Ethics Assessment in Different Fields

Engineering Sciences

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Annex 2.b
Ethical Assessment of Research and Innovation: A Comparative Analysis of Practices and Institutions in the EU and selected other countries
Deliverable 1.1

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Contents

1 INTRODUCTION

This is a report on ethics assessment of research and innovation in engineering. In a broad sense, ethics assessment of engineering refers to any kind of assessment, evaluation, review, appraisal or valuation of research or innovation within engineering that makes use of ethical principles or criteria. The report will cover both the academic traditions of ethics assessment in engineering and the institutionalisation of it in different types of organisations, including national and international standards and legislation. It is part of a larger study of the SATORI project that focuses on ethics assessment of research and innovation in five scientific fields: the humanities, the medical sciences, the social sciences, the natural sciences, and engineering.

Let us begin with a description of the nature and scope of the engineering field. Engineering is the design and development, using scientific and mathematical principles, of structures, machines, materials, devices and processes for practical ends, as well as the construction, operation, maintenance or improvement of such structures, or the modelling, diagnosis and prediction of their behaviour based on knowledge of the principles of engineering design. Whereas the application of principles of natural science and mathematics is particularly important to engineering, the activity often also involves the application of other bodies of knowledge, including economic, social, ergonomic and behavioural knowledge.

Engineering is an extremely broad field, which includes many engineering disciplines or branches that are characterised by the particular structures, devices or processes that they are focused on, or, less frequently, by a particular method or objective. It is generally recognised that there are four major branches of engineering: chemical engineering, civil engineering, electrical engineering and mechanical engineering. Within these major branches, there are dozens of more specific disciplines and fields, such as molecular engineering, optical engineering and transport engineering. There are also fields of engineering between or above the four major branches, such as systems engineering, aerospace engineering and industrial engineering.[1]

In this study on ethical assessment in engineering, the scope of engineering excludes computer engineering and computer science. These fields are covered separately in the study of ethics assessment in information technology. The engineering of living systems, as in biomedical engineering, genetic engineering and agricultural engineering is also treated separately, in the study of medical and life sciences.

There are many types of ethical issues in the field of engineering. Ethical issues in *engineering research* may involve scientific integrity, institutional integrity, social responsibility, human subjects' research, and animal welfare. *Engineering innovation* may give rise to the same issues, as well as issues relating to social responsibility and responsibility to clients, and issues concerning the impacts of technology that may relate to: the environment; health; safety; justice, access and equality; rights and liberties; individual rights and liberties; autonomy, authenticity and identity; human dignity; bodily integrity; dual use; hubris. Sometimes, ethical issues concern the moral permissibility of technological innovations themselves, independently from their potential or actual impacts; an engineer's

[1] For an extended overview, see: http://en.wikipedia.org/wiki/List_of_engineering_branches.

work might, for example, be seen as playing God.[2] Finally, there are various ethical issues with technologies that are associated with specific engineering branches, such as nanotechnology and robotics.

Ethics assessment in engineering has a relatively short history. It did not start until the twentieth century with the development of the *ethics of technology* as an (more or less) independent sub-discipline of philosophy. A plausible reason for this late development is the positive ethical assessment of technology that was long held: technology increases the possibilities and capabilities of humans, which seems, in general, desirable.[3]

Over the course of the twentieth century, the ethics of technology has developed greatly. As it moved from *technological determinism*[4] to an emphasis on technological development being the result of choices, and also from ethical reflection on technology *as such* to ethical reflection on specific technologies and specific phases in the development of technology, the number and scope of ethical questions that were asked about technology greatly increased.[5] Over the last decades, the ethics of technology has also branched into a number of subfields, which include *computer ethics*, *nanoethics*, and *roboethics*. Some prominent works on the ethics of technology have been authored by the German philosopher Hans Jonas.[6]

Another major development within ethics assessment in engineering was the emergence, in the latter half of the twentieth century, of *engineering ethics*, which is specifically concerned with actions and decisions made by engineers. Gradually, it became common for professional organisations for engineers to publish general ethical principles and professional codes and provide methods and techniques that engineers can use to resolve moral issues and dilemmas they encounter in their work.

In various ways, ethics (assessment) in engineering has steadily become institutionalised over the last decades: many national professional ethical codes for engineers were formulated in the 1970s; technology assessment organisations were set up in different countries in the 1970s and 1980s; national and international legislation and standards concerning health, safety and environmental risks of engineering emerged around that same time; and dedicated international journals and conference series on ethics of technology were established in the 1980s and 1990s.

The remaining sections of this report offer a description of ethics assessment approaches and principles in engineering, an overview of ethical issues, a description of the institutionalisation of ethics assessment, and a final evaluation of ethics assessment in engineering. Section 7 of this report contains lists of key publications, journals and book series, and conference series on ethics assessment of engineering, as well as lists of major international, European and national organisations that engage in ethics assessment of

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[2] Samenow, Jason, "Geoengineering and the folly of playing God with the planet", *The Washington Post*, 10 February 2015. http://www.washingtonpost.com/blogs/capital-weather-gang/wp/2015/02/10/geoengineering-and-the-folly-of-playing-god-with-the-planet/

[3] Franssen, Maarten, Gert-Jan Lokhorst & Ibo Van de Poel, "Philosophy of Technology", *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), Winter 2013. http://plato.stanford.edu/archives/win2013/entries/technology

[4] This theory states that a society's technology drives the development of its social structure and cultural values and assumes that technology is a given self-contained phenomenon which develops autonomously.

[5] Franssen et al, op. cit. 2013.

[6] See section 7.1.

engineering. As regards methodology, the report is based on desk research and a number of structured interviews with experts on ethics assessment in engineering.

2 ETHICAL ASSESSMENT: APPROACHES AND PRINCIPLES

There are three ethical traditions that are directed, in part or in whole, at the ethical assessment of research and innovation in engineering: *engineering ethics*; *ethics of technology*; and *research ethics*. The first three subsections offer a description for each of these traditions—focusing on aims, methodologies, guiding principles and/or actors, and organisations that develop and practice these traditions. The fourth subsection provides some general concluding remarks about the aims and methods of the traditions, and the ethical values and principles used in them.

2.1 ENGINEERING ETHICS

Engineering ethics is a subset of professional ethics: it is professional ethics of and for engineers. It focuses on assisting engineers in shaping their professional responsibility through the formulation of general ethical principles and professional codes, and by providing methods and techniques for tackling the moral issues and dilemmas that engineers encounter in their work.

The focus of engineering ethics is on the roles and responsibilities of engineers. This focus is somewhat different to that of research ethics and innovation ethics. In these types of ethics, the respective focuses are on research processes and innovation processes, and the ethical principles and protocols concerning practices within those processes. Although the practices ultimately relate to the individual scientists and engineers and their individual actions and professional roles, these are often not the immediate focus of research and innovation ethics. In addition, although research and innovation constitute an important part of the professional responsibilities of many engineers, they are not the only practices that engineers engage in. Engineers, amongst other things, also engage in diagnosis, maintenance and repair of technological systems and processes. Professional ethics for engineers is therefore by definition broader than the professional ethics of research and innovation in engineering.

The ethical principles of engineering ethics are for the most part found in codes of ethics that have been created by professional engineering organisations, and in textbooks on engineering ethics. Most ethics codes do not contain explicit reference to values, but rather describe a number of virtues that engineers ought to have and, more importantly, a number of professional duties and responsibilities. Some of these are clearly recognisable as motivated by ethical values and principles, whereas others are not. The duties typically relate to major actors that engineers engage with—clients, colleagues, and employers—as well as society as a whole, and the natural environment. The virtues, duties and responsibilities outlined in the ethics codes serve as a guide; engineers require sound judgment to determine how the codes would apply in specific circumstances.

Ethical codes typically specify that professional conduct by engineers is bound by virtues such as honesty, integrity, competence, dignity, and objectivity. An example of a code listing such virtues is the World Federation of Engineering Organizations Code of Ethics.[7] They typically specify that engineers have a paramount responsibility for the health, safety and

[7] World Federation of Engineering Organizations, "Code of Ethics". http://www.wfeo.net/wp-content/uploads/WFEO_MODEL_CODE_OF_ETHICS_Final.pdf

welfare of the public. They specify a number of obligations, such as the obligation of furthering the interest of clients in giving advice, of not divulging confidential information, and of not making public statements that discredit the profession. Often, they contain an obligation to take proper care of the environment or to practice principles of sustainable development. They rarely contain clauses that specifically refer to research or to engineering design. Ethical codes that pertain to specific engineering fields may contain clauses that are specific to the field, although such codes tend to be quite general as well.

To the extent that ethical codes explicitly spell out rules, duties, and obligations, they represent a clear application of *deontological* ethical theory, which prescribes adherence to particular rules or fulfilment of particular duties or obligations.[8] Furthermore, to the extent that they express virtues that are beneficial to ethical engineering practice, they are also an application of *virtue ethics*, which focuses on the character traits of the person who acts, rather than the action itself. Beyond ethical codes, it has been argued that in engineering practice, engineers mostly use *consequentialist* ethical reasoning:[9] knowingly or unknowingly, they apply consequentialist ethical theory, which evaluates a morally significant action on the basis of its actual or expected consequences. Engineers' preference for consequentialism allegedly derives from the nature of their profession—making things better and more efficient for their clients, thus causing them increased happiness.[10] This preference might have been strengthened by the fact that the courts and the public generally assign liability to engineers primarily in accordance with the results (consequences) of their work.[11]

Engineers are generally familiar with the codes of ethics that their professional organisations have promulgated.[12] However, it is doubtful that many engineers have taken the step to memorise the codes. In fact, it seems unlikely that many engineers even feel the need to refer to the code of ethics on a regular basis.[13] It has been suggested that, in everyday situations, they seem to be making ethical decisions based on little more than what might be called intuition and fortune.[14] Nevertheless, many jurisdictions, (an example being the Texas Board of Professional Engineers[15]) require a certain amount of continuing education in ethics for engineering license renewal, and anecdotal evidence suggests that many engineers find this to be annoying, tiresome and a waste of time and money.[16]

The codes of ethics of some professional bodies, such as the Engineers Australia code of ethics,[17] contain rules that are enforceable by disciplinary action by the professional body.[18]

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[8] Schmidt, Jon Alan, "Changing the Paradigm for Engineering Ethics", *Science and Engineering Ethics*, December 2014, Volume 20, Issue 4, p. 985. http://link.springer.com/article/10.1007/s11948-013-9491-y
[9] Lloyd, Peter, & Jerry Busby, "Things that went well — No serious injuries or deaths: Ethical reasoning in a normal engineering design process", *Science and Engineering Ethics*, 2003, Volume 9, Issue 4, p. 503. http://link.springer.com/article/10.1007%2Fs11948-003-0047-4
[10] Ibid., p. 513.
[11] Schmidt, op. cit., 2014, p. 992.
[12] Lloyd & Busby, op. cit., 2003, p. 503.
[13] Ibid.
[14] Lloyd & Busby, op. cit., 2003.
[15] Texas Board of Professional Engineers, "Continuing Education Program (CEP): Frequently Asked Questions (FAQ)". http://engineers.texas.gov/cep_faq.htm
[16] Schmidt, op. cit., 2014, p. 986.
[17] Engineers Australia, "Our Code of Ethics". https://www.engineersaustralia.org.au//sites/default/files/shado/About%20Us/Overview/Governance/codeofethics2010.pdf

Generally, however, the principles discussed in them are more in the nature of precepts, providing authoritative ethics guidance to engineers.

Among engineers, engineering ethics is generally regarded as a sub-problem of an ongoing engineering design process: it is the idea that, at some point in an engineering design project, a project leader might assign an "ethics manager" to make sure that all ethically questionable implications of a design have been adequately addressed.[19] This way of dealing with ethics is instilled due to the fact that engineering ethics is largely taught using case studies which focus on "big decisions".[20] It has been argued, however, that engineering design might be better thought of as a process of accumulating micro-ethical decisions, rather than a small number of explicitly ethical decisions.[21]

2.2 ETHICS OF TECHNOLOGY

A second ethical tradition that is relevant to engineering is *ethics of technology*. We may usefully distinguish between professional ethics and applied ethics, defining applied ethics as the analysis of ethical issues in society from a general point of view. Ethics of technology is a form of applied ethics focused on ethical issues involving technology that concern to society as a whole. Ethics of technology is in part an offshoot of applied ethics in general, and in part of engineering ethics—a field in which considerations of professional responsibility have sometimes given rise to more general ethical reflections on technologies and their role in society. An example may help clarify the distinction between engineering ethics and ethics of technology: The question of whether and how software engineers should be protective of privacy in the design of software is a question of engineering ethics. The question of whether and how privacy should be protected on the Internet is a question of ethics of technology.

For the most part, ethics of technology is an academic tradition. Academics within this tradition have diverse backgrounds and they do not always consider themselves (primarily) ethicists of technology.[22] The fact that ethics of technology is a form of "applied" ethics entails that it generally involves top-down application of formal "principles" supplied by normative ethics. The number of publications on ethics of technology has increased notably in the past decades.[23] This growth is said to correlate with the social need to remove collective uncertainty in dealing with the consequences of technology and to create orientation criteria for technological development.[24]

Alongside the general ethical studies of technology, there exist nowadays several specialised fields of applied ethics (often in combination with professional ethics) that focus on specific fields of technology. These include, prominently, *computer and information ethics*, which focuses on information technology, *nanoethics*, which studies the ethical implications of

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[18] The Royal Academy of Engineering, *Engineering Ethics in Practice: A Guide for Engineers*, The Royal Academy of Engineering, London, 2011, p. 37. http://www.raeng.org.uk/publications/other/engineering-ethics-in-practice-shorter
[19] Lloyd, & Busby, op. cit., 2003, p. 505.
[20] Ibid.
[21] Lloyd, & Busby, op. cit., 2003, p. 505.
[22] Franssen et al, op. cit. 2013.
[23] Grunwald, Armin, "Technology Assessment or Ethics of Technology?: Reflections on Technology Development between Social Sciences and Philosophy", *Ethical Perspectives*, Vol. 6, No. 2, 1999, p. 171. http://www.ethical-perspectives.be/viewpic.php?LAN=E&TABLE=EP&ID=237
[24] Ibid.

nanotechnology, and *roboethics*, focused on robotics. Many other technologies are also studied from an applied ethics point of view.

Ethics of technology adheres to ethical principles that are quite different from those of engineering ethics, and that are more in line with familiar principles of (applied) ethics. Issues in ethics of technology are typically governed by values such as justice, autonomy, freedom, privacy, dignity, and general welfare. Ethical issues typically concern ways in which the development or use of a technology may threaten the realisation of particular values, how technologies may be designed, used or regulated to better realise our values, and how to deal with conflicting values and principles in the development, use and regulation of technologies. They also concern the proper way of dealing with risks, particularly risks that pertain to health, safety, security and welfare.

The ethics of technology is dominated by consequentialist ethical theory, which makes the morally correct dependent upon the compatibility of the consequences with the accepted rules or values.[25] Against consequentialist ethics, certain authors have argued that the consequences of technical action are not sufficiently clearly predictable with regard to their nature or their probability of occurring, and therefore recommend applying deontological ethical theory, which makes engineering practice subject to irrefutable ethical obligations.[26] Recently, virtue-ethical conceptions have also started to be represented in the ethics of technology.[27]

It is also worth mentioning the *precautionary principle*, which is sometimes used in the ethics of technology. There are various interpretations of this principle, including consequentialist and deontological interpretations.[28,29] The precautionary principle states that any action or policy that could carry a risk of causing (major) harm to the public or to the environment should not be carried out in the absence of scientific consensus that the action or policy does not present any (major) risk, with the burden of proving the action is not harmful falling on those intending to take the action.

2.3 Research ethics

A third ethical approach relevant to engineering is research ethics, specifically research ethics as it has been developed for the natural sciences. It is a professional ethics for and by researchers, and is aimed at addressing ethical issues in various scientific fields, such as engineering research.

The most salient practice in engineering is engineering design. However, another important practice is fundamental engineering research (sometimes called engineering science, in contrast to engineering proper). Such research is focused on the fundamental properties of

[25] Ropohl, G., "The Ethics of Technology", in Philippe Goujon & Bertrand Hériard Dubreuil (eds.), *Technology and Ethics: A European Quest for Responsible Engineering*, Peeters Publishers, 2001, p. 51. https://books.google.nl/books?id=IZUlsz_aEKMC&printsec=frontcover#v=onepage&q&f=false
[26] Ibid., p. 51.
[27] Ropohl, op. cit. 2001, p. 50.
[28] Zaharatos, Brian, "Alternative Methods? Cost Benefit Analysis and the Precautionary Principle", 6 August 2013, p. 10–11. http://www.academia.edu/9334851/Alternative_Methods_Cost_Benefit_Analysis_and_the_Precautionary_Principle
[29] Hans Jonas, who first formulated the precautionary principle, is said to have interpreted this principle in a deontological manner, as a fundamental social security obligation. See: Ropohl, op. cit. 2001, p. 51.

materials, chemicals, systems and processes, with an eye towards possible later application in engineering design. It has many resemblances to research in non-applied science.

Engineering research is largely subject to the same ethical principles that are relevant to (non-applied) research in the natural sciences. The relevant principles of research ethics include: scientific integrity, collegiality, data integrity, institutional integrity and social responsibility, the protection of human subjects, and animal welfare in cases in which human subjects or animals are involved in the research process. Based on these principles, many different professional associations, government agencies, and universities worldwide have adopted specific codes, rules, and policies for research ethics.

All three major approaches to philosophical ethics are represented in research ethics, virtue ethics perhaps to a lesser degree than consequentialism and deontology. Codes of conduct, often containing duties and obligations, are for the most part an application of deontological ethical theory. Furthermore, deontological and consequentialist reasoning are widely practiced in specific, ethically important fields such as research with human and animal test subjects. Finally, sometimes virtue-ethical reasoning is represented in codes of conduct when such virtues are listed as: courage, respectfulness, resoluteness, sincerity, humility, reflexivity, fairness, openness, resourcefulness, conscientiousness, flexibility, and integrity.

Concluding remarks

As we have seen, there are three ethical traditions that are directed, in part or in whole, at the ethical assessment of research and innovation in engineering: engineering ethics; ethics of technology; and research ethics. Engineering ethics is professional ethics of and for engineers. It focuses on assisting engineers in shaping their professional responsibility through the formulation of general ethical principles and professional codes, and by providing methods and techniques for tackling the moral issues and dilemmas that engineers encounter in their work. Ethics of technology is a form of applied ethics focused on ethical issues involving technology that concern to society as a whole. It is an academic tradition that involves top-down application of formal principles supplied by normative ethics. Finally, research ethics is a professional ethics for and by researchers. It is aimed at addressing ethical issues in various scientific fields, such as engineering research, and focuses on developing principles, codes, rules, and policies for ethical research.

The engineering ethics and research ethics approaches are similar to each other in that they are both a form of professional ethics. Within both traditions, there is consensus on the importance of having professional codes of ethics or codes of conduct, and on the importance of values such as honesty, integrity, objectivity, and social and environmental responsibility. Ethics of technology is different from these approaches in that it has a scope that is wider than the engineering and research professions. Issues in the ethics of technology are typically governed by values that relate to the wider discussion of the role of technology in society as a whole, such as justice, autonomy, freedom, privacy, dignity, and general welfare. What all three traditions have in common, however, is a focus on the health, safety and welfare of the public and the environment.

3 OVERVIEW OF ETHICAL ISSUES

This section offers a structured list of ethical issues in engineering, with a focus on applied ethical issues in technological innovation. Subsection 3.1 lists ethical issues in engineering research and design; subsection 3.2 focuses on ethical issues intrinsic to technological innovations; subsection 3.3 lists ethical concerns with impacts of technology; and subsection 3.4 lists ethical issues in specific fields of engineering and technology.

3.1 ETHICAL ISSUES IN ENGINEERING RESEARCH AND DESIGN ("INTERNAL" ISSUES)

In engineering, a distinction is sometimes made between engineering science and engineering design. *Engineering science* is applied scientific research concerned with the understanding of natural phenomena for practical applications. *Engineering design* is the development of plans for the realisation of technological products, systems and processes. The ethical issues in the two are somewhat different. Ethical issues in engineering research are mostly similar to those of research in the fundamental natural sciences. They involve scientific integrity, institutional integrity, social responsibility, human subjects' research, and similar issues.

Ethical issues in engineering design are somewhat different because the aim of design is not new knowledge, as in research, but interventions in the real world. Many of the ethical issues therefore concern the nature and potential impacts of these interventions. They are discussed separately in subsection 3.2. Other than these issues, however, there are also ethical issues internal to the design practice, which are partially similar to those in scientific research such as professional integrity (analogous to scientific integrity), institutional integrity and collegiality (both involving somewhat different ethical issues than those found in scientific research), human subjects research and animal welfare. An important ethical issue in engineering design is the responsibility to clients, in terms of, for example, working at a level of competence and providing honest advice. Social responsibility is also a central issue, with a strong focus on safety, health and environmental risks (see subsection 3.3), and human welfare.

Academically, the internal ethical issues mentioned above, and the "external" issues of social responsibility, are usually discussed under the heading of *engineering ethics*. Concern about the impacts of technology and larger societal concerns regarding technological innovations are often discussed under the heading of *ethics of technology* (or technology ethics).

3.2 ETHICAL ISSUES INTRINSIC TO TECHNOLOGICAL INNOVATIONS

These are ethical issues that concern the moral permissibility of technological innovations themselves, independently from their potential or actual impacts.[30] There seems to be one major group of issues, which might be called *unnaturalness* or *playing God*. This group comprises ethical concerns with the intrinsic nature of some technological innovations. These ethical concerns include the positions that some technological innovations are unnatural, violate nature, go against divine prohibitions, or involve actions that should only be the province of Gods and divine beings. This applies in particular to genetic technologies (e.g., genetic modification of crops, cloning, germ-line engineering), human enhancement technologies, geo-engineering and ecological restoration.

[30] This subsection is inspired by the list of ethical issues in the introduction of Sandler, R. (ed.), *Ethics and Emerging Technologies*, Palgrave-Macmillan, 2013.

3.3 Ethical concerns with impacts of technology

The impacts of technology that raise ethical concerns include so-called *hard impacts* (physical impacts on environment, health and safety) and *soft impacts* (impacts on social realities and ideals such as justice, equality, individual rights, identity, etc.). Environmental, health and safety impacts are often assessed together as so-called *EHS impacts*. When the impacts of a technology are uncertain, the language used to discuss these impacts is that of *technological risks*. Ethical concerns have been raised in relation to the following impacts:[31]

- *Environment:* these are ethical concerns regarding the question whether the environmental impacts of a technology can be justified.
- *Health:* these are ethical concerns with the impact of technologies on physical and mental health.
- *Safety:* these are ethical concerns about the safety of technologies and the potential damage they could do, e.g. injury and death, economic damage, social and political damage, damage to national security, etc.
- *Justice, access and equality:* these cover ethical concerns regarding the distribution of goods and risks for harm that result from the use of new technologies (justice issues), the question of whether everyone has adequate access to important new technologies (access issues, which are also a kind of justice issue) and whether or not technologies help increase or decrease equality and equal opportunity of human beings in society.
- *Individual rights and liberties:* these cover ethical concerns about whether and how the impacts of technologies may reduce or violate individual rights and liberties, such as the right to privacy, right to freedom of information, right to freedom of movement, property rights, etc.
- *Autonomy, authenticity and identity:* these cover ethical concerns regarding the impact of technology on free will, the ability to have one's own thoughts, to make one's own decisions, to be an authentic person, and to form and to develop one's own biographic and social identity. Some technologies that have been controversial in this regard include neurotechnologies, human enhancement technologies, reproductive technologies, and artificial intelligence.
- *Human dignity*: This covers ethical concerns regarding the impact of technologies on human dignity for instance, by human cloning, reengineering of humans, and human enhancement.
- *Bodily integrity*: This covers ethical concerns concerning technologies that infringe the inviolability of the physical body and take away self-determination of human beings over their own bodies.
- *Dual use:* This covers the possibility that a new technology or technological product can be used in ways other than its intended use, and that this alternative way of using it is morally controversial. Thus there is a "good" and an "evil" way of using the technology, hence the term "dual use". Dual use issues arise with regard to civilian technologies that can be used for military purposes, as well as benign technologies that can be used for harmful purposes such as terrorism, substance abuse, or other abuse. Dual use issues often occur in relation to chemical, biological and nuclear technologies.
- *Hubris:* This is a concern that for some technologies we overestimate our ability to predict their consequences as well as our ability to mitigate consequences that are

[31] The following list is inspired by the list of ethical issues in the introduction of Sandler, R. (ed.), *Ethics and Emerging Technologies*, Palgrave-Macmillan, 2013.

undesirable. This particularly applies to complex and dynamic technologies that have potential impacts on biological and ecological systems. These include geo-engineering to combat climate change, the release of genetically modified organisms, reproductive cloning, human enhancement, and others.

3.4 Ethical issues in specific fields of engineering and technology

There are many ethical issues associated with specific engineering branches and technologies developed within them. In addition, ethics of technology pays special attention to ethical issues of *emerging technologies*, which are new technologies that are expected to yield interesting new products and applications, some of which still have to be realised (e.g., nanotechnology, synthetic biology). What follows is a listing of ethical issues in some of the most important fields of engineering:

Chemical engineering

- Toxic by-products in the creation of chemicals
- Difficulty in establishing long-term effects of exposure of new chemicals
- Environmental issues: environmental impacts and safety
- Consumption of natural resources for chemicals

Civil engineering

- Safety of built structures
- Accessibility issues for different stakeholder groups (buildings, roads, bridges)
- Utility of built structures for different stakeholder groups
- Environmental issues
- Design of spaces for torture or incarceration considered inhumane
- Destruction of cultural heritage

Robotics

- Responsibility for actions by robots and artificial intelligence programs
- Well-being and safety issues
- Ethical issues concerning social robots and humanoid robots (such as the reduction of human contact)
- Ethical issues concerning unmanned aerial vehicles (drones) (such as the violation of privacy)
- Military applications of robotics
- Ethical issues involving technological singularity (such as the threat of harm to humans by an unethical artificial intelligence)

Environmental engineering

- General issues in environmental ethics (such as the level of responsibility for future generations)
- Ecological restoration
- Ethical issues with geo-engineering (such as those relating to hydraulic fracturing and drilling for exploration and production of water, oil, or gas)
- Ethical issues with climate engineering (such as the threat of unforeseen harmful side-effects)

Nuclear technology

- Development of nuclear weapons
- Risks of nuclear catastrophes
- Problems of waste disposal

Nanotechnology

- Health and environmental risks
- Ethical issues with nanomedicine
- Runaway self-replicating nanobots
- Just distribution of benefits and risks
- Military applications
- Privacy risks (molecular monitoring and tracking devices)

4 INSTITUTIONALISATION: EU AND INTERNATIONAL

At the EU and international level, ethics assessment in engineering is in some ways institutionalised, and in other ways, less so. The professional ethical codes for engineers are very much institutionalised. Almost every international engineering organisation has a professional ethical code, and many organisations also have working groups for professional ethics. The journals, publication series and conference series in ethics of technology are also institutionalised. Aside from this, the degree of international institutionalisation of ethics assessment in engineering is quite low.

This section first offers a discussion of EU and international legislation, standards, frameworks and protocols that concern ethical principles and issues. Next, it presents an overview of all major EU and international organisations and their role in ethics assessment. Finally, it discusses the level of institutionalisation in major EU and international journals, publication series and conference series.

4.1 EU AND INTERNATIONAL LEGISLATION, STANDARDS, FRAMEWORKS AND PROTOCOLS THAT CONCERN ETHICAL PRINCIPLES AND ISSUES

There appears to be little international legislation that specifically considers ethical issues in engineering. At the EU level, however, there are legislation, guidelines and standards concerning health, safety and environmental risks of engineering. Such legislation, guidelines and standards concern general management of health and safety at work[32], environmental liability,[33] industrial emissions,[34] resource use[35], and so forth. Besides EU-level legislation, guidelines and standards, there are also quite a few international codes of engineering ethics, offered by such organisations as the Federation of Engineering Organizations[36] and the International Federation of Consulting Engineers.[37]

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[32] A wide variety of EU directives setting out minimum health and safety requirements for the protection of workers have been adopted. The most important directive is Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work, *OJ L* 183, 29.6.1989. For an overview of individual directives focusing on specific aspects of safety and health at work that were adopted on the basis of the Framework Directive, see: https://osha.europa.eu/en/legislation.

[33] The European Parliament and the Council, Directive 2004/35/EC of 21 April 2004 on environmental liability with regard to the prevention and remedying of environmental damage, *OJ L* 143, 30.4.2004.

[34] The European Parliament and the Council, Directive 2010/75/EU of 24 November 2010 on industrial emissions (integrated pollution prevention and control), *OJ L* 334, 17.12.2010.

[35] Commission of the European Communities (2005), *Thematic Strategy on the sustainable use of natural resources.* http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52005DC0670

[36] World Federation of Engineering Organizations, "Code of Ethics". http://www.wfeo.net/wp-content/uploads/WFEO_MODEL_CODE_OF_ETHICS_Final.pdf

[37] International Federation of Consulting Engineers, "Code of Ethics". http://fidic.org/about-fidic/fidic-policies/fidic-code-ethics

There are certain recurring values and principles in ethics of engineering and technology. In section 2, we discussed some of the recurring principles in engineering ethics codes, most notably the obligation to promote the health, safety and welfare of the public. We also discussed recurring values and principles in ethics of technology. There are, however, few ethical codes in engineering or statements of ethics concerning technology that have global or even European recognition.

The closest to a global code of engineering ethics is the model code of ethics of the World Federation of Engineering Organizations.[38] This eight-page long code of ethics contains four basic principles, which are further elaborated in several dozen more specific principles. The four principles are: *demonstrate integrity*; *practice competently*; *exercise leadership*; and *protect the natural and built environment*. The document strongly emphasises the principles of sustainable development, and also emphasises the importance of enhancing the quality of life in society, in part through promoting health, safety and the quality of the environment.

Another influential code of ethics is the IEEE code of ethics of the Institute of Electrical and Electronics Engineers (IEEE) which has over 400.000 members and is the world's largest organisation of professional engineers. The IEEE code of ethics[39] states that members are to commit themselves to the highest ethical and professional conduct, and further states ten principles, such as (no. 1) "to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment", (no. 6) "to improve the understanding of technology; its appropriate application, and potential consequences", and (no. 8) "to treat fairly all persons and to not engage in acts of discrimination based on race, religion, gender, disability, age, national origin, sexual orientation, gender identity, or gender expression".[40]

Global statements on the ethics of technology originate from international ethics committees and academic organisations. UNESCO has set up an advisory body on the ethics of science and technology, the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST).[41] This organisation has been active since 1998, but its official reports so far have focussed on climate change, and its work on science and technology ethics has not led to official reports. No other international bodies with a similar focus on science and technology ethics seem to exist that have developed ethical positions about or frameworks for technology, although other international organisations do sometimes make ethical statements about technology. An example is Human Rights Watch, which has issued a report on the ethics of the use of fully autonomous weapons.[42]

At the European level, the European Group on Ethics in Science and New Technologies (EGE) is an advisory body of the European Commission that advises it on ethics in science and new technologies in connection with EU legislation and policies. Since 1993, the EGE has issued several dozen opinions; almost all of them, however, in the area of medical and life sciences and information technologies, both of which are beyond the scope of this report. The only one that clearly concerns engineering technologies (as defined in this report) is on

[38] World Federation of Engineering Organizations, op. cit.
[39] Institute of Electrical and Electronics Engineers, "IEEE Code of Ethics". http://www.ieee.org/about/corporate/governance/p7-8.html
[40] Ibid.
[41] World Commission on the Ethics of Scientific Knowledge and Technology. http://www.unesco.org/new/en/social-and-human-sciences/themes/comest/
[42] Human Rights Watch, "Mind the Gap: The Lack of Accountability for Killer Robots", 9 April 2015. http://www.hrw.org/reports/2015/04/09/mind-gap-0

energy.[43] This Opinion—*Opinion No 27: An ethical framework for assessing research, production and use of energy*—contains ethical criteria and a number of recommendations for research, production and use of energy.

In addition to these efforts, there are several international and European codes of ethics for specific fields of engineering. There have also been efforts for the ethical regulation of particular technologies, including nanotechnology and robotics. In 2008, the EU published a Code of conduct for responsible nanosciences and nanotechnologies.[44] There have been several other such efforts (see the report on nanotechnology). Furthermore, the *IEEE Robots and Automation Society* has instituted a Technical Committee on Robot Ethics, which is developing a framework for raising and addressing ethical questions concerning robotics research and technology.[45] In 2007, the *European Robotics Research Network* (EURON) published a Roadmap for Roboethics.[46]

4.2 MAJOR EU AND INTERNATIONAL ORGANISATIONS

This subsection discusses some major EU and international organisations engaged in ethics assessment (including standard setting) in engineering. It appears that there is no academic professional organisation specifically focused on *ethics of technology*, although there are several associations that include ethics of technology in their focus. There is no professional organisation or research centre for *engineering ethics*, although there are several working groups and sub-organisations for this within engineering organisations.

International organisations

- *World Federation of Engineering Organizations* (WFEO):[47] One of the tasks of this organisation is providing advice and guidance on policies, interests and concerns relating to engineering and technology. It offers an eight-page long code of ethics that can be considered the closest to a global code of ethics.
- *Institute of Electrical and Electronics Engineers* (IEEE):[48] The IEEE is an international association of engineers in the field of electrical and electronics engineering with over 400,000 members. It hosts the Ethics and Member Conduct Committee[49] and the Society on Social Implications of Technology[50]. The latter focuses on: environmental, economics, health, and safety implications of technology; engineering ethics and professional responsibility; engineering education in social implications of technology; history of electrotechnology; technical expertise and public policy; peace technology; and social issues related to energy, information technology and telecommunications.

[43] European Group on Ethics in Science and New Technologies, *Opinion No 27: An ethical framework for assessing research, production and use of energy*, 16 January 2013. https://setis.ec.europa.eu/system/files/opinion_no_27.pdf
[44] European Commission, *A code of conduct for responsible nanosciences and nanotechnologies research*, April 2009. http://ec.europa.eu/research/science-society/document_library/pdf_06/nanocode-apr09_en.pdf
[45] IEEE Robots and Automation Society, "Robot Ethics". http://www.ieee-ras.org/robot-ethics
[46] European Robotics Research Network, *Euron Roboethics Roadmap*, January 2007. http://www.roboethics.org/index_file/Roboethics%20Roadmap%20Rel.1.2.pdf
[47] World Federation of Engineering Organizations. http://www.wfeo.net
[48] Institute of Electrical and Electronics Engineers. http://www.ieee.org
[49] Member Conduct Committee. http://www.ieee.org/about/ethics.html
[50] Society on Social Implications of Technology. http://www.ieeessit.org

- *World Commission on the Ethics of Scientific Knowledge and Technology* (COMEST): Discussed in the previous subsection.
- *International Association of Engineers* (IAE):[51] The IAE is a professional organisation for engineers, which takes into consideration issues of professional ethics.
- *Society for Philosophy and Technology* (SPT):[52] The SPT is an independent international organisation that encourages, supports and facilitates philosophically significant considerations of technology.
- *Global Research Council* (GRC):[53] The GRC is an organisation comprising the heads of science and engineering funding agencies from around the world. It has a statement of principles of research integrity.[54]

European organisations

- *European Federation of National Engineering Associations* (FEANI):[55] FEANI is a federation of professional engineers that unites national engineering associations from 32 European countries. The organisation represents the interests of over 3.5 million professional engineers in Europe. It provides a code of ethics to its members.[56]
- *European Charter of Engineers Chambers* (ECEC):[57] The ECEC is the umbrella organisation of European Engineers Chambers. It represents the professional interest of Chartered Engineers at the European level. Currently, the ECEC represents 16 Chambers and over 300,000 European Chartered Engineers who are members in these Chambers. The ECEC has devised a Code of Conduct and a Code of Quality for its members.
- *European Group on Ethics in Science and New Technologies* (EGE):[58] The EGE is an independent, multidisciplinary body advising the European Commission on ethics in science and new technologies with regard to EU legislation or policies.

4.3 MAJOR EU AND INTERNATIONAL JOURNALS, PUBLICATION SERIES AND CONFERENCE SERIES

In engineering ethics, there is not a lot of EU and international institutionalisation as regards international journals, publication series and conference series. There is just one major international journal—*Science and Engineering Ethics*—that is devoted in large part to ethical issues in engineering. This is a multi-disciplinary journal that explores ethical issues that are of direct concern to scientists and engineers. There also exist a number of internationally published (text) books on engineering ethics. *Ethics in Engineering Practice and Research* by

[51] International Association of Engineers. http://www.iaeng.org/
[52] Society for Philosophy and Technology. http://www.spt.org/
[53] Global Research Council. http://www.globalresearchcouncil.org/
[54] Global Research Council, *Statement of Principles and Actions for Shaping the Future: Supporting the Next Generation of Researchers*, http://www.globalresearchcouncil.org/sites/default/files/pdfs/grc_statement_principles_research_integrity_FINAL.pdf.
[55] European Federation of National Engineering Associations. http://www.feani.org
[56] European Federation of National Engineering Associations, *FEANI Code of Ethics*. http://www.feani.org
[57] European Charter of Engineers Chambers. http://www.ecec.net/startseiteninhalte/european-chartered-engineers
[58] European Group on Ethics in Science and New Technologies. http://ec.europa.eu/bepa/european-group-ethics/welcome/index_en.htm

Caroline Withbeck has been an influential publication over the last few years.[59] Besides this (and international professional ethical codes), there is not much else. For example, there is no conference series in engineering ethics that has shown longevity.

The situation in ethics of technology is somewhat better than it is in engineering ethics. There are several international journals and book series in ethics of technology, and there are several conference series that focus in part on ethics of technology—although there is no conference series that focuses exclusively on ethics of technology. For a listing of the major journals, publications, and conference series, see subsection 7.1 of this report. Furthermore, there are also various international journals, book series and conference series on research ethics, but none seem specifically focused on engineering research.

5 INSTITUTIONALISATION: NATIONAL

Within EU countries, there is some national legislation that specifically considers ethical issues in engineering. There are national legislation and standards concerning the health, safety and environmental risks of engineering. Many of these are based on EU legislation and guidelines. Furthermore, many national organisations for engineering professionals have formulated their own codes of engineering ethics. These codes are similar to those offered by international organisations.

Within European national ethics committees, there is little attention paid to ethics assessment in engineering. Ethics assessment in these organisations mostly covers the medical sciences, and sometimes the social sciences (in particular psychology). Often, their focus on the medical sciences is clearly apparent in their name, through use of the term bioethics. Any attention to engineering is often in the context of bioethical issues. The French national ethics committee, for example, evaluates certain medical devices.[60] Furthermore, the German national ethics council has issued an opinion on so-called “life boxes” or “baby hatches” (Babyklappe), where people can bring babies, usually newborn, and leave them anonymously in a safe place where they can be found and cared for.[61]

Besides European national ethics committees, European research ethics committees also seem mostly focused on ethics assessment in the medical sciences and (to a lesser degree) the social sciences. There seem to be only few research ethics committees with a focus on engineering. The fact that ethics assessment is more rooted in the medical sciences is likely due to the perceived importance of ethical issues in this field where human subjects’ research is prevalent.[62]

Most national research funding organisations in Europe rely on external ethics committees for ethical assessment of research proposals. By and large, ethical clearance of research proposals is compulsory only for animal and human subjects’ research.

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[59] Interview with Tom Børsen, PhD, Associate professor at the Department of Education, Learning and Philosophy of Aalborg University, 3 February 2015.

[60] Interview with Elisabeth Frija-Orvoën, President of the National Conference for the Committees for the Protection of Persons (Conférence Nationale des Comités de Protection des Personnes or CNCP), 5 January 2015.

[61] Interview with Dr. rer. nat. Joachim Vetter, Head of Office, German Ethics Council, 3 December 2014.

[62] Interview with Tom Børsen, op. cit.

In Europe, there are a number of national organisations for *technology assessment* (*TA*). The *European Parliamentary Technology Assessment* (*EPTA*)[63] is a network of TA institutions specialising in advising parliamentary bodies in Europe. Its full members are in Germany,[64] France,[65] the United Kingdom,[66] Spain,[67] the Netherlands,[68] Austria,[69] Denmark,[70] Sweden,[71] Finland,[72] Norway,[73] and Greece.[74] With the exception of a Polish associate member,[75] there are no Eastern European members. The assessments performed by these TA institutions often cover ethical questions surrounding new technologies. Generally, they do not have a special focus on medical technology. In the U.S., a national organisation for technology assessment is notably absent; the U.S. Office of Technology Assessment was abolished in 1995.

There are no national academic journals, book series or conference series on ethics assessment in engineering. However, some attention is paid to engineering ethics in the curricula of engineering programs at universities and colleges, although this is the exception rather than the rule. There are quite a few (internationally published) introductory textbooks in engineering ethics that discuss engineering ethics topics and cases.[76] There also exist some master and PhD programs that focus on *ethics of technology*, but there are no master and PhD programs specifically devoted to *engineering ethics*. There are, however, research centres, such as the Dutch 3TU.Centre for Ethics and Technology, which has a PhD program that focuses partially on engineering ethics.

6 EVALUATION

Comparing the levels of development of ethics assessment of research and innovation across the five scientific fields—the humanities, the medical sciences, the social sciences, the natural sciences, and engineering—one finds that engineering ranks second, behind the medical sciences, in terms of volume of research on ethical issues, and the degree of institutionalisation of ethics assessment. The fact that ethics assessment is more rooted in the medical sciences is due to the perceived importance of ethical issues in this field in which human subject research prevalent.[77]

Most (academic) research on ethical issues in engineering occurs within the discipline of *ethics of technology*. This tradition has witnessed a sharp increase in the number of publications in the past decades, which is correlated to a social need to remove collective

[63] European Parliamentary Technology Assessment. http://www.eptanetwork.org
[64] Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (Office of Technology Assessment at the German Parliament). http://www.tab-beim-bundestag.de/en/
[65] Office Parlementaire d'Evaluation des Choix Scientifiques et Technologiques (Parliamentary Office for Evaluation of Scientific and Technological Options). http://www.senat.fr/opecst/english.html
[66] Parliamentary Office of Science and Technology. http://www.parliament.uk/post
[67] Consell Assessor del Parlament sobre Ciència i Tecnologia (Advisory Board of the Parliament of Catalonia for Science and Technology). http://www.parlament.cat/web/composicio/capcit
[68] Rathenau Instituut (Rathenau Institute). http://www.rathenau.nl/en/
[69] Institut für Technikfolgen-Abschätzung (Institute of Technology Assessment). http://www.oeaw.ac.at/ita/en
[70] Teknologirådet (Danish Board of Technology Foundation). http://www.tekno.dk/
[71] Utvärderings- och forskningsfunktionen (Parliamentary Evaluation and Research Unit). http://www.riksdagen.se/
[72] Tulevaisuusvaliokunta (Committee for the Future). https://www.eduskunta.fi/en/Pages/default.aspx
[73] Teknologirådet (Norwegian Board of Technology). http://www.teknologiradet.no/
[74] Committee on Technology Assessment of the Greek Parliament. http://www.parliament.gr/
[75] Biuro Analiz Sejmowych, Kancelaria Sejmu (Bureau of Research at the Polish Parliament). http://www.bas.sejm.gov.pl/
[76] A number of these are listed in subsection 7.1.
[77] Interview with Tom Børsen, op. cit.

uncertainty in dealing with the consequences of technology and create orientation criteria for technological development. There now exist several specialised fields of technology ethics, which notably include *computer and information ethics*, *nanoethics*, and *roboethics*. The range of issues considered in engineering is quite broad: there are ethical issues in engineering research and design, issues intrinsic to technological innovations, general issues with impacts of technology; and issues in specific fields of engineering and technology. Some issues, such as issues with unmanned aerial vehicles (drones) and energy production and consumption technologies (such as the risks concerning "fracking", nuclear power, and CO_2 emissions), are relatively high on the political and societal agendas of many countries.

Ethics assessment in engineering is in some ways institutionalised, and in other ways much less so. It is definitely less institutionalised than ethics assessment in the medical sciences, but more institutionalised than the other scientific fields. Very much institutionalised are professional ethical codes for engineers. Almost every international engineering organisation has a professional ethical code, and many of the organisations also have working groups for professional ethics. Many national engineering organisations in the EU have ethical codes as well. Also institutionalised are international journals, publication series and conference series in ethics of technology. Furthermore, there are European and national legislation, guidelines and standards concerning health, safety and environmental risks of engineering. Finally, there exist a number of EU national organisations for technology assessment. Research performed by these organisations often covers ethical questions surrounding new technologies.

Aside from the above, there is little institutionalisation. Notably, there is not much attention for ethics assessment in engineering in (national) research ethics committees. Ethics assessment in these organisations mostly covers the medical sciences, and sometimes the social sciences (in particular psychology). If there is attention for engineering, then this often seems to be in the context of bioethical issues.

There are a number of gaps in ethics assessment of engineering that need to be addressed. For these gaps, a number of recommendations have been made. First, it is argued that there should be more initiatives for research on engineering ethics, as research efforts in this tradition have been few;[78] engineering ethics has only recently started to take off as a research discipline. Second, it is argued that the engineering community should do more to address ethical issues and integrate ethical thinking in engineering programs of educational institutions and in engineering firms.[79] Incorporation of compulsory courses on ethics in engineering curricula is still the exception, rather than the rule.[80] Third, it is argued that traditional engineering ethics instruction focuses on *microethical* problems—dilemmas confronting individual engineers—to the neglect of *macroethical* issues with respect to the nature and development of technology.[81] In order to create a more responsible engineering practice, the scope of engineering ethics could be widened to include these macroethical issues that concern society as a whole, which are usually only studied in the ethics of technology.

[78] Brumsen, Michiel, & Sabine Roeser, "Research in Ethics and Engineering", *Techné: Research in Philosophy and Technology*, Vol. 11, No. 1, Fall 2007. http://scholar.lib.vt.edu/ejournals/SPT/v8n1/brumsen.html
[79] Interview with Tom Børsen, op. cit.
[80] Zandvoort, H., I. Van de Poel, & M. Brumsen, "Ethics in the engineering curricula: Topics, trends and challenges for the future", *European Journal of Engineering Education*, Vol. 25, Iss. 4, 2000, p. 297. http://www.tandfonline.com/doi/abs/10.1080/03043790050200331
[81] Ibid., p. 296.

7 ANNEXES

7.1 KEY PUBLICATIONS, JOURNALS AND CONFERENCE SERIES

The following are lists of key publications, journals and book series, and conference series on ethics assessment in engineering.

7.1.1 KEY PUBLICATIONS

Engineering ethics: General

- Baura, G., *Engineering ethics: an industrial perspective*, Elsevier, Amsterdam, 2006.
- Bowen, W. R., *Engineering Ethics: Challenges and Opportunities*, Springer, 2014.
- Fledderman, C., *Engineering Ethics*, 4th ed. Prentice-Hall, 2011.
- Harris, C., "Internationalizing professional codes in engineering", *Science and Engineering Ethics,* Vol. 10, No. 3, 2004, pp. 503-521.
- Harris, Charles E., et al., *Engineering Ethics: Concepts and Case*s, 5th ed. Cengage Learning, 2013.
- Martin, M., and R. Schinzinger, *Ethics in Engineering*, 4th edition, McGraw-Hill, New York, 2004.
- Martin, M., and R. Schinzinger, *Introduction to Engineering Ethics,* McGraw-Hill, 2009.
- Van de Poel, Ibo, and Lamber Royakkers, *Ethics, Technology and Engineering: An Introduction*, Wiley-Blackwell, 2011.
- Weil, V., "The rise of engineering ethics", *Technology in Society*, 6 (4), 1984, pp. 341-345.
- Whitbeck, C., *Ethics in Engineering Practice and Research*, 2nd ed. Cambridge University Press, 2011.

Technology ethics: General

- Brey, P., "Philosophy of Technology after the Empirical Turn", *Techné: Research in Philosophy and Technology*, 14, 1, 2010, pp. 36-48 (section on engineering and technology ethics)
- Brey, P., "Values in Technology and Disclosive Computer Ethics", in L. Floridi (ed.), *The Cambridge Handbook of Information and Computer Ethics*, Cambridge University Press, Cambridge, 2010.
- Brey, P., "Anticipatory Ethics for Emerging Technologies", *Nanoethics*, Vol. 6, Iss. 1, 2012, pp. 1-13.
- Budinger, T., and M. Budinger, *Ethics of Emerging Technologies: Scientific Facts and Moral Challenges,* Wiley, 2006.
- Chadwick, R. (ed.), *The Concise Encyclopedia of the Ethics of New Technologies*, Elsevier Science, 2000.
- Jonas, H., *The imperative of responsibility: in search of an ethics for the technological age*, University of Chicago Press, Chicago/London, 1984.

- Meijers, A., (ed.), *Philosophy of technology and engineering sciences* (*Handbook of the philosophy of science, volume 9)*, Amsterdam: North-Holland, parts V and VI, 2009.
- Olsen, J., S. Pedersen, and V. Hendricks (eds.), *A Companion to the Philosophy of Technology*, Blackwell, 2009, part IV – VII.
- Sandler, R. (ed.), *Ethics and Emerging Technologies,* Palgrave MacMillan, 2014.
- Swierstra, T., and A. Rip, "Nano-ethics as NEST-ethics: Patterns of Moral Argumentation about New and Emerging Science and Technology", *Nanoethics* 1(1) 2007, pp. 3-20.
- Van de Poel, Ibo, and Lamber Royakkers, *Ethics, Technology and Engineering: An Introduction*, Wiley-Blackwell, 2011.

Special Fields of Engineering and Technology

Civil Engineering

- American Society of Civil Engineers Code of Ethics. http://www.asce.org/leadership-and-management/ethics/code-of-ethics/
- Institution of Civil Engineers (UK) Code of Ethics. http://www.ice.org.uk/About-ICE/What-we-do/Professional-conduct
- Japan Society of Civil Engineers Code of Ethics. http://www.jsce-int.org/about/p_engineer
- Hansen, K. and K. Zenobia, *Civil Engineer's Handbook of Professional Practice,* Wiley, 2011.
- Mirsky, R. and J. Schaufelberger, *Professional Ethics for the Construction Industry,* Routledge, 2014.

Mechanical Engineering

- Institution of Mechanical Engineers Code of Ethics. http://www.imeche.org/about-us/governance/ethics

Electrical Engineering

- IEEE Code of Ethics. http://www.sfjohnson.com/acad/ethics/FourCodesOfEthics.pdf

Chemical Engineering

- American Institute of Chemical Engineers (AIChE) Code of Ethics. http://www.aiche.org/about/code-ethics

Nanotechnology and Nanoengineering

See the report on nanotechnology and emerging technologies.

Environmental Technology and Engineering

- Russ, T., *Sustainability and Design Ethics,* CRC Press, 2010.

- Vesilind, P. A., and A. Gunn, *Engineering, Ethics and the Environment.* Cambridge University Press, 1998.
- *WFEO Code of Environmental Ethics for Engineers*. http://www.tek.fi/tekniikanetiikka/saanto/saanto8.htm

Energy Technology and Engineering

- Sovacool, B. (2013). *Energy & Ethics: Justice and the Global Energy Challenge*. Palgrave MacMillan.
- Sovacool, B., Sidortsov, R. and Jones, B. (2014). *Energy Security, Equality and Justice*. Routledge.

Robotics

- Anderson, M. and Anderson, S. (eds.) (2011). *Machine Ethics*. Cambridge University Press.
- Lin, P, Abney, K. and Bekey, G. (eds.) (2011). *Robot Ethics: The Ethical and Social Implications of Robotics*. MIT Press.
- Wallach, W. and Allen, C. (2010). *Moral Machines: Teaching Robots Right from Wrong*. Oxford University Press.

7.1.2 JOURNALS AND BOOK SERIES

Journals

- Bulletin of Science, Technology & Society. http://bst.sagepub.com/
- Engineering Studies. http://www.tandfonline.com/loi/test20#.U0ZiY6ITcgg
- IEEE Technology and Society Magazine. http://www.ieeessit.org/technology_and_society/
- International Journal of Technology, Policy & Management. http://www.inderscience.com/jhome.php?jcode=ijtpm
- Journal of Professional Issues in Engineering Education & Practice. http://ascelibrary.org/journal/jpepe3
- Knowledge, Technology and Policy. http://link.springer.com/journal/12130
- Nanoethics. http://www.springer.com/social+sciences/applied+ethics/journal/11569
- Poiesis & Praxis, International Journal of Ethics of Science and Technology Assessment. http://www.springer.com/social+sciences/applied+ethics/journal/10202
- Science and Engineering Ethics. http://www.springer.com/social+sciences/applied+ethics/journal/11948
- Science, Technology & Human Values. http://sth.sagepub.com/
- Studies in Ethics, Law, and Technology. http://www.degruyter.com/view/j/selt

Book Series

- Indiana Series in the Philosophy of Technology, Indiana University Press. http://www.iupress.indiana.edu/index.php?cPath=1037_3130_3164
- The International Library of Ethics, Law and Technology, Springer. http://www.springer.com/series/7761

- Emerging Technologies, Ethics and International Affairs, Ashgate. http://www.ashgate.com/default.aspx?page=5097&series_id=645&calcTitle=1
- Engineering Studies, MIT Press. https://mitpress.mit.edu/books/series/engineering-studies
- Philosophy of Engineering and Technology, Springer. http://www.springer.com/series/8657
- Philosophy, Technology and Society, Rowman & Littlefield. http://www.rowmaninternational.com/series/philosophy-technology-and-society

7.1.3 CONFERENCE SERIES

- American Society for Engineering Education Annual Conference. https://www.asee.org/conferences-and-events/conferences/annual-conference/2014
    - Pays some attention to engineering ethics education
- Association for Practical and Professional Ethics (APPE). http://appe.indiana.edu/
    - Has a technology and engineering ethics stream
- Conferences of the Society for the Study of Nanoscience and Emerging Technologies (S.NET). http://www.thesnet.net/
    - Pays attention to ethical issues
- Computer Ethics Philosophical Enquiry (CEPE). http://inseit.net/
- Sometimes covers areas in ethics of technology outside the area of computer and information ethics
- Engineering Philosophy & Ethics in Society. http://www.kurzweilai.net/engineering-philosophy-ethics-in-society-2014
- Forum for Philosophy, Engineering and Technology (fPET). http://philengtech.org/
- IEEE International Symposium on Ethics in Engineering, Science, and Technology. http://sites.ieee.org/ethics-conference/
- International Conference on Applied Ethics. http://ethics.let.hokudai.ac.jp/en/events.html
    - Often considers issues in technology and engineering ethics
- International Conference on Ethics and Human Values in Engineering. http://www.icehve.com/en/human_values.php
- International Conference on Engineering Professional Ethics and Education. http://www.iium.edu.my/icepee/2013/
- Society for Philosophy and Technology Conference Series. http://www.spt.org/
    - Has a large number of presentations on technology ethics

7.2 LIST OF ORGANISATIONS

The following is a list of major international, European and national organisations that engage in ethics assessment of engineering.

7.2.1 INTERNATIONAL ORGANISATIONS

- World Federation of Engineering Organizations. http://www.wfeo.net/
    - *WFEO serves society and is recognised as a respectable and valuable source of advice and guidance on the policies, interests and concerns that relate to engineering and technology.*
- Institute of Electrical and Electronics Engineers (IEEE)
    - *IEEE is an international association with 400,000 members. It contains an Ethics and Member Conduct Committee (http://www.ieee.org/about/ethics.html) and a Society on Social*

Implications of Technology (SSIT) (http://www.ieeessit.org/), which focuses on environmental, economics, health, and safety implications of technology; engineering ethics and professional responsibility; engineering education in social implications of technology; history of electrotechnology; technical expertise and public policy; peace technology; as well as on social issues related to energy, information technology and telecommunications.

- World Commission on the Ethics of Scientific Knowledge and Technology (COMEST). http://www.unesco.org/new/en/social-and-human-sciences/themes/global-environmental-change/comest/
    - *The World Commission on the Ethics of Scientific Knowledge and Technology COMEST* is an advisory body and forum of reflection that was set up by UNESCO in 1998.*
- International Association of Engineers. http://www.iaeng.org/
    - *A professional organisation for engineers that also considers issues of professional ethics*
- International Federation of Consulting Engineers (FIDIC). http://fidic.org/
    - *A professional organisation for consulting engineers that also considers issues of professional ethics*
- International Council on Systems Engineering (INCOSE). http://www.incose.org/about/ethics.aspx
- International Association for Continuing Engineering Education. http://www.iacee.org/
- International Technology and Engineering Educators Organization. http://www.iteaconnect.org/
- International Network for Engineering Studies. http://www.inesweb.org/
- Society for Philosophy and Technology. http://www.spt.org/
- Global Research Council. http://www.globalresearchcouncil.org/
    - *An organisation comprised of the heads of science and engineering funding agencies from around the world. It has a statement of principles of research integrity at http://www.globalresearchcouncil.org/statement-principles-research-integrity*
- OECD. http://www.oecd.org/
    - *The OECD has issued a report on scientific integrity. http://www.oecd.org/science/sci-tech/40188303.pdf*
- World Conferences on Research Integrity; they have issued the Singapore Statement on Research Integrity. http://www.singaporestatement.org/statement.html
- InterAcademy Council (IAC). http://www.interacademycouncil.net
    - *An international organisation of science academies. Has published, together with IAP, an international report on research integrity. http://www.interacademycouncil.net/24026/28250.aspx*
- IAP – the global network of science academies. http://www.interacademies.net/

7.2.2 EUROPEAN ORGANISATIONS

- European Federation of National Engineering Associations (FEANI). http://www.feani.org
- European Federation of Engineering Consultancy Organizations. http://www.efcanet.org/
- European Council of Engineers Chambers (ECEC). http://www.ecec.net
    - *The ECEC is the umbrella organisation of European Engineers Chambers.*
- European Chartered Engineers. http://www.ecec.net/startseiteninhalte/european-chartered-engineers/
    - *Chartered Engineers in ECEC countries are legally authorised academic Engineers who are obliged to professional legislation and the ethical and professional principles of the ECEC Code of Conduct and the ECEC Code of Quality*
- European Engineering Industries Organization (Orgalime). http://www.orgalime.org/

    - Represents the interests of mechanical, electrical &electronic, metalworking and metal articles industries.
- European Association of Research and Technology Organizations (EARTO). http://www.earto.org/
- European Council of Civil Engineers. http://www.ecceengineers.eu/
- The Association of European Civil Engineering Faculties. http://kps.fsv.cvut.cz/aecef/
- European Higher Engineering and Technical Professionals Association (EurEta). http://www.eureta.org/
- European Society for Engineering Education (SEFI). http://www.sefi.be/
    - Has a working group on Ethics in Engineering Education.
- Convention of National Associations of Electrical Engineers of Europe (EUREL). http://www.eurel.org/
- European Group on Ethics in Science and New Technologies. http://ec.europa.eu/bepa/european-group-ethics/welcome/index_en.htm
    - *The EGE is an independent, pluralist and multidisciplinary body advising the European Commission on ethics in science and new technologies in connection with Community legislation or policies.*
- The Scientific Committee for Engineering Sciences of Science Europe. http://www.scienceeurope.org/scientific-committees/Engineering/engineering-sciences-committe
    - *The Scientific Committee for Engineering Sciences advises Science Europe members on subjects related to engineering sciences. Science Europe is an association of European Research Funding Organisations and Research Performing Organisations based in Brussels.*
- Europäische Akademie zur Erforschung von Folgen wissenschaftlich-technischer Entwicklungen GmbH. http://www.ea-aw.org
    - *The Europäische Akademie carries out research on the consequences of scientific and technological advances for individuals, society and the natural environment*
- Institute for Prospective Technology Studies. http://ipts.jrc.ec.europa.eu/
    - *IPTS is one of the seven scientific institutes of the European Commission's Joint Research Centre (JRC). It promotes and enables a better understanding of the links between technology, economy and society.*
- Science and Technology Options Assessment. http://www.europarl.europa.eu/stoa/
    - *The Assessment of Scientific and Technological Policy Options for the European Parliament*

7.2.3 National organisations in Europe

(This is only a selective and indicative listing.)

- The National Committee for Research Ethics in Science and Technology (NENT). https://www.etikkom.no/en/In-English/Committee-for-Research-Ethics-in-Science-and-Technology/
    - A Norwegian national ethics committee.
- Council for Science and Technology. https://www.gov.uk/government/organisations/council-for-science-and-technology
    - *The Council for Science and Technology (CST) advises the UK Prime Minister on science and technology policy issues which cut across the responsibilities of government departments.*
- Institute of Science and Ethics (IWE). http://www.iwe.uni-bonn.de/
    - *The German IWE has set itself the objective to carry out research in the field of Ethics of Biomedicine and Science and their applications.*
- Deutscher Ethikrat (German Ethics Council). http://www.ethikrat.org

  - *The German Ethics Council is composed of twenty-six members specializing in scientific, medical, theological, ethical, social, economic, and legal concerns and is independent from governmental bodies*
- Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag (Office of Technology Assessment at the German Bundestag). http://www.tab-beim-bundestag.de
  - *The Office of Technology Assessment at the German Bundestag is an independent scientific Institution created with the objective of advising the German Bundestag and its committees on matters relating to research and technology.*
- Fraunhofer Institut für System und Innovationsforschung (ISI). http://isi.fraunhofer.de/
  - *ISI investigates the scientific, economic, ecological, social, organisational, legal and political framework conditions for generating innovations and their implications.*
- Institut für Technikfolgenabschätzung und Systemanalyse (Institute for Technology Assessment and Systems Analysis, ITAS). http://www.itas.fzk.de
  - *ITAS creates and communicates knowledge on the impacts of human action and their evaluation in view of the development and use of new technologies. Its work focuses on environmental, economic, social and political institutional issues. Alternative options for action and design are developed and assessed. In this way ITAS supports politics, science, business and the general public in future decision-making.*
- Institut für Wissenschafts und Technikforschung an der Universität Bielefeld (Institute of Science and Technology Studies). http://www.uni-bielefeld.de/
  - *IWT is concerned with investigating the institutional and epistemic forms of science and technology, their patterns of change, and the accompanying ethical challenges and social consequences.*
- Institut für Zukunftsstudien und Technologiebewertung (IZT) (The Institute for Futures Studies and Technology Assessment). http://www.izt.de/
  - *The main tasks of IZT are the realisation of research projects, delivering expert opinions, and advising political and industrial decision makers. IZT develops strategies and 'tools' in relation to future technologies as well as ecological and social structural changes in the economy and society*
- National Ethics Advisory Committee (Comité consultatif national d'éthique CCNE). http://www.ccne-ethique.fr/réseau
  - *Main ethics committee in France. Focus on relaying information to the general public.*
- Ethics committee of CNRS (Comité d'éthique du CNRS, COMETS). http://www.cnrs.fr/fr/organisme/ethique/comets/index.htm
  - *Ethics committee in France of main research organisation, CNRS.*
- Ethics committee of IRD (Comité d'éthique de l'IRD). http://www.ird.fr/l-ird/organigramme/instances-et-comites/le-comite-consultatif-de-deontologie-et-d-ethique
  - *Ethics committee in France of main development research organisation (Institut de recherche sur le développement).*
- Office parlementaire d'évaluation des choix scientifiques et technologiques (OPECST, Parliamentary office for the evaluation of scientific and technological choices). http://www.senat.fr/opecst/
  - *The French parliamentary technology assessment body composed of members of parliament.*
- 3TU Centre for Ethics and Technology. http://www.ethicsandtechnology.eu/
- Rathenau Institute. http://www.rathenau.nl
  - *The Rathenau Instituut studies developments in science and technology, interprets their potential impact on society and policy, and fosters dialogue and debate in support of decision-making on science and technology.*
- Koninklijk Instituut Van Ingenieurs. https://www.kivi.nl/CM/PAG000002086/Koninklijk-Instituut-Van-Ingenieurs.html
  - Dutch Royal Institute for Engineers
- Engineering Council. http://www.engc.org.uk/

  - *As the UK regulatory body for the engineering profession, the Engineering Council sets and maintains internationally recognised standards of professional competence and ethics.*
- The Institution of Engineering and Technology. http://www.theiet.org
  - *Professional engineering organisation in the UK*
- Royal Academy of Engineering. http://www.raeng.org.uk/societygov/
  - *The U.K. Academy organises a number of events, activities and reports on ethical issues in engineering, and has developed a 'statement of ethical principles' for engineers. It also produces guidance and holds workshops for academics teaching engineering ethics.*

7.2.4 National organisations outside Europe

(This is only a selective and indicative listing.)

- Center for Engineering, Ethics, and Society (CEES) of the National Academy of Engineering (U.S.) http://www.nae.edu/Projects/CEES.aspx
  - *The Center for Engineering, Ethics, and Society (CEES) in the U.S. focuses the talents of the nation on addressing the ethical and social dimensions of engineering, as both a profession and an agent of innovation. It has an online ethics centre: http://www.onlineethics.org/*
- American Council of Engineering Companies (ACEC). http://www.acec.org/about/ethics.cfm
- National Society of Professional Engineers. http://www.nspe.org/resources/ethics
  - *NSPE in the U.S. considers itself the profession's most respected voice on the practice of ethical engineering. It has a board of ethical review.*
- Canadian Council of Professional Engineers (CCPE). http://www.ccpe.ca
  - *CCPE is the national organisation of the 12 provincial and territorial associations/orders that regulate the practice of engineering in Canada and license the country's more than 160,000 professional engineers.*
- Professional Engineers Ontario. http://www.peo.on.ca
  - *PEO's mandate, as described in the Professional Engineers Act, is to ensure that the public is protected and that individuals and companies providing engineering services uphold a strict code of professional ethics and conduct.*
- Commission de l'éthique en science et en technologie (CEST). http://www.ethique.gouv.qc.ca/fr/commission/mandat.html
  - *The primary mission of the Commission on the Ethics of Science and Technology Advisors (CSTA) of Quebec, Canada, is to establish an open, pluralistic and permanent reflection on the ethical issues associated with scientific and technological activity.*
- Engineers Australia. https://www.engineersaustralia.org.au/professional-development/chartered-status
  - *Assesses whether engineers practice in a competent, independent and ethical manner.*
- Asia Pacific Economic Cooperation (APEC Engineer). http://www.washingtonaccord.org/apec/
  - *Assesses whether countries have in place systems which allow the competence of engineers to be assessed to the agreed international standard set by the APEC Engineer agreement.*
- Institution of Professional Engineers New Zealand (IPENZ). http://www.ipenz.org.nz/IPENZ/
  - *The Institution of Professional Engineers New Zealand (IPENZ) represents engineers from all disciplines, aiming to promote and advance the profession and serve the wider community.*
- Engineers Australia. https://www.engineersaustralia.org.au/
  - *Disciplinary processes enable it to take action against members who breach its code of ethics.*