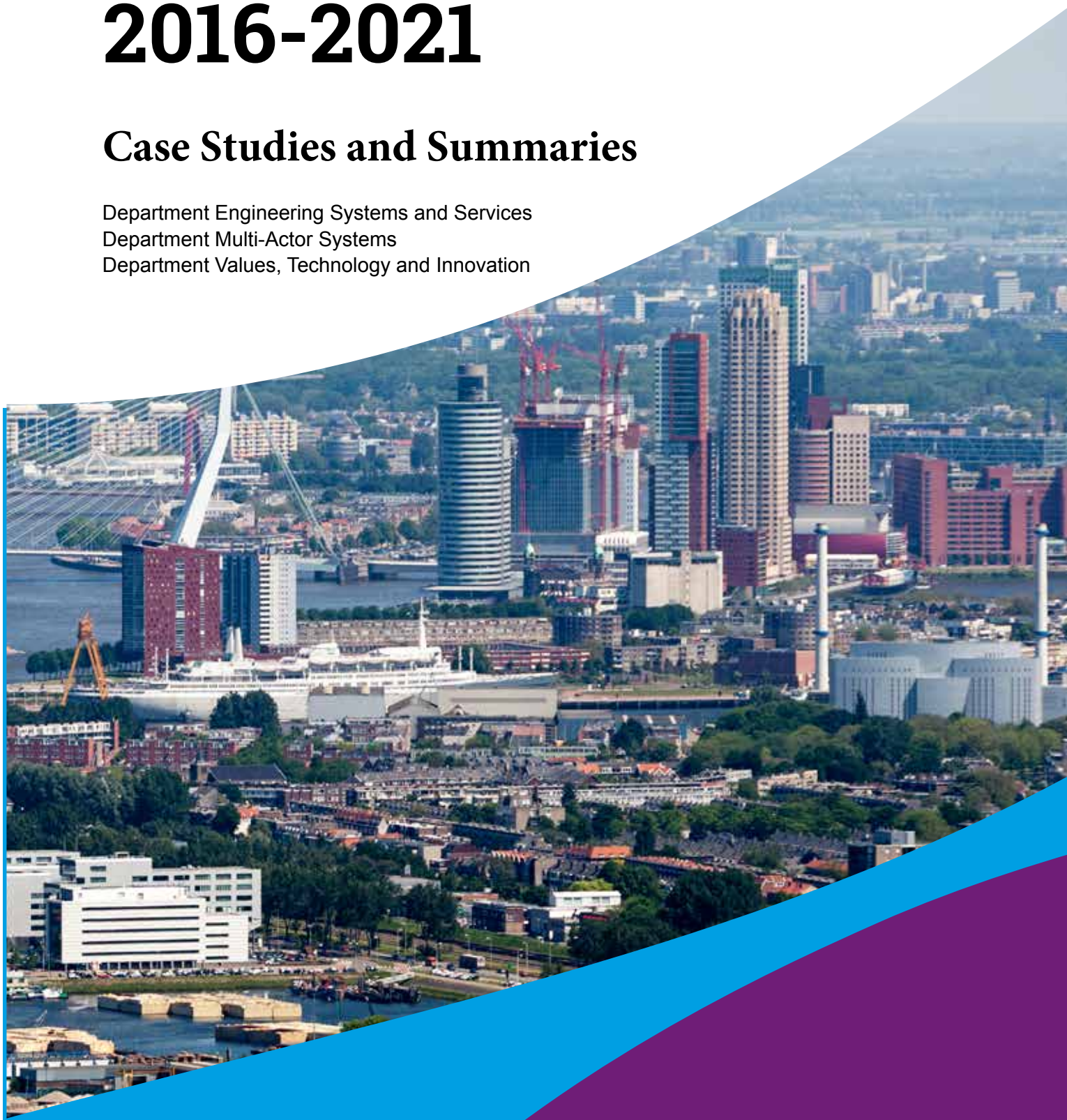
Research Report
2016-2021

Case Studies and Summaries

Department Engineering Systems and Services
Department Multi-Actor Systems
Department Values, Technology and Innovation



TU Delft | Technology, Policy and Management

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Content

Chapter 1

Department Engineering Systems and Services CASE STUDIES

In the following, we illustrate and explain our accomplishments achieved during the assessment period, using four case studies.

CASE STUDY: **PARTICIPATORY VALUE EVALUATION**

In 2017, Participatory Value Evaluation (PVE) was co-developed by ESS researchers. The essence of a PVE is that citizens are put in the shoes of a policymaker. Citizens see which policy options the government is considering, as well as the impacts of these policy options and the constraint(s) that the government faces. Subsequently, citizens are asked to provide a recommendation to the government. A video about the method can be found via: https://www.youtube.com/watch?v=1D_g_HTnS50. PVE was primarily designed to resolve critiques of the economic evaluation instrument Cost-Benefit Analysis. However, practitioners and academics also perceive PVE as a sweet spot between simple public consultation methods such as a referendum and an opinion poll in which complex issues are squeezed down into a yes/no choice, and intensive public consultation methods such as public hearings and citizen assemblies in which citizens can only express their opinion after taking part in events with a long duration. During the 2020-2021 Covid-19 pandemic period, this method was used twice
to allow large numbers of citizens to advise the Dutch government on lockdown measures and their relaxation. More than 30,000 citizens participated In one of these PVEs. This was a very ambitious project in which a large multidisciplinary team of researchers (including from ESS) needed to design the PVE and analyse/interpret the data in a very short time frame to ensure that policymakers could use the results in their decision-making process. Due to the success of this project, the research team was asked by the Dutch National Institute for Public Health (RIVM) and the Ministry of Health to conduct and coordinate various other Covid-19-related research projects. These included a project about citizens' preferences concerning Covid-19 measures in the autumn of 2021, and a project about the effectiveness of the Covid certificate. The first project was used by the government to underpin the decision in November 2021 to close all economic sectors at 5pm. The second project resulted in the decision of the Dutch Parliament to not implement a 2G Covid certificate policy. Several ESS researchers were also involved in the PVE regarding the Dutch Climate Policy ('Klimaatraadpleging'). The outcomes of this PVE formed the basis of the 'Turn it down' ('zet de knop om') campaign in which the Dutch government decided to turn down the heating systems in its own buildings, and citizens were asked to follow this example.

CASE STUDY: **RESILIENCE**

Resilience, defined as the ability to sustain critical functions irrespective of the crises or stresses that a system is confronted with, has rapidly risen to the top of the political and research agenda. While there are many resilience research groups, we offer a unique combination of expertise in how humans act, react and behave in crises thanks to our excellent research into infrastructural systems. This allows us to uniquely capture and describe how resilience emerges in socialtechnical systems, and provides a basis for new tools and methods for societal resilience. Importantly, we strive to combine research excellence and societal impact by exploring behaviour and decision-making problems that arise from society itslef, thereby opening up new research avenues and fields.

In the **HERoS project** (https://www.heros-project.eu/), the only non-medical project funded under the first European call in the response to the Covid-19 outbreak, we created a digital twin of The Hague. This digital twin captures behaviour, urban infrastructure and the urban environment at a very high granularity (sub-building) and combines it with an advanced epidemiological model. Within this 'artificial city', agents are simulated that correspond to the inhabitants of The Hague and its surroundings (ie. more than 1 million agents). The model is *fully based on openly available data and statistical methods*, complementing the more invasive methods that are based on other information such as mobile phone data. The unique aspect of the HERoS model is the high granularity it offers, allowing us to understand the interplay of interventions, behaviour and infrastructure. This model has been used by strategic advisors of the City of The Hague, and we are currently working with the local Municipal Health Service (GGD). It has also led to a collaboration with UN Global Pulse on modelling infectious diseases for the most vulnerable people, and an article in BMJ Global Health[20] that was co-authored by researchers from a range of UN agencies (UN Global Pulse, WHO, UNHCR, UN-OCHA). The resilience research and our unique stance of combining human behaviour and physical infrastructure systems has also allowed us to contribute to two convergence initiatives: the Resilient Delta Institute and the Pandemics and Disaster Preparedness Centre (PDPC).

At the Science Policy interface, prof. Tina Comes is chairing the SAPEA Evidence Review[21] on Europe's Strategic Crisis Management on behalf of the EC's Science Advice Mechanism[22]. The writing team has been selected from all European academies. This report sets out evidence on how to rethink European crisis and disaster resilience in the face of different and interlaced crises such as Covid-19, the climate crisis, and/or the war in Ukraine. Our review stresses the need to build resilience and response diversity in an era that is characterised by protracted, multi-layered and trans-boundary crises. In our research, we emphasise the need to rethink current crisis and resilience research methodologies. The report was presented publicly during the European Civil Protection Forum at the end of June 2022 and will be handed over to the European Commission (Commissioner Lenarcic) in September 2022.

20 Aylett-Bullock J et al. Epidemiological modelling in refugee and internally displaced people settlements: challenges and ways forward. BMJ Global Health 2022;7:e007822.

21 https://sapea.info/

22 https://www.s4d4c.eu/knowledge_resource/scientific-advice-mechanisms/

CASE STUDY: **OPEN SCIENCE**

The department contributes to Open Science in several ways, whereby a distinction can be made between three types of contributions: 1) applying Open Science principles to the research conducted within the department; 2) conducting research on the topic of Open Research data, and 3) offering education on Open Science. Firstly, the department shares TU Delft's ambition to ensure that the university remains a frontrunner in taking Open Science to the next level. In terms of applying Open Science principles to the practices of ESS employees, 90% of all journal articles and conference proceedings are made openly available. Moreover, ESS researchers Dr. Baiba Pudāne, Dr. Aaron Ding and Dr. Anneke Zuiderwijk are part of the Open Science Community Delft[23]: an inclusive learning community that focuses on sharing and promoting Open Science practices. In terms of involving stakeholders in our research, a specific example concerns the European ODECO Project (Towards a Sustainable Open Data Ecosystem[24]), which involves researchers from universities and research institutions, NGOs, businesses, journalists and media offices, civil servants, and policymakers (at local, national, and international level) from all over Europe in the development of more inclusive, circular, user-driven, and skill-based Open Data ecosystems.

Secondly, through its research, the department contributes to TU Delft's strategic Open Science plan 2020-2024 (Haslinger, 2019) and the TU Delft Strategic Framework 2018-2024 (TU Delft, 2018). For example, Dr. Anneke Zuiderwijk's research provides insight into the usefulness of infrastructural and institutional arrangements implemented or considered by the TU Delft and other universities to stimulate openly sharing and reusing research data. As another example, Dr. Stefan Pfenninger created and led the development of the open-source energy system modelling tool Calliope[25] and is a member of the Open Energy Modelling Initiative[26], which promotes openness and transparency in energy system modelling. Thirdly, as part of TU Delft's Open Science Programme, the university runs a yearly Massive Open Online Course entitled 'Open Science: Sharing Your Research with the World'.[27] This course addresses Open Science concepts and objectives, research data management, open research data, open access publishing, research visibility, FAIR software, and citizen science. ESS researchers Dr. Anneke Zuiderwijk and prof. Marijn Janssen have been or are involved in this course as lecturers and/or supervisor.

Year	Journal articles		Conference proceedings		Total	
	N	% OA	N	% OA	N	% OA
2016	105	59.0%	41	31.7%	146	51.4%
2017	101	54.5%	52	55.8%	153	54.9%
2018	106	61.3%	64	67.2%	170	63.5%
2019	120	59.2%	63	69.8%	183	62.8%
2020	138	94.9%	51	74.5%	189	89.4%
2021	172	91.9%	42	83.3%	214	90.2%

Figure 2.10 Open access publications ESS[28]

23 https://osc-delft.github.io/
24 https://odeco-research.eu/
25 https://www.callio.pe/
26 https://openmod-initiative.org/
27 https://online-learning.tudelft.nl/courses/open-science-sharing-your-research-with-the-world/
28 N = number of publications in the open access analysis (both open and non-open).
% OA = percentage of open access publications.

CASE STUDY: **MOOCS**

Over the last few years, the ESS department has provided a contribution to a series of MOOCs (Massive Open Online Courses): 'Intelligent and Integrated Energy Systems' (Professional Certificate | edX), offering unique and multi-disciplinary insights on how to understand, design, plan and operate the intelligent and integrated energy systems required in the rapidly evolving energy sector. This is undergoing one of the most complex technological transformations in history, which will not leave society and everyday life untouched.
The ESS MOOC Intelligent and Integrated Energy systems in Transitions: an introduction for decision-makers addresses the challenges involved in replacing the existing fossil-based energy system by a sustainable one, not only from a technological and economic perspective, but also from an institutional, entrepreneurial and ethical one. It aims to provide insights on how informed decisions about managing infrastructure, actors, policy, and energy markets that support the energy transition and sustainable energy systems can be made.
In common with the majority of edX MOOC courses, which are entirely free to access, the ESS MOOC is also designed as a free open access course for large-scale interactive participation. Moreover, it also offers an optional paid certificate based on graded assignments.

2.6 Summary

The mission of the Department of Engineering Systems and Services is to improve our understanding of complex engineering systems and services, and our ability to change them for the better. We do this by developing, testing, and applying theories, methods and tools that are rooted in (system) engineering disciplines as well as in the (empirical and quantitative) social and behavioural sciences. Our work is based on strong real-world domain knowledge, with a particular focus on the converging domains of energy & industry, ICT, and transport & logistics; with a growing focus on the domain of health & well-being; and with a special interest in the role which AI plays in these domains and their convergence.

Research Quality

The strategic aim of the ESS department is to be a highly reputed research entity that is recognised worldwide as a thought leader in modelling, analysing, and designing real-world complex engineering systems. In keeping with the notion that our mission is defined in terms of a systems-level perspective on converging domains, we emphasise in our organisational set-up the importance of cross-section collaborations. This demands that we engage a wide variety of perspectives in our research, and more generally that we build a diverse community of scholars. We are proud to have three Delft Technology Fellows in our midst. Given our increasingly internationally diverse intake at the assistant professor level, in combination with the talent-based career principle, we see that also more senior positions are becoming more varied in terms of nationality over time. In this light we are particularly proud of the fact that our recent tenure tracker appointees come from reputed international universities such as MIT, New York University, Cambridge University, ETH Zurich, EPFL Lausanne and KU Leuven. The ESS department conducts cutting-edge research, as demonstrated by many research papers published in relevant scientific journals. Theories, models and methods developed by the ESS department are widely used by other researchers from different countries. This is demonstrated by the number of research papers which are built on the research outputs of the ESS department. Several of our colleagues have been commended for their academic impact. Also, in terms of academic prizes, our department often receives international recognition for its work.

Societal Relevance

Our work aligns well with current societal challenges. One way in which ESS delivers societal impact is by means of entrepreneurship. Two academic spin-offs were founded by ESS members during the assessment period. Another way ESS delivers societal impact is through software and data products used globally in companies, NGOs, research institutes and universities. Two examples of research products used by societal groups concern a simulation game aimed at understanding electricity markets, and work on the logistics industry innovation roadmap with the European Technology Platform ALICE (etp-logistics.eu). ESS is also developing web-based systems to communicate complex results to the broader public.

Viability

Our research profile fits the evolving challenges encountered by society well. Examples include the energy transition, the AI revolution, and an increasing focus on how to sustain our healthcare system, all of which call for a multi-domain, interdisciplinary and system-level approach which ESS is ideally suited to deliver. ESS scientific staff shows a strong growth in all segments of academic staff, fuelled by a similar growth in financial means (i.e. our budget). Over the past six years, we have been able to maintain a stable and healthy portfolio of funded projects. Our funding acquisition strategy is successful in all three distinct categories: personal grants, participation in larger consortia, and long-term relations with external parties. Overall, we adopt a combination of strategic (building long-term relationships) and opportunistic (seizing chances when they occur) approaches to secure funding. Combined with the sustained reputation of the department, this is proving to be a successful mix for attracting external funding.

Chapter 2

Department Multi-Actor Systems

CASE STUDIES

The following 4 case studies furthermore show the diversity of the research efforts of MAS and its networks:

CASE STUDY: **WINDMASTER & GRIDMASTER**

Robust energy infrastructures (for the transport and distribution of electricity, natural gas, hydrogen, etc.) are an essential part of the energy transition. They must ensure that the right type of energy is present at the right location, at the right time and with the right capacity, in order to allow decarbonisation of energy production and consumption.

The infrastructures are highly path-dependent and complex sociotechnical systems that require many different parties to operate and maintain, are embedded in complex institutional settings, and must fundamentally transform their structure, while maintaining an uninterrupted delivery of services.

The Windmaster and Gridmaster projects are prime examples of transdisciplinary research done within TPM. They combine various research lines in a practical and actionable set of insights for the practitioners. At their heart, they are structured, participatory, sense-making processes, allowing systematic collection and integration of knowledge from different stakeholders involved in long-term infrastructure planning (MAS/SES). Via visioning, forecasting and back-casting methods (ESS/EI & MAS/OG), scenario spaces are constructed which describe a large number of plausible transition pathways that the future energy infrastructure must be able to support.

Multi-modelling methods (MAS/SE) allow the stakeholders' knowledge to be formalised in networks or interacting models able to compute the performance of integrated infrastructure systems under different scenarios. Exploratory model and analysis methods (MAS/PA) allow for the structural exploration of deeply uncertain transition pathways, offer insights into which investment pathways minimise future regret, and allow for the construction of robust, adaptive investment pathways.

Scientifically, these projects have pushed the boundaries of transdisciplinary knowledge through a very strong integration of participatory process design, modelling methodology, model analysis and collective sense-making process design. These different strands are not merely put together and applied at the same time, but have also been tightly integrated through the concept of a co-evolving boundary object ecology. MAS has created multi-modelling, sense-making processes that co-evolve with, and adapt to, the changing needs of the stakeholders who are going through a social learning process, thereby increasing their ability to create robust future infrastructures.

In practice, the projects are having a profound impact on the ways in which infrastructure providers approach their own work. Traditionally, just 2 to 4 development scenarios are selected, and individual models are constructed by infrastructure operators in isolation. This means that the process is manual and limited, and that little or no attention is paid to aspects of deep uncertainty.

Due to Windmaster and Gridmaster projects, standard operational procedure in infrastructure planning is now being redefined to include multi-models. This enables researchers to consider different infrastructure systems in concert, to use scenario spaces in excess of 10^36 plausible pathways, and to adopt EMA's 'deep uncertainty' methods such as PRIMM in order to identify robust investment.

This change in the way of modelling and planning research is also having a subtle, but profound, change in how infrastructure providers understand themselves: from "we build the best we can for what is requested" to "we build for what you will most likely need".

Traditional perceptions of creating optimal investments for the single predicted future are being replaced by notions of 'regret minimalisation' through robust and flexible investments that can support a wide range of possible futures. This is fundamentally changing the way in which future infrastructure will be developed, and the role that infrastructure providers have in the energy transition.

CASE STUDY: **DP3T DESIGN TEAM**

The DP3T Design Team, which included Dr. Seda Gürses from MAS, co-designed the underlying protocol (later adopted by Google and Apple) to be used in contact-tracing apps across the EU and US. See these links:
https://github.com/DP-3T/documents
https://covid19.apple.com/contacttracing

In response to the call by governments to introduce apps for aiding contact-tracing efforts, privacy engineers and epidemiologists came together to develop the DP3T protocol. The protocol was developed by a consortium of researchers led by EPFL and ETH Zurich, including Dr. Seda Gürses from MAS. The objective of the collaboration was to propose an app that would scale and speed up contact-tracing efforts, without establishing a new surveillance infrastructure that would be hard to undo after the pandemic.

Moreover, the aim was to develop an application that would minimise the impact of a collaboration with Google and Apple on governments and health providers across Europe. Both of these ambitions impacted the design of the app, with interesting political and technical negotiations that coloured the process.

In particular, the DP3T protocol was one of the main inspirations for the final implementation of the Google and Apple Exposure Notification system. The application does not collect identity or location data as these are not necessary for a notification, and introduces a variety of privacy mechanisms to ensure that this information cannot be inferred from the data collected by the system. By design, the protocol leaves most key decisions to the user, although not all of these made it to the implementation of the protocol by Google and Apple. The GAEN Bluetooth solution was used in contact-tracing apps developed in 21 of the 23 EU states that deployed an app, and in many US states and countries around the globe. Spain, Estonia, Portugal and Malta used the (Swiss/DP3T) code, and the team consulted developers in other countries, thereby influencing their designs.

As the pandemic is expected to turn endemic, we see the success of the DP3T design in fulfilling its ambitions. Contact-tracing apps using the decentralised design of DP3T remain encoded in operating systems or available in app stores, but they have not left behind a surveillance infrastructure that can be repurposed for other ends. DP3T was the first contact-tracing project to go public, setting a trend which pushed other design and implementations into public view. The privacy requirements analysis was iterative and negotiated between different stakeholders of varying power positions. Moreover, most public authorities were not aware of privacy engineering and its potential in applications that may impact populations and their trust in governments. Especially in these multi-stakeholder privacy engineering efforts, Seda Gürses' collaborations in the project played a key role.

CASE STUDY: **URBANISING DELTAS OF THE WORLD**

In the period 2014-2021, the MAS department ran different projects under the NWO Urbanising Deltas of the World programme.
This research and innovation programme was established by NWO to "increase knowledge about river deltas worldwide and to contribute to water safety, food security, and to sustainable economic development in these areas". A key feature of the programme, and one that fits the MAS department very well, was its focus on interdisciplinary and transdisciplinary research, whereby teams of scientists and societal stakeholders from different scientific disciplines were integrated, to develop knowledge for emerging societal needs.

The MAS projects had different regional and topical foci, but also shared some important characteristics. These projects all adopted a 'systems' approach and focused on developing new policy analysis methods to effectively address the multi-actor challenges involved in the longer-term management and sustainable development of water and delta systems. Typically, this implied the design and testing of structured ways of engaging with different people from different backgrounds, linking bottom-up transformation processes to higher-level formal institutional structures. It was also because of these characteristics that MAS researchers were able to successfully lead and/or contribute to the various international project teams. The MAS UDW projects produced several noteworthy societal spin-offs, such as: a Massive Open Online Course on Design for Inclusive and Adaptive Delta Management that featured stakeholder-inclusive, nature-based solutions for port

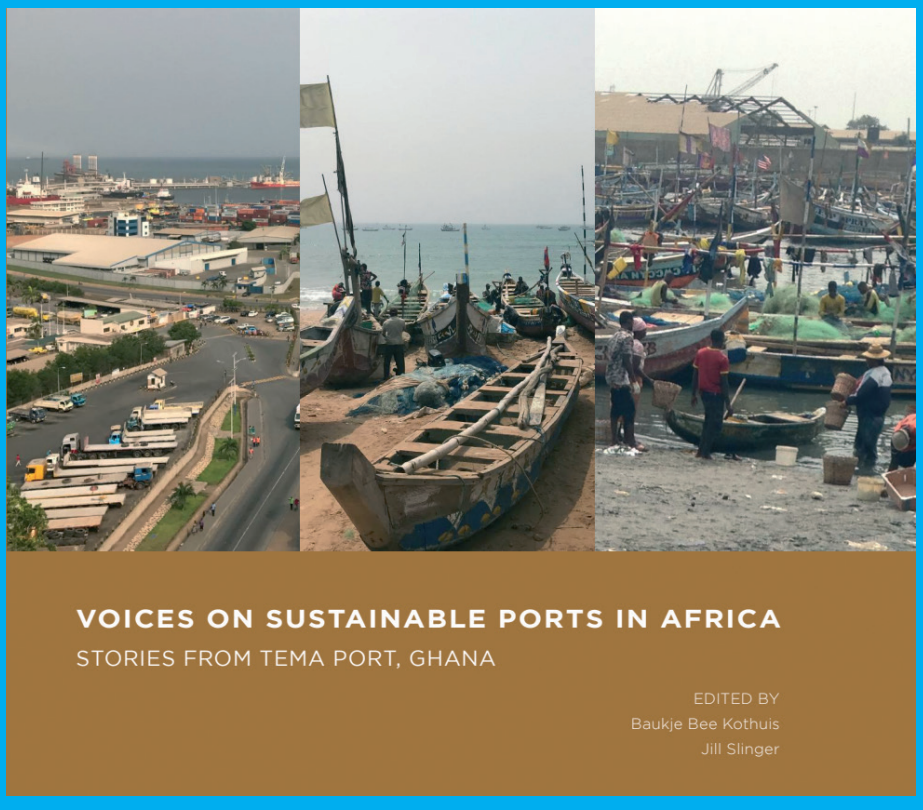
development; a utilisation project to train local water professionals in the use of a participatory method for institutional analysis in Bangladesh; and a stakeholder analysis method for implementation planning that now finds its way to various researchers and users in the Asia and Pacific region.

Beyond these spin-offs for society, the UDW projects also provided a fruitful basis for several follow-up research activities. Sometimes this was a quite direct follow-up, for instance for a NWO/NORFACE/Belmont Forum research project on water-related transformations to sustainability in peri-urban areas. Another follow-up activity was the application of the collaborative visioning 'co-design' method, developed and applied in Ghana, that is being used on the island of Texel in the Netherlands under the CoCOChannel project of the NWO/ALW/Building with Nature programme. Very often, insights from UDW projects have also been combined with insights from other projects to develop the NWA-2019 projects on longer-term adaptations in the water sector (NWO CASTOR and NWO Living Dikes).

Overview of TPM - MAS projects under the NWO UDW programme (chronological order):

UDW Integrated Research projects:
- Shifting Grounds (2014-2019)
- Adaptive Delta Management (2014-202
- Strengthening Strategic Delta Planning Processes (2014-2020)
- Integrated and Sustainable Port Development (2016-2020)

UDW Utilisation projects:
- Design for Inclusive and Adaptive Delta Management: Capacity Development in Ghana, South Africa and the Netherlands (2019-2021)
- Capacity for Participatory Institutional Analysis (2019-2021)



CASE STUDY: **CYBERSECURITY**

The rapid proliferation of IoT devices in consumer and industrial settings is leading to billions of new devices coming online. With this proliferation comes opportunity and risk. Many devices have found to be woefully inadequate in terms of security. They are easy targets for attackers and have been getting compromised at scale. These compromised machines are organised into so-called botnets that are used as criminal attack infrastructure, thereby causing grave societal damage.

How can these compromised devices be cleaned up? Many of them reside with home users and get their connectivity via the networks of Internet Service Providers. Thus, the task of helping the victims also falls to the ISPs. In fact, many governments have assigned them some form of intermediary liability. The problem is that nobody knows whether users are even able to act on these ISP notifications. The ISP has no information about which specific device is infected, let alone what steps to take to fix it, so the notifications only contain extremely generic remediation advice with low usability. This is because IoT devices exist in a stunning variety and are manufactured by tens of thousands of different companies. They often lack accessible interfaces for users to diagnose and remediate problems. Contrary to general-purpose PCs, there are no anti-virus tools and other automated tools for cleaning up infection.

We conducted several randomised controlled trials (RCTs) within a leading Dutch ISP to test (a) whether the notifications have any effect on remediation; and (b) which notification mechanism is more effective in helping and incentivising users to solve this complicated problem. We combined this with network measurements that told us whether the user successfully remediated the problem or not.

These were the first studies world-wide of user remediation of compromised IoT devices in a real-world setting. We found that, to everyone's surprise, the notifications had an enormous impact, even though the advice contained in them was plagued by poor usability. Over 92% of users managed to remove the infection. Somehow, users are able to figure where the problem is and take some action that worked. During follow-up interviews, we learned that some users simply disconnected the device they suspected as being compromised. Other users found help on the website of the manufacturer for the device that they suspected of being compromised.

Our findings have been shared with all ISPs in the country and internationally. They provided clear and compelling evidence for the positive impact that ISPs can have on this fast-growing security problem. Furthermore, the ISP can be effective without incurring prohibitive cost. Support calls are a major cost centre for ISPs, but we found out that only a tiny fraction of the users called the ISP for help.

A shared clearing house called AbuseHub was set up by the ISPs to acquire data on compromised machines. We also provided data on infections collected in our honeypot network to this clearing house. The clearing house was directly connected to processes in the ISPs that sent out notifications warning their customers of the IoT infections and helping them to remediate these. Over the past few years, tens of thousands of users have saved their devices from the hands of criminals, thus reducing the harm these criminals cause not only to the device owners, but also to the Internet at large.

See:
Cleaning Up the Internet of Evil Things: Real-World Evidence on ISP and Consumer Efforts to Remove Mirai
Contributors: Orcun Cetin (Delft University of Technology), Carlos Gañán (Delft University of Technology), Lisette Altena (Delft University of Technology), Takahiro Kasama (National Institute of Information and Communications Technology), Daisuke Inoue (National Institute of Information and Communications Technology), Kazuki Tamiya (Yokohama National University), Ying Tie (Yokohama National University), Katsunari Yoshioka (Yokohama National University), Michel van Eeten (Delft University of Technology).

This publication was the winner of the 2019 NDSS (Network and Distributed System Security) Distinguished Paper Award

Summary

The Multi-Actor Systems department (MAS) engages in transdisciplinary research focusing on understanding, explaining, and changing *complex sociotechnical systems* to address a number of grand societal challenges, such as the consequences of climate change, cybersecurity, the energy transition, and the governance of large-scale interconnected infrastructure systems such as water, energy and IT. Our scientific innovation and impact are characterised by a shared way of thinking about sociotechnical systems that we apply to various research domains, supported by a wide range of methodologies. We use both qualitative and quantitative (data-driven) empirical methods as well as a large variety of participatory quantitative modelling approaches grounded in simulation techniques. Our self-assessment with respect to the three main assessment criteria of the Strategy Evaluation Protocol 2021-2027 are explicated below:

Research Quality

The department's research quality is illustrated by our research publications, research results, products, networks and funding portfolio. We publish in a wide variety of scientific outlets, both in specific domains, such as cybersecurity, climate action, urban development, water governance and energy policy, and in a wide range of methodological domains focused on modelling, simulation, data-driven and other empirical methods, as well as governance and policy fields. Our research products, most notably several simulation-related software libraries, are widely used in related fields and beyond. MAS' funding portfolio focuses on mid- to large-scale projects with various partners. External funding is provided by a mix of NWO and EU (Horizon) funding, and contract research. In addition, members of MAS are also deeply embedded in diverse scientific communities. This is, for example, illustrated by the various roles MAS members play as editors of scientific journals and conference organisers. Several other forms of peer recognition, such as project funding, memberships of scientific committees and scientific awards, further illustrate MAS' research quality.

Societal Relevance

The department's societal relevance is illustrated by the many research projects that we do together with societal partners, including governmental, non-governmental and private parties such as infrastructure providers, European and national governing bodies and private companies. These projects are aimed at addressing societal grand challenges. In addition, department members engage in public debate through national and international media, serve on civil-society committees, and contribute to policy advice on topics such as adaptive delta management and cybersecurity.

Viability

The department's research themes, addressing grand societal challenges, and its transdisciplinary way of working are more relevant than ever. We notice that our expertise is in high demand, as illustrated by a large number of funded research projects.
The department is also financially in good shape. We have enough structural (governmental) and external (project-based) funding to consistently fund about 40-50 staff members and 60-70 PhD candidates and postdoc positions. We expect that the department will continue to expand in the foreseeable future.

Chapter 3

Department Values, Technology and Innovation

CASE STUDIES

In what follows, we will describe a few especially outstanding research projects in a bit more detail.

CASE STUDY: **ESDIT**

The EPT section is one of the founding members of the ESDiT consortium, on the 'Ethics of Socially Disruptive Technologies', which is an NWO-funded Gravitation programme. This 27 million euros, 10-year programme (2019-2029) consists of a consortium of several Dutch universities, with the EPT section playing a key role. The programme aims to provide for breakthrough research into the ethics of technology, with funding for numerous PhD candidates, postdocs and staff members until 2029. Many members of the EPT section are participating in the ESDiT programme. The central goal of this research programme is to take up the challenge that socially disruptive technologies form for core philosophical concepts related to humans, society and nature. For instance, technologies such as robotics, AI and biotechnology challenge the concepts that underlie our moral self-understanding, such as moral agency, autonomy, human interdependence, and responsibility. In turn, digital technologies, energy technologies and climate change challenge the concepts that form the basis of our political, social and legal institutions, such as democracy, justice, equality and solidarity. Socially disruptive technologies also impact the way we understand the world, by challenging the distinctions between natural and artificial, humans and machines, public and private, and agents and physical systems. Furthermore, the ESDiT programme has several intersecting research tracks, for example ones related to collaboration with STEM researchers, intercultural philosophy, and including living labs and art in philosophical research. In the STEM track, collaborations of ethicists with living labs in technological design research are developed. In the art track, researchers explore how works of art can contribute to ethical reflection on socially disruptive technologies. In the intercultural philosophy track, researchers broaden their knowledge in non-Western philosophical approaches. Moreover, they explore how such approaches can shed different lights on our philosophical concepts and theories, which may help to address the challenges of socially disruptive technologies in ways that are novel and effective. For example, in many non-Western philosophical traditions (as well as in feminist ethics), collective notions such as solidarity are much more central than in dominant, more individualistic Western approaches. This can help in addressing the challenges of large-scale sociotechnical problems such as climate change. While most philosophers are trained in Western approaches, we contribute to breaking through this vicious cycle by hiring experts in (for instance) Confucian, Indian, African and indigenous philosophy, who then help other ESDiT members to broaden their knowledge in these approaches via reading groups, conferences etc.

CASE STUDY: **COMET**

All research at VTI feeds into teaching and vice versa, but with regard to the teaching-research nexus, it is worthwhile to specifically mention the COMET project (Comprehensive Ethics Teaching for Engineering and Design students). This is a research project involving several members of the EPT section (most importantly, dr. Janna van Grunsven and dr. Lavinia Marin), funded by the 4TU.Centre for Engineering Education. It was initially funded for two years but recently got extended by another two years due to its success. The field of engineering ethics has grown immensely over the last past decades, which increases the need to have a more focused theoretical underpinning of educational approaches. As such, the goal of the project is to identify and propose best practices for ethics education. The project focuses on the future of engineering ethics education at TU Delft. It is both retrospective and prospective, including by looking back at the successes and challenges of the last 25 years of integrating ethics into the engineering curricula at TU Delft. It does so by following three steps: 1) laying a theoretical foundation through an overview of the state-of-the-art research on engineering ethics and engineering ethics education; 2) developing a specific tripartite framework for thinking about best practices in engineering ethics education; and 3) building a theoretical model to offer practical recommendations – at the level of both form and content – for teaching engineering ethics at TU Delft.

CASE STUDY: **iDREAMS**

With regard to projects in the 3S section, we want to highlight the H2020 iDreams project in which several members of 3S are participating, with dr. Eleonora Papadimitriou in the lead. The consortium consists of 13 partners from academia as well as SMEs. In this project, new Big Data opportunities are investigated to model road safety. Several factors of driver states negatively impact road safety, such as distraction (in-vehicle or external), fatigue and drowsiness, health concerns (e.g. illness, frailty, cognitive state) and extreme emotions (e.g. anxiety, stress, anger). Moreover, differences in sociocultural factors are still among the main determinants of road risks. At the same time, technological developments make massive and detailed operator performance data easily available, for example, via new in-vehicle sensors that capture detailed driving style and contextual data. This creates new opportunities for the detection and design of customised interventions to mitigate risks, increase awareness and upgrade driver performance, constantly and dynamically. The iDreams project investigates the optimal exploitation of these opportunities. The potential users of iDreams are represented by a user advisory board which consists of a dozen organisations and institutions such as the City of Gothenburg, Edinburgh Trams, Toyota Motor Europe, Automóvel Club de Portugal, etc.

CASE STUDY: **IAMRRI**

The H2020-funded IAMRRI project which is led by dr. Geerten van de Kaa, member of the ETI section, is another example to highlight. This project investigates dynamic and complex webs of innovation value chains and identifies and indicates openings for Responsible Research and Innovation (RRI). The central case study is Additive Manufacturing (AM) which is a key enabler in high-value manufacturing where big benefits, such as smarter supply chains, digital manufacturing flexibility and design freedoms are transforming the way products and components are designed, developed, manufactured and supplied in a wide range of sectors. In the IAMRRI project, a dynamic simulation model of networks of innovation value chains in additive manufacturing was developed so that openings for responsible research and innovation could be searched for. Firstly, the underlying conceptual model that relates actors and factors to performance indicators was developed by ETI. This model serves as the scientific backbone of the IAMRRI project. Performance indicators include economic performance (in terms of profits), social performance (in terms of user acceptance) and strategic impact (e.g. in terms of the number of jobs created). Secondly, ETI has given an answer to the question of how actors and stakeholders can affect the performance indicators so that dominant and accepted technological innovation can be achieved. This has led to a list of factors for the selection of additive manufacturing-related technologies. Prioritising factors for additive manufacturing revealed that, for example, customer demand is a very important factor. This is a noteworthy finding, as demand is currently lacking. Furthermore, standardisation organisations may make standards open access, which may positively affect the market share of the standards and user acceptance.

CASE STUDY: **SOCIALLY RESPONSIBLE INNOVATION**

Over the past six years, the VTI department was successful in shaping and conducting research in the programme Socially Responsible Innovation (Maatschappelijk Verantwoord Innoveren, MVI) funded by the Dutch Research Council (NWO). This programme was co-developed and lead by prof. Jeroen van den Hoven (EPT member and founding head of the VTI department). In an open national competition, several MVI projects were acquired by VTI members and used as a tool to generate more collaboration between the various sections as well with other universities, in addition to the involvement of public and private partners, which was a mandatory element of all MVI projects. One example concerns a project capturing the societal value of smart energy systems. This project was a collaboration between members of the ETI and EPT sections, and identified innovative organisational models of smart energy systems that can take moral values into account and are more robust in terms of value conflicts. Another NWO-funded project for MVI was Frugal Innovations and Responsible Entrepreneurship. This project aimed to find determinants of frugal innovations in the health and water sector in Eastern Africa, and was executed by members of the ETI section in collaboration with the LDE International Centre for Frugal Innovation (ICFI).

All the aforementioned projects have resulted in academic publications, PhD defences, and postdoc projects, which in turn have formed stepping stones for further academic careers, public outreach activities and impacts on policymaking and engineering design.

Summary

The Department of Values, Technology and Innovation (VTI) studies sociotechnical systems from a values perspective. It focuses on the overarching research theme of *responsible innovation* (RI).[48] Within VTI, this is defined as the alignment of technological and institutional innovation with societal and ethical values, needs and expectations. Responsible management and innovation of technologies poses major academic and societal challenges. For example, climate change, the energy transition, digitisation, AI, robotisation and health technologies have major implications for society, and policymakers are struggling with how to deal with it all. This requires novel academic approaches to responsible innovation. Attention to *values* is indispensable for the development of technological and institutional innovations that are both socially and morally acceptable. Such values include justice, equity, efficiency, safety, security, sustainability, privacy, transparency, diversity, inclusiveness, and democracy. The approaches we develop in our department can make important contributions to including such values in the responsible innovation of technology.

Research aim

With our unique approach to responsible innovation, we aim to contribute substantially to the understanding and responsible management of major societal challenges, by continuously striving for breakthrough academic research as well as for direct contributions to policy, industry and society, thereby contributing to a more fair and sustainable society.
The VTI department consists of three disciplinarily distinguished sections that collaborate on the overarching topic of Responsible Innovation. VTI's constituent sections are Ethics and Philosophy of Technology (EPT), Economics of Technology and Innovation (ETI), and Safety and Security Science (3S). We integrate mathematical, social-scientific, economic and philosophical-ethical approaches to safety, risk, technological design and innovation. This combination of disciplines in one overarching department is unique in the world. It fills an important academic and societal lacuna, by contributing to research on responsible innovation in a multidisciplinary way, thereby combining empirical, quantitative and normative approaches.

Accomplishments

VTI members are very active and impactful in terms of publishing their writing in leading journals and with first-rate book publishers, as well as in other types of publications. VTI members regularly apply for research funding at national and international funding agencies and they are frequently successful, also where highly competitive personal grants and large research consortia are concerned. Several VTI members are frequently interviewed for public media about their work. Members of VTI collaborate with policymakers and industry in research projects and contribute to national and international policy advisory boards.

Strategic goals for 2022-2028

- Keep on investing in strengthening the academic core of our department
- Continued emphasis on nurturing new talent with diverse profiles through tenure track policy
- Further develop the PhD programme on responsible innovation from a pilot to a mature programme with leading international partners
- Strengthen our overarching research strategy into a more comprehensive approach.

48 This is also often referred to as RRI: Responsible Research and Innovation.