INT	1,858	1,867	2,219	2,773	2,889	3,117	3,114	3,098	2,918	3,554	3,335	-6%	134%
NL	3,120	3,345	3,243	1,788	3,858	4,328	4,532	4,964	6,159	5,643	4,943	-13%	148%

Number of BSc and MSc degrees m/f, NL/international

BSc degrees from 4TU, 2011-2021

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	21/20	21/08
4TU	5,542	4,875	4,955	5,565	5,175	5,617	5,962	6,440	6,685	7,288	6,916	-5%	25%
M	3,863	3,166	3,205	3,651	3,284	3,608	3,854	4,011	4,244	4,562	3,571	-3%	-5%
F	1,679	1,709	1,750	1,914	1,891	2,009	2,108	2,429	2,441	2,726	2,575	-2%	20%
INT	335	399	480	483	541	470	450	649	723	956	1,214	13%	235%
NL	5,207	4,476	4,475	5,082	4,634	5,147	5,512	5,791	5,962	6,332	5,702	-10%	90%

MSc degrees from 4TU, 2011-2021 (incl. Master's degree)

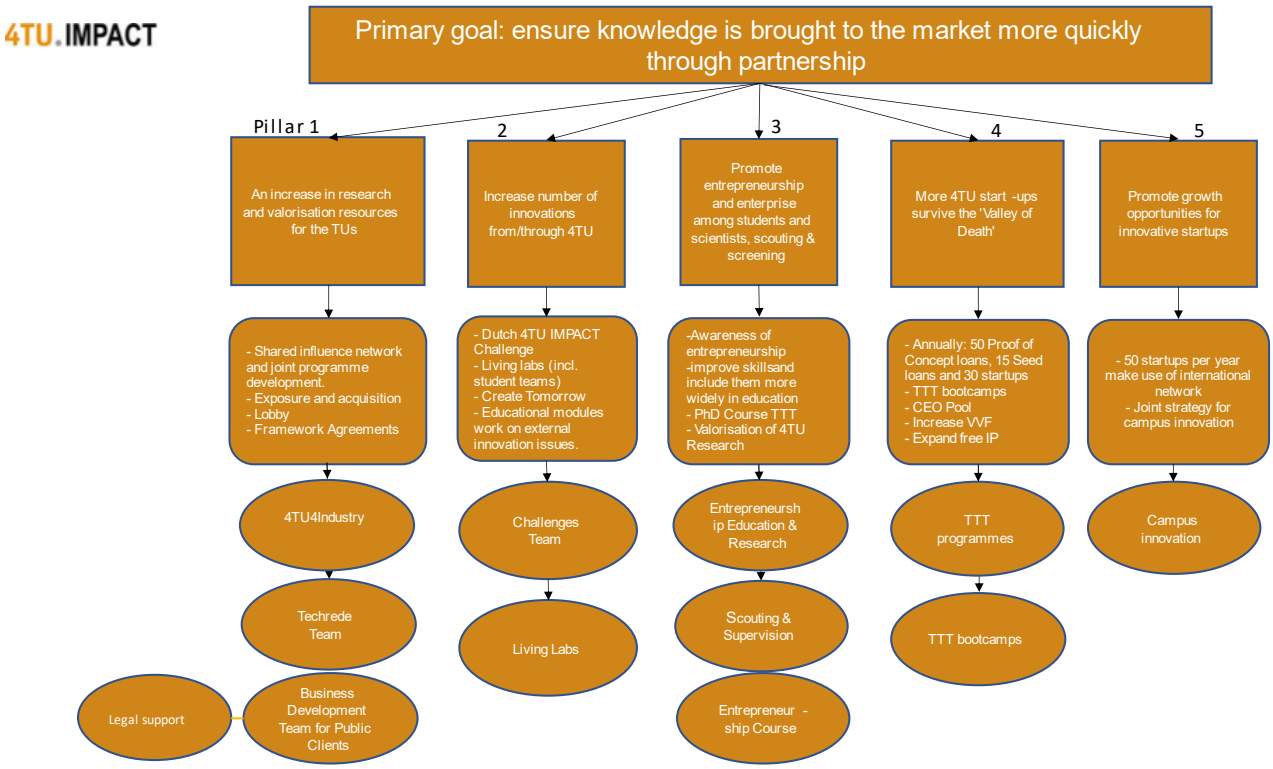
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	21/20	21/08
4TU	5,892	5,556	5,987	6,416	6,960	7,540	8,045	8,448	8,434	9,733	9,140	-6%	55%
M	3,805	3,643	3,845	4,080	4,366	4,701	4,846	5,195	5,156	5,913	5,569	-7%	19%
F	2,087	1,913	2,142	2,336	2,594	2,839	3,199	3,253	3,278	3,820	3,571	1%	36%
INT	1,649	1,674	1,845	1,967	2,164	2,643	2,926	3,058	2,986	3,180	2,941	7%	118%
NL	4,243	3,882	4,142	4,449	4,796	4,897	5,119	5,390	5,448	6,553	6,199	-6%	79%

Source: 1CHO

4 IMPACT

Director	Paul Althuis (TUD)
Programme Manager	Roelyn van der Hoek (UT)
Management team	Paul Althuis (TUD), Jeroen van Woerden (TU/e) Jaap Beernink (UT), Sebastiaan Berendse (WUR)

4TU's work on joint commercial knowledge transfer is based at the 4TU.IMPACT centre. In 2022, it was agreed that proposals for major changes, points for discussion or requests would be submitted to the Executive Board, along with the relevant substantiation.
The new activity plan 2022-2025 was approved in 2021. Below is an overview of the various goals and objectives of the new plan. Some highlights from 2022 are described below in each pillar.



Pillar 1

For the 'Drivers of Technology' (*Aanjagers van Technologie*), who organised the Techrede, 2022 was all about converting words into deeds. The new students built on the insights of their predecessors, working towards that one goal of accelerating transitions through technological innovation. As the 'voice of the future', the students showed that concrete actions can have an enormous impact on the societal transitions that are required so urgently.

The 'Investing in valorisation - the economic opportunity' research report, to which 4TU.Impact contributed, along with the UNL and NFU, was published on 26 January 2022. The report states that, according to research, there is still a significant gap between the impact of commercial knowledge transfer that universities achieve and the potential impact based on actual scientific achievements. Compared to European peers, this gap could easily be closed by providing extra resources for commercial knowledge transfer, and this would result in an additional economic impact of between €900 million and €2.5 billion. 4TU.Impact therefore continues to lobby for structural funding for commercial knowledge transfer activities.

Meanwhile, 4TU.Impact has been working hard to submit a Growth Fund application for commercial knowledge transfer together with the universities, universities of applied sciences and TO2 institutes in order to scale up to the next level. Structural financing for commercial knowledge transfer activities

therefore continues to be required. Other growth fund applications have always been coordinated between the four TUs in the 4TU.4-Industries-Forum.

Pillar 2

The 4TU Impact Challenge was held for the fourth time. The final took place in Helsinki again this year, and was followed by participation in the Slush Tech Fair. The start-ups made plenty of good contacts here, not only among investors, but also businesses, former students and other start-ups. The Challenges team contributed a case for the Create Tomorrow event at the University of Twente. Due to the coronavirus pandemic, it was not possible to hold the large meeting in-person, and so it was held online instead. Recruiting students from the other universities of technology for this proved challenging. In 2023, a separate league will be organised for 4TU honours students. The boards of the honours programmes will meet to arrange this themselves. At the end of 2022, we recruited students from every technical university for WUR's ReThink Waste Challenge using a roadshow on location.

Pillar 3

The 'Create impact through your PhD' pilot on the theme of the TTT Smart Systems for PhD candidates from the 4TUs has been a success. As a result, it was decided to hold workshops for PhD candidates who are involved in, or could become involved in, 4TU.Research. Two workshops were held in 2022.
The Insightful Innovators series tells the stories behind enterprising students and their ambitions to make the world a better place. They are a driving force behind innovation in the Netherlands.
The business developers are conducting a pilot using the AI platform ScoutinScience, which helps identify research with high tech-transfer potential. This provides a good starting point for discussions with scientists as their work and results are published.

Pillar 4

The third Thematic Technology Transfer (TTT) programme also began this year, this one in the field of medical technology. The programmes are going well: several spin-offs have already received a voucher and a number have also secured follow-up investment. TTT masterclasses have been organised and workshops have been given. A follow-up to these successful TTT programmes has therefore been included in the Growth Fund application.

Pillar 5

Following last year's successful mission to the Slush Tech Fair for start-ups and the fruitful partnership with both the Netherlands Enterprise Agency and the alumni offices, it was decided to visit a number of other fairs in 2022 as a trial. Start-ups from every university were selected for this purpose. Boot camps were arranged for these missions, in partnership with the Netherlands Enterprise Agency. Participants were trained and prepared to get the most impact out of participating in the mission. This proved an effective approach. All the start-ups indicated that they would be happy to take part in future missions. They were able to make plenty of contacts, establish relationships with investors and therefore maximise their opportunities for growth. This also contributed to an enormous increase in social media attention and media coverage.

Commercial activity

This annual report also covers commercial activity, an indicator of commercial knowledge transfer. Commercial activity is measured in the number of spin-offs and start-ups. The international definition of these terms, as also used by the UNL, has been chosen.

	Spin-offs	Start-ups
TUD	9	24
TU/e	5	21
UT	6	28
WUR	2	5

5 Applied Mathematics Institute

Scientific director	Johann Hurink (UT)
Coordinator	Ellen van den Bos (UT)
Management team	Kees Vuik (TUD), Luc Florack (TU/e) Richard Boucherie (UT), Peter van Heijster (WUR)
Board	Joost Kok (dean, UT), Johan Lukkien (dean, TU/e) Lucas van Vliet (dean, TUD), Peter van Heijster (WUR)

The overarching goal of the 4TU.Centre for Applied Mathematics (4TU.AMI) is to promote cooperation between mathematics groups/researchers from the four technical universities in order to boost the participation of mathematics in various fields of application.

Strategic Research Initiatives

The AMI uses some of its resources for 'Strategic Research Initiatives' (SRIs), which can be initiated by members of the four mathematics departments. Two project groups were launched in 2022: The aim of the 'Differential Equations for Phytoplankton-Nutrient Ecosystems' SRI is to establish a network of researchers from various fields in order to model phytoplankton. The aim of the 'Bridging Numerical Analysis and Machine Learning' SRI is to submit a research proposal. Both SRIs aim to achieve their respective goals in 2024.

Network

At the end of June, the AMI organised a networking event in Eindhoven to give members who began in 2021 and 2022 the opportunity to introduce themselves to the community and make new contacts. The event was attended by about 50 people from the four technical universities and the University of Groningen. A total of 32 short presentations were given and there was also plenty of time for getting to know one another and knowledge exchange. There were also two guest speakers in the field of research and education. The day was a great success and another such event will be held in 2023.

Math4NL

In 2021, together with the Netherlands Maths Platform (PWN), 4TU.AMI embarked on an initiative to strengthen a sustainable partnership between maths researchers and wider society in the Netherlands. Math4NL was founded for this purpose. Math4NL organised a number of translation sessions with companies in its first year, 2022, and there was a successful networking event for companies and academics. In 2023, Math4NL will finalise its organisational structure and be expanded further.

University of Groningen (RUG)

In 2022, exploratory talks regarding closer collaboration with the University of Groningen took place. The AMI, together with the applied mathematics groups of the RUG's Bernoulli Institute, will develop this partnership over a two-year period based on substantive questions and according to need. During this period, a RUG representative will take a seat on the MT of the AMI.

In addition, 4TU.AMI is also supporting a number of conferences and workshops organised by and for the 4TU.AMI community. The institute also provided financial support to write a Gravitation proposal, partly due to the significant impact that such a programme would have on the entire research field.

Looking ahead

In 2023, 4TU.AMI will continue to build on the foundation that has already been laid. The aim is to launch two new SRIs per year. Another networking event will be held in the summer, this time in Delft. In addition, the partnership with the RUG will be further built on. Finally, the goal is to set up a new research project on education.

6 Built Environment

Scientific director	Max Hendriks (TUD)
Coordinator	Maaike Riemersma (TU/e)
Management team	Frank van der Hoeven (TUD), Erik Schlangen (TUD) André Dorée (UT), Sanda Lenzholzer (WUR), Maarten Hornikx (UT)

The activities of 4TU.Built Environment (4TU.BE) in 2022 focused on facilitating and further developing the Focus Teams (*Domein Aanjaag Teams*, DATs), building the centre's network and increasing its name recognition, its partnership with the TKI for Construction & Engineering, representation to the Social Economic Council (SER) and a commitment to broader cooperation activities.

Max Hendriks (TUD) succeeded Maarten Hornikx (TU/e) as Scientific Director of 4TU.Bouw in 2022. Maarten Hornikx remains involved with 4TU.BE as a member of the MT. The frequency with which the MT meets was increased to once a month from September 2022, with input from a different Focus Team each time. Each Focus Team has its own web page on the website. A total of three deans meetings were held in 2022. Items on the agenda that were discussed included the contribution to the Technology Sector Plans (together with the University of Groningen), positioning in the TKI for Construction & Engineering and the National Mission-Innovation Team (MI-Team) for the Built Environment, and positioning in the broader context of 4TU.BE (RWS, Civil Engineering Council, etc.).

Focus Teams

Five Focus Teams have now been established for the following themes: Digitisation, Energy Transition, Infrastructure & Mobility, Area Development & Climate Adaptation and Sustainability. The teams are in different phases of development and are receiving support accordingly. They will take the long-term ambitions of the universities as their starting point and provide input for the national and international strategic knowledge and innovation agendas. Various meetings will be held to ensure further coordination within and between the teams and the MT in 2023.

Networking & Communication

Further enhancements have been made to the website, in terms of both content and visuals, and it is being further developed based on content and input from the Focus Teams. In 2022, seven articles and two news reports were posted on the website, five of which were written by Innovation Origins. The goal is to raise awareness of the Focus Teams, both internally and externally. Discussions are underway with the other 4TU.Centres within the 4TU.Federation.

TKI for Construction & Engineering

In 2022, 4TU.BE sent a delegation of two (Anita Baas and Maaike Riemersma) to the MT of the BTIC (known as the TKI for Construction & Engineering since 1 July). Various faculties of 4TU.BE took part in (re)submitting the NGF proposal on the 'Future-proof Living Environment'.

SER and sector plan

MT member André Doree continues to represent the BE in the SER core team for Training and the Labour Market. There has been coordination with the Growth Fund application for the LLO Catalyst, which means that the energy transition and co-creation labs are playing a prominent role in the proposal on lifelong development that has been awarded funding. Parallel to the roll-out, a model was developed that facilitates Quadruple helix collaboration between the three different education sectors (MBO, HBO, WO) and the realm of professional practice. The model has been submitted to branches of the network operators, builders and installation companies for their confirmation. This means that lifelong development initiatives from the university sector can be linked to transition paths in terms of content and funding, starting with the Energy Transition.
The chair of the 4TU.Construction deans meeting has accepted a coordinating role in the submission of the Plan for Civil Engineering and Designing the Built Environment.

Agenda for 2023

The plans for 2023 include the continued expansion of the Focus Teams, following up on the work done by 4TU.BE in the TKI Construction & Engineering, as well as collaboration with other 4TU.Centres, RWS, TKI Construction & Engineering, NL-GO and input to the NGF Future-proof Living Environment.

7 Design United

Scientific director	Berry Eggen (TU/e)
Management Team / Scientific co-directors	Daan van Eijk (TUD), Marco Rozendaal (TUD), Daniël Saakes (UT), Dieuwertje de Wagenaar (WUR)
Board	Ena Voûte (TUD), Lin-Lin Chen (TU/e), Mascha van der Voort (UT), Karin Schroën (WUR)

4TU.Design United (4TU.DU) contributes to the specialist work of design professionals by developing new knowledge and opening up existing knowledge. This improves the innovative power of the sector, drives economic growth and helps us to solve social problems. 4TU.DU is a community for Dutch design research and focuses on designers and researchers as well as organisations that are involved in design. The activities of the research centre aim to connect, communicate, coordinate and create. 4TU.DU increases its impact by playing a role in national discussions as a platform/front door for design research, by putting design on the map as a discipline, and by helping to set the agenda for the Creative Industry Top Sector.

Strategic contributions

In 2022, 4TU.DU researchers made an active contribution to the vision and strategy of the creative sector in the Netherlands through CLICKNL (TKI for the Creative Industry). A helicopter view of the Design Engineering sector was presented and a start was made on the Technology Sector Plan that will be presented in 2023.

Design Research and Innovation Festival (DRIVE)

Together with CLICKNL, 4TU.DU organised the annual Design Research & Innovation Festival (DRIVE) during Dutch Design Week (DDW) in Eindhoven, which was held live in the Effenaar again last year. The audience and speakers came together for five inspiring morning sessions and workshops on the following themes: Societal Innovation, Quality of the Living Environment, Circular Design, Immersive Content and Experimental Environments.

Design research meetings and exhibition at DDW

Dutch Design Week was dedicated to five provocative and yet accessible themes: *More than Human Design, Futuring, Politics of Design, Entanglements with AI* and *Neo Craftsmanship.*
The 4TU.DU exhibition stand in the busy Klokgebouw building provided a forum for research projects from the four technical universities and enabled a wide audience to learn about research and try out prototypes. In the afternoon, researchers, experts and other interested guests met to debate, reflect and learn more during the *Transitions* meetings. Both events are documented and explored in the web magazine on the revamped website.
This year, both the exhibition and the workshop format were jointly developed by teams of 4TU design researchers, crossing the boundaries between faculties and showing the commonality and complementarity that demonstrate the unique impact that the design sciences have on societal challenges.

Design perspectives

This year, 4YU.Design began diversifying its activities throughout the year and the first perspectives meeting was held in Twente. Some 25 4TU.Design researchers attended a workshop on new trends in design research and took the first steps towards concrete joint activities and research projects. This meeting provided a direction for 4TU.DU's activities during Dutch Design Week (DDW) and marks the start of an active 4TU.Design United community. 4TU.DU therefore wants to contribute to strengthening design engineering as a discipline, within 4TU and within the Netherlands. Two perspectives meetings are planned for 2023, in Wageningen and Delft.

Probes

The aim of Probes is to support community building by financing joint projects with a seed fund. The plan is that these projects will be a stepping stone to bigger things, and to formalise this through an open call for projects in 2023.

8 Energy

Scientific director	David Smeulders (TU/e)
Coordinator	Lou Sha
Management team	Gerrit Brem (UT), Harry Bitter (WUR), Kornelis Blok (TUD)

The ambition of 4TU.Energy is to contribute to society's transition to a carbon-neutral future by making connections, creating a strong energy community and reaping the benefits of that community. The centre's networking activities led to improved visibility and awareness in 2022.

To strengthen the network, 4TU.Energy has set up an advisory board and a 4TU.Energy Young Board, consisting of Dr Maja Rücker, Dr Akbar Asadi Tashvigh, Dr Pedro Vergara Barrios and Dr Mina Shahi. The Young Board consists of four tenure trackers. The advisory board consists of four members from local energy centres. The Young Board and Advisory Council contribute to the strategy for the development of 4TU.Energy. Below is a brief overview of existing partnerships:

- EIRES Eindhoven: Partnership strengthened, Mark Boneschanscher becomes a member of the 4TU.Energy advisory board
- Center for Energy Innovation UT: Partnership established. Marie-Jose Herik Jonker becomes a member of the 4TU.Energy Advisory Board
- Delft Energy Initiative: Partnership strengthened. Maaike Damen becomes a member of the 4TU.Energy Advisory Board
- Wageningen Energy Alliance: Partnership established, Annemiek ter Heijne becomes a member of the 4TU.Energy advisory council
- TU Delft Global Initiative: Partnership strengthened. 4TU Energy participating in a Delft Global Initiative project on 'Energy access in low and middle-income countries'.
- Centre for Unusual Collaborations: Partnership established, 4TU researchers can make use of opportunities for 'unusual partnerships' to investigate new combinations of themes and methods.

Activities

The 4TU.Responsible Sustainability Challenge (4TU.RSC) has been launched together with 4TU.High-Tech Materials and 4TU.Ethics & Technology. Maja Rücker, member of the 4TU.Energy Young Board, is one of the three coordinators of 4TU.RSC. The project aims to develop sustainable technologies in a multidisciplinary group. The technological solutions must be consistent with the circular economy and assessed using an ethical framework (e.g. fair energy transition). After the successful kick-off event in November 2022, the next steps in this initiative will be taken in 2023.

The 'Underground hydrogen storage' workshop took place at TU/e in September 2022. In addition to participants from 4TU.Energy, there were also attendees from Utrecht University, University of Groningen, EBN, Shell and TNO. The discussions and pitch session led to many scientific ideas and possible partnerships as part of GroenvermogenNL.

The centre has published a new video on the theme of 'Heat in the built environment'. The video is part of a video series in which at least three researchers from the four technical universities present their research in an accessible way. The videos are part of raising the profile of 4TU.Energy.

9 Ethics and Technology

Scientific director	Marcel Verweij (WUR)
Coordinators	Mariska Bosschaert-Bakhuizen and Vincent Blok (WUR)
Management team	Philip Brey (UT), Patrick Smith/Julia Hermann (UT), Vincent Müller (TU/e) Sabine Roeser (TUD), Filippo Santoni de Sio/Udo Pesch (TUD) Marcel Verweij (WUR), Zoë Robaey/Vincent Blok (WUR)

4TU.Ethics & Technology (Ethics) is a community of researchers that promotes and conducts both fundamental and applied research in the field of ethics and technology. The centre aims to address societal and technological challenges in the context of a connected, globalised world. Its goal is to promote an understanding of ethical issues involved in new developments in engineering and technology. An important component of the centre is the graduate school, where PhD candidates come to learn more about philosophy and the ethics of technology.

In 2022, the community included 28 full professors, 16 associate professors, 45 assistant professors, 15 lecturers, 19 postdocs, 54 PhD students and 9 other university researchers and 12 people working outside the university.

Research Day

The Research Day facilitated networking and research. The venue, Montfoort Castle, provided an opportunity for the informal exchange of ideas and a space in which to work and take part in workshops. The day concluded with an open discussion about members' expectations from the 4TU.Ethics centre, and an exploration of elements in the strategy document that is currently under development. About 40 members attended, and their evaluations were positive. Based on a number of interviews with colleagues inside and outside the centre (including overseas) and discussions in the MT, a strategy for 2023-2026 was developed and discussed with the board in January 2023.

Education

In 2022, 4TU.Ethics focused on strengthening its own graduate school. A new course in 'Philosophies of Technology' has been developed and is being taught. In addition, two other new courses, 'Empirical methods for Philosophers of Technology' and 'Empirical methods for Philosophers of Technology', are under development for 2023.
The 'Ethics Education for Engineers' project, which began in 2020, will be further developed in partnership with the four universities of technology. This project involves collecting and publishing case studies involving ethics and engineering as open educational materials, to provide an opportunity to practise. The cases are published on the 4TU.Ethics community page on the edusources platform of SURF.

This year's PhD council was made up of Alessio Gerola, Céline Budding, Cindy Friedman and Nynke van Uffelen. They organised two writing retreats and monthly social events for PhD students, as well as considering what else is required.

Website and Blog

The website was updated in 2022 and the 4TU.Ethics blog was launched. The website team consists of: Anna Melnyk, Anne Marte Gardenier, Cindy Friedman, Leon Rossmaier, Steven Kraaijeveld and Tom Coggins. They have already published several blog series, and are working with teaching staff at the graduate school and the alumni coordinator.

Alumni network

In 2021, a pilot for a 4TU.Ethics alumni network was conducted in order to gauge enthusiasm for this. The response was positive, and so Eliana Bergamin was hired to set up the network in 2022. Eliana has started a newsletter for alumni and will organise various (online) events for alumni.

Agenda for 2023

4TU.Ethics will continue to strengthen its graduate school, hold an education day and a research day, organise PhD days for new members, and arrange monthly social events for both PhD candidates and senior members.

10 Health

Scientific director	Richard Goossens (TUD)
Coordinator	Hanneke Bodewes (UT), Emelie van Bentum (TUD)
Team	Maroeska Rovers, Anneliene Jonker (UT), Noortje Bax (TU/e), Guido Camps, Agnes Berendsen (WUR)

4TU.Health aims to showcase what is happening at the technical universities in the field of improving people's health, improving the quality of healthcare, keeping it affordable and helping ensure there are enough healthcare staff. 4TU.Health is therefore an important driver of the national 'medical technology' programme. 4TU.Health became a Centre in 2022. Our website shows not only which activities are happening at the technical universities in this field (research, education and partnerships with clinical parties), but also communicates our presence to the field of health and healthcare, so that interested external parties can reach out to us. At 4TU.Health, we aim to provide a shared point of contact for questions about health and healthcare through the website.

Research programmes

Over the past year, external parties have increasingly been contacting us, and we are often able to refer them on to the right people at the technical universities. In partnership with the Dutch Cardio Vascular Alliance (DCVA), in 2022 we launched a project to develop a Cardiovascular Technical Research Agenda. Together with the KWF Dutch Cancer Society, we are looking at the role of technology in oncological disorders and helping to come up with solutions for how to use resources for technological developments in as targeted a manner as possible. This led to a call to make better use of the potential of smart measurement technologies.

Committees

We nominate possible reviewers and committee members for ZonMw, NWO and various health funds, so that the limits and opportunities of new technology are taken into account at an early stage when tackling issues in the field of health and healthcare.

Knowledge exchange

A third important area of activity for 4TU.Health is facilitating the exchange of knowledge between the technical universities and their researchers. In 2022, for example, a proactive contribution was made to the development of health-related proposals for the new 4TU.HTSF call, and there was an initiative to establish a 4TU.Health PhD competition to promote future collaboration and help our young researchers to find one another.

Organisation

In January 2022, the chairmanship of 4TU.Health was passed from Nico Verdonschot (UT) to Richard Goossens (TUD). A sounding board group of deans from the various technical universities has been established, and this met twice in 2022. The 4TU.Health team meets six times a year, and has almost weekly contact.

Agenda for 2023

In 2023, 4TU.Health will continue to work actively on an ambitious agenda to coordinate and publicise activities relating to health and healthcare. Major issues in health and healthcare can only be tackled by working together.
4TU.Health makes every effort to use the available resources as effectively and efficiently as possible, thereby maximising the contribution of the technical universities to solutions for the societal challenges that the healthcare sector faces.

Substantive relevance

In 2023, we will look even more closely at the relevance of our content to relevant policy developments. For example, the KIA for Health and Healthcare is being updated, and various major challenges for the healthcare sector are detailed in the Integrated Care Agreement, in which technology plays an essential facilitating role. On behalf of the 4TU, we continue to participate in

discussions about the Medical Technology Programme and the Human-Capital Health & Healthcare Agenda.
Finally, we want to continue strengthening cooperation between the technical universities by building a community of researchers and strengthening relations with relevant HTSF programmes, the MedTech TTT and 4TU.Impact.

11 High-Tech Materials

Scientific director	Arjan Mol (TUD)
Coordinator	Reina Boerrigter
Management team	Ferdinand Grozema (TUD), Marc Geers, Rint Sijbesma (TU/e), Remko Akkerman, Gertjan Koster (UT), Karin Schroën, Louis de Smet (WUR)

The 4TU.Centre for High-Tech Materials (4TU.HTM) promotes outstanding materials research – from fundamental to applied, and from nanotechnology to constructions – at the four TUs. It does this through partnerships and new initiatives, both in research and education. Now that sustainability criteria play a major role in the development of technology, the priority for the period 2022-2025 is to increase awareness about materials and materials research with a view to the materials transition. Sustainable materials and materials required for the energy transition are essential in this respect. 4TU.HTM will also contribute to discussions about the visibility of the infrastructure for materials science (with a particular focus on the website available for this purpose), and work to promote cooperation with external parties – both internationally and within the sector (with M2i).

Partnership & visibility

4TU.HTM promotes collaboration by funding joint materials science activities, and a number of small-scale collaborative projects were awarded funding in 2022. For example, researchers from TUD and colleagues at UT embarked on a project in the field of the additive manufacturing of recyclable multi-materials, while colleagues and Master's students from WUR and TU/e are investigating the effects of electromagnetic radiation on the mechanical properties and texture of fermented food in a solid state. The *Joint Workshop on Circular & Sustainable Materials in 2050*, which was held with the LDE Centre for Sustainability, attracted 75 participants. After holding numerous joint workshops online, an in-person workshop was finally prepared in the autumn of 2022: the *Soft Matter & Self-Assembly* meeting was held in Utrecht on 19 January 2023, with over 40 participants. In addition, 4TU.HTM organised sessions in the field of Metamaterials and Advanced Materials Characterisation during M2i's annual Meeting Materials conference (in April and December 2022).
The number of followers of the Twitter profile of 4TU.HTM grew to 630 in 2022, and in addition to the website and the LinkedIn group of 4TU.HTM, this helped to improve the online visibility of the network's materials science activities.

Education activities

In the autumn, a joint education initiative with the 4TU Ethics & Technology and Energy centres was launched as a pilot: the 4TU.Responsible Sustainability Challenge, a course for Master's Honours students who are working with ProRail and KLM on a multidisciplinary project in the field of sustainability.
In 2022, 4TU.HTM completed the online series in Presenting Materials Science Skills Courses for PhD students at the 4TUs; an in-person follow-up is planned for 2023. The M2i & 4TU.HTM Business Awareness Course for PhD candidates and postdocs in materials science will be held in February 2023, with a view to future careers in industry or science.

Looking ahead

Expanding the materials science research community and diversity are both key concerns. The partnership with RUG – Advanced Materials and the creation of a Young 4TU.HTM network are priorities on the agenda for the years to come. In addition, 4TU.HTM is working with M2i and the MaterialsNL Platform to organise a national materials conference.

12 NIRICT

Scientific director	Mark van den Brand (TU/e)
Programme Manager	Margje Mommers (TU/e)
Board	Marc Geilen (TU/e), Alan Hanjalic / Kofi Makinwa / Justin Dauwels (TUD), Suzan Bayhan/ André Kokkeler (UT), Bedir Tekinerdogan (WUR)

4TU's Netherlands Institute for ICT Research (4TU.NIRICT) focuses on bringing together, coordinating and prioritising all aspects of ICT research. ICT is a very broad field, within which 4TU.NIRICT focuses on the interface between electrical engineering, computer science and data science. As such, NIRICT promotes and facilitates interaction and cooperation between these fields, but also with other disciplines. NIRICT is also working to create a united ICT community and recognises and values the role of young scientists in the institutes. All this is done through community-building activities such as the annual community day and various calls.

Community Day

On 14 November, the annual https://www.4tu.nl/nirict/news/4TU.NIRICT Community Day/ took place, and around 50 researchers took part. The day focused on three themes: Energy and ICT, Health and ICT, and Agriculture and ICT. The aim was to bring NIRICT researchers together to explore the opportunities for interdisciplinary cooperation on each of these themes. The event was a great success, and because of the interest and the need to follow up on the themes discussed, three groups have now been created in Teams. These have enabled documents and ideas to be shared, and contact to be made more easily. In 2023, NIRICT will begin organising meetings on each theme with the aim of promoting interdisciplinary collaboration.

Community and DEI funding

To support ICT-related activities that help strengthen the NIRICT community, NIRICT has funded four projects through the call for Community Funding. In addition to this call, NIRICT also has a DEI fund (diversity, equity and inclusion) to promote more diversity, equality and inclusion within the community. The Building community of LGBTIQ+ ICT researchers has received funding through this call and the DEI4 Embodied AI project won the NWO Diversity Initiative Award 2022.

ICT.OPEN, EIA and pitches

As in previous years, NIRICT once again partnered with ICT.OPEN. NIRICT sponsored the 'creative thinking' workshop and, prior to this, some MT members gave a presentation about NIRICT with the aim of improving its visibility. There was also an exhibition of 25 banners relating to the 'Alice and Eve Go Digital' project and two poster presentations for the Smart Bikes and Robots for Pain Management in Children projects.
Three students were able to take part in the European Innovation Academy (EIA) with funding from NIRICT. The participants learned a great deal and indicated that this is a unique and very good programme of extremely high quality.
NIRICT launched a new initiative to strengthen its relationship with the faculties and four ICT researchers have now been invited to pitch their research at board meetings.

Agenda for 2023

In 2023, NIRICT plans to continue its calls for Community and DEI funding, like the partnership of ICT.OPEN, and the partnership with the Next Generation and EIA. NIRiCT will also focus on increasing its visibility. The University of Groningen will join NIRICT and a member from Groningen will join the MT, as well as a second member from Wageningen. In 2023, more targeted projects on the above themes will be facilitated by writing proposals. These relate to current societal challenges and require an interdisciplinary effort in order to be addressed effectively.

13 ResearchData

4TU.ResearchData	Marta Teperek (Director) Madeleine de Smaele (Repository Manager), Paula Martinez Lavanchy (Carpentries Member Coordinator), Egbert Gramsbergen (Data Engineer), Roel Jansen), Jan van der Heul (Data Curator), Eric Rumondor (Data Curator), Alessandra Soro (Community Manager), Carlos Utrilla Guerrero (Trainer), Iulia Popescu (Communications Advisor), Zita Bernhoeft (Secretary)
TUD	Irene Haslinger (Director, TUD Library), Alastair Dunning (Head of Research Services)
TU/e	Sandor Schmikli (Area Lead Research), Floor Luub (Data Steward)
UT	Wendy van Ginkel (Director, UT Library), Wiljan Puttenstein (Head, Archive) Maarten van Bentum (Data Librarian)
WUR	Hubert Krekels (Director, WUR Library), Hilda van der Pol (Data Librarian)

4TU.ResearchData was founded in 2010 as an initiative of three technical universities (Delft, Eindhoven and Twente), and since then it has grown to become the largest data archive of its kind in the Netherlands. In January, Wageningen University & Research (WUR) joined 4TU.ResearchData with a bronze membership. WUR researchers can now benefit from all services, including the free publication of 5GB of research data (per researcher, per year) and access to the community, advice and technical support.

Working partnerships

In 2022, 4TU.RD committed itself to the 'Skills4EOSC' project, which involves setting up an overarching European network of knowledge centres to accelerate the training of European researchers. 4TU.ResearchData is contributing by developing a curriculum for data stewards, building communities for them and creating a connection with the broader European Open Science Cloud (EOSC).

4TU.RD has joined forces with the Thematic Digital Competence Centre for the Natural & Engineering Sciences (TDCC NES). TDCC NES is hosted by 4TU.RD and aims to facilitate FAIR data and software practices by addressing the numerous challenges that NES researchers currently face.

2023

In 2023, 4TU.RD's own open source software repository, known as Djehuty, will go live. Various partnerships will be continued, both at the national and international level.

14 Engineering Education

Director	Perry den Brok (WUR)
TU Delft	Marcus Specht (leader), Remon Rooij (leader), Renate Klaassen (programme coordinator), Tanja Emonts (communication)
TU/e	Esther Ventura-Medina (leader), Caroline Vonk (programme coordinator)
UT	Cindy Poortman (leader), Luuk Bunk (programme coordinator)
WU	Emiel van Puffelen (leader)
Advisory Board	Kristina Edström (KTH Stockholm, chair), Marc de Vries (TUD), Ines Lopez (TU/e), Nieck Benes (UT), Erik Heijmans (WU), Ellen Siebers (Student UT)

The 4TU.Centre for Engineering Education (CEE) promotes innovation and research in the field of education in engineering. This involves educational innovation, in combination with research, strategy development and international cooperation. Its projects and activities range from short-term innovation projects to longer PhD projects. Connecting with international experts and relevant literature is part of the CEE's approach. The centre regularly presents its results at conferences and workshops, as well as at its own events and in (scientific) journals.

The board said goodbye to Birgit Pepin (TU/e leader) in 2022, and she was succeeded by Esther Ventura-Medina. Chris Rouwenhorst stepped down as UT coordinator and was succeeded by Luuk Buunk.

Themes

Last year, the focus was on the themes from the strategic plan 2022-2025: (1) entrepreneurial learning and academic entrepreneurship, (2) educating for responsible engineering or the ethical and responsible engineer, (3) ICT enhanced education and the digital literate engineer, (4) challenge-based learning and (5) teaching excellence in engineering education. New joint projects were initiated with respect to all of these themes. For example, a postdoc (UT/TUD) and a PhD candidate (TU/e/WUR) began work on the theme of 'entrepreneurial learning and academic entrepreneurship'.

Teaching cultures

The 4TU.CEE was active in the Sector Plan for Science and Technology, in a project entitled 'Educational quality and careers'. As part of that project, the second round of the survey on Teaching Cultures (by Ruth Graham) was carried out and data was collected on career paths in education, criteria for educational quality and professional development opportunities for teaching staff. CEE also sponsored UNL's Advancing Teaching Network event in Amsterdam.
Various online seminars were again held around the theme of 'Challenge-Based Education'. There was also a follow-up to the seminar on 'Post-Covid Education', providing an opportunity to exchange information on blended learning, wellbeing and stress among teaching staff and students, and students' results.

Partnerships

In 2022, the first steps were taken in building a closer partnership with the Faculty of Engineering at RUG. Teaching staff and managers from RUG will be invited to take part in CEE activities, there will be active cooperation on a number of strategic themes, such as teaching excellence and ICT-enhanced engineering education, and mutual dissemination will be strengthened.
A working visit was made by staff from Aalborg University (Denmark, led by Professor Annette Kolmos) on the theme of interdisciplinary and transdisciplinary education in engineering.

Innovation map

The CEE Innovation map was expanded to include 283 innovation projects and 418 contact persons. The number of unique visitors to the 4TU.CEE website rose to over 13,000. The website reported on 19 activities in 2022, five newsletters were sent out (to over 3,000 subscribers), and six blogs and various articles and conference contributions were published.

A total of thirteen PhD candidates were appointed by 4TU.CEE in 2022. Nine postdocs also worked on projects. The 'Practese' symposium for engineering education for PhD candidates was continued, in partnership with KU Leuven in Belgium and the University of Western Australia.

Local CEE activities

In Delft, a PhD candidate began research focusing on the evaluation of innovation in engineering education. In 2022, CEE was the co-initiator of a new type of festival of activities, called '100 days of…' based on a specific theme in education: reflection. The Healthy Challenge Design Education project, carried out at Industrial Design Engineering and Architecture, was formally concluded with several publications.

Under theme (5) of 'Teaching Excellence', the Inspiration lunch meetings for the teaching community were launched at UT, with themes ranging from the specific (e.g. learning analytics) to the more general (e.g. Reward & Recognition). Under the themes of 'ICT-Enhanced Education' and 'the Digitally Literate Engineer', a second edition of the Teaching & Learning Fellows pilot got underway in 2022, and a hackathon was held on feedback in education, involving participants from TU/e, UT, VO, and 4TU. Finally, in 2022, PhD candidate Rike Bron received her doctorate for a thesis entitled Collaborative course design in higher education: A team learning perspective.

At WUR, a new PhD candidate began work on the subject of the 'Mixed classroom' – a form of education where students and professionals learn together. The project on Boundary Crossing was also completed. An article was written about research into course innovations, and a Delphi study on Challenge-Based Learning was also completed.

New projects were launched at TU/e on the themes of Sustainability in Engineering Education, Learning Analytics, Modularisation, Multi-disciplinarity and Student Learning Experiences within Challenge Based Learning. Presentations on the results of the latter four of these projects were given at international conferences in 2022. All conference contributions were shared with interested colleagues at an inspiring meeting held in December. New projects will begin at TU/e in 2023 regarding transformative education for sustainability and learning together through challenge-based learning. In addition, a PhD candidate will begin working on the theme of Learning Analytics for the assessment and personalised support of student well-being.

Looking ahead to 2023

The CEE will be involved in a number of major events in 2023. From 24 to 26 May 2023, UT will hold the SEFI Deans Conference, and the centre will make a significant contribution to organising this conference as well as to the content of the programme. In addition, the first Challenge-Based Education Conference will be held at TU/e on 15 June 2023, and the CEE will again make a significant contribution to organising as well as to the content of the programme.

In 2023, the results of various projects from the previous strategic period will be delivered and presented, and staff will make presentations at a series of local events and national and international conferences, such as the Education Research Days, the SEFI conference, the CDIO conference and the EARLI conference. The partnership with the University of Groningen will also be developed further in 2023.

15 Resilience Engineering

Scientific director	Tina Comes (TUD)
Managing director	Stephanie Hessing (UT)
Management team	Bas Jonkman (TUD), Tatiana Filatova (DeSIRE/TUD), Geert Jan van Houtum (TU/e), Ahmadreza Marandi (TU/e), Joanne Vinke-de Kruijf (UT), Andy Nelson (UT), Miranda Meuwissen (WUR)

The 4TU.Centre for Resilience Engineering (4TU.RE) is a knowledge centre that develops, implements and disseminates knowledge, methods and technologies that can be used to make societies more resilient. 4TU.RE focuses on engineering solutions (technical solutions and system designs), in interaction with socio-ecological systems. This section complements the annual report of the DeSIRE (Designing Systems for Informed Resilience Engineering) programme.

Community

The community continued to grow and become closer in 2022. Eight of the twenty PostDocs have now acquired a permanent position in the field of RE, and five of them have been appointed by one of the affiliated RE faculties. In addition, three former DeSIRE fellows have now been appointed to tenure track positions at 4TU.RE, which has also enhanced the international network.

Networking in the region

The number of partnerships in the various regions has also increased through regular consultation with the external stakeholders who participate in the Strategic Advisory Board. For example, this year the centre joined the ambitious Delta Future Lab. A delegation from RE was also invited to participate in the Resilience Strategy brainstorm session at the Municipality of The Hague. Each sending a delegation of five people, 4TU.RE, the Utrecht Safety Region and the NIPV embarked on a long-term partnership in the field of resilience in the region of Utrecht. 4TU.RE is now participating in talks at Infa Capacity Alliance regarding risk management, also through the Utrecht Safety Region. In the same field, the network is affiliated to the new UT-ITC Centre for Disaster and Risk Management. The events are well attended, presentations are shared and there is cooperation within the Growth Fund (PCPD and ReThink the Delta). RE is a member of Safety Delta Netherlands and is working on a project on the digital resilience of the digital infrastructure of process engineering factories and sites.

External impact

Thanks to the Open Educational Resources platform, which the centre has been able to build with the aid of SURF funding, knowledge intended for didactic purposes can now be shared with the world. In fact, the platform is so 'open' that it is not possible to trace end users, but its educational resources are reportedly being used as far afield as Pakistan.
At the request of external stakeholders, a clear brochure has been created and provides six examples of how RE's research is having an impact.

Agenda for 2023

The annual 4TU.RE conference is combined with the biennial International Conference on Resilient Systems (ICRS), organised together with ETH-FRS (Switzerland), Stevens (US) and Monterrey (Mexico). A delegation from the RE will help organise this event in Mexico in June 2023, and a delegation of five to ten people will also be involved in choosing the content of the sessions and leading them.
Following the DeSIRE event, potential new partners have joined 4TU.RE and over the next year new partnerships will be developed. These new partners include the Karlsruhe Institute of Technology and Resilience colleagues at the Emergencity Centre (including Darmstadt University). 4TU.RE will also take part in Resilience Week this summer in Darmstadt, sending a large (junior) delegation in order to take the first steps in creating joint PhD programmes with this international partner.

In addition to a number of individual proposals (ERC STG) and several joint projects (NWO Open Competition, Dinalog), three RE subgroups are working on larger project proposals; two national proposals (Dutch National Research Agenda and Perspectief), and one international proposal in the field of agri-food. The projects within the Growth Fund programmes will also continue.

Several members of 4TU.RE are also playing an active and/or leading role in two of the three new HTSF programmes, which means that several lines of research are accommodated here as well as the network that has emerged.

Thanks to an Open Education grant from TU Delft, it will be possible to continue working on the OER platform in 2023. New courses will be added, and a team of scientists will also consult several 4TU programme coordinators to review the curriculum for opportunities to incorporate more Resilience Engineering into the package.

16 Stan Ackermans Institute

Director	Paul Koenraad (TU/e)
Coordinator	Laurie Baggen (TU/e) (also coordinator TU/e)
Board	Ariana Need (UT), Andrea Ramirez Ramirez (TUD), Wouter Hendriks (WU)
Coordinator TUD	Pieter Swinkels
Coordinator UT	Hans Voordijk
Coordinator WUR	Claudius van de Vijver, Femke Brouwer

The Stan Ackermans Institute (SAI) is the banner under which design programmes at the technical universities in the Netherlands are presented to potential trainees and to the business community. The members of the SAI board are the deans of Graduate Schools of the four technical universities, chaired by TU/e.
The SAI has a website, publishes brochures and posts on social media. To recruit potential trainees, the SAI attends company days at the four technical universities and other relevant career events. These activities are supported by the EngD ambassadors (a group of enthusiastic trainees). An annual brochure is produced to showcase a selection of design projects that the trainees have implemented.

Educational programmes

TU Delft has three active programmes, the University of Twente five and TU Eindhoven nine. Wageningen University has made preparations for its first EngD programme: Designs of AgriFood and Ecological Systems. SAI is also in contact with the University of Groningen, where there are also plans to set up design programmes.
The total number of new students joining these programmes fell from 168 to 140 in 2022, while the number of graduates rose from 135 to 140. An overview of incoming and outgoing students in each programme and institute can be found in the table that accompanies this section.

A year of celebrations

2022 was a year of celebrations, as we marked 35 years of education in technology design and 15 years of SAI. A symposium was held in May to celebrate this occasion.
Due to the plans of universities of applied sciences for third-cycle programmes known as 'Professional Doctorates', the four technical universities have decided to switch from the Professional Doctorate in Engineering (PDEng) degree to an Engineering Doctorate (EngD). Since 1 September 2022, graduates have been awarded the title of EngD. Alumni of PDEng programmes are also free to use the title of EngD if they wish. The new name emphasises the academic level of the programmes and differentiates the programmes from those of the universities of applied sciences. The aim is to anchor the EngD degree in the Higher Education Act at a later stage.

Overview of incoming students and degrees awarded by design programmes 2017-2022

	2017		2018		2019		2020		2021		2022	
	Degree	New registrations	D	I	D	I	D	I	D	I	D	I
TU Eindhoven												
Process and Product Design (PPD)	23	28	30	21	26	22	19	22	20	24	18	22
Information and Communication Technology (ICT)[2]	3	12	10	5	8	5	8	6	3	8	5	5
Logistics Management Systems (LMS)[3]	4	0	8	0	1	0	0	0				
Mathematics for Industry (MI)	5	0	0	0	0	0	0	0				
Software Technology (ST)	16	17	20	18	15	19	16	17	18	19	12	18
Design and Technology of Instrumentation (DTI)	6	9	9	0	6	0	1	0				
Architectural Design Management Systems (ADMS)	0	0	0	0	0	0	0	0				
User-System Interaction (USI)	18	0	10	1	2	1	1	1			0	3
Automotive Systems Design (ASD)	14	14	14	14	13	15	13	16	13	16	14	11
Smart Energy Buildings & Cities (SEBC)[4]	8	13	1	12	15	9	10	23	9	13	17	5
Clinical Informatics (CI)	10	13	12	13	10	14	12	14	10	11	15	11
Qualified Medical Engineer	0	5	6	7	5	4	7	7	4	6	7	11
Data Science (DS)		20	9	20	16	25	19	12	21	16	11	16
Total	*107*	*131*	*129*	*111*	*117*	*114*	*106*	*118*	*98*	*113*	*99*	*102*
TU Delft												
Process and Equipment Design (PED)	8	13	10	10	12	13	7	9	6	7	14	8
Bioprocess Engineering (BPE)	7	7	8	7	7	7	6	7	7	7	7	7
Comprehensive Design in Civil Engineering (CDCE)	0	0	0	0	0	0	0	0				
Chemical Product Design (CPD)	7	6	9	8	6	8	6	6	6	5	5	1
Civil & Environmental Engineering			0	5	0	6	2	5	4	6	3	6
Total	*22*	*26*	*27*	*30*	*25*	*34*	*21*	*27*	*23*	*25*	*29*	*22*
Twente												
Energy and Process Technology (EPT)	4	6	9	12	6	10	7	5	6	6	5	5
Robotics	2	4	4	3	2	1	4	1	1	7	0	1
Civil Engineering (CE)	4	2	4	7	6	7	5	6	4	6	5	6
Healthcare Logistics	0	0	0	0	0	0	0	0			2	0
Maintenance	1	4	8	7	2	2	3	4	3	3	0	4
Business & IT						0	0	1		8		
Total	*11*	*16*	*25*	*29*	*16*	*20*	*19*	*17*	*14*	*30*	*12*	*16*
Total 4TU	**129**	**185**	**169**	**154**	**166**	**198**	**140**	**173**	**181**	**170**	**140**	**140**

[2]*New name: Design of Electrical Engineering Systems*
[3]*New name: Industrial Engineering*
[4]*New name: Smart Buildings & Cities*

17 High Tech for a Sustainable Future

Through the allocation of a total of €22 million to five research programmes in the High Tech for a Sustainable Future theme in 2018, the 4TU.Federation gave a shot in the arm to research and education in the field of sustainable technology. This shows how the four technical universities are taking the lead in creating significant impact on societal challenges in the long term. The four TUs will make this funding available in the framework of the profiling budget intended for research that contributes to the Dutch National Research Agenda. The research proposals reflect the focus themes of the top sector policy, the Dutch National Research Agenda and the Sustainable Development Goals of the United Nations.

17.1 DeSIRE

Programme leader: Tatiana Filatova, TU Delft

Designing Systems for Informed Resilience Engineering (DeSIRE) is an interdisciplinary capacity-building programme that is currently funding seventeen tenure trackers (TTs) and twenty postdocs across fourteen different 4TU faculties, as well as over fifty Resilience Fellows nationally and internationally. Its aim is to build a thriving community in the field of Resilience Engineering. DeSIRE functions as the core of the 4TU.Centre for Resilience Engineering. In order to design solutions within complex socio-technical environmental systems, various domains and disciplines need to be connected, both inside and outside the academic world. Many of 4TU.RE's external stakeholders are therefore closely involved in the activities of the ever-growing DeSIRE community. The scientists are clustered into six thematic working groups: Water, Energy & Cyber, Urban, Agri&Food, Transportation Networks & Supply Chains, and Decision-making for Resilience.

Community

2022 was the last full year of 4TU funding and also the year when the community was able to reap the benefits of the network that has been built up for the first time following the lengthy pandemic period. The network has already resulted in permanent appointments for eight of the twenty PostDocs in the domain of RE, and five of them have actually been appointed by one of the affiliated RE faculties. 2022 was also the year when the DeSIRE Fellowship programme became a reality. Dozens of fellows strengthened their partnership with members of the community through visits, joint studies, or by writing papers together. Three former DeSIRE fellows were also appointed to positions in 4TU.RE, which has enhanced its international network.

Events and outreach

In 2022, DeSIRE arranged several very well-attended and interactive events. These were held for and organised by its own TTs, PDs and even fellows. For example, there was a meeting based on the developments in the thematic working groups and the profiling of DeSIRE themes on the international academic Crowdhelix Platform. A workshop was held on various methodologies, with internationally renowned speakers as well as visitors from other universities. Currently active research lines and the results they have achieved were celebrated at a two-day conference in Delft, with over a hundred attendees. There was a jam-packed programme including lab visits, live demonstrations, poster pitches and content presentations. DeSIRE's online activities included a series of eight seminars throughout the year on themes spanning the entire spectrum of resilience. These seminars attracted participants from around the world through the fellowship programme.

External impact in 2022

The tenure trackers, postdocs and fellows had a very busy year, publishing an excellent body of work and applying for and acquiring (individual) grants. This DeSIRE leaflet provides numerous examples.

The DeSIRE team reached out to the three new HTSF programmes: the first constructive discussions have already taken place and experiences will continue to be shared.

Agenda for 2023

Even though funding for DeSIRE stopped on 1 January, the DeSIRE community remains active. The working groups will continue to meet as they did before, and partnerships already initiated will be pursued further in 2023. There is also plenty of enthusiasm for more cooperation. Under the umbrella of the 4TU.Centre for Resilience Engineering, DeSIRE has the opportunity to organise substantive meetings with partners into 2023 and beyond.

Also in 2022, DeSIRE researchers and affiliated members were very active in the area of pursuing funding together. DeSIRE gave junior researchers the opportunity to design the support they felt they needed in this regard, and workshops on scientific storytelling were held. Two DeSIRE members were provided with professional visualisations for their ERC applications. In the months to come, two groups from DeSIRE will submit a larger-scale proposal to NWO Open Competition and Dinalog, and the two proposals will also be supported professionally by DeSIRE.

Within DeSIRE, the theme of 'Reward & Recognition' and Team Science has always been a area of discussion. In 2021, a special workshop with two speakers from the Young Academy was attended, and interviews were held with the tenure trackers. This remained the common feature of both our own approach and DeSIRE's approach to coaching and embedding junior tenure trackers and post-docs. It led to a recommendation that the DeSIRE team should be present on the 4TU board.

17.2 Plantenna

Programme leader: Peter Steeneken, TU Delft

The Plantenna programme focuses on the closely interrelated issues of climate change, sustainability and food scarcity. Given the world's ever-expanding population and ongoing urbanisation, these issues will only grow in salience. The focus of the programme is the development of sensor technology directly in and around plants which can gather data about the condition and productivity of crops. By linking plants equipped with sensors into networks – a kind of 'internet of plants' – the observations collected can be used to monitor climate and weather and to boost crop yields through more efficient fertilisation and irrigation.

Some important steps were taken in 2022 involving the various Plantenna sensor technologies. For example, an ultrasonic remote sensor was developed that can monitor a plant's vascular system in a non-destructive manner. This method has recently been validated in greenhouses using a large number of crops, and a Plense Technologies start-up was launched by two graduates from TU Delft. A sensitive hot-wire flow sensor was developed to measure the air flow around fruit trees in order to prevent damage from night frosts. Another Plantenna study successfully demonstrated that plants can act as antennas, helping to communicate sensor data more easily. Research was also carried out to see whether micro-organisms can be used to reinvigorate degraded soils.

Greenhouse research

Researchers from Plantenna jointly carried out a demonstration experiment in a greenhouse at Delphy. Numerous sensors were mounted in a greenhouse full of tomato plants for three months to test the effect of drought stress using various different sensors. The sensors included ultrasound microphones, curtains of distributed temperature sensors, micro-radars and a stomatoscope. Soil and humidity meters, sap flow meters, gas exchange meters, chlorophyll fluorescence meters and leaf temperature sensors were also used to gauge the effects of drought on the plants in several different ways during the hot month of August. The results of this research exercise are now being written up into a joint article by the consortium.

New funding

New Plantenna-related projects were also launched in 2022 thanks to various funding mechanisms. For example, a TKI project regarding an electronic nose for detecting pests was launched at TU Delft in collaboration with the companies Koppert and NXP Semiconductors, with support from the Growth Fund. A new NWO project was awarded at TU Eindhoven (in collaboration with TU Delft) to monitor the weather using 5G networks in order to improve crop yields. In addition, an NWO Perspective proposal was submitted by Plantenna partners. A proposal for funding for a joint Plantenna Lorentz workshop was approved, and this will take place at the end of August 2023. TU Delft and Plant-e have also recently been awarded an NWO OTP for the development of a 'plant-powered sustainable pheno-camera' for environmental monitoring, and they are participating in the EU Key Digital Technologies project 'Agrarsense' to focus on electronics to improve productivity in agri-food and forestry.

Impact

We can conclude that the project has generated considerable output, impact and outreach, such as a recent article in the *NRC* newspaper. The formal part of Plantenna was therefore successfully completed in 2022, and has led to several new lines of research by young researchers. Members of the Plantenna network stay in touch regularly, and research is continuing through ongoing collaboration and new projects for which Plantenna researchers acquire funding together.

17.3 Precision Medicine

Programme leader: Michel Versluis, UT

The new 4TU programme, *Precision Medicine*, hopes to raise diagnostics to a new level by integrating a special form of artificial intelligence known as deep learning with medical imaging techniques. The researchers' goal is to provide better access to relevant medical information. This will mean a shift from a one-size-fits-all approach to a made-to-measure, personalised diagnosis for every individual. The researchers believe this is the best way to ensure that healthcare remains accessible and affordable for the long term.

Position of the Tenure Trackers

There are seven tenure trackers working within this cross-domain programme; these are young, highly talented researchers, who work alongside nineteen postdocs. In addition to a unique and independent academic profile, these tenure trackers are directly involved in improving university-wide education and rolling out innovation. They are educating the academics of the future: physicists and mathematicians, biomedical engineers and technical physicians. The tenure trackers are now also integrated into the academic structures of the technical universities through successful personal grants, such as NWO VENI grants, and two starting grants from the European Research Council, both in exact sciences, engineering and technology and in the life sciences, EU Marie Skłodowska-Curie flagship programmes for the postdocs, and private fundraising from the Hanarth Fund and the Chan Zuckerberg Initiative.

The network continues to grow

The network achieved further growth in 2022. Every track reinforces the Precision Medicine network by appointing start-up PhD candidates, supplemented by researchers from NWO-funded Open Technology and Perspective programmes, as well as projects in the Dutch National Research Agenda and the Knowledge and Innovation Covenant. In 2022, we also focused on larger funding applications such as for the National Growth Fund, NWO Gravitation, and Research on Routes by Consortia in the Dutch National Research Agenda and NWO's Scientific Infrastructure: national consortia. These applications mainly relate to public-private partnerships and have been submitted jointly with medical device manufacturers, ranging from large companies to SMEs, and in close collaboration with medical-imaging centres, university medical centres and leading clinical hospitals. The societal character of these interdisciplinary applications ensures direct input, not only from the primary care chain, but also from policymakers, charitable funds, patient associations and health insurers.

Cross-pollination

Medical imaging and artificial intelligence were traditionally discrete areas of research, each with their own community, specialist journals and conferences. However, over the last decade we have seen far-reaching cross-pollination between these two disciplines around the world: in academia, in industry, and in clinical application. 4TU.Precision Medicine has taken advantage pf these developments and synergies in an intuitive manner, in particular through cross-pollination that has been achieved through the exchange of technology and data, and above all the exchange of human capital – the postdocs and PhD candidates who are part of the tenure track network. All this leads to new opportunities and ways of interpreting existing data – faster, with greater accuracy and even more closely tailored to individual patients. But above all, it provides improved imaging across the full spectrum, from simple diagnostics in primary care to image-guided therapeutic interventions as part of complex specialist care.

17.4 Pride and Prejudice

Programme leader: Aarnout Brombacher, TU/e

The *Pride and Prejudice* (P&P) programme aims to generate new scientific knowledge and innovative technology with the aim of convincing people to adopt healthier lifestyles.
In this HTSF programme, real-life monitoring using sensors (food intake, physical activity and health parameters) is combined with the development of design interventions at various levels in the system (person, group, society). The effectiveness of these combined interventions is then evaluated.

Follow-up steps

At the beginning of the year, the P&P Tenure Core Team organised a research day for all consortium members in order to review research themes and activities within the P&P consortium and identify the next steps for the final part of the programme and beyond. It emerged that a wide range of projects spanning the dimensions of sensing, monitoring and intervention are active in the domain of nutrition. Opportunities were also identified in extending research activities into the field of physical activity, as well as the combination of physical activity and nutrition – through lifestyle interventions, for example. This resulted in various smaller and larger-scale partnerships with the purpose of raising funding for further research, so that research results can be built on within P&P.

4TU.NIRICT

P&P scientists have jointly obtained a 4TU grant from 4TU's NIRICT centre. This is *FLOW: Measures of breastfeeding and infant suckling behaviour.* The project was completed successfully in the autumn of 2021 and led to the preparation of a follow-up proposal by the scientists involved.
The research proposal *Promoting physical activity through self-experimentation in cardiac rehabilitation patients* (TUD in collaboration with ErasmusMC and Capri Revalidation) was awarded by the TU Delft Sports Engineering Institute and the TU Delft Health Initiative 2021, as part of the 'Technology that makes people move!' call.

Education

The majority of the educational activities in the P&P programme involve supervising graduating students. This type of education focuses on building a good bridge between the P&P research and the educational activities. For example, WUR and UT are supervising a Master's student who is studying strategies to encourage people to make healthier, vegetarian choices in restaurants. Another Master's student was supervised by TU/e and WUR and explored the breastfeeding ecosystem within the FLOW project.
In addition to supervising students, a number of courses are being developed within and at the intersection between the fields of nutrition and exercise. For example *Experience, Motivation and Behaviour* (Bachelor's in Industrial Design Engineering, TUD), *Product Use, Understanding and Experience* (Master's in Industrial Design Engineering, TUD), and *Design for Behaviour Change* (Master's in Industrial Design Engineering, Computer Science, Communication Science). In addition, the knowledge generated through P&P research is being incorporated into the courses offered to students in the design curriculum.

Commercial knowledge transfer

A two-day event was held during Dutch Design Week 2021. On the first day, the research within the consortium was demonstrated with the première of the P&P film, intended to celebrate achievements and introduce the members of the consortium who are involved. In addition, there was a panel debate with senior researchers from all four technical universities and MMC Eindhoven on the subject of 'Designing out inequality: Pride and prejudice in the design of technology for chronic disease prevention'. The second day began with a *Science Slam*, in which junior P&P researchers competed to pitch their research.

Publications

Several articles were published by members of the consortium. Mailin Lemke and Roelof de Vries were even given an 'Outstanding Article' award from Frontiers (computer science).

17.5 Soft Robotics

Programme leader: Herman van der Kooij, UT/TU Delft

Robots that interact with or move around among people need to have a 'soft touch'. Industrial production robots are extremely precise and fast, but also rigid. This makes them unsuitable for safe physical contact with people or, for example, handling fragile foodstuffs. 4TU's Soft Robotics aims to find inspiration in nature – such as the grip of a tree frog or the flexible arms of an octopus. Biological knowledge, new control technology and innovative robot design go hand in hand here: the 4TU partners complement one another, so that the Netherlands can achieve a leading position in this emerging field.

Education

Ali Sadeghi (UT) has developed and taught the MSc course in 'Soft Robotics'. Guillermo Amador (WUR) has made improvements to the course on Biomimetics, teaching biology students how to carry out quantitative studies on animals and how to translate these into bio-inspired solutions.
Michael Wiertlewski (TU Delft) has continued his course on 'control in human-robot interaction'.
Additionally, a number of projects have been awarded:
Guillermo Amador (WUR) has received a VIDI grant for the subject of 'the functional morphology of cuttlefish suction cups'. Guillermo Amador also recruited and helped Brett Klaassen van Oorschot to write a proposal for a two-year postdoctoral fellowship (which was honoured). Ali Sadeghi (UT) and Marit Zandbergen were awarded the PiHC 2023 grant for 'developing a promising technique to measure the 3D ground reaction force using pressure insoles'.

Past and upcoming Events

Guillermo Amador (WUR) and Irene Kuling (TU/e) led a focus session during Physics@Veldhoven entitled 'Getting a grip in soft robotics: Physics and control of grasping' on 27 January 2022.

- Dutch Soft Robotics Summer School & Symposium 2022 at TU Delft (Link to photos).
- Dutch Soft Robotics Symposium 2023 at the University of Twente on 16 and 17 May 2023.
- Workshop on Untethered Soft Robotics Symposium at the University of Twente on 15 May 2023.

Milestones

The consortium was the focus of media attention, including in the NRC podcast (Ali Sadeghi, Twente Soft Robotics Lab) How can a robot be soft? An article was also published in the *NRC* newspaper (Ali Sadeghi, Twente Soft Robotics Lab) New robots: not hard 'metal people'. In addition, various internship partnerships were established, including between TU/e and UT, and a paper is currently being written about these. Grants in partnership with Fontys and CUCo (Centre for Unusual Collaborations). Finally, the first steps have been taken for a national community for soft robotics, and preparations are underway. A series of meetings between all partners was organised to work on both the design and development of various demonstrators for soft robotics. The result of this was a 'soft robotic' hand that was developed and produced at UT, while the control unit for the hand was developed at TU/e. It is currently being tested for its ability to pick up fruit at WUR.

Published articles

Various articles have been published by the tenure trackers involved and other team members. These include:

- Gerjan Wolterink, Stijn Kolkman, and Gijs Krijnen. "3D Printed Soft Robotic Actuator With Embedded Strain Sensing For Position Estimation." *2022 IEEE Sensors*. IEEE, 2022.
- Sridar, S., Veale, A. J., Sartori, M., & van der Kooij, H. (2023). Exploiting a simple asymmetric pleating method to realise a textile based bending actuator. *IEEE Robotics and Automation Letters*.
- Willemstein, Nick, Herman van der Kooij, and Ali Sadeghi. "3D printing of soft fluidic actuators with graded porosity." *Soft matter* 18.38 (2022): 7269-7279.
- Goshtasbi Arman and. Ali Sadeghi, "A Bioinspired Stiffness Tunable Sucker for Passive Adaptation and Firm Attachment to Angular Substrates." *Frontiers in Robotics and AI* 10: 16.
- Ortiz, J., Grioli, G., Rossiter, J., Helps, T., Sadeghi, A., & Xiloyannis, M. (2022). Actuation, sensing and control systems for soft wearable assistive devices. *Frontiers in Robotics and AI*, *9*, 992699.

18 External partners

In addition to many external partners and associates, the 4TU.Federation has agreements with a number of external parties.

NEMO Kennislink (Knowledge Link, part of the NEMO Science Museum)

For over 15 years, NEMO Kennislink has been bringing scientific news and information to a wide audience in an accessible way – specifically, secondary school pupils and teachers. They do this using news stories, background stories, dossiers and multimedia involving the full range of science. The support of the 4TU.Federation is reflected in Kennislink's output in the field of engineering and technology. This not only includes research that might easily have made the headlines anyway, but also fundamental research with less direct appeal. In 2022, they wrote about many themes that touched on societal issues, such as the energy transition and climate ('How climate affects you') and the housing shortage ('Building upwards' and 'New buildings from used materials'). Other more fundamental themes were also covered, such as the 'Origin of Life'.
In 2022, a total of 49 articles were published on the subject of engineering and technology.

Foundation for the History of Technology (*Stichting Historie der Techniek*)

The Foundation for the History of Technology was established in 1988 on the initiative of the Royal Institute of Engineers and the universities of technology. The foundation carries out pioneering work in the field of the history of technology. With financial support from the 4TU.Federation, it showcases the history of technology and, through historical research and publications, reveals how closely the processes of societal and technological development are intertwined.

19 Visibility

In 2022, the various partnership initiatives of the four technical universities led to a great deal of internal and external visibility – from the announcement of the second edition of *High Tech for a Sustainable Future*, and the Drivers of Technology, to the new 4TU.VO Platform. This success is evident in the website statistics and the LinkedIn page. The number of visitors to the website grew to 6,429 unique visitors per month, while the LinkedIn page had 2,499 followers by the end of 2022.

Centres and programmes

The 4TU centres and programmes communicated actively regarding the activities that took place there. For example, the HTSF Plantenna programme followed up on its successful Plantenna blogs in which researchers from the project explained which agri-food research or technology they were working on with their team. IMPACT ran extensive social media campaigns to publicise the Techrede organised by the Drivers of Technology and the Dutch 4TU.Impact Challenge. A new series known as 'Insightful Innovators' was also released in partnership with Innovation Origins, featuring stories from enterprising students from the four technical universities.
The other centres also regularly published news about their partnership initiatives, funds and conferences. By way of illustration, the following links lead to a number of interesting articles, such as the Cardiovascular technical research agenda (Health), the 4TU.Responsible Sustainability Challenge (HTM, Energy and Ethics & Technology) and the DeSIRE Conference 2022 (Resilience Engineering).

The four technical universities in the media

De Ingenieur devoted extensive coverage to the appointment of the new chair of 4TU, Vinod Subramaniam, including an interview about his ambitions with the federation and the role of engineers in the future.
The 4TU.VO platform – an online platform for secondary education – was also the subject of media attention. Using digital teaching modules, students can get a taste of the research and design characteristics of engineering education. The *Algemeen Dagblad* newspaper featured a report on a kitesurfing lesson given at a school in Zwijndrecht in order to generate more enthusiasm and knowledge around 'boring math formulas' by applying them to an exciting real-life case study.

There was also plenty of coverage of the HTSF programmes. The Plantenna programme installed a test set-up in Delphy's tomato greenhouse in Bleiswijk using sensors from all four technical universities,

and the press were invited to attend the event. *NRC* wrote an extensive piece on this. The *Financiële Dagblad* reported on Plantenna and Green Sensors in a summer series.

In November, a report was published by the British research agency BIGGAR Economics on the economic impact of the four universities of technology. The *Financiële Telegraaf* interviewed the chair of 4TU Vinod Subramaniam about the results of the report, and secretary Marjolein Dohmen-Janssen was also interviewed about it on BNR radio (search here on 17 November at 8.15)