

## **Research Program Department Values, Technology & Innovation (VTI)**

The Department of Values, Technology & Innovation (VTI) focuses on the value dimension of *comprehensive engineering*, the overarching research theme of the Faculty Technology, Policy and Management (TPM). Attention to the value dimension matches not only with TPM's mission but also with the broader mission of the TU Delft which is to make a significant contribution towards a sustainable society by, amongst others, helping to translate knowledge into technological innovations with both economic and social value. Attention to the value dimension of technology and innovation is crucial if technological innovation is to contribute to solutions of the grand societal challenges such as security, global warming, energy, water, and public health. Recent technological innovations that have been proposed to deal with these challenges include robotics, information and communication technology (ICT), biotechnology, sustainable energy technologies and nanotechnology. Also big data are increasingly used to address the societal challenges. The value dimension is important for the further development, social acceptance and moral acceptability of technological innovations, and for the use of big data. In the past decades, we have witnessed innovations that have failed because of a lack of social acceptance and moral acceptability. For example, innovations in biotechnology have been much less accepted by the public in Europe than for example in the US. Another example is the rejection of the introduction of smart meters by Dutch parliament, because of insufficient attention to the value of privacy. Also in the ongoing transition toward sustainable energy systems, one of the biggest challenges is to sustain societal acceptance and moral acceptability.

With our research focus on values we engage in empirical, practical but also moral investigations: our aim is not just to study how we can further the social acceptance of new technologies, but also to critically reflect on the moral acceptability of such innovations. Therefore the central research theme of the department is *responsible innovation*.

Responsible innovation is a normative notion that reflects the idea that innovation in the 21<sup>st</sup> century should not only bring economic growth, profit and more efficiency, but that it should also meet certain non-instrumental values and contribute to the solution of societal challenges. The notion of responsible innovation refers both to a process of innovation which has to meet certain norms, like the inclusion of stakeholders, or anticipation of risks and social consequences, as well to products of innovation that should reflect important societal values like safety, security, (distributional) justice, privacy, responsibility, inclusiveness, and sustainability.

In our research, we study the role of values in technological innovations, bringing together experts from economics, risk and safety science, and philosophy. 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, combining empirical, quantitative, conceptual and normative approaches.

### **Main research question**

How can we make innovations more responsible, so that processes as well as products of innovation do justice to important social and ethical values, also taking into account that the effects of innovations are often uncertain or unknown, and that innovation takes place in sociotechnical systems?

### **Research Mission**

The research mission of the VTI department is to contribute to responsible innovation by:

- (a) Identifying, analyzing and improving the attention for the value and responsibility dimensions of governance, engineering and technology from a sociotechnical systems perspective, with special attention to (but not limited to) values such as safety, security, efficiency, justice, privacy, and sustainability, and to trade-offs between these values, and with a focus on design, innovation and diffusion of responsible innovation.
- (b) Studying the institutional design of large sociotechnical systems, innovation processes and systems, and the role of entrepreneurship in innovation with special attention for their value dimension, with the aim of identifying opportunities for making innovations and innovations processes (more) responsible.
- (c) Developing, applying and empirically testing theories, methodologies, methods, approaches, tools, conceptualizations for, or contributing to, responsible innovation.

### **The three sections within VTI**

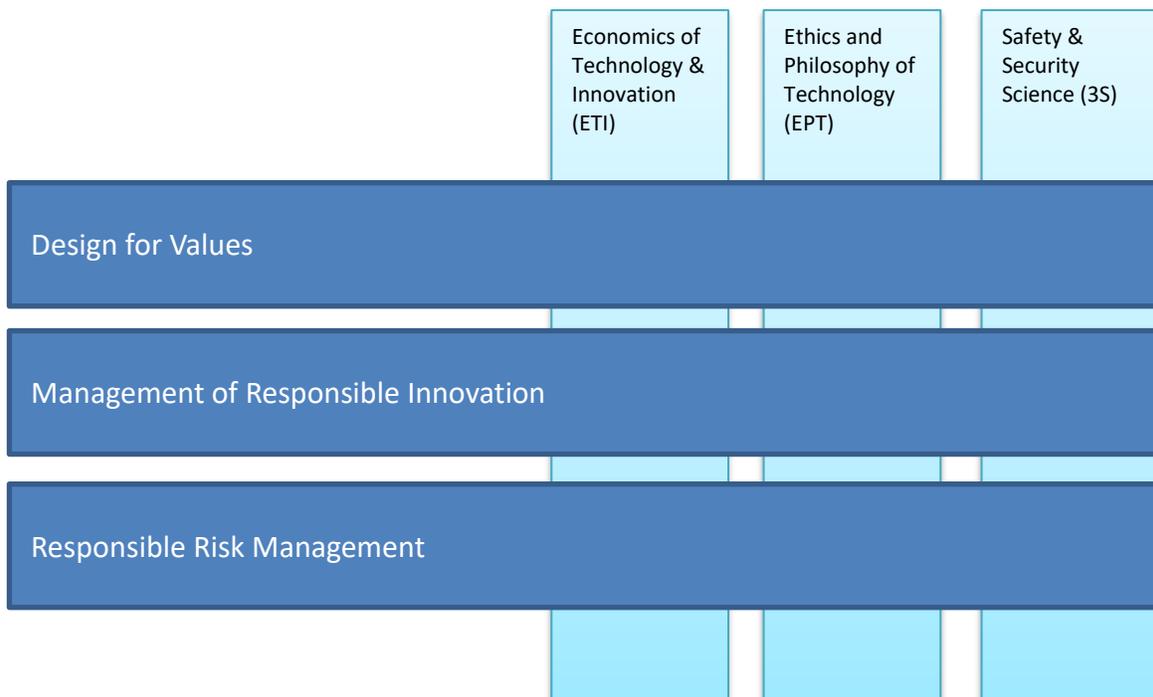
The VTI department consists of three sections: Economics of Technology & Innovation (ETI), Ethics and Philosophy of Technology (EPT), and Safety & Security Science (3S). Each of these contributes on the basis of its specific expertise to the research theme of responsible innovation:

- The Section **Economics of Technology & Innovation (ETI)** focuses on three more specific topics: (1) economics of innovation, (2) innovation management and entrepreneurship, and (3) institutional economics and governance of sociotechnical systems. This contributes to responsible innovation in a number of ways: it provides more insight in the institutional design, processes and drivers of innovation and what is needed in this respect to make innovation more responsible; it sheds light on the role of management and entrepreneurship in innovation and how (social) entrepreneurship might contribute to responsible innovation; and, it helps to devise institutional and governance strategies to further responsible innovation in (regulated) infrastructural systems.

- The Section **Ethics and Philosophy of Technology (EPT)** focuses on the following research topics (1) moral issues raised by (new) technologies, (2) risk ethics, (3) incorporating ethics in design, (4) conceptual analysis of technical artefacts and socio-technical systems. The section contributes to responsible innovation by conducting ethical analysis of a wide variety of (emerging) technologies; it also contributes to the ethics of technological risk; it clarifies issues of responsibility in engineering and design contexts and it develops theories and approaches for identifying values and facilitating their inclusion in design. It also does conceptual work on notions like technical artefacts and sociotechnical systems.
- The Section **Safety & Security Science (3S)** focuses on four topics: (1) risk modeling for design and management, (2) the incorporation of risk criteria into the design process, (3) the learning organization as manager of risk, and (4) risk regulation. It contributes to responsible innovation by developing innovative approaches to risk assessment and safety and security management, like the application of Bayesian Belief Networks (BBN), exploiting the availability of big data to feed probabilistic cause-consequence relationships, by providing insights how to integrate safety and security criteria in technological design and by investigating value trade-offs in risk regulation with multi-objective multi-criteria frameworks.

### Research themes

Striving for responsible innovations is not a trivial matter. It requires fundamental research into a range of issues. First, it requires insights into what values are important from a social and ethical point of view and how to make values bear on design and innovation processes.



These philosophical and empirical challenges are investigated by us in the theme of 'Design for Values'. In addition, bringing about responsible innovation often means breaking through existing patterns of innovation, requiring new modes of managing innovations. This we investigate in the theme of 'Management of Responsible Innovation'. A third challenge is that the impacts of innovations on society are often not known beforehand, which means that one needs to deal with ignorance, uncertainty and risk. This we study under the theme of 'Responsible Risk Management'. These three themes cut across the three disciplinary research groups within VTI: Economics of Technology & Innovation (ETI), Ethics and Philosophy of Technology (EPT), and Safety & Security Science (3S).

## **Research themes**

### ***Design for Values***

*Main research question: How can values be integrated into the design of technologies, institutions and sociotechnical systems?*

One of the main approaches to responsible innovation that the VTI department is working on is Design for Values, which aims at integrating non-instrumental values in the design of new technologies and innovations from the start. This raises a number of challenges. One challenge is how to deal with value conflicts in design. Value conflicts may arise because different stakeholders hold different values but also because a technology can usually not meet all values that are relevant for its design, so that decisions have to be made for example through value trade-offs. Another challenge is the role of institutions and how they should be designed in order to justice to values and responsible innovation. Institutions can often not be designed from scratch because they usually already exist and evolve over time. This requires insights both in how institutions develop, how institutions impact technological development and how they relate to values. A third challenge has to do with the value of responsibility. Determining and enhancing responsibility in sociotechnical systems is often problematic. Innovation and design are collective efforts and the causal chains between the innovators and the eventual social effects are long. In addition, a range of new technologies raise new responsibility problems; think for example of drones, robots and self-driving cars that autonomously make decisions. This may result in tensions between collective and individual responsibility and in responsibility gaps.

### ***Management of responsible innovation***

*Main research question: How can we operationalize, manage and incentivize responsible innovation in sociotechnical systems?*

We make a novel contribution to innovation systems research by incorporating responsible innovation and a value dimension. We do this by building on insights that we have developed in the past with respect to innovation management. However, our more recent focus on managing responsible innovation gives rise to new challenges. One challenge is that making innovations more responsible often requires breaking through existing

patterns of innovation. From innovation studies, it is known that new players, like start-ups, may play a crucial role in doing so. Studying the role of entrepreneurship for responsible innovation is therefore very important. Another important challenge is how to operationalize and incentivize responsible innovation in sociotechnical systems. For example, an intrinsic motivation to take responsibility by making innovations more sustainable might be “crowded out” by economic incentives. Moreover, in many sociotechnical systems, such as energy, transport and communication infrastructures, the incentive structure is embedded in the sector regulations and/or public oversight. This raises the question how we can stimulate responsibility in sociotechnical systems given that incentive structures are usually difficult to change and given that incentive structures that work on the short term might have detrimental effects (due to “crowding out”) in the long run. This requires empirical studies and indicator development in combination with a normative perspective.

### ***Responsible risk management***

*Main research question: How are we to assess, manage and evaluate the risks of technologies and sociotechnical systems in a responsible way?*

Risk is a key concern when it comes to responsible innovation. Effects of (responsible) innovation are frequently uncertain and may only surface once technologies are introduced into society. This raises the question how to model and predict risks taking into account technological, organizational and human factors. In order to address this, an important approach we develop and apply is that of Bayesian Belief Networks (BBNs) for risk assessment. A second challenge is how to integrate safety (unintentional harm) and security (intentional harm) in risk assessment and management, as safety and security increasingly interact and depend on each other. Here, among other things, we apply game theory to better understand and model such interactions. A third challenge has to do with the question as to how safe is safe enough. We investigate how moral values can be integrated in risk assessment and risk management, while also paying attention to an economic point of view. This gives rise to the question as to how to take into account the role of moral values and of emotions in the already existing more formal frameworks for making decisions about acceptable risk. From a philosophical point of view, the topic of risk requires new theories because traditional ethical theories have a hard time dealing with probabilities and uncertainties. The Ethics and Philosophy of Technology Section is internationally a key player in this new domain of risk ethics. A fourth challenge is dealing with the fact that risks cannot be completely predicted or anticipated. We investigate this for example by considering the introduction of new technology into society as a social experiment in which risks and benefits only gradually become clear.

## **Research institutes and centers**

The VTI department cooperates with a large number of research groups within and outside TU Delft. We participate in a number of research institutes and centers to further foster such collaboration.

Until 2016, the VTI department was home to the *Delft Center for Entrepreneurship (DCE)*, which fosters entrepreneurship at TU Delft and provides teaching in this area. As of 2016, DCE is an independent center within TPM, but cooperation with VTI especially on research on entrepreneurship and (responsible) innovation will continue.

We chair= the *Delft Safety & Security Institute (DSyS)*, in which a large number of departments from various faculties of TU Delft cooperate with respect to safety and security research, and we also chair the Delft Design for Values Institute (DD4V).

We participate in the *4TU.Centre for Ethics and Technology (4TU.Ethics)*, a world-leading center in the ethics of technology, which combines the research on ethics and technology at the three Dutch technical universities in the Netherlands (TU Delft, TU Eindhoven and Twente University).

We also participate in the *NITIM (Networks, Information Technology and Innovation Management) graduate research school*, which is positioned at the interface of management, specifically entrepreneurship, innovation and technology management, computer science and information systems.

We are board member of DUWIND (Delft Institute for Wind Energy), Delft Energy Initiative, and PowerWeb. These are the main research centers at TU Delft in the field of energy research.

The VTI department also participates in various centers that have been established as part of the cooperation of TU Delfts with the universities of Leiden and Rotterdam (Erasmus University) like the *LDE (Leiden, Delft, Erasmus) Centre for Safety & Security*, and the *LDE Centre on Frugal Innovations in Africa*.

## **International collaboration**

We are cooperating with various research groups in the world that work on similar topics. This includes, among other, the Oxford Uehiro Centre for Practical Ethics (UK), the Centre for Applied Philosophy and Public Ethics (CAPPE) in Australia, the Science Policy Research Unit (SPRU) of the University of Sussex (UK), Risk Center at ETHZ (Switzerland), the Centre for Risk Analysis and Risk Management at the University of Stavanger (Norway), the VSD Research Lab at the University of Washington (US), Portsmouth Business School (UK), Public Safety Center at Tsinghua university (China), the Center for Responsible Innovation and Design (CRID) at the University of Siegen (Germany), and through the 4TU.Centre for Ethics and Technology we are cooperating with eight Chinese top technical universities on responsible port innovation.