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D6.1: Generalised methodology for ethical assessment of emerging technologies

[WP6 – Generalizing project methods and exploitation measures]

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Due date	26 February, 2021
Delivery date	26 February, 2021
Embargo	Embargoed for publication until 1 September 2021
Type	Report
Dissemination level	PU = Public

Keywords	Ethical assessment, impact assessment, emerging technologies, generalised methodology

The SIENNA project - *Stakeholder-informed ethics for new technologies with high socio-economic and human rights impact* - has received funding under the European Union's H2020 research and innovation programme under grant agreement No 741716.

Abstract

This report provides a unique, comprehensive and carefully tested methodology for the ethical analysis of emerging technologies, a methodology that is motivated by our earlier studies in the SIENNA project. Our methodology contains seven key steps, the first four of which are directed at defining subject of analysis, aim and scope, and engaging in conceptual analysis and description, and the final three of which specify the actual ethical analysis, with both descriptive and normative components. We provide a detailed account of each of these seven steps and illustrate the application of our methodology to different emerging technologies. Our methodology makes use of methods of foresight analysis and social and environmental impact assessment (SIA), and of stakeholder engagement, and methods for these processes are described in additional sections of the report. We conclude the report by situating our approach within the broader landscape of approaches for technology assessment and impact assessment.

Document history

Version	Date	Description	Reason for change	Distribution
V1.0	08 Feb 2021	Review version		
V2.0	28 Feb 2021	Final version		
V2.1	16 Jul 2021	Amended version	Minor revisions	

Information in this report that may influence other SIENNA tasks

Linked task	Points of relevance
T6.2: Adapt and exploit methods developed in this project for legal analysis of emerging technologies in other domains.	The further development of methods for ethical analysis in this task may influence the methods for legal analysis.
T6.3: Adapt methods for translating ethical analysis into ethical codes and operational guidelines.	The further development of methods for ethical analysis in this task may influence the development of ethics by design approaches and guidelines.

Table of contents

Executive summary

This report intends to provide a comprehensive methodology for the ethical analysis of emerging technologies. Such a methodology is needed because emerging technologies often raise major ethical issues: they may challenge privacy, civil liberties, equality, well-being and democratic politics, and other things of value. Early ethical analysis may identify such challenges, as well as opportunities, and help guide the development and deployment of new technology in more desirable directions. Few methodologies currently exist for their analysis, and the ones that do exist lack detail and confirmation from their application in concrete cases. In this report, we present a methodology that builds on previous academic work, particularly the Anticipatory Technology Ethics approach of Brey (2012a, b), on results of earlier EU projects, especially the ethical impact assessment approach of the SATORI project (CEN, 2017),[1] and on extensive testing and calibration of a candidate methodology in the SIENNA project, through large ethical studies of three areas of technology: artificial intelligence and robotics, human enhancement, and human genomics. Our methodology has uniform features, yet is also flexible to account for special characteristics of different technologies.

The introductory *section 1* of this report describes its background, objectives, scope and limitations, introduces key terminology, and previews the remaining sections.

Section 2 gives an overview of our proposed **methodology for ethical analysis**. ("Ethical analysis" and other terms are defined below). It presents a seven-step approach and briefly describes each of the steps. The first four steps of the approach are conceptual and descriptive, and directed at (1) determination of subject, aim and scope of the analysis, (2) stratification of the subject of analysis, (3) description of the subject of analysis, and (4) identification of impacts and stakeholders. In the last three steps, the actual ethical analysis take place. These include (5) identification and specification of potential ethical issues, (6) analysis of ethical issues, and (7) evaluation and recommendations for ethical decision-making.

Section 3 gives a detailed account of the first four steps of the methodology, which focus on **conceptual analysis and description**. For step 1, we describe steps to take in determining the subject, aim and scope of the ethical analysis. We describe the variety of subjects of analysis, such as technology fields, technological products, deployments of technology in a domain, and impacts of technology, as well as a variety of aims for ethical analysis, and relevant parameters for determining the scope. In step 2, we argue that many ethical analyses include multiple levels of description, and explain how the relevant levels can be distinguished prior to further analysis. The key levels that we distinguish are the *technology level*, which specifies the technology in general, its subfields, and its basic techniques and approaches, the *product level,* which is defined over artefacts and processes that are being developed for practical application, and the *application level*, which defines particular uses of products, in particular contexts and domains, by particular users. In our account of step 3, we then state how a thorough, empirically informed description of the subject of analysis can take place. This will usually be an area of technology, which is then described in great detail, including possible future developments in the field. Finally, we describe how step 4 should be carried out, in which key stakeholders of the technology are identified, and likely and actual social, environmental and economic impacts associated with the technology are assessed, to the extent that these are relevant to the

[1] SATORI CEN Workshop Agreement, "Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework", CWA 17145-2, June 2017. http://satoriproject.eu/publication_type/standards/

ethical analysis. For this step, we describe a comprehensive approach to social and economic impact assessment (SEIA).

Section 4 provides a detailed account of step 5 to 7 of the methodology. These are steps in which the actual **ethical analysis** takes place. In our account of step 5, we describe methods for identifying and specifying ethical issues associated with the subject of analysis. These consist of analysis of the ethics literature, checklist approaches, bibliometrics, expert consultation, ethically informed foresight analysis, and several others. We also describe what it means to have identified a (potential) ethical issue. In our account of step 6, we describe methods of ethical analysis, drawing from familiar approaches to ethical analysis in applied ethics. In our account of step 7, finally, we distinguish different forms of moral evaluation and ethical guidance, aimed at making moral decisions and solving moral dilemmas, and we distinguish different methods for attaining them, and the possible involvement of stakeholders in these processes.

While sections 2, 3 and 4 contain the core of our methodology, further elaboration is needed, since these sections reference foresight analysis and stakeholder engagement without going into detail on methods and procedures to be used for them. In *section 5*, therefore, a more detailed account is given of methods for **foresight analysis**, and their application to our approach for ethical analysis. This section describes the foresight methods of environmental scanning (recommended for step 1 and 2 of the methodology), relevance tree (for step 2, 4 and 5), roadmapping (for step 3, 4 and 5), multiple perspectives (for step 3) and future visions (for step 5).

In *section 6*, we provide a detailed account of the **inclusion of stakeholders**. We discuss in which steps of the methodology which stakeholders may be included, and in which ways they can be included. We pay special attention to inclusion of viewpoints and perspectives from the general public. We provide a number of heuristics for the successful inclusion of stakeholders in ethical analysis.

In *section 7*, we show, by looking at several cases, how our approach can be applied. We discuss the application of our approach in the SIENNA project, in our ethical analyses of AI and robotics, human enhancement, and human genomics, and we demonstrate application in a case study of autonomous vehicles.

In *section 8*, we take up the issue of how our approach is to be situated within the **broader landscape of approaches for technology assessment and impact assessment**. We pay particular attention to two issues: the relation of our approach to social and economic impact assessment (SEIA) approaches, and its relation to human rights impact assessment (HRIA). We aim to show when the approaches are complementary and whether and when they could also be competitors.

In a concluding *section 9*, we summarize the results of this report, and consider limitations and future research opportunities in relation to our approach. Our conclusion is followed by an *annex* to the report, which goes into detail on our proposed methodology for SEIA, which is discussed in sections 3 and 7.

List of figures

List of tables

List of acronyms/abbreviations

Abbreviation	Explanation
AI	Artificial Intelligence
ATE	Anticipatory Ethics for Emerging Technologies
CCTV	Closed-Circuit Television
CGE	Computable General Equilibrium
EC	European Commission
EIA	Ethical Impact Assessment
ESLA	Ethical, Legal and Social Aspects
ELSI	Ethical, Legal and Social Implications
HET	Human Enhancement Technologies
HRIA	Human Rights Impact Assessment
IAF	Institute for Alternative Futures
IEEE	Institute of Electrical and Electronics Engineers
OECD	Organisation for Economic Co-operation and Development
RRI	Responsible Research and Innovation
R&D	Research and Development
R&I	Research and Innovation
SATORI	Stakeholders Acting Together On the ethical impact assessment of Research and Innovation (EU project)
SAE	Society of Automotive Engineers
SEIA	Socio-Economic Impact Assessment
SIENNA	Stakeholder-Informed Ethics for New techNologies with high socio-economic and humAn rights impact (EU project)
STEM	Science, Technology, Engineering and Mathematics
STS	Science and Technology Studies
TRL	Technology Readiness Level

Table 1: List of acronyms/abbreviations

Glossary of terms

Term	Explanation

Application level	The application level in SIENNA's ethical analysis approach defines particular uses of these products, in particular contexts and domains, by particular users.
Artefact (or product) level	The artefact or product level in SIENNA's ethical analysis approach gives a systematic description of the artefacts and processes that are being developed for practical application outside the field.
Comprehension-oriented ethical analysis	Comprehension-oriented ethical analysis is a type of ethical analysis that is directed at an understanding of ethical issues as well as possible ways of resolving moral dilemmas.
Comprehensive ethical analysis	A comprehensive ethical analysis is an ethical analysis of the technology in general, and particular products and applications, including associated social and environmental consequences.
Domain analysis	A domain analysis is an analysis of the deployment of the technology in a particular application domain, such as healthcare, defence, education, or entertainment.
Emerging technologies	Emerging technologies are innovative, new, and still in development. They are innovative in the sense that they promise new and potentially superior solutions to problems. They are new in the sense that they employ new concepts, methods and techniques and cannot be subsumed under existing technologies. They are still in development in that they are still, to some extent, a promise: few, if any, products and applications have resulted from them, and few, if any, are marketed and used on a large scale.
Ethical analysis	Ethical analysis is the process by which ethical issues associated with a situation, action, process or thing are studied in a systematic manner.
Ethical issue	An ethical issue is any situation in which moral harm might occur. That is, it refers to situations in which the realization of moral values, virtues, norms or principles might be negatively affected.
Foresight	A collection of methods to look into possible future technological developments.
General ethical analysis	A general ethical analysis is an ethical analysis of the technology in general, its general features, main techniques and approaches, and generic consequences. (A narrower analysis could be directed at a particular technique, approach or subfield only.)
Human rights impact assessment	The analysis used to identify and assess the human rights impacts of a technology on society.
Impact	A potential change – whether positive or negative, direct or indirect, in whole or in part – caused by or associated with the technological field under consideration.
Impact analysis	An impact analysis is an analysis of ethical issues in relation to a particular type of impact or consequence of the technology, e.g., the impact of robotics on employment, or the impact of human enhancement technologies on self-esteem and self-awareness.
Mature technologies	Mature technologies are established technologies that have attained market penetration.
Moral dilemma	A moral dilemma is a situation where (1) a choice has to be made between two moral goods (values, norms, or principles), where either choice can be considered problematic, or (2) a way has to be found in which this choice would be avoided.

Product analysis	A product analysis is an analysis of a particular type of product associated with the technology. E.g. a study of enhanced bionic eyes within the field of human enhancement. (Instead of a product, the focus could also be on a function or capability enabled by the technology field across a range of products, e.g., enhanced locomotion.)
Socio-economic impact assessment	A tool used to identify and assess the economic and social impacts of new and emerging technologies.
Solution-oriented ethical analysis	Solution-oriented ethical analysis is a type of ethical analysis that is directed at solving moral dilemmas and recommending courses of action.
Stakeholder	A relevant actor (person, group or organisation) who: (1) might be affected by the project; (2) have the potential to implement the project's results and findings; (3) have a stated interest in the project fields; and/or, (4) have the knowledge and expertise to propose strategies and solutions in the fields of genomics, human enhancement and artificial intelligence.
Technology level	The technology level in SIENNA's ethical analysis approach is the most general level of description, specifies the technology in general, its subfields, and its basic techniques and approaches.
User group or stakeholder analysis	A user group or stakeholder analysis is an analysis of ethical issues in relation to a particular user group or stakeholder group with regard to the technology.

Table 2: Glossary of terms

1. Introduction

1.1 Background

This report intends to provide a methodology for the ethical analysis of emerging technologies. *Ethical analysis* is the process by which ethical issues associated with a situation, action, process or thing are studied in a systematic manner. We distinguish two types of ethical analysis that each have different aims. *Comprehension-oriented ethical analysis* is directed at an understanding of ethical issues as well as possible ways of resolving moral dilemmas, whereas *solution-oriented ethical analysis* is directed at solving moral dilemmas and providing courses of action. To illustrate, we will consider an example of each.

Some CCTV cameras are equipped with facial recognition capabilities, allowing security personnel to match faces of observed individuals with faces in a database. This could be a database with wanted criminals or previous convicts, but it could also include members of the general public at large. Confronted with the phenomenon of CCTV cameras being used for facial recognition for security reasons, one aim of ethical analysis might merely be to understand the ethical issues and dilemmas involved with this phenomenon. One such ethical issue is the threat to privacy that such technology poses, and this issue turns into an ethical dilemma if it is realized that efforts to reduce this threat might also reduce the security benefits of the system. To reduce the threat to privacy, one would need to eliminate individuals from the database, or reduce the amount of information made available about them, both of which could reduce security benefits. Comprehension-oriented ethical analysis aims to understand, at a minimum, how exactly this technology threatens privacy, and how the demand for privacy potentially conflicts with that for security. Optionally, it could also sketch possible courses of action to resolve this moral dilemma, and provide pros and cons for each.

Solution-oriented ethical analysis aims to provide solutions to moral dilemmas that have been identified. It takes all the steps of comprehension-oriented analysis, in its minimal version, sketches possible courses of actions, and advocates for a particular course of action as the best one. So, in the example that was provided, solution-oriented ethical analysis would assess different ways of resolving the trade-off between privacy and security, and recommend, based on moral arguments and reasons, a particular solution to this trade-off, for example that the technology can be used, but only with a database of wanted criminals, and only if further safeguards are included to avoid secondary usage of their personal data.

Two terms that we use here might benefit from further clarification: ethical issue and moral dilemma. Sometimes, these terms are used synonymously. Here, we define an *ethical issue* as any situation in which moral harm might occur. That is, it refers to situations in which the realization of moral values, virtues, norms or principles might be negatively affected. In the CCTV example, the fact that the CCTV cameras could harm privacy raises an ethical issue even if there were no security benefits to the technology. The fact that there are security benefits, and that an increase in privacy protections may also reduce security benefits raises a moral dilemma. In a *moral dilemma*, a choice has to be made between two moral goods (values, norms, or principles), where either choice can be considered problematic, or a way has to be found in which this choice would be avoided.

1.2 Objectives

The objective of this report is to provide a methodology for the ethical analysis of emerging technologies, including both comprehension-oriented and solution-oriented ethical analysis.

Why is such a methodology needed? First of all, it is increasingly evident that new technologies often have a major transformative impact on society, affecting the economy, work, everyday life, and the functioning of institutions. This has been evident since the invention of the steam engine, and it has become evident in recent decades by the way in which digital technologies have transformed society. New technologies may have particular consequences for the things that we value, both in a positive and negative sense: well-being, personal relationships, health, security, privacy, equality, and democracy, and, may all be significantly affected by new technological innovations. Because of the serious moral challenges that are raised by emerging technologies, as well as the opportunities they offer to provide moral benefits, it is important for us to have an understanding, as early as possible in the innovation cycle, an understanding of the ethical issues, dilemmas and opportunities engendered by emerging technologies. The earlier we engage in ethical analysis, the earlier we can flag important ethical issues and dilemmas, and the earlier we can plan for solutions. The longer we wait, the more choices will already have been made in the development and deployment of new technology in which moral issues have not been considered, and the more difficult it will be to intervene.[2]

While methods for ethical analysis in general have been around for a long time, specific methods for ethical analysis for emerging technologies have only been proposed quite recently. Emerging technology raises unique challenges. First of all, there is the unique character of technology. Technology extends human agency in unique ways, making new actions possible that are qualitatively and quantitatively different from those that we were able to perform in the past. These actions may have consequences that are difficult to oversee or foresee, and that may span large distances over time and space. Technology may often proceed autonomously or semi-autonomously, since machines are capable of performing operations and engendering consequences with little or no human intervention. And many people are involved in the development, deployment and use of new technology, often making it difficult to make any one party responsible for particular consequences. In addition, emerging technology is still in the making. In case of early-stage emerging technologies, we do not know yet what products will come out, in what domains they will be applied, and how. This makes it particularly difficult, then, to ethically assess them.

The methodologies that have been proposed for ethical analysis of emerging technologies can be counted on one hand, and have for the most part not been subjected to extensive application and testing in relation to actual cases (Brey 2012, 2017; Reijers et al., 2018).[3] This was a reason for us to choose to develop a new methodology (on the basis of parts of existing methodologies). The SIENNA project included three emerging technologies (AI – including robotics -, human enhancement technologies, and human genomics) which could be used for extensive application and testing of a methodology. We devised a draft methodology based on the SATORI Framework for Ethical Impact

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[2] Collingridge, David (1980). The Social Control of Technology. New York: St. Martin's Press.

[3] Brey, P. (2012a). 'Anticipatory Ethics for Emerging Technologies,' *Nanoethics* 6(1), 1-13; Brey, P. (2017). Ethics of Emerging Technologies. In S. O. Hansson (Ed.), *Methods for the Ethics of Technology.* Rowman and Littlefield International; Reijers, W., Brey, P., et al. (2018). 'Methods for Practising Ethics in Research and Innovation: A Literature Review, Critical Analysis and Recommendations.' *Science and Engineering Ethics*. 24 (5), 1437-1481.

Assessment[4] and the Anticipatory Technology Ethics approach (Brey, 2012a, b)[5], two important existing approaches for the ethical analysis of emerging technologies. We tested it out on these three technologies, and proposed modifications based on our findings. This report contains the resulting methodology.

1.3 Scope and limitations

We present a methodology for the ethical analysis of emerging technologies. *Emerging technologies* are innovative and still in development. They are innovative in the sense that they promise new and potentially superior solutions to problems. They are new in the sense that they employ new concepts, methods and techniques and cannot be subsumed under existing technologies. They are still in development in that they are still, to some extent, a promise: few, if any, products and applications have resulted from them, and few, if any, are marketed and used on a large scale. Emerging technologies stand in contrast to *mature technologies*, which are established and have attained market penetration. Examples of emerging technologies are artificial intelligence, Internet-of-Things, quantum computing, synthetic biology, 3D printing, and smart materials. Examples of mature technologies are automotive technology, radio technology, nuclear technology, and plastics technology. Although our methodology is not intended for mature technologies, it is applicable to them with a few modifications. The largest difference is that with mature technologies, no foresight analysis is needed (see sections 3 and 5), and more extensive information is available for use in analysis, including information about products, applications, impacts, and ethical issues.

Life cycle analyses of technology, which aim to study the different stages technologies go through throughout their existence, often distinguish between stages of research and development, ascent, maturity, and decline. Emerging technologies encompass both the R&D and ascent stage. Maturity of a technology is also assessed through the approach of technology readiness levels (TRLs), in which nine levels are distinguished, from the observance of basic principles (TRL1) to proof of the actual system in an operational environment (TRL9). Emerging technologies typically have not reached TRL9 yet, or at least have not generated many products that have reached TRL9.

The objects of analysis in our methodology are, of course, emerging technologies. But emerging technologies are complex phenomena, and in practice, we will often be doing an ethical analysis of aspects or dimensions of emerging technologies, as well as their implications for society. To be precise, our objects of analysis include techniques, subfields, approaches, types of products, the deployment of the technology in particular application domains and by particular user groups, and social and environmental impacts of the technology. For each of these, ethical issues can conceivably be discerned that are raised by them. For example, the approach of deep learning in AI raises particular ethical issues relating to accountability and transparency, the development of brain-computer interfaces raises issues of autonomy and privacy, the use of genomic technologies in forensics raises particular issues, and the impact of robotics on work and employment raises certain ethical issues as well.

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[4] Reijers, W., Brey, P., Jansen, P., Rodrigues, R., Koivisto, R., & Tuominen, A. (2016). A Common Framework for Ethical Impact Assessment. *SATORI Deliverable D4.1.*

[5] *Ibid.*; Brey, P. (2012b). Anticipating Ethical Issues in Emerging IT. *Ethics and Information Technology*, 14(4), 305–317.

In most cases, our objects of analysis are *types* of technologies, products, applications or consequences, rather than particular *tokens* of such phenomena. We are focused on ethical issues associated with product types, such as humanoid robots, drones, brain-computer interfaces and gene therapy drugs, not a particular product used by a particular user. We are focused more generally on the use of AI in healthcare, and the use of human genomics in forensics, not on particular uses by particular persons. This is not to say that our methodology could not be used for ethical analysis in specific cases; it could with minor adaptations. However, it is primarily intended to identify and analyse ethical issues that apply to a wide range of cases, across different types of phenomena rather than tokens.

Finally, our approach is intended for broad, quasi-comprehensive ethical analysis of emerging technologies. That is, it is capable of identifying and assessing a broad range of ethical issues that can be expected to come into play with an emerging technology, including quite general issues, as well as issues that are associated with particular products, application domains, or user groups. The approach is however adaptable to focus only on general issues, or particular products, or particular application domains or user groups, or on particular types of ethical issues, such as issues relating to privacy or fairness. This narrowing of the scope of analysis is easily done by restricting the set of objects of analysis that is studied in relation to a technology (e.g., only certain types of products, or only applications in healthcare), or by restricting the set of values, norms and ethical principles that are included in ethical analysis (e.g., only privacy issues are considered).

1.4 Relation to other approaches

The approach that we propose, while having many novel elements, builds on previous approaches and stands in various traditions. The two main traditions in which it stands are those of *ethics of technology* and *Responsible Research and Innovation*. The ethics of technology is an academic field that is concerned with the analysis of ethical aspects of technology and its impact on society.[6] It emerged as a recognisable field in the 1980s and 1990s, supported by a general surge of research in applied ethics, and has grown very rapidly in the past twenty years.

Most work in the ethics of technology focuses on the ethical analysis of specific technologies, such as information and communication technology, biomedical technology, nanotechnology and neurotechnology. Studies in the ethics of technology tend to focus on either a technique, a type of device, a practice that involves a particular technology, or a social problem that involves the use of technology, and then go on to carry an ethical analysis of their object of study. This ethical analysis that then proceeds can be a mere mapping and brief analysis of ethical issues or a more profound analysis of one or more of them, and may or may not result in firm evaluative conclusions or normative recommendations. Ethical studies would for example investigate the extent to which internet users are entitled to privacy, whether new neurotechnological therapies adequately support the autonomy and well-being of patients, whether the health and environmental risks of new nanotechnologies are morally acceptable, and what the ethical implications are of cognitive enhancement. Some studies in

[6] Hansson, S. O. (ed.), *Methods for the Ethics of Technology*, Rowman and Littlefield International, 2017; Van de Poel, S. and Royakker, L., *Ethics, Technology and Engineering: An Introduction*, Wiley, 2011.

ethics of technology focus on ethical issues in relation to technology in general, and on theoretical and methodological issues in the field.

The multidisciplinary field of responsible research and innovation (RRI) aims to align research and innovation with broader social values.[7] In the words of by philosopher and EC policy officer René von Schomberg:

> "Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)." [8]

RRI is best understood as a science policy framework, championed by the European Union, though it has also become an academic field of study. In relation to technological innovation, the more specific term "Responsible Innovation" (RI) is sometimes used.[9] Projects in RRI typically involve a collaboration between humanities (notably, ethics), social sciences and STEM fields, with empirical scientists contributing empirical knowledge of social and behavioral processes and STEM researchers scientific, medical or technological knowledge. They often also include nonacademic actors such as industry, governmental organisations and civil society actors. Many countries in Europe and elsewhere in the world now have research funding programs to stimulate responsible innovation research. RRI is, to some extent, intended as a success or approach to ELSI (in the United States) or ELSA (in Europe), which refers to research activities in emerging sciences that anticipate and address ethical, legal and social implications (ELSI) or aspects (ELSA).

RRI is characterized by its advocacy of a proactive approach of research and innovation to be responsive to the values, needs and expectations of society, the involvement of societal stakeholders in the research and innovation process, its emphasis on anticipation and reflection in R&I, transparency of R&I processes, the adoption of social responsibility by technology actors, and multi-stakeholder governance. Ethics is considered to be one of the key pillars of RRI. It identifies relevant social and moral values to which R&I is to adhere, it analyses and assesses ethical issues, and it works towards solutions aimed at ethical guidance of research and innovation. It does so, however, in collaboration with other fields, such as foresight analysis, technology assessment, governance studies, and science and technology studies, and in collaboration with non-academic actors. Ethical analysis of emerging technologies is therefore not just an academic pursuit in the ethics of technology, it is also a key practice in RRI. The approach to ethical analysis that we propose in this document is well positioned to take a key role in RRI, since it is compatible with it. Our approach aims to carry out ethical analyses that can be used for subsequent assessment, guidance and governance of emerging technology within an RRI context. To this effect, our approach includes some key elements of the RRI approach, including

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[7] R. Gianni, J. Pearson, B. Reber (eds.), *Responsible Research and Innovation: From Concepts to Practices*, Routledge, 2018.

[8] Von Schomberg, R. Prospects for technology assessment in a framework of responsible research and innovation, M. Dusseldorp and R. Beecroft (eds). *Technikfolgen abschätzen lehren: Bildungspotenziale transdisziplinärer Methoden*, Springer, 2012, p. 50.

[9] Hoven, J. van den, Doorn, N., Swierstra, T., Koops, B., Romijn, H. (Eds.) (2014). *Responsible Innovation 1: Innovative Solutions for Global Issues.* Dordrecht, The Netherlands: Springer. Koops, B., Oosterlaken, I., Romijn, H., Swierstra, T., & Van den Hoven, J. (Eds.). (2015). *Responsible Innovation 2: Concepts, Approaches, and Applications.* Dordrecht, The Netherlands: Springer.

the inclusion of stakeholders in the ethical analysis process and of practices of reflection and anticipation (through foresight analysis and social impact assessment).

Within the ethics of technology, much of the research is now directed at the ethical analysis of emerging technologies. This is also congruent with the emergence of RRI, in which the emphasis typically also is on emerging technologies. Ethical analysis of emerging technologies raises challenges because these technologies have not yet fully formed, and it is often unclear what the products and applications will be that come out of them, and how society will change as a result of them. For this reason, specialized methodologies for ethical analysis need to be in place. Over the past ten to fifteen years, several such methodologies have been developed. Literature overviews of these methods and useful ways of categorising them can be found in Reijers et al.[10] and Brey[11]. As Brey has argued, approaches to ethical analysis of emerging technologies fall into five categories: (1) *generic approaches*, which identify general ethical issues only, that are not dependent on particular products or applications; (2) *ethical risk analyses*, that focus on an ethical analysis of risks that emerging technologies can pose, including health, security, safety, economic and environmental risks;[12] (3) *experimental approaches*, that see the introduction of a new technology into society as a social experiment with uncertain outcomes, and assesses the conditions for responsible experimentation;[13] (4) participatory and deliberative approaches, in which ethical analysis is performed by stakeholders, supported by ethicists;[14] (5) anticipatory approaches, which combine ethical analysis with various kinds of foresight or futures studies methods to arrive at ethical analysis of possible, plausible and probable future technological developments, products, applications and impacts.

Each of these approaches has strengths and limitations. Generic and ethical risk approaches can be criticized for being limited in scope, with generic approaches only covering generic ethical issues, and ethical risk approaches only covering risks, and not other ethical issues. Experimental approaches can be criticized for not directly addressing ethical issues raised by emerging technologies, but only addressing some general conditions for its ethical management. Participatory and deliberative approaches can be criticized for risking suboptimal outcomes due to the lack of expertise of participants and because power inequalities, that are difficult to manage, may bias outcomes. Anticipatory approaches have as a handicap that they aim to have insight into the future, whereas our knowledge of it is quite uncertain. This handicap also applies to ethical risk approaches, and most participatory and deliberative approaches, as they also involve assumptions about the future.

The approach that we advocate stands in the tradition of anticipatory approaches, though it also includes participatory and deliberative methods, and allows for references to generic ethical issues and to risks. The tradition of anticipatory approaches includes a handful of approaches that have been

[10] Reijers, W., D. Wright, P. Brey, K. Weber, R. Rodrigues, D. O'Sullivan, B. Gordijn, "Methods for Practising Ethics in Research and Innovation: A literature Review, Critical Analysis and Recommendations", *Science and Engineering Ethics*, 2017. https://doi.org/10.1007/s11948-017-9961-8
[11] Brey, P.A.E., "Ethics of Emerging Technologies", in S. O. Hansson (ed.), *Methods for the Ethics of Technology*, Rowman and Littlefield International, 2017.
[12] Asveld, L., & Roeser, S. (Eds.). *The Ethics of Technological Risk*. London: Earthscan Publishers., 2009.
[13] Van de Poel, I. An Ethical Framework for Evaluating Experimental Technology. *Science and Engineering Ethics*, (online article) 1–20. http://link.springer.com/article/10.1007%2Fs11948-015-9724-3#/page-1, 2015.
[14] Cotton, M. *Ethics and Technology Assessment: A Participatory Approach*. Berlin: Springer-Verlag. 2015.

published since the 2010s, including the techno-ethical scenarios approach,[15] ethical technology assessment,[16] the moral plausibility approach,[17] the ETICA approach,[18] anticipatory technology ethics[19] and ethical impact assessment[20] [21] . They are reviewed in articles by Brey and Reyers et al.[22] Our approach builds on two of these approaches: anticipatory technology ethics and ethical impact assessment. These are approaches for the ethical assessment of new and emerging technologies that focus on ethical analysis of current and anticipated impacts of these technologies on humans, society and the environment.

Anticipatory technology ethics (ATE), developed by Philip Brey, is an approach for broad ethical analysis of emerging technologies. It is characterized by four key characteristics: (1) the objective to do broad ethical assessments of emerging technologies at general, product and application levels of description; (2) an emphasis on foresight and social impact assessment methods to anticipate potential future developments and consequences; (3) orientation towards a recognition and identification of ethical issues, followed by analysis, evaluation and prescription, and (4) engagement of stakeholders and experts at different phases of the analysis process. All four of these characteristics persist in the current approach.

Ethical impact assessment (EIA) has two incarnations: an early version, EIA I, proposed by David Wright,[23] which focuses mostly on impact assessment of products within an organisational context, and which, like ATE, emphasizes anticipation and stakeholder engagement, and a later version, EIA II, in which Wright and Brey join forces, and which combines the best features of ATE and EIA I to yield a

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[15] Boenink, M., T. Swierstra, and D. Stemerding, "Anticipating the Interaction between Technology and Morality: A scenario Study of Experimenting with Humans in Bionanotechnology", *Studies in Ethics, Law and Technology*, 4(2), 2010.

[16] Palm, E., & Hansson, S. O. The case for ethical technologyassessment (eTA). *Technological Forecasting and Social Change*, 2006, 73, 543–558.

[17] Lucivero, F., *Ethical Assessments of Emerging Technologies. Appraising the moral plausibility of technological visions*, International Library of Ethics, Law and Technology, Springer, 2016; Lucivero, F., T. Swierstra, M. Boenink, "Assessing Expectations: Towards a Toolbox for an Ethics of Emerging Technologies", *NanoEthics,* 5(2), 2011, pp. 129–141.

[18] Stahl, B. C., R. Heersmink, P. Goujon, C. Flick, J. van den Hoven, K. Wakunuma, M. Rader, "Identifying the Ethics of Emerging Information and Communication Technologies", *International Journal of Technoethics*, 1 (4), 2010, p. 27. http://doi.org/10.4018/jte.2010100102 42; Stahl, B. C., "IT for a better future: How to integrate ethics, politics and innovation", *Journal of Information, Communication and Ethics in Society*, 9(3), 2011, pp. 140–156. doi:10.1108/ 14779961111167630

[19] Brey, P.., "Anticipatory Ethics for Emerging Technologies", *Nanoethics*, Vol. 6, 2012, pp. 1–13. https://link.springer.com/article/10.1007%2Fs11569-012-0141-7

[20] Wright, D., "A framework for the ethical impact assessment of information technology", *Ethics and Information Technology,* Vol. 13, 2011, pp. 199–226. http://doi.org/10.1007/s10676-010-9242-6

[21] CEN, "CEN Workshop Agreement: Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework, CWA 17145-2, June 2017. http://satoriproject.eu/media/CWA17145-23d2017.pdf; Reijers, W., P. Brey, P. Jansen, R. Rodrigues, R. Koivisto, & A. Tuominen, "A Common Framework for Ethical Impact Assessment.", SATORI Deliverable D4.1, 2016. http://satoriproject.eu/media/D4.1_Annex_1_EIA_Proposal.pdf

[22] Brey, P., 2012, ibid.; Reijers et al., 2017, ibid.

[23] Wright, 2011, *ibid.*

comprehensive approach for ethically assessing emerging technologies.[24] Our current approach aims to further improve on EIA II, which constitutes its main starting point.

1.5 Structure of the report

We will present our methodology in the seven sections that follow this introduction. Sections 2 through 4 present the core methodology, and sections 5 through 8 provide elaborations and discussion.

In *section 2*, we provide an overview of our proposed methodology for ethical analysis, including an account of its seven key steps, which we describe briefly. In *section 3*, we describe the first four steps of the methodology, which are directed at defining subject of analysis, aim and scope, and engaging in conceptual analysis and description, aimed at informing the actual ethical analysis that is to follow. In *section 4*, we describe the subsequent three steps of our methodology, in which the actual ethical analysis takes place. This includes steps for the identification of ethical issues, their further analysis, and moral evaluation, guidance and decision-making.

Next, in section 5, we describe methods of foresight analysis, which we recommend for use in several steps of our methodology. In section 6, we propose detailed approaches for the inclusion of stakeholders, which we recommended to be included in several of the steps of our methodology. In section 7, we discuss how our approach is to be situated within the broader landscape of approaches for technology assessment and impact assessment, with special attention to its relation to social and economic impact assessment (SEIA) and human rights impact assessment (HRIA).

In the concluding *section 8*, we summarize the results of this report. Our conclusion is followed by an *annex* to the report, which goes into detail on our proposed methodology for SEIA, which is one of the methods used in our approach to ethical analysis.

[24] CEN, 2017 and Reijers et al., 2016*, ibid.*

2. Overview of the approach

2.1. Motivation and assumptions

In this section, we provide an overview of our general method of ethical analysis. In this first subsection we describe the goals, assumptions, and applicability of the approach. In subsection 2.2, we summarize the seven steps of the approach (each of which will be elaborated in later sections of this report).

The SIENNA project has studied the ethical, legal, and social issues of emerging technologies in human genomics, human enhancement, and AI and robotics. The aim of these studies was to identify, analyse, and evaluate ethical issues pertaining to these technologies and, where appropriate, to provide recommendations for possible solutions for these issues.

Because of the diversity of the fields investigated by SIENNA, we expect our methodology to be sufficiently general so that it can be fruitfully applied across any domain or field of emerging technologies. We make the following assumptions about the projects for which this method is suitable:

1. Ethical analysis is desired for a particular emerging technology, emerging field of technology, or technological development.
2. A systematic approach is sought for comprehensive identification of a range of ethical issues arising from different aspects of the technology at different levels.
3. The ethical analysis spans both current the technology and its use, as well as the foreseeable or potential future technology and its use.
4. The analysis is intended to be responsive to the needs and concerns of stakeholders involved in the development and use of the technology, as well as the interests of those stakeholders affected by the technology.
5. The analysis can constitute a basis for normative recommendations and resulting early-stage interventions in the innovation process.

The first assumption narrows the range of application of the method described here. Although this method, or a lightly adjusted version of it, may well be suitable for ethical analysis in a variety of other subjects, it has been designed and tested to address emerging technologies and the associated technological fields.

The second assumption is that the analysis aims to be comprehensive within its scope. The analysis is intended to identify (to the extent possible) the *full* range of ethical issues in relation to the subject, and any judgments reached are supposed to be reached in the light of this full range of issues. Although the scope of the technology in question may be restricted, the analysis is intended to be comprehensive within this scope, not limited to particular values or priorities.

The third assumption is about the temporal orientation. With ethical evaluation of emerging technologies, we are not only interested in the immediate and current ethical issues, but also those that may arise in the future. For this reason, the method makes use of foresight methods at various steps in the process.

The fourth assumption is that input from a variety of stakeholders is valuable and, in many cases, essential to the creation of a rich and comprehensive analysis. Different types of stakeholder input will be most relevant at different stages in the analysis. SIENNA has defined a stakeholder as a relevant actor (person, group or organisation) who: (1) might be affected by the project; (2) have the potential to implement the project's results and findings; (3) have a stated interest in the project fields; and/or, (4) have the knowledge and expertise to propose strategies and solutions in the technological field.

The fifth assumption is about the practical goals of the analysis. The analysis should be able to frame and help justify policy and development choices about the technology. Hence, descriptions of the technology, descriptions of ethical issues, and analysis of these issues are attuned to the exigencies of practical guidance.

3.2. Summary of the method of ethical analysis of emerging technologies

The method consists of seven steps (see figure 1), which are intended to be sequential, although, in practice, some may be performed in parallel and/or iteratively. Method is neutral with respect to different moral theories and viewpoints. In this subsection, we summarize each of the seven steps.

Figure 1. Overview of the seven steps of the general method.

Step 1: Specification of subject, aim and scope of ethical analysis

In this step, we identify the subject of the analysis, and we specify other aspects of the analysis to be performed. Because many constraints may be set before any ethical analysis begins, this step may consist largely in making these features explicit, to anchor and guide the other steps of the analysis. This requires, first, identification of the technology or area of emerging technology in question. With that subject matter identified, the aims of the ethical analysis should be specified. The aims may range from more exploratory, perhaps mapping the various ethical issues, or more prescriptive, issuing frameworks or guiding decision-makers. Any limitation on those aims should be stated, to the extent known. Additionally, the stakeholders to whom the analysis will be accountable should be noted.

Finally, in this preliminary step, any additional requirements or constraints on the ethical analysis should be made explicit.

This step should be undertaken by the coordinator or principal investigator for the ethical analysis, in conjunction with those stakeholders who may use or depend on it.

Step 2: Stratification of the subject of ethical analysis

In this step, we undertake a more thorough scoping exercise by stratifying the subject of analysis into the different levels at which the analysis will take place. The objective with this step is to bring into view a nuanced conception of the subject of study. The method is to describe the area of technology at three levels. The *technology level*, the most general level of description, specifies the technology in general, its subfields, and its basic techniques and approaches. The *artefact* or *product* level gives a systematic description of the artefacts and processes that are being developed for practical application outside the field. The *application* level defines particular uses of these products, in particular contexts and domains, by particular users. The benefit of stratifying the subject into these three levels is that different ethical issues arise at the different levels, which is essential for the overall analysis.

The expertise required for this step is conceptual analysis, with a background in philosophy, especially philosophy of technology, and science and technology studies (STS). The division of the technology into levels may require thinking about the technology in ways that are unfamiliar to or awkward for some technologists in the field.

Step 3: Description of the subject of ethical analysis

In this step, we describe the subject of the ethical analysis, including its likely future developments. The description should contain sufficient detail for the intended ethical analysis, and should be broken down to match the levels of analysis described in Step 2 above. The subject of analysis is to be described comprehensively. At each level of description, the relevant objects should be catalogued and described in detail, with clarity and conceptual rigor.

Executing of this step requires general scientific literacy, as well as expertise in scientific writing, especially the ability to summarise and explain technical issues to readers with less technical knowledge. For describing likely and possible future developments of the technologies in question, forecasting methods may be useful, as will consultation with and review by expert stakeholders.

Step 4: Identification of potential impacts and stakeholders

In this step, we describe the likely and possible impacts of the technological developments described in the previous step, along with the stakeholder groups consisting of the populations that will be affected by these impacts. We consider impacts in a broad sense and take them to include such things as the symbolic meaning of a technology (e.g., a sex robot that looks like a child). This step, like the preceding step, is primarily descriptive, laying the groundwork for identifying ethical issues in the next step. The range of impacts to be described depends on the aims and scope of the overall ethical analysis, as specified in Step 1 above. These can be social, economic, environmental, or other kinds of impacts. The stakeholders identified in this step are those most likely to be affected by the technology in question, and, hence, those whose interests are most relevant to the substance of the ethical analysis.

This step requires expertise in methods of impact assessment. In addition, relevant disciplinary backgrounds include sociology, STS, economics, comparative law, ecology, and complex systems.

Step 5: Identification and specification of potential ethical issues

In this step, we identify and describe all the ethical issues relevant to the subject, including those that pertain to the (potential) impacts uncovered in Step 4. Specifically, we identify issues, principles and values that may be affected or challenged by a given technology, due to its applications and impacts that were described in the earlier steps. As with the preceding steps, this should take place at the three levels of description for the technology in question.

The primary expertise required for this step is philosophy, especially ethical theory, including familiarity with a broad range of axiological and deontic concepts across applied ethics (such as biomedical ethics, business ethics, environmental ethics, etc.). Comprehensive identification of issues may be aided by conducting literature reviews, perusing codes of ethics, using checklists, and consulting the most diverse range of stakeholders possible.

Step 6: Analysis of ethical issues

In this step, we further analyse the ethical issues that were identified in Step 5. We conduct what we call *comprehension-oriented ethical analysis*, which is an analysis that is directed at an understanding of ethical issues as well as possible ways of resolving moral dilemmas. This further analysis involves, first of all, further clarifying, providing nuance about, and contextualising the ethical issues that have been identified. It also essentially involves showing how different ethical issues relate to each other, including their conflicts, dependencies, parallels, exacerbating factors, etc. Analysis should aim to unpack the evaluative significance of such relationships, which should uncover some of the pros and cons of particular ways of addressing value conflicts, but stops short of reaching any unconditional evaluative conclusions.

Work by and in consultation with philosophers and ethicists is essential at this stage, with their primary contributions being the ability to put normative issues into relationship with each other and diagnose inconsistencies.

Step 7: Evaluation and recommendations for ethical decision-making (optional step)

In this step, we conduct *solution-oriented ethical analysis*. We assess arguments and competing considerations regarding ethical issues examined in preceding steps, to reach evaluations and possibly recommendations. Evaluation entails making and defending moral judgments regarding the moral desirability or undesirability of particular actions, persons, things, events, and outcomes, including environmental and all that entails. Depending on the scope of the overall ethical analysis, this may yield various forms of ethical guidance such as recommendations about particular decisions or policies, frameworks for assigning responsibilities to different actors, and development or revision of codes of ethics.

Essential expertise for this step is philosophy, especially moral, social, and political philosophy. This step also requires collaboration between ethicists and those who design policy, including governmental legislators, organization executives, members of professional bodies, and attorneys. A wide range of stakeholder input is relevant at this stage, both from the populations identified in Step 3, as well as those implementing, administering, or enforcing any regulations proposed.

3. Methods for conceptual analysis and descriptive studies in preparation for ethical analysis

It is a key assumption of our approach that ethical analysis of an emerging technology should be based on an adequate understanding of the technology in question, including its techniques, products, and applications, stakeholders, and consequences for society. Only with such an understanding will it be possible to identify and analyse the ethical issues associated with the technology. This conceptual and descriptive study of the technology is, of course, not divorced from the ethical analysis that follows. Yet, we claim, it logically precedes the actual ethical analysis that involves the application of ethical concepts and principles. In practice, conceptual and descriptive analysis and ethical analysis could take place in an interactive process, in which further insight into ethical issues after initial conceptual analysis and description may prompt further conceptual and descriptive analysis, that is then followed by additional ethical analysis. But our experience in the SIENNA project has shown that by and large, conceptual and descriptive studies precede ethical analysis.

In this section, we provide a detailed description of our methods for conceptual analysis and descriptive studies in preparation for ethical analysis. These methods are covered in steps 1 to 4 of SIENNA's general approach to ethical analysis, for which an overview was given in the previous section. The results of these steps constitute input for steps 5 to 7 (covered in section 4), where the focus is on substantive ethical analysis.

Four subsections in this section provide further detail and clarification on these first four steps, in order of sequence. In subsection 3.1, we provide additional explanation on step 1 (*Specification of subject, aim and scope of ethical analysis*). Then, subsection 3.2 offers further detail on step 2 (*Specification of subject, aim and scope of ethical analysis*). Next, subsection 3.3 details step 3 (*Description of the subject of ethical analysis*). And finally, subsection 3.4 covers step 4 (*Identification of potential impacts and stakeholders*).

These four subsections further clarify the purpose of the steps and their theoretical underpinnings, offer detailed instructions on how to carry out the steps, and describe good practices and examples gleaned from practical application of the steps within SIENNA.

It should be noted that proper execution of these steps depends on the right expertise of those undertaking them, the application of foresight methods to look into possible future technological developments, and the inclusion of input by relevant stakeholders. Therefore, at the end of each subsection, requirements and recommendations are given about specific expertise, foresight methods, and stakeholder input in carrying out the relevant step.

Finally, it deserves to be reiterated that, although the steps described in this section are intended to be sequential, in practice, some may be performed in parallel and/or iteratively.

3.1. Step 1 – Specification of subject, aim and scope of ethical analysis

In this step, we identify the subject of the analysis, and we specify other aspects of the analysis to be performed. Because many of these constraints may be set before any ethical analysis begins, this step may consist largely in making these features explicit, to thereby anchor and guide the other steps of the analysis.

First, it is important to analyse the context in which the results of the methodology will be used. Will it be, for instance, for an academic study in ethics, a policy study for governmental actors, a guidance study for industry, or some other purpose. Awareness of this context is important for being able to make the right methodological choices, not just in step 1, but in the other steps as well. In addition, this will be important for determining the right reporting format, and for taking into account issues like the potential misuse of the ethical analysis.

Second, it is necessary to identify the subject of analysis. According to the assumptions of this method, the subject of analysis will be a particular technology, or aspect or dimension of it. Following our discussion of broad and narrow scope in section 2, the following are the main scoping possibilities:

(1) *Comprehensive analysis:* the technology in general, and particular products and applications (including associated social and environmental consequences)[25]
(2) *General analysis:* analysis of the technology in general (its general features, main techniques and approaches, and generic consequences). (A narrower analysis could be directed at a particular technique, approach or subfield only.)
(3) *Product analysis:* analysis of a particular type of product associated with the technology. E.g. a study of enhanced bionic eyes within the field of human enhancement. (Instead of a product, the focus could also be on a function or capability enabled by the technology field across a range of products, e.g., enhanced locomotion.)
(4) *Domain analysis:* analysis of the deployment of the technology in a particular application domain, such as healthcare, defence, education, or entertainment.
(5) *User group or stakeholder analysis:* analysis of ethical issues in relation to a particular user group or stakeholder group that is affected by the technology.
(6) *Impact analysis:* analysis of ethical issues in relation to a particular type of impact or consequence of the technology, e.g., the impact of robotics on employment, or the impact of human enhancement technologies on self-esteem and self-awareness.

We expect that the initial identification of the subject will often happen before any process of ethical analysis has begun. The demand for ethical analysis of a technology often arises from an ascending social, political, economic, or environmental concern with the technology. From there arises demand for a general, comprehensive ethical analysis, including present and future developments of the technology. Even if the subject of analysis has been given in advance, in this step it should be clearly stated in a few sentences, perhaps citing a few examples, as an anchor for the analysis that will follow.

Third, once this initial identification of the subject has taken place, the exact aim of the ethical analysis to be performed should be determined. For example, one possible aim is a mapping of all potential ethical issues regarding the subject. This would only include step 1 to 5 in the ethical analysis

[25] For a good example of a comprehensive ethical analysis of a technology, see [SIENNA D.4.4] on AI and robotics.

procedure. Such a limited ethical analysis might be appropriate for a study, which is to feed into a more extensive analysis, or for a quick overview of ethical issues that is to feed into further policy analysis or business decision-making, for example.

A further-going aim is to carry out a comprehension-oriented ethical analysis, which would include step 6 – either the more minimal version that is directed at a better understanding of ethical issues, or the extended version that would also map and analyse possible solutions. This type of study one is suited to inform relevant stakeholders about ethical issues and possible solutions to them, so that these stakeholders could then discuss and select solutions and integrate them into their planning. Still going further, a solution-oriented ethical analysis would include step 7, and would propose particular solutions for moral issues and dilemmas that were uncovered in the ethical analysis. This type of analysis would normally involve stakeholders (where that could still conceivably be avoided in the two other types) and could be chosen in those situations in which ethical analysis needs to provide direct recommendations to be incorporated into further planning and decision-making procedures, for example in public policy, in company decisions, or to provide concrete guidance to technology developers or deployers. As with the identification of the subject of analysis, we expect that the aims of the analysis will often be given in advance, according to the social, political, ethical, or practical concerns that motivate the development of such an ethical analysis. Nevertheless, with this step, the aims should be stated explicitly.

Fourth, the scope and expected limitations of the analysis should be determined and articulated. The determination of the such of analysis was a first step towards such scoping. Second and third steps are to determine the scope of the ethical issues that are to be considered, and the temporal scope of the domain that is analysed. In the SIENNA project, our three ethical analysis studies were intended to be broad, covering all of the main ethical issues regarding the technologies we examined, in relation to the social, economic, legal impacts and the associated ethical issues. However, for some projects it may be desirable to limit the scope of the ethical issues that are covered. For instance, it may be desirable to focus on only one category of ethical issues, e.g., ethical issues pertaining to fairness or to accountability, or ethical issues in relation to human rights.

It is also advisable, at this stage, to explicitly address the temporal scope, specifying, at least roughly, the timespan within which the subject of analysis is studied. One possibility is to study only the emerging technology as it currently exists. Another is to do a foresight analysis, which means that also potential future manifestations and consequences of the technology are studied. It then needs to be determined for what period into the future foresight analysis is performed. This could for instance be five, ten, twenty or fifty years, or indefinitely. In the SIENNA project, we picked a foresight horizon of twenty years. How far into the future the examination may plausibly be directed depends partially on the technology in question and may not fully be known in advance of a review of the state of the art (in Step 3). However, at this first step, the desired temporal scope should be at least roughly specified.

Fifth, the stakeholders to whom the analysis is accountable must be documented. This may be the organizations or bodies that solicited the analysis or those who will use it. This may include, for instance, funding bodies, governmental organizations, or other policy- and decision-making bodies. It must also include any populations that will be affected by any *choices* that may be based on or guided by the ethical analysis. (The stakeholder group consisting of the people likely affected by the technology itself will be included below within the substantive analysis.) In identifying stakeholders that may be impacted by the analysis, it is essential to deliberately scan for vulnerable populations, including in socio-political and economic terms, as well as those that might otherwise be overlooked.

For the latter, there needs to be sufficient expertise so as to recognise where populations may be considered vulnerable in relation to the development and use of the ethical analysis.

Finally, additional requirements and constraints regarding the analysis may be introduced. These may involve procedures or the actual content of the analysis. For example, constraints may be imposed by the time allotted to the project, the expertise and availability of those who will conduct it, the resources available for research, etc. If the analysis is intended to be consistent with a substantive conceptual or evaluative framework, this should be stated along with any justification for such constraints. It is important to be aware that any such restrictions, in constraining *ab initio* the conceptual or evaluative repertoire may artificially limit the analysis. A thorough and genuinely investigative ethical analysis should not constrain the evaluative possibilities too tightly in advance. Such constraints are not advisable unless unavoidable, and the parameters for what constitutes the unavoidable should themselves be carefully assessed.

Relevant discipline and expertise required: No special expertise is required for performing this step. The most relevant perspectives are those of policy makers and project coordinators who will drive, oversee, and use the project results.

Relevant use of foresight: In this step, foresight methods could be used to help clarify an appropriate temporal scope for the analysis, but this may also wait until Step 3.

Relevant stakeholder input: In this step, the most relevant stakeholders are those who are soliciting, funding, or otherwise in need of this analysis. Question to ask include, why is this analysis being undertaken in the first place, and who will make use of it, and for what purposes? To the extent there is any unclarity about any of these issues, the relevant parties should be consulted. Typically, informal, direct questions or interviews will suffice.

3.2. Step 2 – Stratification of the subject of ethical analysis

In this step, we undertake a more thorough scoping of the subject of analysis by stratifying it into different levels at which the analysis will take place. Whereas Step 1 defined the scope in general terms, in this step we determine the scope in greater detail, with attention to the interplay between the technology as defined and its material and social dimensions. In this step, it is crucial to identify the different *levels* at which ethical issues may arise. Analysing the technology at different levels clarifies the subsequent analysis and ensures its thoroughness.

Stratification into levels is a task that requires serious research and analysis, and while applying our approach within SIENNA, we have found that the challenging nature of this task is easy to underestimate. We have therefore opted for this step to be separate from the next step, which is closely linked. In step 3, we use the obtained stratification of our subject in terms levels of analysis to create full descriptions of these levels.

In SIENNA, we adopted many features of the Anticipatory Technology Ethics (ATE) approach to technology evaluation.[26] In particular, the SIENNA project followed the ATE recommendation of describing a field of technology at three levels. The *technology level*, the most general level of description, specifies the technology in general, its subfields, and its basic techniques and approaches.

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[26] Brey, Philip, "Anticipatory Ethics for Emerging Technologies", *Nanoethics*, Vol. 6, 2012, pp. 1–13. https://doi.org/10.1007/s11569-012-0141-7

The *artefact* or *product* level gives a systematic description of the artefacts and processes that are being developed for practical application outside the field. The *application* level defines particular uses of these products, in particular contexts and domains, by particular users. The benefit of stratifying the subject into these three levels is that different ethical issues arise at the different levels, which is essential to Step 4.

The first level is the *technology level*. We adopt a useful definition of technology as "a collection of techniques that are related to each other because of a common purpose, domain, or formal or functional features."[27] Importantly, this means that a technology, or a field of technology, may be circumscribed in one of several ways. First, consider the *purpose* of the technology. One technology examined in the SIENNA project was human enhancement technology, which is defined by the purpose of human enhancement. Since human enhancement can be achieved in many ways, the technology defined by this aim spans medical technology, pharmaceuticals, information technology, and neurotechnology, amongst others. Similarly, military technology could be defined as the collection of technologies with the purpose of supporting military objectives. Alternatively, military technology could be defined in terms of the techniques and products that fall within the military domain. Other technologies are most readily circumscribed in functional terms. Human genomic technology, which was another SIENNA area, can be defined in functional terms, as the scientific approaches and techniques involved in reading, analysing, and altering human genomic information.

When an area of technology is defined by a purpose, it is important to be clear about whether all technologies serving that purpose are the intended subject of analysis, or whether it is only specific technological subfields. This is part of establishing the scope of the overall analysis. For instance, within surveillance technology, facial recognition technology or online tracking tools may be the more specific interest. Within climate change mitigation technology, more specific technologies of possible interest could include carbon sequestration technology and solar radiation management technology, which represent approaches with very different scientific underpinnings to the aim of mitigating climate change. Ideally, this further determination of scope is implied or suggested by the specification of the subject of analysis in Step 1. If it was left open earlier, it should be determined in the current step.

Other technologies are not primarily defined in terms of a purpose, function or domain, but are defined instead in terms of techniques, types of systems, or technological innovations. For example, quantum computing is an area of computing focused on developing computer technology based on the principles of quantum theory. Nanotechnology is the development of materials and devices on the scale of atoms and molecules. Robotics is a field concerned with the design, construction, operation, and use of machines that are capable of sensing, thinking and acting autonomously in an environment. Technologies such as these could have many functions and purposes. Note, though, that even in technologies that are defined in terms of techniques or systems, there is usually still an appeal to function: quantum computing is aimed at realizing computational capabilities, nanotechnology at realizing usable materials and devices, and robotics at realizing systems with unique abilities that can replace human functions.

As the examples just mentioned already indicate, it is not always obvious or straightforward how to define a technology or field of technology to ascertain the scope of analysis. However, achievement of clarity on this is fundamental. Hence, a crucial part of the current step in the ethical analysis is to clarify

[27] Brey, op. cit., p. 7.

how the technology in question is to be defined, whether in terms of its purpose, domain, function, techniques, types of systems or technological innovations, or some conjunction of these.

A second level at which the relevant technology should be described is the *product level*, also known as the *artefact level*. Every technological field, no matter how defined, generates products: particular artefacts and processes intended to be useful. To the extent that a scientific field does not generate such products, the field counts as *pure*, as opposed to applied, science, and so can be only peripheral to an analysis directed at emerging technologies. Identification of objects at the product level is usually fairly straightforward. We can identify examples associated with the technologies just mentioned. Products associated with human enhancement technologies include smart drugs. Products associated with military technologies include drone aircraft and missile detection systems. For climate change mitigation technology, the relevant products would include carbon capture devices and associated computer systems for retrofitting smokestacks. Note that a product can also be a process: new processes for oil refining or for analysing proteins in living cells are also technological products that have utility to their intended users (Brey, 2012).

There is a grey area between the fundamental techniques that characterize a technology *at the technology level* and the processes that characterize it *at the product level*. This is the case because the same procedure can sometimes both be understood as a fundamental technique that is used by scientists and engineers as a tool for developing products in a technology field, as well as a product itself, that is used by third parties for purposes other than developing such products. For example, CRISPR gene editing is a genetic engineering technique by which the genomes of living organisms may be modified. It can both be understood as a fundamental technique in human genomics, that is used to develop particular products and applications, as well as a useful process has resulted from of innovations in human genomics that can be used by others outside the field for various useful ends, including the development of further processes in medicine in which the process is applied.

Methods that are more theory-laden and adaptable according to fundamental concepts and principles of a scientific discipline are better classified in the category of techniques at the technology level. Methods and processes based on such techniques and then standardized to be used by non-specialists are better considered processes at the product level. What counts as a technique or process changes over time, with techniques being standardized as processes for wider use. For example, in genomics, Sanger sequencing is better thought of as a fundamental technique, whereas sequencing with a nanopore sequencer is now a process which constitutes a product of the field of genomic technology. We can draw a similar distinction with regard to AI, with convolutional neural networks counting as fundamental techniques that characterize the field of technology, and python libraries implementing convolutional neural networks according to user-specified parameters counting as products of the field of AI.

A third level of description is the *application level*, where the objects from the product level are configured and deployed in actual contexts of use. Analysis at this level does not look at the artefacts and processes themselves, but at the actions, activities, and practices in which they are used, bringing about many of their impacts. Consider surveillance technology and its products. At the application level a possible object would be the use of surveillance software by a company to monitor the productivity of its employees or the use of similar techniques in online examination software to prevent test-takers from cheating.

We do not advocate a survey of all possible users, user groups, and contexts of use for a technology at the application level. Instead, we advocate that the focus is on identifying a number of application domains, and optionally a number of key user groups. The OECD (2016) has argued that current emerging technologies can be divided up into four broad technological areas: biotechnologies, advanced materials, digital technologies and energy and environment.[28] Following this division, we can make the following suggestions for relevant application domains in these four categories:

- *Digital technologies* are often enabling technologies with broad applicability across many social and economic domains or sectors. They may raise different ethical issues in these domains. Therefore, it is advised that a large number of institutional domains are considered at the application level, with a particular focus on those that appear, at first analysis, to raise the most ethical issues. Domains that could be considered include: healthcare, defense, government/public services, law enforcement, education, media, leisure & entertainment, agriculture, retail & marketing, transportation, manufacturing, service sector, the legal sector, the workplace, the home, the public sector, the private sector.
- *Advanced materials* may have an impact on many social and economic domains, but are particularly likely to affect – and raise ethical issues in - healthcare, manufacturing, retail & marketing, transportation, agriculture and environmental management.
- *Bio(medical) technologies* are most likely to have applications in the following domains: healthcare, agriculture, manufacturing, and environmental management.
- *Energy and environment technologies*, such as fuel cells, carbon capture and storage, hydrogen energy and smart grids, have the most direct application in environmental management, but may also affect all kinds of sectors in which these technologies are applied, such as transportation, manufacturing, and agriculture.

Next to social and economic domains, we also advise the inclusion of particular user and stakeholder groups for ethical analysis. Particular ethical issues may apply to particular groups that use or are affected by the technology. Specifically, we advise to give special consideration to gender, age, race and ethnicity, educational and income level, and (dis)ability as factors to consider. In relation to age, it may be advisable to study ethical implications for children and the elderly. In addition, we advise consideration of vulnerable groups (other than the categories already mentioned). Vulnerable groups include people with chronic health conditions, mental health conditions, genetic conditions, disabilities (including impairments to vision, hearing, mobility, breathing or dexterity and learning difficulties), aged 70+ (potentially including those living in nursing/care homes), homeless persons, poor people, and immigrants (1st and 2nd generation). Another group that could be considered consist of people living in lower- and middle-income countries.

The table below (table 3) summarizes the three levels of analysis.

Level of analysis	**Object of analysis**
Technology level	- Broad features of the technological field (central concepts, methods, techniques, approaches, subfields). - A set of aims or purposes for which the technology is developed or applied. - General features and impacts that apply to artefacts and

[28] -OECD (2016). *OECD Science, Technology and Innovation Outlook 2016.* Published online, December 8, 2016. https://www.oecd.org/fr/sti/oecd-science-technology-and-innovation-outlook-25186167.htm.

	applications emerging from the field.
Product level	- Specific technological artefacts, whether material or digital/informational. - Specific standard processes and procedures developed by applying techniques of the scientific field.
Application level	- Specific uses of the technological products in particular domains, projects or activities. - Specific practices and activities that essentially involve the technological products. - Specific user and stakeholder groups affected by the technology.

Table 3. Overview of the levels of analysis.

The stratification is achieved when the subject of analysis has been clearly defined at the technology level, and the full field within the scope of the ethical analysis has been roughly described at the product and application levels. Describing a technology at several levels may be a difficult conceptual task. It requires deliberate effort and critical reflection, and may require for the subject matter to be considered in ways that are unfamiliar to practitioners in the area. That is because these levels of analysis are important for identifying ethical issues, even if they are not essential to the thinking involved in developing or applying the technology.

Relevant discipline and expertise required: Proper execution of this step requires expertise in conceptual analysis and expertise in analysing technology. The appropriate background is philosophy, especially philosophy of technology, and STS.

Relevant use of foresight: In this step, which is largely conceptual, there will likely be little need for rigorous foresight methods.

Relevant stakeholder input: Stakeholder input must be used with caution during this step. The division of the technology into levels may require thinking about the technology in ways that are unfamiliar to or awkward for some technologists in the field, and so tying the analysis closely to expert input may distort the process. This step is best undertaken by researchers with expertise in the philosophy of technology or STS. That said, the stratified levels of description, which are the outcome of this step, should be intelligible, if not immediately intuitive, to all stakeholders. The step should also be reviewed by experts in the specific technology to ensure technical accuracy.

3.3. Step 3 – Description of the subject of ethical analysis

In this step, we describe the subject of the ethical analysis, including its likely future developments. The description should contain sufficient detail for the intended ethical analysis. We make sure that the structure of the task in this step, as well as the documentation of it, matches the levels of analysis described in Step 2 above. In the SIENNA project, this step was carried out with the creation of state-of-the-art reports for each of SIENNA's particular areas of focus.

We describe the subject of our analysis comprehensively. At each of the three levels of analysis defined for this subject, we catalogue the relevant objects at that level and describe them in detail. This is inherently a research-intensive activity. While the stratification of the subject into levels could take place through conceptual analysis, perhaps with input from several domain experts, the background research involved at the current step for the description of the subject is typically much more intensive. Research is required to identify the most relevant objects, and then further research may be required to describe them with sufficient scientific and conceptual rigor for the subsequent ethical analysis.

To describe the subject at the technological level, we need to summarise the state of science and engineering regarding the relevant technology. The work at this level breaks down in the following key tasks, which are best completed in order:

> *Defining the technology:* To the extent that this has not happened during step 1, we provide accurate easy-to-understand definitions of the subject of our analysis, the technology in question, as well as important concepts associated with this technology. It is vital that definitions of key terms are well-considered since they help determine what exactly is to be considered for the ethical analysis later on.
>
> *Describing the field's aims and history:* In this task, we provide descriptions of the aims and history of the technology, the latter in broad strokes. Both these descriptions help in gaining a clearer understanding of the nature of the subject and the direction in which its development is headed. Since the aims of a particular field may evolve over time, it is worth speculating which, if any, direction(s) these aims may take in the future.
>
> *Description of key subfields, techniques, methods and approaches:* In this task, we provide detailed descriptions of key subfields, techniques, methods and approaches subsumed under the technology in question.

Then, to create descriptions at product level, we need to catalogue and classify the different products based on this technology. The work at this level breaks down in the following key tasks:

> *Description of key technological artefacts:* In this task, we provide detailed descriptions of key technological artefacts, if any exist, based on the technology. Potentially impactful, novel and/or technologically complex artefacts may warrant longer, more detailed descriptions than less impactful, familiar and/or technologically simpler artefacts. In describing the artefacts, one should distinguish between current capabilities and potential future capabilities.
>
> *Description of key refined procedures:* In this task, we provide detailed descriptions of key refined procedures, if any exist, based on the technology. As with the technological artefacts, the length of the descriptions here should be relative to potential impact, novelty and/or technological complexity, and a clear distinction should be maintained between current and potential future capabilities.

Finally, to formulate descriptions at the application level, we need to conduct a thorough survey of how those products are used—for what aims, in what domains, and with what effects. The work at this level breaks down in the following key tasks:

> *Description of key uses of the products in different application domains:* In this task, we provide detailed descriptions of key (potential) uses of the technological products in different application domains (e.g., military, healthcare, industry, education). These descriptions should encompass different types of uses, including uses according to proper function, alternative uses, dual use, and malicious use. Potentially impactful and novel uses may warrant more detailed descriptions, and a clear distinction should be maintained between current and potential future uses.
>
> *Description of key uses of the products by different types of users and stakeholders:* In this task, we provide detailed descriptions of key (potential) uses of the technological products by different types of users and stakeholders (e.g., adults, young people, the elderly, and where these groups

may be members of disadvantaged or otherwise vulnerable groups). It is useful to perform this task iteratively with step 4, where affected stakeholder groups are identified. It is especially important to pay attention to uses by disadvantaged and vulnerable groups given the potentially increased severity and risks of harm to these groups.

Because an adequate description of a technology requires a description of the items outlined above, a satisfactory description may be lengthy and complex. This complexity is increased by the necessity of considering each level of analysis from both present and future perspectives. The methodologies for addressing present and future perspectives may differ considerably. To address the present perspective, we focus on reviews of the relevant scientific and technical literature, as well as input from expert technologists, which will often be of great value. In contrast, in describing the future developments of the technology, we will have to make use of some prediction and speculation. For this, literature reviews, especially of existing foresight studies, will be valuable. However, actually using foresight and forecasting methods will often be required as well.

A further challenge is to identify, above and beyond the most obvious items, those less familiar items that appear to be potentially relevant for further ethical analysis. For this reason, work done at this step should be revisited and perhaps revised in light of subsequent steps, especially Step 5, in which the most important ethical issues have been identified.

Relevant discipline and expertise required: This step may not require expertise in the particular science and technologies in question, but it does require general scientific literacy, as well as competency in scientific writing, especially the ability to summarize and explain technical issues to readers with less technical knowledge.

Relevant use of foresight: For describing likely and possible future developments of the technologies in question, foresight methods will be useful, especially if extensive foresight has not already taken place regarding this area. Examples of relevant methods are given in section 5 of the report. Appropriate time horizons for the foresight exercises could be 5, 10 and 20 years from present.

Relevant stakeholder input: In this step, the most relevant stakeholders will be expert technology developers and users. Because the goal is primarily to describe (not yet ethically analyse) technologies, the input from these experts will be most valuable as information about how the technology works and is developed. It is advisable to have several technical experts review drafts of reports generated in this step, to ensure accuracy and proper coverage.

3.4. Step 4 – Identification of potential impacts and stakeholders

In this step, we describe the likely and possible impacts of the technological developments described in the previous step, along with the stakeholder groups consisting of the populations that will be affected by these impacts. This step, like the preceding step, is primarily descriptive. This step looks beyond the technologies to the consequences of the technologies for society, economies, the environment, and various affected populations. This step serves lays the groundwork for uncovering, identifying, and articulating ethical issues in the next step.

The range of impacts to be identified and described depends on the aims and scope of the overall ethical analysis, as specified in Step 1 above, these can be social, economic, environmental, or other kinds of impacts, and may occur at the level of particular individual persons and choices, all the way up to the functioning of global systems. Methods to identify current impacts may include literature reviews, brainstorming, interviews with experts and other stakeholders, and participant observation. Depending on the scope and goals of the ethical analysis, it may be beneficial to perform a general socio-economic impact assessment (SEIA) of the likely development of the technology in question. Although SEIAs are ordinarily performed regarding impacts of policy proposals or changes, they can also be performed regarding the impacts of the continued development and use of technology. The next subsection (subsection 4.5) summarizes a SIENNA proposal for a generalised methodology for SEIA of new and emerging technologies. Additionally, foresight methods should be used to identify potential future impacts that are associated with projected future developments and uses of the technology.

It is important that impacts be identified in relation to the three levels of description: broad impacts related to the technology in general, its purpose, and its core fields and techniques; contingent impacts due to specific artefacts or procedures; and application-dependent impacts tied to specific uses of the technological products in particular application domains.

Earlier, in step 1, we identified *stakeholders to whom the ethical analysis itself was to be accountable*. Now, at the current step, this list of stakeholders can be extended to include *those who may potentially be affected by the technology*. This process of stakeholder identification cannot be thoroughly achieved at an earlier step because it is dependent on the description of the technology, its future development, and its likely impacts. The stakeholders identified in the present step are those whose interests and, hence, whose input is most relevant to the substance and results of the subsequent ethical analysis. This may include technologists, the public at large, individuals with particular interests or identities, and members of particular groups. Examples may include particular groups of technology users, patient groups (in cases of medical technology), geographically defined groups (when technologies have environmental impacts), and especially populations that have distinctive vulnerabilities to potential impacts. Special attention is required to ensure inclusion not only those stakeholders who are more prominent and mostly loudly demand attention, but also the stakeholders, equally relevant from the standpoint of ethical evaluation, whose voices are less often heard.

In identifying stakeholders whose lives may be affected by the impacts of the technology, it is important to look at both stakeholders who may be consulted and those who will not be. As a result of this step, all relevant stakeholders (ideally) have been identified. Hence, practical plans for contacting them can be drawn up, and initial steps for consulting them can commence. However, it is also essential not to be blind to stakeholders who cannot or will not be consulted. Even without consultations, their situations and interests should be studied, considered, and taken into account by the ethical analysis.

Relevant discipline and expertise required: This step requires expertise in producing assessments of social, economic, legal, and/or environmental impacts. In addition to knowledge of the methods of impact assessment, relevant disciplinary backgrounds include sociology, STS, economics, comparative law, ecology, and complex systems science.

Relevant use of foresight: This step centrally involves future-oriented impact assessments. Depending on the scope of the overall ethical analysis, this may include social, economic, legal, and environmental impacts. Various forecasting methods will be relevant if these assessments are directed farther in the future. Examples of relevant methods are presented in section 5.

Relevant stakeholder input: The chosen methods of impact assessment and foresight are likely to rely on expert stakeholders and may well include other stakeholders as well. A further part of this step is completing the identification of all relevant stakeholders for the overall ethical analysis. With these stakeholders identified, plans for consulting them can be devised. However, some of the questions and issues on which their input will be most relevant depends on the results of the next two steps.

3.5. Proposal for a generalised methodology for socio-economic impact assessment of new and emerging technologies

This subsection presents a summary description of SIENNA's generalised methodology for carrying out a socio-economic impact assessment (SEIA) of new and emerging technologies. The guidance included here is meant to be a practical tool for conduct of a SEIA study on new and emerging technologies.[29]

We define a SEIA as a tool to identify and assess the economic and social impacts of new and emerging technologies. The resulting analysis allows us to understand and assess how new and emerging technologies will evolve in society and the economy and affect different social groups. SIENNA's SEIA methodology consists of 6 steps (see figure 2), which are detailed below in terms of objectives, process, results, tools and methods and resources and expertise required.

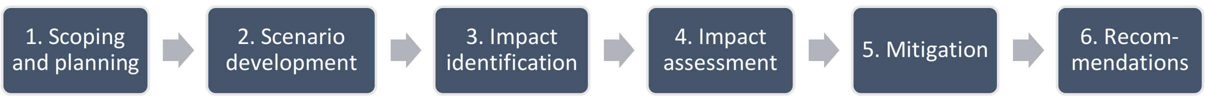

Figure 2: Six steps of SIENNA's SEIA methodology

Scoping & planning

Objective: To plan and conduct a preliminary scoping analysis that identifies SEIA considerations and required information or knowledge. At the end of this step, researchers should have a deep understanding of the technology to be assessed and should have identified the users, stakeholders and the socio-economic forces at play. Additionally, other specifics of the assessment should be planned. One, the boundaries of the scope of the assessment process need to be identified. Two, case-specific indicators and significance criteria should be determined. Three, team composition, resource allocation and the time-line for the SEIA must be outlined.

Process: In order to more fully grasp the consequences of new and emerging technologies, some preliminary questions should be answered. Examples of relevant questions include: (1) What is the intended purpose of the technology? (2) What are the typical applications of the technology? (3) In which sector does it operate? And (4) Who are the affected and unaffected stakeholders?

Once these questions and other questions have been answered, researchers should start thinking about the possible sources of data (if available) to identify and assess impacts, the accessibility of users and stakeholders identified, and the steps further required.

Result: This step will result in a plan for the SEIA that will, *inter alia*, help understand the functioning of the target technology and its impact flows.

Tools and methods: Internal team discussion, desk-based research, literature review and consultations with expert, stakeholders, or general public (if required).

[29] For a fuller description of the SEIA process including references, please see Annex 1 of this report.

Resources and expertise required: To proceed with the next steps of the SEIA, a good understanding of the state of the art of the technology to be studied is key. It is also important to have a general level understanding of the processes by which the technology is developed. If the team lacks expertise, consultations with experts or an extended literature review might be desirable.

Scenario development

To envision future impacts, using scenario thinking to foresee the development of new and emerging technologies is helpful. Scenario thinking is defined as “a description of a possible set of events that might reasonably take place”.[30] It is a very useful tool to envision possible future outcomes that cannot be currently observed. Its importance must be emphasised particularly in the context of the advent of new technology, which brings its own complexities and implications for society, and potential alternatives of future impact whose understanding needs to be deepened and broadened.

Despite this being a very valuable step, scenario development is very demanding in terms of efforts, resources, and expertise. Additionally, the benefits derived from it depend on the type of technology being assessed. We recommend conducting it when the resources, team expertise and type of target technology allow it.

Objective: The main objective of developing scenarios is to stimulate thinking about possible occurrences, assumptions related to these occurrences, possible opportunities and risks, and courses of action. Additionally, it allows stakeholders to engage in the assessment and explore issues expected to influence the development and uptake of new technologies.

Process: First, we recommend organising a brainstorming session. This meeting should be coordinated by the impact assessment team and led by a scenarios expert who will usually develop a general briefing version of the scenarios based on the desk-based research with the aim of scoping the exercise. The scenarios be time limited to a five to seven years’ timeframe to enable predictions based on existing knowledge and at the same time, to take into account the timescales of policy change and investment cycles. At the end of the first session, participants should have identified several factors relating to the drivers of technology innovation, potential barriers to and inhibitors of technology adoption and a list of social and economic positive and negative impacts attached to each scenario. Depending on the scenario approach, participants may be asked to weigh the impact of each factor and the likelihood of effecting the anticipated impact. The findings of this initial session should be synthesised into a draft scenario. This is an intensive and skilled writing process, as conflicting views emerging from a participatory group process need to be reflected into a coherent story.

Second, we recommend a validation session in which the results and initial scenario are shared with the participants of the brainstorming session for their review. This is important for many reasons: to ensure that all views are captured and represented accurately, cross-check assumptions, give participants an opportunity to revise their views and include any afterthoughts, gather comments and recommendations, and reassess the scenarios.

This step should be repeated as many times as groups of stakeholders, users or affected parties until the scenario is stable, i.e., researchers have resolved most if not all stakeholder comments and issues, and the remaining stakeholders have only a few minor comments or none.

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[30] Kwon, Heeyul, Jieun Kim and Youngtae Park, “Applying LSA text mining technique in envisioning social impacts of emerging technologies: The case of drone technology”, *Technovitation,* 2017. http://dx.doi.org/10.1016/j.technovation.2017.01.001

Result: At the end of this step, researchers should have developed a list of possible scenarios including main drivers, barriers and potential impacts. Scenarios should be formulated in a precise and accessible manner.

Tools and methods: Each type of scenario has its own construction methods. For the visioning, we recommend using creative tools such as diagrams, decisions trees or mental maps. For the consultation and validation of scenarios with stakeholders we recommend using participatory methods such as workshops or the Delphi method (when resources and expertise permit).

Resources and expertise required: Developing scenarios is a complex and time-intense activity and requires good resources and expertise. Scenario building requires visionary and creative experts and the collaboration of different types of expertise – e.g., foresight analysis experts, scenario building professionals, creative thinkers, technology developers and experts from different backgrounds to provide useful insights e.g., science and technology, social sciences, environmental sciences, economics, demography, etc. Team members with experience in participatory methods are also required. Adequate time and human resource must be devoted to the scenario building and validation process.

Impact identification

Objective: Impact identification requires a logical and systematic approach. The goal is to consider all important impacts. The narrowness or broadness of the impacts identified would depend on the scope of analysis of the SEIA. Having said this, all types of important impacts should be considered and attached to the corresponding impact level (see section 2.4.A- Categorisation of impact levels) . However, there should be a differentiation between, and clarification of, direct and indirect impacts, and ensuring that indirect effects, which may be potentially significant, are not missed out.

Process: We propose a two-fold approach. First, desk-based research should be carried out using specialist technology futures resources. Here two factors should be taken into consideration. First, the resource must cover the target new or emerging technology, and experts and public should actively discuss the target technology. Second, a future-oriented context is necessary, i.e., opinions should be mainly about the future development of that technology and its potential implication for society.

When identifying impacts, researchers should first consider direct impacts of the technology target by referring to the following suggested categories of potentially affected groups: individuals, consumers, workers, enterprises, public authorities, members of the public and vulnerable groups. Depending on the target technology, the potentially affected (including vulnerable) groups will differ. Second, to understand indirect or second-order effects, insights from multi-sectoral analysis and the scenarios should be considered. Researchers should categorise impacts by macro, meso and micro-level and associate them to one or more of the scenarios, sectors or groups identified in the previous steps. For instance, the introduction of robots in the industrial chain, has been found to improve supply chains and reduce costs (direct effects). In turn, these impacts will increase consumer demand and the competitiveness of the firm or industry (indirect effects).

Second, researchers will need to identify which of these impacts are likely to be relevant. To carry out this task, we recommend a combination of technical and participatory approaches. Once each impact has been captured by a scenario (if previously identified), experts should assess its relative relevance against the following factors: direction of the impact, magnitude of the expected impacts, and relative size of expected impacts for specific stakeholders.

Next, the analysis should be shared with experts or stakeholders for validation. Consultations via surveys, focus groups or interviews could be carried out. During these consultations, researchers should assess together with stakeholders and users the relevance of the impacts.

Result: A stakeholder-validated mapping of all potentially relevant impacts connected to affected parties and sectors of relevance of the technology being studied.

Tools and methods: The most common tools and methods used for impact identification are checklists, matrices, and professional judgement. Selection of these tools and methods depends on target of evaluation and sector. However, given the nature of the topic, literature review and professional judgement via surveys or interviews are expected to be the most appropriate tools (and have been proven to function well when used).

Resources and expertise required: The impact identification stage could take a long time given the lack of resources on new and emerging technologies. Teams with a mix of expertise are very beneficial at this stage as many fields and sectors might be implicated. Experts such as social scientists, economists, experts from key sectors of relevance, ethical and legal experts are critical to involve.

Impact assessment

Objective: Once impacts are identified; they should be evaluated to determine their significance. Thus, the main purpose of this step is to assess the magnitude or extent of the impacts identified.

Process: When data is available, quantitative assessments should be prioritised. Analytical methods such as cost-effectiveness, cost-benefit analysis, risk analysis, multi-criteria analysis or quantitative tools as econometric models, sectorial models or Computable General Equilibrium (CGE) could be used. Despite being highly valuable, using these methods could be a challenging task given the nature of new and emerging technologies as a subject of socio-economic analysis. Thus, we suggest that for new and emerging technologies, qualitative assessments might be more suited or desirable. Among the existing qualitative methods, participatory tools as dialogue or Delphi methods are useful.

We recommend following an impact significance methodology. Impact significance analysis is a common practice in impact assessments that makes judgments about what is important, desirable, or acceptable. It also interprets degrees of importance. In general terms, an impact significance is determined by the joint consideration of its characteristics: magnitude, duration, and likelihood.

In order to determine the level of magnitude, duration and likelihood, the study should design significance criteria during the scoping stage. These criteria will help researchers have a common approach and assess impact uniformly.

Results: Assessment of each of the impacts according to its characteristics.

Tools and methods: There are different approaches to conducting significance analysis. In general, these can be divided into technical approaches and participatory approaches. Technical methods use technical tools and depend primarily on expert assessments, technical details, and interpretation of data. Participatory methods concentrate on the relative significance given to an effect by a person or a group. The decision of which approach to follow will depend on the resources available, the expertise or the data availability, and should be set at the scoping stage.

When the team has enough resources, we recommend using a mixed methodology. First, the impact assessment team will assess the significance based on their expertise or secondary data. Second, the conclusions derived should be validated with stakeholders. However, we do not define this validation step as compulsory. Furthermore, it will depend on resources and time available.

Resources and expertise required: The resources and expertise needed for conducting the impact assessment stage will depend on the final approach taken. For instance, if the SEIA includes a quantitative assessment, there should be provisions for adequate time, finances (to obtain the data), and expertise on such methods. A SEIA that follows the impact significance methodology could be less time and resource intensive.

Mitigation of impacts

One of the most significant and critical steps in a SEIA is the identification of mitigation measures and mitigation of impacts, which is carried out based on the assessment of the impacts. Mitigation involves design changes and/or other interventions to overcome socio-economic impacts. The SEIA team analyses what are the options for mitigate the negative impacts identified. However, given the nature of the topic here discussed, this step might not be included in all SEIAs as mitigation itself might not be within the control of the research project carrying out the SEIA. The decision on whether to include this step and its extent (identification of measures might be possible in all cases but actual mitigation responsibility might lie elsewhere) depend on several factors such as the nature and type of technology studied, its purpose and scoping and whether such a step is able to be implemented by the organisation commissioning the SEIA. Outlined below is a general recommendation for this step, which will need to be tailored to each case.

Objective: The objective here is to identify and take mitigating measures to manage, reduce or eliminate adverse socio-economic impacts.

Process: To identify and refine appropriate mitigation actions, researchers should collect information on measures (e.g., by looking at what measures have been taken by similar technologies, related research projects) and discuss these with potentially impacted groups, policy-makers and other stakeholders and implement appropriate measures (as feasible). The impact identification, assessment and mitigation steps should be conducted in an iterative fashion and there should be a constant feedback loop between these steps. This process should be repeated until the possible effects are no longer significant or the implementation of additional mitigation actions becomes financially unfeasible.

Results: Mitigation plan, including identification and implementation of mitigation measures and responsibilities and review provisions.

Tools and methods: There is no specific method for identifying and implementing mitigation actions. However, when designing mitigation actions, it could be helpful to concentrate on minimizing the possible major negative effects, improving the long-term beneficial socio-economic effects, and eliminating the root of the effect rather than controlling the result.

Resources and expertise required: Developing a strong mitigation action plan requires time and resources. The participatory approach here suggested requires several sessions with stakeholders and users and a constant validation process. It also requires the right expertise on the team. For instance, experts on participatory methods will be needed, and team members with knowledge on how to construct mitigation plans and deal with different types of stakeholders whose interests might not be compatible or come into direct conflict.

Recommendations

In some SEIAs, this is the final step (and this step might also immediately follow the impact assessment step where the mitigation step is not carried out).

Objective: To analyse the main opportunities and risks attached to each impact and formulate recommendations.

Process: Here, researchers should look back at the analysis conducted and draw conclusions from it. Following previous steps, researchers should work upon the scenario planning (if any) and impact assessment tables and analyse them. Researchers should consider both positive and negative impacts identified and think how they will evolve. By doing so, opportunities attached to positive impacts, and the risks that come along with negative effects would be identified. Once, this have been identified final recommendations can be formulated.

Results: Insights on opportunities and risks and/or a list of recommendations.

Tools and methods: Although a participatory approach should we taken, we recommend following a technical approach and basing recommendations on team expertise and the mitigation actions formulated (if any). By doing so, we ensure that final recommendations are not biased toward personal interests or judgments from a specific group. We suggest framing the recommendations on different time terms i.e., the short, medium and long term.

Resources and expertise required: This final step does not require specific expertise on the part of the team.

4. Methods for ethical analysis of emerging technology fields

In this section, we provide a detailed description of our methods for ethical analysis of emerging technology fields, covering both *comprehension-oriented ethical analysis* and *solution-oriented ethical analysis*. These methods are presented in steps 5 to 7 of SIENNA's general approach to ethical analysis, for which an overview was given in section 2 of this report. They build on the results from steps 1 to 4, which are described in section 3.

Three subsections in this section provide further detail and clarification on the three ethical analysis steps, in order of sequence. In subsection 4.1, we provide additional explanation on step 5 (Identification and specification of potential ethical issues). Then, subsection 4.2 offers further detail on step 6 (Analysis of ethical issues). Finally, subsection 4.3 details step 7 (Evaluation and recommendations for ethical decision-making).

These three subsections further clarify the purpose of the steps and their theoretical underpinnings, offer detailed instructions on how to carry out the steps, and describe good practices and examples gleaned from practical application of the steps within SIENNA.

It should be noted that proper execution of these steps crucially depends on the right expertise of those taking them on, the application of foresight methods to look into possible and plausible future developments, and the well-considered inclusion of input by relevant stakeholders. Therefore, at the end of each subsection, requirements and recommendations are given about specific expertise, foresight methods, and stakeholder input in carrying out the relevant step.

Finally, it deserved to be reiterated that, although the steps described in this section are intended to be sequential, in practice, some may be performed in parallel and/or iteratively.

4.1. Step 5 – Identification and specification of potential ethical issues

In this step, we identify and describe all the ethical issues relevant to the subject, including those that pertain to the (potential) impacts uncovered in Step 4 (see section 3). Specifically, we identify issues, principles and values that may be affected or challenged by a given technology, due to its applications and impacts that were described in the earlier steps.

Some identification and specification of ethical issues may already have been performed in the preceding steps. Particularly, at the outset, in Step 1, the analysis may have been solicited or justified in the light of the observation or expectation of particular ethical issues. Any such issues that have previously been identified should be described more thoroughly during the current step, with explanations of the technological, social, and material conditions that give rise to them, in the light of the descriptions produced during the preceding steps.

As with the preceding steps, analysis should take place at the multiple levels identified for the technology in question. We can briefly mention some examples. At the technology level, if the subject were artificial intelligence, an ethical issue would be the potential for systems to learn bias from biased training data. For human genomics, an issue at this level would be the risk that increased knowledge of the human genome invites discrimination. If the subject were surveillance technology, an ethical issue would be the potential for chilling effects. With human enhancement technology, a potential issue would be risk of increased competition and widespread pressure to use enhancement technologies. At the product level, if the technology is social robotics, an ethical issue would be the threat to privacy. If the subject were neurostimulators, an ethical issue would be the potential for dual use. At the application level, an issue regarding genetic enhancement would be autonomy and informed consent. For autonomous weapons and military robotics, an ethical issue would be about moral responsibility and accountability in military decision-making. These are just some examples. In any actual execution of this step, the ethical issues would be more clearly identified and also situated in relation to the particular characteristics of the technological area that gives rise to the issue and make it pressing.

A challenge in this step is to comprehensively include the familiar and intuitive ethical issues to which various technologies give rise, but also to look beyond these to the novel, yet unanticipated ethical issues. There is no process for doing this that guarantees success. However, combining and mixing different methods improves the chance of identifying hidden and recondite issues. We note several methods that may be employed.

In the SIENNA project, we used surveys of the existing ethics literature on the technology, in which many ethical issues were already identified. This was, for us, a major source for locating ethical issues. In addition, we did our own ethical analysis, mostly based on our moral intutions and mainstream methods of applied ethics that we applied to topics and cases for which little ethics literature was in existence. We also consulted ethics experts other than ourselves to help us identify ethical issues that we might have missed ourselves.

We also used bibliometrics to identify and examine relevant debates that were taking place in different national, geographic, and linguistic communities. Careful searches of popular media in carefully chosen locales can uncover concerns and associated ethical issues that may not be in the mainstream international discussion or in the awareness of the researchers performing the ethical analysis.

Another method used in the SIENNA project is the systematic consideration of checklists of standard ethical issues. This is a method prescribed by the ATE approach to ethical analysis of emerging technologies.[31] A checklist, such as the one associated with the ATE approach (table 4), prompts the researcher to examine how standard ethical concerns and issues appear in the context of the area of technology under investigation. Checklists can and should be used at each of the levels of description for the relevant field of technology. Although a checklist is not the best tool for uncovering completely novel ethical issues, it offers some assurance that standard ethical issues are surveyed, identified, and documented at this step in the ethical analysis, so that they can be taken into account in subsequent steps.

- **Harms and risks**
    - Health and bodily harm
    - Pain and suffering
    - Psychological harm
    - Harm to human capabilities
    - Environmental harm
    - Harms to society

[31] Brey, op. cit., pp. 11-12.

- **Rights**
  - Freedom
    - Freedom of movement
    - Freedom of speech and expression
    - Freedom of assembly
  - Autonomy
    - Ability to think one's own thoughts and form one's own opinions
    - Ability to make one's own choices
    - Responsibility and accountability
    - Informed consent
  - Human dignity
  - Privacy
    - Information privacy
    - Bodily privacy
    - Relational privacy
  - Property
    - Right to property
    - Intellectual property rights
  - Other basic human rights as specified in human rights declarations (e.g., to life, to have a fair trial, to vote, to receive an education, to pursue happiness, to seek asylum, to engage in peaceful protest, to practice one's religion, to work for anyone, to have a family, etc.)
  - Animal rights and animal welfare
- **Justice (distributive)**
  - Just distribution of primary goods, capabilities, risks and hazards
  - Nondiscrimination and equal treatment relative to age, gender, sexual orientation, social class, race, ethnicity, religion, disability, etc.
  - North-south justice
  - Intergenerational justice
  - Social inclusion
- **Well-being and the common good**
  - Supportive of happiness, health, knowledge, wisdom, virtue, friendship, trust, achievement, desire-fulfillment, and transcendent meaning
  - Supportive of vital social institutions and structures
  - Supportive of democracy and democratic institutions
  - Supportive of culture and cultural diversity

Table 4: The anticipatory technology ethics checklist (Brey, 2012a)

Brey (2012b) also proposes different types of ethical issues to scan for at the three technology levels. At the technology level, particularly for those technologies that are defined in terms of techniques or types of systems, ethical issues tend to either inherent to the technique or type of system (e.g., gene editing technologies inherently involve manipulation of genomes, which has generated moral controversy), or are associated with general consequences and risks of developing and applying the technology (e.g., nuclear energy technology has as a consequence the generation of hazardous waste with long-term radioactivity). We can also add to this list ethical issues pertaining to the general function(s) associated with these techniques or systems. E.g., for robotics, such an issue is whether it is desirable to have systems with autonomous capabilities that can replace human function. When technologies are defined in terms of purpose or function, the ethical issues at the technology level will also include issues concerning the desirability of these purposes or functions, but in addition, one would need to identify techniques and technological innovations within the field that can be the subject of further ethical analysis regarding their intrinsic nature, function or purpose, or generic risks or consequences. When technologies are defined in terms of an application domain, like military technologies or healthcare technologies, the diversity in technologies, techniques, functions and purposes may be too great. Ethical analysis could proceed by selecting key techniques, types of systems and technological solutions, and/or purposes and functions that are then subjected to further ethical analysis.

At the product level, products can similarly be analysed in terms of inherent properties that raise ethical issues, as well as their proper function, and any across-the-board consequences and risks. At the application level, finally, ethical issues include the issues associated with the purposes for which products are used, as well as ethical issues relating to (often unintended) consequences and risks, including consequences and risks for users and other stakeholders.

Finally, more speculative methods are helpful for uncovering the truly novel ethical issues raised by a new or changing area of technology. For this, methods of foresight are relevant, in consultation with stakeholders and futurists. Careful construction of techno-ethical scenarios and analyses of these scenarios may also be useful.[32]

Relevant discipline and expertise required: The most important expertise for this step is philosophy, especially ethical theory, including familiarity with a broad range of axiological and deontic concepts across practical ethics. Ideally this includes researchers in theoretical ethics and in applied ethics (such as biomedical ethics, business ethics, environmental ethics, etc.)

Relevant use of foresight: The relevant kind of foresight here is about what moral issues will arise and how moral debates will unfold. For this, speculative scenario-building methods are relevant.

Relevant stakeholder input: Consultations and workshops with ethicists, technologists, futurists, and other members of the public may uncover unnoticed ethical issues. Consultations with members of the public regarding technology acceptance and uptake may also provide insights. For this step, less heavily structured interactions, especially with opportunities for creative input and interaction, may be helpful.

4.2. Step 6 – Analysis of ethical issues

In this step, we further analyse the ethical issues that were identified in Step 5, including those raised by stakeholders. We engage in comprehension-oriented ethical analysis. This further analysis involves, first of all, further clarifying, providing nuance about, and contextualising the ethical issues that were identified. It also essentially involves showing how different ethical issues related to each other. At this stage, we abstain from outright evaluative judgments, overall conclusions, or solutions; those (optionally) take place in the next step.

This step will involve some or all of the following: identifying different moral values that apply to an ethical issue; articulating potential conflicts between these values; identifying roles, rights and interests of stakeholders with regard to the ethical issues; identifying reasons or arguments for and against certain moral judgments. It will also involve examining and articulating the relationships between the ethical issues that have been identified, including their conflicts, dependencies, parallels, exacerbating factors, etc. Analysis should aim to unpack the evaluative significance of such

[32] Boenink, Marianne, Tsjalling Swierstra, and Dirk Stemerding, "Anticipating the Interaction between Technology and Morality: A scenario Study of Experimenting with Humans in Bionanotechnology", *Studies in Ethics, Law and Technology*, 4(2), 2010.

relationships, which should uncover some of the pros and cons of particular ways of addressing value conflicts. Again, note that this step stops short of reaching any evaluative conclusions.

A few examples point to the varieties of relationships among ethical issues that should be examined in a successful execution of this step. A familiar example is the purported trade-off between privacy and security for surveillance technologies. The use of some sorts of surveillance by security agencies may increase the security of a population, but at the cost of reductions of privacy for members of that population. However, this trade-off is anything but straightforward and manifests differently (if at all) at the technology, product, and application levels. For instance, at the product level, particular surveillance products may be designed to provide surveillance of a particular vicinity and increase security of that area, but with minimal threat to any individual's privacy. The potential trade-off also varies by domain. For instance, in the workplace, surveillance of employees may achieve an employer's goals, with no real effect on security, but with a substantial impact on an employee's privacy. Thus, analysis at the three levels enables a rich articulation of the relationship between the issues of security and privacy, with regard to surveillance technology.

For another example, with regard to human enhancement technology, consider the natural tension that arises between the value of using human enhancement technology to increase individual flourishing and the undesirability of the pressure this may put on peers to follow suit. This problem can be raised, in general, at the technology level just in terms of the basic purpose of enhancement technologies: The value for the individual of enhancement comes with the social disvalue of pressure on others to engage in enhancement as well. This general tension could be examined as a particular tension at the application level, as manifested in the domain of competitive sports. At the product level, further analysis could explain for which products this tension is greatest or least. For instance, with affective or emotional enhancement, the tension may be less severe, at least to the extent that these enhancements primarily support hedonic values and do not offer substantial competitive advantages.

To perform the ethical analysis in this step, we use instruments for ethical analysis from the field of ethics (i.e., ethical concepts, theories, frameworks, and arguments). Work by and consultation with philosophers and ethicists is essential at this stage, with their primary contributions being the ability to show how issues relate, overlap and diverge, and to draw attention to subtle conflicts and inconsistencies, or to suggest ways to navigate, manage, or dissolve apparent inconsistencies. In contrast, the actual evaluative judgments or conclusions of various stakeholder groups are not relevant for this step. Rather, the point is to establish the conceptual and empirical relationships among different sets of issues.

Note that it is difficult to avoid making some (perhaps implicit) moral judgments during this ethical analysis step, but even so, ethical analysis can still be neutral on key ethical issues, especially those that concern key value conflicts. Conflicting evaluative principles can be identified without reaching a conclusion about which side(s) to favour or how to resolve the conflict.

The output of this step could be a report organizing ethical issues into themes, showing their mutual dependencies and conflicts, and articulating any general patterns or dialectical structures that emerge. An important aspect of such a report would be an articulation of conflicts, trade-offs, or choice points that must be addressed, at each level of analysis, in order to reach evaluative or normative conclusions about the ethical issues previously identified in Step 5.

Relevant discipline and expertise required: The most important expertise for this step is philosophy, especially ethical theory and moral argumentation. Social and political philosophy, including political theory, may be relevant also.

Relevant use of foresight: Foresight methods are not especially relevant at this step.

Relevant stakeholder input: Stakeholder input may be helpful, but is not a strict requirement for this step. Focus groups may help uncover trade-offs. However, the actual judgments of various stakeholder groups are less relevant for this step.

4.3. Step 7 – Evaluation and recommendations for ethical decision-making (optional step)

In this step, we conduct solution-oriented ethical analysis. We assess arguments and competing considerations regarding ethical issues examined in preceding steps, to solve moral dilemmas and provide courses of action. While comprehension-oriented ethical analysis (as in the preceding step) may aim at better understanding of ethical issues and possible ways of resolving them, this step includes actual evaluations. Evaluation entails making and defending moral judgments regarding the moral desirability or undesirability of particular actions, persons, things, events, and outcomes. Because the ethical questions arise for the development and use of particular technologies, these evaluations will have immediate practical implications. Hence, the ethical analysis directly gives rise to prescriptions and recommendations.

We consider this step optional, because the prior steps of ethical analysis may be aims in themselves. Whether and to what extent this final step is performed, as well as the form its output takes, depends largely on the aims and scope of the overall ethical analysis, as specified in Step 1.

Depending on the scope of the analysis described in Step 1, evaluations may be required at one or more of the levels of analysis at which the technology has been described. We sketch a few examples of evaluations that might result from execution of this step, in the analysis of particular technologies. At the technology level, it may be concluded, in some cases, that an entire field of technology, or one of its subfields, should not be pursued. For instance, a possible conclusion might be that germline genetic modification of humans is always impermissible. At the product level, another set of judgments may be reached. For instance, regarding robots with visual systems, a possible conclusion might be that all robotic systems should be built to provide a clear indication of when their cameras are activated. Finally, at the application level, one might conclude, for example, that cognitive enhancement technologies should be permissible in military contexts, but impermissible outside of such contexts. These examples of particular evaluations may be incorrect, but they serve to illustrate the *types* of evaluations reached during this step. During this step, any such evaluations would be accompanied by substantial and thorough argumentation, showing that, all things considered, the evaluative conclusion can be considered superior to competing evaluations.

When reaching an evaluation requires weighing competing objectives or choosing among incompatible values, it may be difficult to find common, let alone unobjectionable, grounds for coming down on one side rather than another. At this point, stakeholder input from affected populations may lend additional normative weight favouring one among several possible evaluations. The basis for honouring this sort of stakeholder input in reaching evaluative conclusions is not morally neutral; it is itself a substantive moral commitment. However, it is in accord with widely accepted premises to the effect that the reflectively endorsed values of the people who will be affected by some development provide *pro tanto* reasons for adoption of courses of action that are consistent with those values. Such premise may be understood as expressions of democratic principles about majority rule and the legitimacy of a population's self-determination regarding policies that affect it. That said, such input must be used with caution. Members of affected populations may have reasonable moral intuitions and strong values, but they sometimes lack the specific expertise to articulate ethical principles, resolve evaluative conflicts, or thoroughly justify complex courses of action. Evaluations reached through structured deliberative forums, as opposed to just opinion surveys, may produce more helpful, robust input from stakeholder populations.

Other grounds for reaching evaluative conclusions may be supplied by evaluative principles or frameworks adopted in advance of the analysis and specified in Step 1. For instance, the SIENNA project has aimed for ethical evaluation that is consistent with broadly European values, and has also adopted a broad framework of *human rights* as a normative foundation for its evaluations and prescriptions. A limited normative anchor or foundation along these lines, in conjunction with the results of the earlier steps of the ethical analysis, and buttressed by stakeholder guidance, may provide sufficient premises for arguments that yield substantive evaluative conclusions.

Ethical decision-making and guidance may go beyond evaluative judgements by proposing comprehensive courses of action for one or more actors or proposing specific practices for navigating ethically contentious cases. Ethical decision-making and guidance involves moving from general evaluative judgments to recommendations of specific actions. This requires careful attention to the concrete situations requiring decision, action, and policy.

The appropriate form of ethical decision-making and guidance depends not only on the scope determined in Step 1, but also what other guidance already exists, and whether the existing guidance meets the needs of the current state of technological development and use. For instance, one of the areas studied by the SIENNA project was artificial intelligence. By the time that the researchers reached this final step, it was found that numerous frameworks and sets of principles for ethical AI already existed, and that adding another one would be unhelpful. Instead, more valuable would be formulation of guidance about how such principles could be operationalized, and that was the path pursued by the SIENNA project.

A typical form that ethical decision-making and guidance may take is the development of a framework for responsibilities for different actors with respect to an ethical issue or a set of ethical issues. This framework would define actors' individual responsibilities, define tools and mechanisms for supporting these responsibilities, and define specific actions that actors can or should take to meet their responsibilities. This framework could amount to specific (professional) ethical guidelines for particular types of actors. In the context of such a framework of responsibilities for various actors, one could also look specifically at the role of governments in stimulating or enforcing certain responsibilities through policy-making. That is, one can ask what policies governments should institute and what actions they should take to stimulate or require other actors to accept certain responsibilities that contribute towards ethical outcomes regarding new technologies and their applications.

Relevant discipline and expertise required: An essential expertise for this step is philosophy, especially moral, social, and political philosophy. This step also requires collaboration between ethicists and those who design policy, including governmental legislators, organization executives, members of professional bodies, or attorneys.

Relevant use of foresight: At this stage, a further round of impact assessments may be appropriate to anticipate and evaluate the possible outcomes of the policy alternatives under consideration.

Relevant stakeholder input: For this step, a range of stakeholder input is relevant. Surveys and panel discussions are relevant to eliciting the values and intuitions of members of populations that may be affected by the relevant area of technology. More intensive deliberative forums may be suitable for generating more sophisticated evaluative principles that remain acceptable to broad sectors of the relevant populations. Finally, it is essential to solicit and use input from those parties that will be charged with implementing and administering any decisions or policies adopted. In case of legal recommendations, input from those who would enforce new laws is essential.

5. Methods for the inclusion of foresight analysis

This section identifies foresight methodologies which are especially suited to each step in the research process detailed above. However, there are many well-known methodologies which can be used at any step, such as expert panels, literature reviews and bibliometric analysis. Such methodologies are, for the most part, suited to any form of research rather than being specifically designed for foresight analysis. The methodologies listed below can all draw data from, or interact with, these well-known methodologies. It is not the purpose of this section to provide detailed instructions on how to perform any methodology, merely to suggest some foresight methodologies which are especially suited to the requirements of each step. The methodologies discussed here have been selected because they are relatively uncomplicated, do not require specialist training, are especially suited to ethical analysis and can be used on projects of any size, including work by a single researcher. At the same time, most can be taken to highly sophisticated levels and are therefore also well suited for large projects. In other words, we have tried to identify the methodologies most suited to the widest possible range of projects. Table 5 lists the methodologies recommended for each step in SIENNA's ethical analysis approach.

STEP	RECOMMENDED FORESIGHT METHODOLOGY
Step 1: Specification of subject, aim and scope of ethical analysis	Environmental Scanning
Step 2: Stratification of the subject of ethical analysis	Environmental Scanning, Relevance Tree
Step 3: Description of the subject of ethical analysis	Science and Technology Roadmapping, Multiple Perspectives
Step 4: Identification of potential impacts and stakeholders	Environmental Scanning, Technology Roadmaps
Step 5: Identification and specification of potential ethical issues	Environmental Scanning, Technology Roadmaps, Futures Vision
Step 6: Analysis of ethical issues	N/A
Step 7: Evaluation and recommendations for ethical decision-making	N/A

Table 5: Recommended foresight methodologies

5.1 Issues common to all ethical foresight analysis

Databases. Good database design is the foundation of any foresight research project. However, this does not mean all projects need large complex database systems. At the simplest level, Microsoft Excel and Open Office Calc offer sufficient functionality, while Microsoft Access and Open Office Base represent the next step up in capabilities. Not all spreadsheets can serve as research databases. A spreadsheet needs to be capable of linking to external documents, annotating cells with comments, and support formulas which can search text. It may also need to support a programming language of some form if repetitive but complex tasks are required. Databases will also need specific features or usages for some of the steps below. It is important database designers understand not just what data will be stored, but how it will be used.

Data Sources. A primary axiom of foresight research is that the future is unpredictable.[33] Foresight studies are not predictions of what *will* happen, but what *might* happen. In most studies, the more likely it is that something will occur, the more important it is. This is not the case with ethical foresight

[33] Bell, *Foundations of Future Studies*.

analysis. Probability must be weighed against ethical importance. An ethical issue which is almost certain to occur, but which will only affect one person, is much less important than an issue which would affect the entire human race, but which has a small chance of arising. In addition, technology evolution is often significantly affected by "disruption." This occurs when an individual invents something new which no one anticipated, or when external events, such as wars, cause rapid changes in the direction of technological innovation. It is therefore important that data is selected from a wide range of sources, not just formal research activities. This also means it is possible the range of issues found may overwhelm a small project. Some of this can be handled by changing the scope or objectives of the project, which is a key task in Step 1 (below). In other cases, it will be necessary to prioritise by cross-referencing estimated probability against ethical importance in Steps 4 and 5 (below).

Literature reviews. There is a tendency for academic researchers to restrict their literature searches to peer-reviewed journals. This is dangerous. The vast majority of emergent technologies do not emerge from universities or similar research establishments. To count as "emerging" a technology must at least have reached the status of prototyping commercially deployable applications.[34] Thus, the majority of emerging technologies originate from commercial organisations with no obvious academic connections. When designing the parameters for literature reviews, consider material from commercial sources, such as trade magazines, PR statements, commercial conferences, social media, investment companies and patent applications.

5.2 Step 1 – Specification of subject, aim and scope of ethical analysis

Every project starts as an idea. This idea will include some definition or description of the technology of interest. Before research can commence the parameters must be set which guide the gathering of data, such as timeframes and key terms, which determine what data will be obtained. However, one cannot assume the initial, unresearched, parameters and technology definition exactly match the aim of the project or the topic of interest.

The aim of foresight analysis in Step 1 is to test the incoming data to see if it matches what is needed. If it does not, parameters can be adjusted until data fits the project's needs.

Recommended Methodology: Environmental Scanning

Environmental Scanning

Environmental scanning[35] involves using experts or expert groups to assess the data being produced. It does not matter what methods are being used to gather data. Experts, usually the project researchers (possibly with some stakeholders) evaluate the suitability of the incoming data. The evaluation is then used to refine the data gathering process. The new data is once again evaluated. This process is repeated until the data being produced accurately reflects the subject of the research. *At this stage there is no attempt to use the data itself, merely to ensure it is the right data for the project.*

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[34] Dainow, "Threats to Autonomy from Emerging ICTs"; Stahl, "ETICA Report Summary".
[35] Also called 'Futures Scanning Systems', 'Early Warning Systems,' 'Futures Intelligence Systems' and 'Collective Intelligence.'

Historically, environmental scanning has been used by corporations and governments to maintain a watch over a wide technology domain in order to spot new (unanticipated) trends. It therefore does not depend for its efficacy on the initial technology identification in Step 1, but allows for surprises. It is therefore ideal for validating or refining the initial characterisation of the technology prior to using the characterisation to gather data.

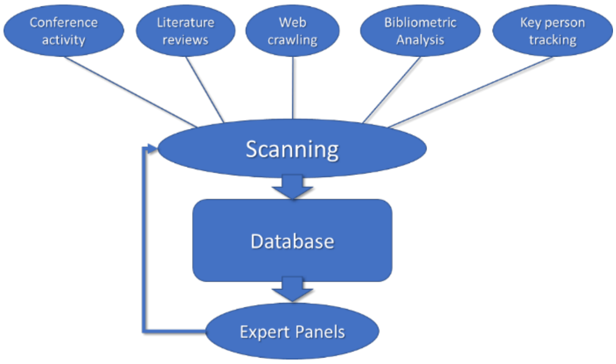

Figure 3: Environmental Scanning combines multiple techniques to create a cycle of analysis and refinement.

For example, estimated time-lines for the deployment of self-driving vehicles from 2010 through to 2019 have now been shown to be wildly optimistic. Researchers set time scales by evaluating the progress of AI development within the self-driving cars themselves, and estimated they would be in wide use within 5-10 years.[36] These estimates were based on the development of the technology of the cars themselves, and did not consider necessary changes required of the environment around the cars, such as the infrastructural changes required, the difficulties of creating regulation, or the degree to which efficiency of self-driving cars was dependant on particular road usage patterns (for example, self-driving cars are extremely bad at detecting bicycles).[37] If time scales had been evaluated by experts in these areas, such as legal scholars, urban planners, sociologists or even those involved in traditional car industry, the projected time scales for wide use of self-driving cars would most likely have been significantly longer.

Environmental scanning focuses on the validation of the following processes:[38]

1. Criteria by which to search for data.
2. Searching or screening information resources.
3. Selecting information to scan.
4. Assessing, validating and refining search criteria based on what is found.

Any methodology which produces information about the nature of the technology or its trends can be used. However, not all methodologies have been formally evaluated in this respect. The methodologies which have been shown to work effectively together for technology identification are:[39]

1. *Literature reviews.* There is nothing unique to ethical foresight as far as literature reviews are concerned. However, it is important to note our recommendation (above) not to restrict the scope of the source literature too early. It is better to filter material out and narrow the parameters if

[36] Gomes, "When Will Google's Self-Driving Car Really Be Ready?"; Kelly, "Self-Driving Cars Now Legal in California".
[37] Alqatawneh, Coles, and Unver, "Towards the Adoption of Self-Driving Cars"; Stilgoe, "Self-Driving Cars Will Take a While to Get Right".
[38] Renfro, *Issues Management in Strategic Planning*.
[39] Gordon and Glenn, "Environmental Scanning".

irrelevant material is being produced. If parameters are too narrow at the start of a project, one may not later discover valuable information that has been missed at this stage.

2. *Bibliometric analysis.* During Step 1, bibliometric analysis is evaluated in terms of the sources it identifies. Any potential source of written data can be subject to bibliometric analysis. Bibliometrics is most useful to identify sources which can be used for literature reviews and other analytic purposes later in the research. Since the main sources of technology development have not been validated at this stage, industry material should be included. For example, patent registrations can be analysed.[40] Bibliometrics can also be used to track commercial activity by trawling investor announcements, company annual reports and so forth. The aim is to develop "word clouds",[41] statistically weighted clusters of relevant terms which can then be used to identify other sources which can be used for technology definition.

3. *Web crawling.* Search systems which "crawl" the web can be used to identify items of interest. Web crawling requires optimised search terms, which can be drawn from bibliometrics and literature reviews. However, it is important to recognise the limitations of all such systems. Systems like SCOPUS are restricted to peer-reviewed literature, while public search engines such as Google are not designed for comprehensive searches. Google search personalises the results based on the user.[42] Steps should therefore be taken to de-personalise Google search. In addition, Google ranks websites according to many "peripheral" factors, such as font, layout and artwork[43] and cannot be relied upon to deliver the most relevant results. Furthermore, Google does not, and has never claimed to, index all the world's web pages. Estimates are that Google lists no more than 5% of the world's web pages.[44] Should budget permit, dedicated web crawlers should be constructed which search for new sites or use de-personalised criteria for assessment.

4. *Key person tracking.* Particularly in its early stages, many technologies have their evolution driven by a limited number of people. Identification of key individuals within a field should commence with those who have a reputation of expertise or significant "drivers" of technology, such as important investors and inventors. At this stage, it is more important to locate individuals who understand the technology *trends* than to locate experts within the technology itself. It is therefore important that key person tracking is not reflexively limited to academic researchers. Many technology areas have specialist investment firms whose existence depends on accurate predictions of technology developments. They are, in effect, professional foresight companies whose accuracy has been validated by their financial success. Their market predictions and investment patterns can indicate important trends in emergent technologies. Many leading industry figures have strong presences in social media. Social media keyword systems can track their activities and also scan social media sources for discussions using those terms.

5. *Expert panels.* The aim of environmental scanning is to review the entire published environment relating to a technology, not draw detailed information from a particular source. The above techniques are used to compile an initial database of source material. However, once they have produced the first dataset, this data is analysed in two stages. Firstly, results are compared with the initial project parameters. The first concern is to determine whether the definitions of the technology accord with the manner in which data sources, such as literature, define the technology. It may be that other terms are used, or that some features which were initially considered necessary for the definition are in debate. A more detailed analysis of the source data

[40] Kim, Suh, and Park, "Visualization of Patent Analysis for Emerging Technology".
[41] Heimerl et al., "Word Cloud Explorer: Text Analytics Based on Word Clouds".
[42] Horling and Kulick, *Personalized Search for Everyone*.
[43] Dainow, "173 Rules for Improving Your Google Listings".
[44] Schwartz, "Google: We Never Index All Your Pages".

may therefore reveal important nuances in a technology which affect the definition of it, and consequently affect which sources are relevant. Similarly, the temporal scope may need to be adjusted if initial analysis reveals unanticipated factors affecting the pace of development. The role of the expert panel at this stage is to review the material which the analytic methods are producing in order to determine whether the right data is emerging. Expert panel selection for this purpose need not be comprised of experts in the technology, so much as those who understand the purposes for which the data will be used within the project. Ideally, the expert panel should combine both.

Other considerations

Database design. Environmental scanning requires that one can tell where an item of data came from. It is therefore important to document the parameters of the search which produced the source. For example, each item retrieved through web crawling or bibliometric analysis should record the terms and logic used which resulted in its discovery. The algorithms driving bibliometric analysis should be fully documented in case they need refinement. The aim of the human review is to ensure the data being obtained accurately reflects the technology in a manner which suits the project's objectives. For example, if the project does not intend to consider legal issues, but bibliometric analysis is producing legal data, the search terms driving it need to be refined.

Methodologies to use. The only required methodology within environmental scanning is the human assessment of the incoming data. The methodologies we have discussed above are not the only ones which can be used with environmental scanning, they are merely ones which have been proven effective.

Scalability. It is not required that multiple methodologies are used to gather data. Budgets and other limits may preclude the use of multiple methodologies. In addition, the nature of the concerns may not justify such extensive research efforts. Conversely, more methodologies may be used, such as public surveys or Delphi. While we have discussed the use of expert panels, a single person can perform the evaluation role. Here it is simply important the panel or individual possess both knowledge of the technology and understanding of the project's objectives. Environmental scanning is therefore well suited to research projects of any scale.

Evaluating expert panels. Expert panels are often used to produce foresight research data or set the parameters of a project. For example, an expert panel could be used to define the technology and set time scales. If this is the case, the output from the expert panel needs assessing by other experts within the project. It could be the panel has misunderstood the project objectives, or that they provide too much, or too little, nuance. For example, we indicated above the over-optimistic timescales for self-driving cars by experts within the self-driving car development community. An evaluative group within the project could have questioned these and recommended changes in the expert panel, such as the addition of urban planners.

5.3 – Step 2: Stratification of the subject

When seeking to comprehend ethical issues, technologies are best understood as socio-technical systems. They cannot be understood as mere collections of devices because ethical issues only arise when the devices interact with people (and possibly the environment). People determine how devices enter into society and how they are used. Most technologies can be used to produce both positive and negative ethical effects. Furthermore, technologies have a complex nature, stretching from a single foundational theoretical basis through to multiple individual artefacts operationalised within social, commercial, cultural and political mediation. In order to understand this range of factors, it is necessary to organise the technology into some form of ontology or schema. Our methodology uses Anticipatory Ethics for Emerging Technologies (ATE)[45] to create a 3-level ontology.

The aim of foresight analysis in Step 2 is to organise the data in order to make analysis possible.

Recommended Methodologies: Environmental Scanning and/or Relevance Tree

Environmental Scanning

If Environmental Scanning has been used in Step 1, it should be used in Step 2. However, the experts consulted may need to change. The role of the expert panel in Step 1 was to ensure the data being gathered suited the project objectives. The role of the expert panel in Step 2 is to assist in the organisation of the technology description into the ATE framework. This can proceed through an initial organisation by the researchers, followed by panel evaluation, or the panel can organise the technology directly. The structure of the database holding the data can be important for this work. It should permit editable annotation of data items. If budget supports the effort, the database should permit cross-referencing of data items so that it becomes possible to programmatically pull together evidence supporting each element of the ATE framework, or quickly list data items pertaining to a particular level. Most database systems will provide such capability, but will require structuring by a database administrator to the format desired by the project.

Relevance Tree

This method involves the creation of a schema organising the structure of the technology domain. Because relevance trees are traditionally used to organise a topic into increasingly smaller subtopics, it is ideal for the organisation of a technology into the layers required for ATE. Relevance trees are usually pictorial representations of a hierarchical structure displaying the way a topic is subdivided into increasingly finer levels of detail. In this case, the pictorial representation is created by mapping aspects of the technology onto the ATE layers. Relevance trees often support other foresight methodologies, especially morphological analysis and scenario construction.[46]

Creating a relevance tree involves the following steps:

1. Formulation and definition of a problem. *This was achieved in Step 1.*
2. Characterization of all aspects of the technology in an unsorted list. *This was achieved in Step 1.*
3. Conversion of the list into a series of levels and groups. In the case of ATE, this will be a 3-level relevance tree.
4. Simplification of the relevance tree by combining items within each level to the maximum degree possible.

In terms of the overall project process, relevance trees are a way of annotating the data for later analysis. They are not intended to provide new data. Annotation of each data item is the most efficient way to do this.

[45] Brey, "Anticipatory Ethics for Emerging Technologies".
[46] The Futures Group International, "Relevance Trees".

The process proceeds as follows:

1. Each item of data describing the technology is annotated with the relevant ATE level to which it pertains (technology, artefact, or application).
2. All items allocated to the Technology level are combined to form a single description of the technology. This must be done by humans. It can be done, or reviewed, by expert panels.
3. All items allocated to the Artefact level are combined until there are only a small number of them. It is not possible to predict the exact number in advance. This will be influenced by the scale of the project and the degree to which analysis will focus on the Artefact level. There will come a point at which it is not possible to combine artefact descriptions without generalising them to such a degree that the unique distinguishing characteristics of the artefacts become lost. To combine further would then result in technology level descriptions. Once this becomes a danger, artefacts have been combined to the maximum degree possible. Should the scale of the project not permit analysis of all the artefacts, or the objectives not require it, artefacts can then simply be identified as outside the scope of the research.
4. All items allocated to the Application level are combined in a similar way to those of the Artefact level. The same concerns for scope and budget apply to this level as with the Artefact level. Furthermore, this system permits artefacts to be defined in multiple, incompatible, ways. For example, some artefacts can be organised by their usage in society, while others are described by their functionality. The same item of source data could support both approaches and be used by multiple defined artefacts. This permits the same data to be accessible via multiple routes, according to the purpose of the analysis.

Relevance trees have been proven effective for organising large quantities of raw data. They were used extensively (and successfully) in the ETICA project to define eleven emerging technologies from an initial list of over 140 technology descriptions drawn from bibliometric analysis and literature reviews, and to organise the individual descriptions gathered.[47] The ETICA database was designed so that ethical concerns could be further annotated onto the data items, permitting the relevance tree to be used at later stages of the project when ethical issues were considered.

Other considerations

Database design. Unless the project is very small, a database is essential and must be designed for this type of work. Each item of source material must be annotatable. Annotations must be distinct, so that they can be categorised and sorted. For example, the system must be capable of listing all data items pertaining to a specific level or a specific artefact or application. Conversely, for any given item of data, the system must be capable of listing all the levels, artefacts or applications to which it pertains. It is possible some data items will discuss enabling technologies relevant to multiple artefacts or applications, or characteristics which are shared by many artefacts. Further annotation will be useful once the project commences analysis of the data, such as relevant ethical issues. The database should be able to generate lists or tables of relevant items. To aid this, annotations should themselves be characterised in a manner which supports the project. For example, an annotation could be characterised as "ATE level attribute" or "ethical issue identification". This will permit the system to produce lists of annotations of interest. Any database will be capable of doing this, but must be designed with this usage in mind. It is important that database designers understand that while annotations are data to be held in the database, they are different type of data from the source material being annotated and will need to be indexed and queried in a different manner from the

[47] Ikonen, Kaneva, and Kouri, *D.1.1 Heuristics & Methodology Report - Final*.

source data. In other words, database designers need to understand that annotations of data are themselves also items of data. They will themselves need indexing and searching as well as being used as keys for indexing and searching source data. On the other hand, the database need not be large or expensive. For example, a sophisticated spreadsheet, such as MS Excel, which supports SQL query language and programming, can handle such a task in small-scale projects. Assuming one has a basic knowledge of MS Excel, the skills required to do this can be learned in a 3-4 day Advanced Excel training course.

Methodological neutrality. Relevance trees annotate and organise pre-existing data. They are therefore unconcerned with how that data was acquired and can be used with any data-gathering methodology.

Morphological Analysis. Relevance trees are often used as the first step within morphological analysis. It is so rare to use morphological analysis without relevance trees that many accounts treat them as one and the same methodology. However, relevance trees are simply ways of organising large amounts of qualitative data. They are, effectively, just annotation systems and can therefore any methodology which produces data. Morphological analysis is well suited the development of ATE schemas, but is too complex to describe here. Morphological analysis is usually conducted by expert panels guided by a trained morphological specialist.[48] It is therefore unsuitable (and probably unnecessary) for small research projects.

Scalability. Relevance trees do not demand minimum or maximum amounts of data. The degree of effort required is proportional to the amount of data being gathered. They are therefore well suited to small-scale research programs. In small projects, spreadsheets can handle the data and annotation requirements. It can even be done manually with index cards and post-it notes. The larger the project, especially in terms of the number of researchers, the more planning will be required for the database. Their proven ability to pool large volumes of data into a limited set of annotations makes them highly suitable, almost essential, for larger research projects.

5.4 – Step 3: Description of the subject of ethical analysis

Step 3 produces a forward-looking description of the technology. It is at this point the technology is described in detail, using the results of the previous steps. It may also seek to map the steps leading from now to the future and possibly estimate probabilities. This map into the future is not essential in every project, but is customary and frequently useful. It is a fundamental axiom of foresight analysis that the future cannot be predicted with certainty. Every description of a future is therefore nothing more than a description of possibilities. Assessing the importance of any given ethical concern must therefore consider the probability of the concern coming to pass. If the impact is due to universal and essential characteristics of the technology, that probability is relatively high. However, most issues of concern will be the result of decisions made in the future or the outcome of interacting factors which have yet to interact. Such issues therefore have different probabilities of arising and these must be considered when assessing ethical concerns. In addition, if the aim is to recommend ways of avoiding these issues, it is essential to know what needs to change in the future so as to push the path of technology development away from these unwanted destinations.

[48] Ritchey, “Morphological Analysis”.

Recommended Methodologies: Science and Technology Roadmapping with Multiple Perspectives

Science and Technology Roadmapping

A science and technology roadmap describes how a technology will develop from its current state of affairs to the final destination of concern. It shows the major steps in the development, deployment, and then operation of the technology. These steps are most likely to be moments of interaction between the technology's features and its social context.

Program Evaluation and Review Technique (PERT) charts are ideal for technology roadmapping and by far the most commonly used.[49] A PERT chart depicts the steps leading to the final state of affairs. A PERT chart can depict alternate pathways, identify critical "milestones" which affect timing, understand the resources required for each step in the path and the impact the availability of those resources will have on technology development. PERT software usually contains extensive functionality for automatically calculating resource usage and the impact of changes in elements of the path. Sophisticated PERT charting software can work with probabilistic estimates and multiple branching paths. Some PERT systems can handle thousands of variables producing hundreds of potential pathways.

A science or technology roadmap involves constructing a chart which displays events and other relevant factors, such as resource requirements, timeframes and interdependencies. Not only does this provide a map to the future, it allows for analysis of the impact of changes – either in the technology or in the external factors surrounding it. If the paths connecting the nodes of the path are assigned probabilities, they can be used to forecast the steps that will be achieved and the nature of the course to a goal. The paths between nodes may also be used to indicate timing between one step and the next, providing the ability to estimate the timing of technology development.

The U.S. Department of Energy has been a major developer of technology roadmapping. It describes three types of technology roadmaps.[50]

- A *product* roadmap showing the steps from the present to a final product.
- An *emerging* technology roadmap showing how a technology is evolving focusing on factors which could change the course of the emerging technology.
- An *issue-oriented* roadmap in which the technology is displayed in the network as one or multiple steps in the emergence of an issue.

Sophisticated roadmaps may be used to access source data. Each node or resource can be linked to relevant source data. The roadmap then comes to form a visual representation of the data. However, roadmaps need not be complex, as the example below illustrates:

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[49] Barker and Smith, "Technology Foresight Using Roadmaps".
[50] Bray and Garcia, "Technology Roadmapping: The Integration of Strategic and Technology Planning for Competitiveness".

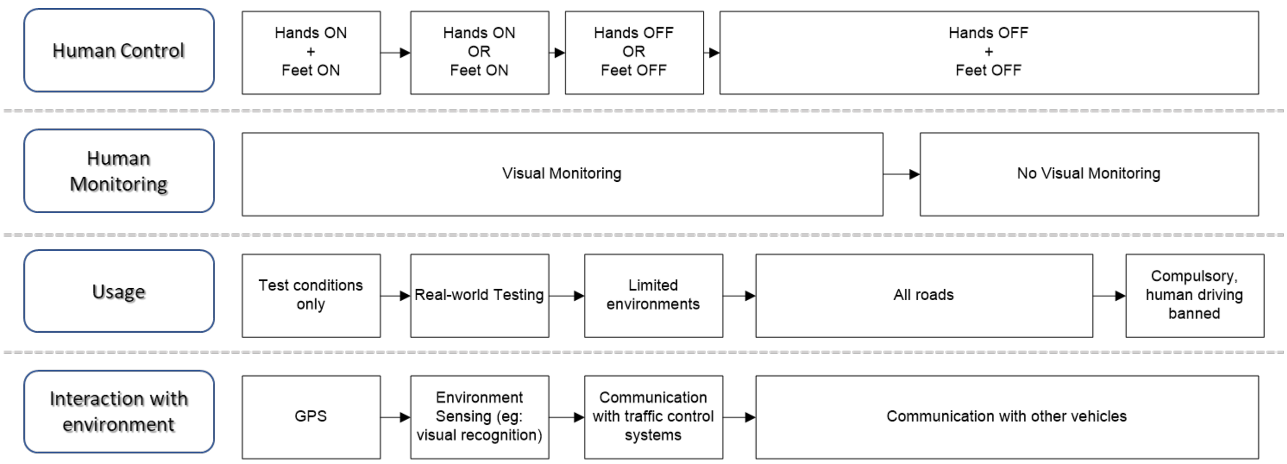

Figure 4: Simple Technology Roadmap for Self-Driving Vehicles

A PERT roadmap is more sophisticated and is primarily a diagram of interconnected nodes. The lines connecting the nodes can also carry information. For example, the lines might represent the number of citations made by one node of another or to represent the linkages as one technology functions as a resource for another. Alternatively, the lines can carry information about probabilities that one node will lead to another.

Construction of a roadmap involves the following steps:

1) Identify the nodes.
2) Specify the node attributes.
3) Connect the nodes with links.
4) Specify the link attributes.

Because much of this work can be complex and may need to process a large amount of data, it is usually undertaken by groups. However, this can require extensive labour and a wide range of expertise. Furthermore, the appropriate expertise may not be fully known until roadmap has been fully constructed. An iterative roadmap development process may therefore be advisable. Under this process a "top-level" roadmap is first developed. Individual nodes and connections can then be developed in more detail, possibly with different groups or individuals. The process of roadmap development allows the process of constructing the roadmap itself to function as a guide to research tasks. For example, if a node is seen as important in the first round of development, this can trigger research into that node in order to define it adequately in the final diagram.

Other considerations

Scalability. Roadmaps are very scalable. The amount of work required to create one depends on the amount of source data and the detail in the final map. More detail and more data does not automatically make for a better roadmap. A roadmap's value in this respect is determined by its usage. Simple project management software or other system for generating basic PERT charts can provide adequate roadmaps, while expensive and sophisticated software can handle thousands of pathways with probabilistic connections. Roadmapping is a very popular form of planning in many fields, so there are numerous online systems which can generate roadmaps without needing to invest in any software at all. Almost all PERT mapping systems can programmatically adjust connections, times and nodes when the operator changes a preceding factor or resource. This type of software is in wide use in many fields for project management purposes, so recruiting people skilled in even highly sophisticated PERT chart construction is relatively easy.

Methodological neutrality. The source data for a roadmap can come from any methodology at all. Databases designed for relevance trees are extremely suitable, especially if the PERT chart software can link directly to the source data.

Multiple Perspectives

Multiple perspectives works from the premise it is not possible to understand the future of a technology purely by looking at the functional elements of the technology itself. Instead, understanding requires knowledge of the social context and the impact of important individuals. It arose from analysis of government and corporate decision making in moments of crisis, which found that decision makers frequently took too narrow a view of the issue. Multiple Perspectives is a methodology designed to ensure a wider view of the technology is used.[51] It is an effective antidote to technological determinism[52] because it forces consideration of technologies as techno-social systems. It is particularly effective as a way to structure expert panel discussions, develop scenarios and future visions, and assist in roadmapping future technology pathways.

Three perspectives are used:

Technical perspective. The technical perspective is characterised by an implicit assumption of reductionism - that technologies can be understood as the combination of a set of ontologically lower functional components. This works well for technologies within restricted contexts, such as a factory. However, this approach becomes less effective the more people affect the operation of the technology. The technical perspective has difficulties with "broader" technologies, such as those with widespread usage across multiple sectors of society. When applied to ATE, the technical perspective is most useful for characterising artefacts.

Organisational perspective. While the technical perspective is focused on the functional characteristics of a technology, especially at the artefact level, the organisational perspective is primarily focused on power dynamics in society. The organisational perspective recognises that how a technology is used, and especially the ethical impact thereof, is significantly influenced by the organisations which use it and the responses of other organisations around them. Thus, the organisational perspective focuses on *processes*, especially processes of deployment and use. It allows for factors such as the conflict between budgets and features during creation of a technology, or between organisational power structures and governance requirements. The organisational perspective also provides an opportunity to consider the ways in which different cultural settings may affect the way artefacts are deployed or ethical concerns perceived.

Personal perspective. The personal perspective considers the role of influential individuals. This allows for the important effect a significant individual, such as an inventor or investor, can have. Of particular importance for roadmapping and other predictions of paths to the future, the personal perspective recognises that technologies can be significantly influenced, if not determined, by influential individuals. Perhaps the clearest example of the importance an individual can have on the evolution of

[51] Linstone, "Multiple Perspectives".
[52] The fallacious belief that the social effects of a technology can be predicted purely from its functional or engineering characteristics and that how people understand or use it has no impact on its ethical effects. (Wyatt, "Technological Determinism Is Dead; Long Live Technological Determinism").

a technology is seen in Thomas Edison's invention of the lightbulb. Having invented the device itself, he turned his attention to its commercialisation. Edison needed a way to power lightbulbs that was not only affordable but also easily available. So he created the electricity industry. He invented or acquired all the necessary components of the world's first electricity grid; light sockets, switches, fuses, insulated wiring and electricity meters and fused them into a single, integrated system. He then needed a limited area of high-value customers which offered a sufficient mass market for these products to justify the cost of creating this system and to keep the cost of electricity low enough to be affordable. He identified Manhattan as suiting these requirements and launched the world's first electricity industry in Lower Manhattan in 1882.[53] Understanding the engineering aspects of technology of electricity or the lightbulb would not have revealed this path. Nor would understanding the social, organisational or political context of the time. His electricity system did not emerge from either. Only by understanding Edison's own plans and commercial priorities would it have been possible to predict such developments.

The personal perspective is not applicable to all technologies. It depends on their origin and state of development. For example, genetic engineering has arisen as the result of the evolution of a discipline, not a single invention, with many organisations entering into the field simultaneously. Consequently, no single individual has a significant influence on the development or use of the technology. By contrast, many social media systems, such as Twitter and Facebook, were created by individuals and those people continue to control the use and development of some of the more popular of these technologies. Their perspectives, as seen in press interviews and management decisions, are fundamental to understanding the future path of their technologies.

Combining the perspectives

Each perspective is used to develop some aspect of the description of the technology. The technical perspective focuses on the components of a technology, its resource requirements and other material needs, its functional capabilities and purpose. The organisational perspective looks at the cultural and/or organisational setting in which the technology is used. The importance of the personal perspective depends on the project, the technology and its stage of development. For example, in its early years, Google's development path was strongly controlled by the inventors of Google search, Larry Page and Sergey Brin. Once the company reached a certain stage of maturity, especially once it floated on the stock market, their individual influence was overpowered by the organisational aspects of the company, and with some fluctuations in aims and values.

While many technologies start as inventions by one or a small group of people, for the technology to have significant ethical effects it must be deployed and operated by organisations. When setting roadmaps from the technology's current state to the time of ethical concern, one must therefore anticipate the time and nature of the switch from the personal to the organisational perspective. Many analysts consider the shift from personal to organisational perspective to be signalled by the company's launch onto the share market. Technology assessment therefore often focuses on the technical perspective at the early stage, the personal perspective during prototyping and early deployment, and the organisational perspective in the latter stages.

Multiple perspectives are created by expert panels able to work with all perspectives. This usually requires individuals from a variety of backgrounds. The organisational perspective may call for legal,

[53] Cardwell, *The Fontana History of Technology*.

economic, political or business expertise, while an engineering background is best suited to the technical perspective. Interviews can be used to bring the personal perspective, as can examinations of documents outlining ambitions and plans by important individuals.

Other considerations

Scalability. The multiple perspectives approach is not suited to very small research projects. It calls for expert panels composed of a combination of backgrounds, and so is unlikely to be possible in groups smaller than six people. Often understanding the organisational perspective requires extensive interviews within a number of organisations and so requires considerable resources and time.

5.5 – Step 4: Identification of potential impacts and stakeholders

The descriptions of the technology developed in Step 3 become the basis for determining impact the technology will have and on whom. By this stage in the process, the technology should be understandable as a stream of changes, many of which will have personal, social, environmental, political, economic or other effects. Effectively, Step 4 is the annotation of the technology's projected evolution with the effects that evolution can be predicted to generate.

Recommended Methodologies: Environmental Scanning with Relevance Tree

We recommend the following approach:

1. *Environmental scanning of source material.* At this stage of the process the expert panel reviewing the material should possess expertise in social impacts. Such people may be sociologists, experts in business or government, legal scholars and the like. Technologists may be included, but it is important to recognise this step is not about the technology itself, but the *effects* of the technology. Source material is identified which discusses such effects. The expert panel use a database, possibly a relevance tree, to annotate any source material discussing an impact, so as to indicate what that impact is.
2. Following the methodology used in Step 2 to organise the technology into the three layers of ATE, impacts are similarly organised into the 3 ATE layers by a process of combination and summarisation. Many of the source data items will already be allocated to their appropriate ATE level. However, impact annotation should not assume any single effect will be limited to the same position as the source data from which it is drawn. Many impacts will be shared across all levels. The aim here is to determine the highest possible level for each effect. This determines whether an effect is inherent in the technology or simply the result of specific artefact designs or particular usages. This determines the scope of any particular effect.
3. If a technology roadmap has been developed, this should now be annotated with the impacts. Typically, impacts are treated as nodes rather than linkages. Using a PERT chart allows for tracking the interaction between effects. It may be that one effect only arises if another arises first, or that effects are dependent on particular paths being followed as the technology develops. Doing this will identify whether an issue is inherent in a technology or artefact's functionality or whether it is a possibility (which depends on decisions made during the evolution of the technology). If a sophisticated PERT system is being used which can handle probabilities, putting the effects onto the chart as nodes will also indicate the potential likelihood of each ethical issue arising. This can be used to control research scope if the number of individual issues exceeds the resource capacity of the project. By determining impact, those who will be affected by the impact become identified. It is possible these stakeholders will already be participants in the research project, but it is also possible new stakeholders will be

identified. If this is the case, and if budgets permit, these stakeholders should be drafted into the expert panels and the cycle repeated.

4. A relevance tree can then be created identifying the effects of the technology. If a relevance tree is already being used for technology description, and the database design permits, it can be used to generate an "impact" relevance tree mirroring the description relevance tree. Alternatively, an impact relevance tree can be generated from the technology roadmap. It is important to generate some form of top-level summary of the impacts so as to facilitate communication of project concerns and findings.

5.6 – Step 5: Identification and specification of potential ethical issues

Ethical foresight analysis assumes that the effects of a technology can have an ethical dimension. The aim is now to derive the ethical effects from the impacts of the technology determined in Step 4. We separate these two aspects into discrete steps because sometimes the ethical effect is caused by the combination of multiple impacts. Furthermore, as indicated in the overview, the skills of anticipating impacts and the skills of assessing ethics are different and so each step requires different expertise and therefore different people. It is therefore most efficient to first clearly map out all the impacts and then analyse them for ethical concerns as two discrete processes.

Recommended Methodology: Technology Roadmap, Relevance Tree

By this stage in the process, the technology has been defined and a roadmap into the future has been developed which includes the effects of the technology. If a technology roadmap has been developed with impacts, those impacts should now be annotated with their relevant ethical issues. A relevance tree is thus created containing the ethical issues. If a relevance tree is already being used for technology description or impact assessment, and if the database permits, it can be used to generate an ethical relevance tree mirroring the description relevance tree. Alternatively, an impact relevance tree can be generated from the technology roadmap.

This technique was used in the ETICA project. The project's relevance tree contained source data which discussed an impact had been annotated with the type of impact described in the data item. A second set of annotations was then added identifying the ethical issues of these effects. In other words, "ethical annotations" were added to "impact annotations." The relevance tree data can then be analysed to combine the ethical issues as much as possible so as to create a structured schema of ethical issues.

The ethical data can then be used to organise the ethical issues for analysis. Databases can, for example, count the number of times each ethical issue occurs in order to determine its importance, or the volume of source data available about it. This data should then be reviewed by an expert panel *within* the project. The aim here is to determine whether sufficient data on each ethical issue exists for an analysis of the depth and scope required by the project's objectives. This panel can also assess the number of issues to determine if they can all be accommodated within the project's budget. Some issues may be eliminated because they are deemed improbable or too minor, while others may be unsuitable because their complexity requires time or resources the project cannot afford.

By the completion of this step the project should have a fairly detailed description of the technology and an extensive list of individual ethical issues.

Other considerations

Conflicting terminology and perspectives. Multi-person ethical research projects can encounter difficulties in terminology by which to designate ethical issues. Researchers should not be permitted free choice of terminology when identifying issues because this may result in different researchers using different terms for the same thing. This is especially the case where different researchers have differing philosophical approaches or beliefs. Lists of terms for ethical issues should be centrally created to which researchers should be encouraged to comply. If systems permit, researcher annotation should not be in the form of free text, but by forcing them to select from a limited list. This ensures the same terms are used by all, and permits automated process for indexing, counting and search purposes. Developing such lists is best accomplished by discussion, for example, in a workshop or through chat facilities. This process will also expose philosophical differences regarding ethical issues and may even expose different understandings of the project's objectives. For example, the development of commercial services from a technology may be termed "monetisation" by a capitalist and "exploitation" by a Marxist. The capitalist is likely to regard monetisation as ethically positive while the Marxist may regard exploitation as ethically negative. This is especially likely where social effects are being examined which will produce changes in social or political structures. If multiple people are involved in the project, especially if they will independently produce their own findings, failing to get a shared perspective on ethical issues risks the project producing conflicting or contradictory outputs. Some projects allow researchers to comment on each other's annotations, so that each data item records the discussions and positions of different researchers. These can be used in later reports to justify particular attributions of ethical issues. Developing shared terminology and ethical positions ensures that all researchers can work within a common perspective. This increases the chance in large projects that reports from different researchers are coherent with each other and limits scope for contradiction.

Scalability. Identification of ethical issues is mapped onto the previous output from Step 4 because issues are mapped to effects. Whichever method was used to fully define the technology and its roadmap will therefore be appropriate for ethical identification.

At this stage the project will have a list of effects and ethical issues. However, this may be hard to grasp as a whole, especially for people outside the project. We therefore recommend an additional step of creating a single vision combining all effects and issues.

Vision in Futures (an optional communication tool)

A vision is a compelling image of a future state of affairs. Historically, they have been widely used to create aspirational visions. However, in ethical foresight analysis the analysis is typically focused on detecting matters of ethical concern – possible negative ethical issues. Consequently, Vision in Futures is used here to create a negative vision of the future, identifying issues which are to be avoided. George Orwell's novel *1984* could be considered such a vision.

A negative future vision is a valuable tool for communication and motivation. It provides a short summary of concerns for those outside the project, such as funding bodies and those who will receive the project's reports. It can be used to address questions such as "why do this research at all?" It can be used to motivate acceptance of remedial steps in projects which recommend ways to avoid ethically negative outcomes. It positions the individual ethical issues into a wider context. It may reveal new ethical issues resulting from the combination of several.

Visions are similar to scenarios, but less detailed. Scenarios in ethical foresight analysis are typically used to illustrate specific ethical conflicts and to prompt considerations of specific remedies. Negative future visions are instead intended to provide a vision of a world in which the technology's multiple ethical problems combine to form an undesirable state of affairs. To be effective, they need to possess the following characteristics:

- **Be accepted as legitimate.** This legitimacy derives from the source of the vision. Expert panels are typically considered the most legitimate sources, especially if containing members involved in the development of the technology. However, the vision must also align with accepted ethical values. A vision will not be considered a legitimate description of unethical issues if it is based on values not shared by the researchers.
- **Express general concerns.** A vision must reach beyond the concerns of the researchers or their particular culture. It must encompass all those who can possibly be affected by the future state of affairs. This can be most easily attained by ensuring expert panels are representative of the full range of stakeholders, especially those not involved in the development of the technology, but who may be affected by it.
- **Be possible within the time frame set for the technology evaluation.** Emerging technology research typically uses 5-10 or 20-year timeframes. The Future Vision must sit within the temporal scope of the project, and that scope needs to be accepted. If the vision concerns a time too remote from today, it loses legitimacy.
- **Be readable in a single sitting.** A future vision is designed to present the big picture and show how ethical issues are related, their context and effects. It should therefore be as short as possible, while doing justice to the issues. Ideally it should be readable in one or two hours. The aim is to provide the reader with a coherent overview of the matter. However, it should not be so short that it simplifies matters to the point of inaccuracy.

Creating a negative future vision

The process of creating a negative future vision will depend on research project's organization, but in all projects key stakeholders need to participate. The first step is selecting the core group who will draft the initial vision. The group needs to include representation from both inside and outside the project. However, the group needs to be small enough to create consensus within timeframes permitted by the project's budget. The Institute for Alternative Futures (IAF) pioneered Future Visions and recommends groups of approximately 25 participants who can develop the vision in a single extended session (one or two days), or over several shorter meetings.[54] If the project is following the procedure detailed above, the negative future vision is developed from the technology roadmap and the group should include members who have worked on the roadmap.

The output should be a description of the world in which the final stage of the technology roadmap has been reached. It should assume all the ethical issues identified have come to pass. It should describe the experience of people as they move between different contexts and usages of the technology and are subject to its effects. Such visions should not be overly technical – the aim is to provide a description of an overall state of affairs, not provide detailed understanding of every ethical issue. If necessary, minor ethical issues can be left out if they will make the vision too complicated or too long.

[54] Bezold et al., "Using Vision in Futures".

Other considerations

Methodological neutrality. The raw material the group uses to develop the vision can come from any suitable methodology which has been used in the previous steps. The IAF primarily used environmental scanning.[55] Technology roadmaps are an extremely useful because of their visual representation.

Scalability. The number of participants creating the negative future vision can be scaled according the size and budget of the project. It can be created by a single individual, and it has been used with very large groups.[56] It has not been shown that larger groups necessarily create better visions.

Writing skill. Future visions are powerful tools for justifying a project's existence to funding bodies, or for quickly communicating motivations for concerns to others who need to be involved in the project, such as potential stakeholders. While based on data, negative future visions are essentially works of fiction. It is, unfortunately, the case that not all researchers are good fiction writers. It is important the vision is compelling. It may be appropriate to employ a professional ghost writer or journalist to draft the text of the vision.

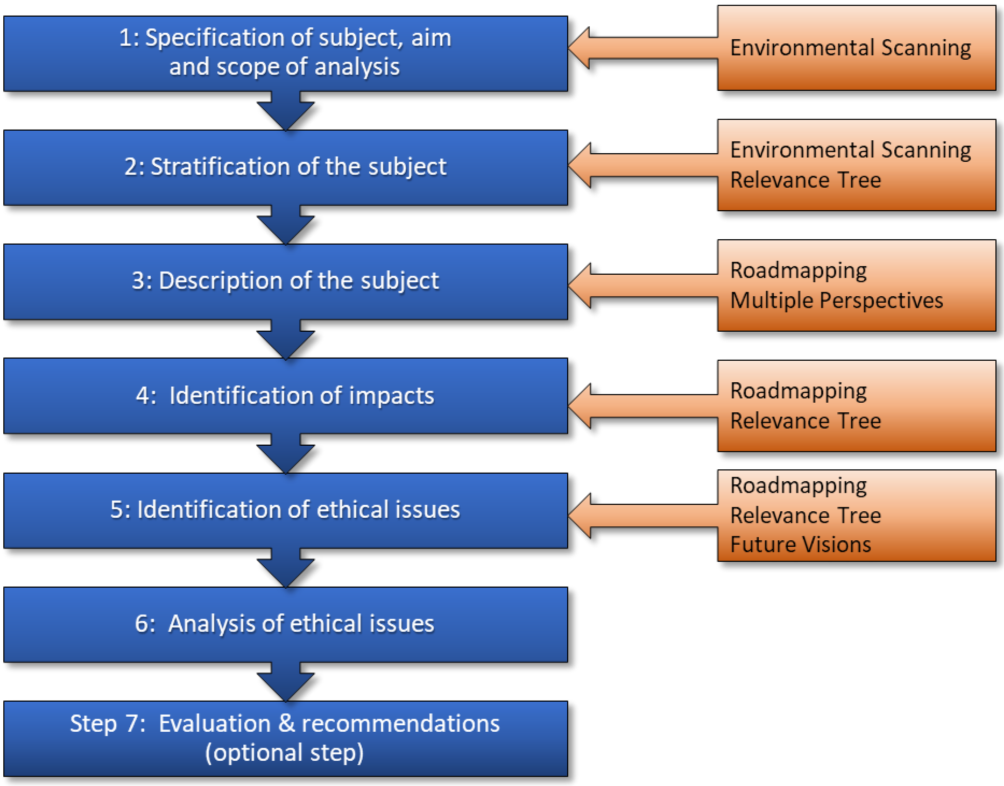

Figure 5: The foresight methodologies recommended for each step in the analysis

[55] Bezold, "Anticipatory Democracy and Aspirational Futures".
[56] Bezold et al., "Using Vision in Futures".

6. Methods for the inclusion of stakeholders and stakeholder perspectives

6.1 Stakeholders in SIENNA

Stakeholder engagement in the different stages of ethical analysis proved vital during the SIENNA project. In the handbook D 1.1, a stakeholder was defined as: “as a relevant actor (person, group or organisation) who: (1) might be affected by the project; (2) have the potential to implement the project’s results and findings; (3) have a stated interest in the project fields; and/or, (4) have the knowledge and expertise to propose strategies and solutions in the fields of genomics, human enhancement and artificial intelligence”[57,58]. Additionally, stakeholder analysis was described as “gathering and analysing qualitative information to determine whose interests should be taken into account when developing and/or implementing a policy or program”[59], which was adopted from Kammi Schmeer, 1999 [60].

Stakeholders were categorised in SIENNA as internal and external. The former are actors working together towards a project or a purpose. In SIENNA, these included but not limited to, members of the three work packages and scientific advisory board, consortium members and the European Commission. External stakeholders encompass a wider scope of interested actors who were further classified in categories (civil society, economists, research ethics committee members, clinicians, industry) or as falling within a specific scientific domain such medical field, engineering and so forth. Within SIENNA, a distinction was made between expert and non-expert stakeholders; the former includes professionals with specialized proficiency of a field and the latter involves lay public[61]. Stakeholder analysis and compiling were performed reiteratively throughout the duration of the SIENNA project[62].

6.2 Engagement methods for stakeholders

Stakeholder engagement is “the process of involving and interacting with stakeholders to inform and influence the project and enable it to maximise its influence and impact” [63]. There are a variety of ways stakeholders can be engaged in the ethical analysis. However, the method employed to enrol stakeholder depends on the goal of such engagement. If the purpose is to communicate information,

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[57] Jensen, Sean R., Heidi C. Howard, Alexandra Soulier, Emilia Niemiec, Rowena Rodrigues, Stearns Broadhead and David Wright, *D1. 1: The consortium’s methodological handbook*, SIENNA, 2019, pp. 62.
[58] European Commission, *Stakeholder consultation guidelines 2014, public consultation document*, 2014. https://ec.europa.eu/smart-regulation/impact/docs/scgl_pc_questionnaire_en.pdf
[59] Schmeer, Kammi, "Stakeholder analysis guidelines", *Policy toolkit for strengthening health sector reform*, Vol. 1, 1999.
[60] *Ibid*., pp. 62
[61] Rodrigues, Rowena, Stearns Broadhead, *D1.2: Stakeholder analysis and contact list*, SIENNA project, 2018.
[62] Jensen, Sean R., Heidi C. Howard, Alexandra Soulier, Emilia Niemiec, Rowena Rodrigues, Stearns Broadhead and David Wright, op. cit., 2019.
[63] Rodrigues, Rowena, Stearns Broadhead,op. cit., 2018.

or results of the project, then adopting a one-way communication would be the best way to go for example, via newsletters. To acquire stakeholders' insights and feedback, a two-way communication is the optimal method of engagement. This can be achieved through both qualitative (such as interviews, focus groups, citizen or expert panels) and quantitative methods such as surveys.[64].

Besides suitability for purpose, the method adopted should comply to scientific rigorousness requisites such as sampling procedures[65] or data saturation[66], if the goal is to obtain scientifically valid and reliable input from stakeholders.

6.3 Merits of stakeholder engagement

Engaging stakeholders in the ethical analysis can lead to broadening and deepening the scope of ethical analysis. It can expand the number of ethical and societal issues identified and analysed. They are essential to capture missing or unpopular concerns and enable researchers to consider the multi-plural and complex views and attitudes that exist in modern societies.

Furthermore, stakeholders can be used as a "sounding board" before results are distributed to a wider public. Moreover, they can help with obtaining buy-in and advocacy for the generated results or guidelines or regulations[67].

6.4 Stakeholders engagement in ethical analysis

The SIENNA approach for ethical analysis is composed of different stages. In the following paragraphs, we describe how stakeholders can be engaged at each stage, potential impact and methods of engagement.

Specification of subject, aim and scope of analysis

The first stakeholder group important for this stage is the internal group. They are all those who are assigned to work in a project together with the funding body, relevant partners. Their discussions are important to agree on the subject and aim of the analysis. The discussion can take place via a couple of informal discussions and meetings. One the consensus is reached another stakeholder group can be engaged.

External stakeholders, particularly expert professional stakeholders who work within the field of technology, are useful to help internal stakeholders outline the subject and the scope of the analysis. They can explain better the overall technology field and give an overview of the components within the technology area. In addition, they can describe potential impacts whether negatively or positively on the society, environment or health. This can be achieved through informal interviews or

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[64] *Ibid*.
[65] Sandelowski, Margarete, "Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixed-method studies", *Research in nursing & health*, Vol. 23, No. 3, 2000, pp. 246-255.
[66] Fusch, Patricia I., Lawrence Ness, "Are we there yet? Data saturation in qualitative research", *The qualitative report*, Vol. 20, No. 9, 2015, pp. 1408.
[67] Rodrigues, Rowena, Stearns Broadhead,op. cit., 2018.

consultations with 2-3 experts. Furthermore, they can guide researchers or task leaders on identifying "easy to miss" realms which are not in the spotlight.

Description of subject of analysis

The stakeholders who might best describe the subject of analysis would be experts in ethics and in the technology area, together with internal stakeholders. However, they would need to build up on information obtained from the step above. The subject of analysis can be further concretized by a thorough literature review. Both approaches would define the extent and depth of analyses. The experts would demarcate the three levels of analysis 1- technology level, 2- artefact level and lastly 3- application level, and contribute to foresight analysis. Interactive focus groups or roundtable discussions with experts would be the more suitable method of engagement.

Identification of stakeholders and (potential) impacts

In order to ensure a thorough and exhaustive compiling of potential impacts from the technology and the stakeholders that can be affected by the technology, again experts' views are imperative. But here experts can come from different backgrounds, for example sociologists, physicians, environmentalists, technology consultants, depending on the subject of analysis outlined above.

For this stage, a larger number of experts would be recruited to ensure exhaustive input. Therefore, a short survey with open-ended questions can be used to reach a larger group of experts. However, if the scope of analysis is narrow, a smaller interactive focus group or interviews can be employed.

Identification and specification of ethical issues

Lay public input can be very valuable at this stage of analysis. The layman categories would include workers unions, civil societies, advocacy groups and patients. The obvious advantage of engaging the wider public is to get a comprehensive view of the multi-plurality and gravity of ethical and societal concerns as well as threatened values as conceived by the public. Therefore, it is particularly important to ensure adequate representation in terms of sample size, gender, political views, religion, etc. It is as essential to include the disfranchised members of the society in this step.

To achieve this, quantitative methods are most suitable such as surveys. The expected number of lay public depends on the scope, funding and sample size calculation. Though, citizen panels have been used in SIENNA to identify and specify ethical issues from the public, the method lacks representation and employs small samples of the public, therefore the results cannot be generalizable to the rest of the population.

Analysis and evaluation of ethical issues

After identifying, through the previous stages, the ethical and societal concerns, it is time for deeper analysis and appraisal of these issues. The best category of stakeholder to carry out the task would be ethicists and bioethicists both internally and externally, because they can methodologically conduct the analysis. They can employ ethical impact analysis, economic and societal impacts[68], or ELSI method[69] or depending on the type of technology under scrutiny.

Optimally, the stakeholders would interact via focus groups, expert panel discussions and interviews. It is advisable to attempt to capture the various viewpoints of analyses of stakeholders and as such accommodate the multi-plural perspectives of current societies, we live in. Therefore, a larger group of experts should be consulted.

6.5 Engaging the public

In the SIENNA project, we made an attempt to include the values, needs, and viewpoints of the general public in our ethical analysis of emerging technologies.[70] This turned out to be one of the most difficult tasks to do adequately, and we cannot claim to be satisfied with the result. We utilized two methods to engage the general public. First, we carried out opinion surveys of 11.000 citizens, 1000 per country in 11 countries. For each of the three technology areas we studied, we had a small list of questions regarding the awareness and acceptance of the technology in question, and citizen's answers were recorded in a telephonic survey. Second, we ran one-day panels of citizens in five countries, with sixty citizens per panel. In each panel, we ran discussion questions on the three technologies that were the focus of the SIENNA project. Third, we opened up some of our draft reports for public consultation.

Running surveys and panels at this scale is costly and labour-intensive. A quarter of our project budget was devoted to them. Smaller surveys and panels would have brought serious methodological limitations. A survey with less than 1000 citizens per country would have had limited statistical validity. A survey in fewer countries would have been an option, but it would either have meant fewer EU countries (seven of the countries surveyed were EU member states), meaning that the survey would not have been sufficiently representative for the EU, or eliminating non-EU countries, meaning that comparisons between EU and non-EU states would not have been possible. The panels were run in EU countries only, and having less than five would have made it difficult to claim that they were representative in any way for the EU in all its diversity. Moreover, having less than 60 citizens per panel was an option, but it would have reduced the diversity of the panels and their reliability as vehicles that represent the opinions of the general public.

Ideally, surveys and panels that focus on people's acceptance of different technologies give insight into people's values, moral judgments and moral recommendations. These could then be used to influence ethical analysis, including evaluations, recommendations and decisions. In practice, we found there to be several obstacles in using surveys and panels in this way. First, the experts in surveys and panels that supported us (Kantar Public) made it clear that there are serious limitations to the kinds of questions that can be asked to the public, and the significance of the responses that can be elicited. It is not possible, for example, to directly ask questions about ethics and morality to citizens, because many will not be able to adequately comprehend the questions. In addition, many citizens have a very limited knowledge of the technologies in question, so testing for their knowledge, and, if possible,

[68] Jensen, Sean R., Heidi C. Howard, Alexandra Soulier, Emilia Niemiec, Rowena Rodrigues, Stearns Broadhead and David Wright, op. cit., 2019.
[69] Alexandra Soulier, Emilia Niemiec, Heidi Carmen Howard, *D2.4: Ethical analysis of human genetics and genomics,* SIENNA project, 2019.
[70] Deliverables D2.5, D2.6, D3.5, D3.6, D4.5, D3.6, available at https://zenodo.org/search?page=1&size=20&q=SIENNA.

informing them (which happened in the panels), becomes a large part of the effort. Many of the questions that one end up formulating are questions that test for moral viewpoints in a rather indirect way, e.g., "Do you support technology that makes people more intelligent" (human enhancement survey) or "How much would you agree or disagree that all babies should have all their genes or DNA analysed at birth?" (human genomics survey). The results of our surveys and panels were often difficult to connect directly to the ethical analysis that we were performing.

Second, we ended up having extensive methodological discussions on the validity of our survey and panel results, and their limitations. Perceived limitations caused some project members to be very hesitant in using the results in ethical analysis. In particular, many project members believed that the one-day panels were too short to have a meaningful discussion of three technology areas, and that perceived trends (e.g., older citizens having certain viewpoints more often than younger ones, or French citizens having certain preferences not present in Greek citizens) were insufficiently reliable from a methodological point of view.

Third, we had difficulty reaching a unified position on how to use the citizen surveys and panels in ethical analysis. At one extreme, there was the viewpoint that ethical analysis, evaluation and recommendations should be compatible with, and guided by, the values, viewpoints and recommendations of citizens. But very few ended up defending this position. In balancing different types of inputs for our ethical analysis, such as previous publications in ethics, expert opinions from ethicists, non-citizen stakeholder opinions, and existing ethics guidelines, the viewpoints of citizens ended up being but one data point in our analysis. The majority in the consortium defended this by means of several arguments: some non-citizen stakeholder also represent citizens (e.g., civil society organisations, government employees and politicians), there are methodological limitations to our surveys and panels, the input that citizens are able to provide is not reliable and focused enough to provide strong guidance for ethical analysis. We did not succeed, however, in formulating a methodology for the systematic inclusion of citizen opinions as data points in ethical analysis, and ended up using the results of the surveys and panels in an ad hoc way.

The conclusion that can be drawn from our exercise is that much work still needs to be done to address a multitude of methodological issues that hamper the engagement of members of the general public in ethical analysis, evaluation and prescription. Our own viewpoint is that instead of costly surveys, it might have been better to focus on longer panels of citizens, in which more depth could be gained, and periodic interactive meetings between project members and citizens, at different stages in the project, in which we attempt to discuss some of our questions and issues with citizens and elicit their opinions.

6.6 Recommendations for improving stakeholder engagement

- For emerging technologies, the relevant stakeholder groups usually include academia, industry, government, and civil society as core constituencies.
- Each technology area can pose its own challenges to the process and way in which stakeholders can be incorporated in ethical analysis. The relevant stakeholder groups can also be different for different technologies (e.g., medical vs. nonmedical). This should be adequately addressed during stakeholder analysis.
- Ensure that stakeholders represent the main technology actors as well as the main groups that are impacted by the technology

- Be mindful of power imbalances between stakeholders in stakeholder engagement, and try to correct for them.
- Transparency and clear communications between and within external and internal stakeholder groups is vital. Informed consent is a must.
- When the need arises to outsource project activities to stakeholders, attention should be paid to robustness of methodologies used.
- Never exclude a stakeholder because of the potential risk of bias or lobbying, however always ensure that stakeholders are transparent about their affiliations and declare all their conflict of interests.
- When possible widen the scope and type of stakeholders engaged to encompass civil society and human rights organisations, patient groups and stakeholders of disfranchised backgrounds.
- When members of the public are consulted, the group should be representative for the population as a whole, and vulnerable populations (or people who are able to represent them, if they are not able to participate themselves) should be included.
- Additional research is necessary to investigate better ways of engaging with viewpoints of members of the public in ethical analysis, evaluation and prescription.

7. Applying the Methodology

Here, we briefly show how the methodology has been applied to specific technologies and how it could be applied in the future. As stated, our approach is intended to be flexible, so it can be used for broad, comprehensive ethical assessments of emerging technologies, but also for zooming in on a particular technique, product, application domain, impact or ethical issue. We will first review the application of the approach on previous technologies in the SIENNA project, after which we will demonstrate the application of the approach to a specific case, autonomous vehicles.

7.1 Application in the SIENNA project

In the SIENNA project, three technology areas were studied using an earlier version of the approach presented here. This earlier version is documented in one of our earlier reports. The differences between the current and the earlier version are small enough to be able to use our studies as examples of the application of our approach.

The most elaborate and successful application of our approach has been to the field of artificial intelligence (AI) and robotics. For this field, the approach was applied faithfully, and no major adaptations were necessary to accommodate the characteristics of the specific technology that it was applied to. Our application was extended over two reports: one (*State-of-the-art Review: AI and Robotics*)[71] was a stand-alone report in which, by and large, steps 1 to 4 of the ethical analysis were carried out. We created this separate report because these earlier steps, which focused on conceptual and descriptive analysis, yielded a text that could function as a stand-alone report on the state of the art in AI and robotics, with information about key terms and concepts, key information about AI and robotics technology, its development, and their applications, expectations for the future, and information on stakeholders and impacts on society. We surmised that this kind of state-of-the-art report could have a wider value beyond its application in ethical analysis, and therefore we made it into a separate document.

Next, we produced a second study (*Ethical Analysis of AI and Robotics Technologies*),[72] which contains the actual ethical analysis. For this study, we largely relied on the state-of-the-art report for steps 1-4 of the ethical analysis, but performed some remedial work for these steps, since in the state-of-the-art report they were not carried out fully; in particular, the aim of the ethical analysis, specified in step 1, was defined here for the first time. In the ethical analysis report, we carried out steps 5 and 6 of ethical analysis, which focus on the identification and specification of potential ethical issues and analysis of ethical issues, but not the optional step 7.

After the ethical analysis report, we originally intended to develop an ethical framework for AI and robotics, with ethics guidelines. These ethics guidelines would be of a general nature, and therefore

[71] Jansen, P., Broadhead, S., Rodrigues, R., Wright, D., Brey, P., Fox, A., and Wang, N. (2018). SIENNA D4.1: *State-of-the-art Review: AI and Robotics* (Version V.04). Zenodo. 102 pp.
[72] Jansen, P., Brey, P., Fox, A., Maas. J., Hillas, B., Wagner, N., Smith, P., Oluoch, I., Lamers, L, Van Gein, H., Resseguier, A., Rodrigues, R., Wright, D. and Douglas, D. (2019). SIENNA D4.4: *Ethical Analysis of AI and Robotics Technologies* (Version V1.1). Zenodo. 226 pp.

correspond with what we called the technology level in our approach. They would be a way of carrying out step 7. However, as it turned out, several high-profile international organisations, including the European Commission (by virtue of the High-Level Expert Group on AI), the OECD and the IEEE issued general ethics guidelines for AI in 2019. We concluded, after consultation with stakeholders, that the development of additional SIENNA ethics guidelines for AI and robotics would not be a good idea. What we focused on, instead, is the development of strategies and instruments for implementing ethical considerations for AI and robotics.[73] Most of this work can be conceived of as a further step beyond step 7: the implementation of ethics recommendations and guidelines in concrete tools and strategies.

In our ethical analysis of AI and robotics, we started out, in our state-of-the-art report, by defining the field of AI and robotics. We defined central concepts and described key approaches and methods in AI and robotics. We then identified and described subfields for each, twenty-four in total. These are subfields like machine learning, natural language processing, robot locomotion, swarm robotics, and nanorobotics. Based on the consultation of experts, we also considered the possible future development of the field. We then discussed different application domains for both AI and robotics, such as transportation, agriculture, defence, education, and others. We discussed twenty-one such domains in total, in each case considering present applications as well as potential future ones – the latter based on foresight analysis that involved expert consultation. Subsequently, we did a social, economic and environmental impact assessment of AI and robotics, in which we identified and assessed several dozen impacts associated with them. These included impacts like diminishing privacy, improving healthcare, increasing surveillance, and decreasing (but possibly also increasing) energy consumption. We also identified key stakeholders for AI and robotics.

We then did the actual ethical analysis. We started with an identification, specification and analysis of general ethical issues (ethical issues at the technology level). We identified about thirty-five ethical issues at this level of description, relating to current and potential future aims, fundamental techniques and methods, and general implications and risks associated with these technologies. These included ethical issues pertaining to the development of AI with the aim of developing superintelligence or cognitive enhancement, ethical issues pertaining to fundamental techniques like machine learning, knowledge representation techniques and robot actuation, and ethical issues relating to risks to privacy, dual use and mass unemployment.

We then did an ethical analysis of the product level, identifying seventeen key product types in AI and robotics, such as intelligent agents, computer vision systems, humanoid robots and microrobots. For each, we identified and assessed current and potential future ethical issues. Finally, we did an ethical analysis of the application level, in which we identified twenty-three application domains (largely identical to the domains recognized in the state-of-the-art report, though with some adaptations in order to have a better fit between domains and ethical issues), and six key parameters for categorizing user groups. The user group dimensions we considered included. For each application domain and user dimension, we did an analysis of current and potential future ethical issues.

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[73] Brey, P., Jansen, P., Lundgren, B. and Resseguier, A. (2020). *An Ethical framework for the development and use of AI and robotics technologies.* Deliverable D4.4 of the SIENNA project. https://www.sienna-project.eu/publications/. 93 pp.

We did similar state-of-the-art reports and ethical analysis reports for human genomics and human enhancement.[74] Our approach was perhaps not applied as thoroughly for these fields as for AI and robotics. This was in part the case because these fields raised complications that our previous version of our methodology was less well equipped for. A complication for human enhancement was that it is a much looser field than many technology fields are. There are few shared concepts, methods and techniques that bind the field together. Rather, the field is defined in terms of purposes: to enhance human beings. In our current approach, we have a better recognition of the fact that some fields are defined by a purpose or application domain, and not so much by shared methods or techniques. Another obstacle was that a mostly medical field like human genomics has few application domains beyond medicine, so that the application level ethical analysis would be rather restricted. Nevertheless, we located some important nonmedical application domains for human genomics, which include law enforcement, surveillance and defense.

7.2 Application to a case: Autonomous Vehicles

In what follows, we provide detailed example of how SIENNA's 7-step approach can be applied at the product level. We take autonomous cars as our example.

To begin, in **step 1**, we identify the subject of the analysis, and we specify other aspects of the analysis to be performed, including its aims and constraints. We want to assess the operating software of autonomous cars (which is our subject), with the aim of determining ethical issues in the operating decisions that this software makes or could make in the future, and we are specifically interested in ethical issues relating to road safety (which determines our scope). We are going to do a product analysis, which is an analysis of a particular type of product associated with the technology.

Then, **step 2** is about undertaking a more thorough scoping exercise by stratifying the subject of analysis into the different levels at which the analysis will take place. Since we have determined we want to a product analysis, we forego analysis at the technology and application levels. The product level analysis gives a systematic description of the artefacts and processes that are being developed for practical application outside the field. Having studied the field, we can usefully classify autonomous cars software according to their levels of automation. The Society of Automotive Engineers contends there are six levels of automation (table 6):[75]

SAE level	Name
Level 0	No Automation
Level 1	Driver Assistance
Level 2	Partial Automation
Level 3	Conditional Automation
Level 4	High Automation
Level 5	Full Automation

[74] SIENNA Deliverables D2.1, D2.4, D3.1 and D3.4, available at https://zenodo.org/search?page=1&size=20&q=SIENNA

[75] SAE International (2014). *Automated Driving – Levels of Driving Automation are Defined in New SAE International Standard J3016*. https://cdn.oemoffhighway.com/files/base/acbm/ooh/document/2016/03/automated_driving.pdf

Table 6: SEA levels of automation in autonomous cars

In **step 3**, we describe the subject of the ethical analysis, including its likely future developments. At SAE levels 1 and 2, the human driver monitors the driving environment while self-driving features are operational. Level 1 (driver assistance) means that either an aspect of steering or acceleration/deceleration can be taken over by driver assistance system, with the expectation that the human driver performs the remaining aspects of the driving task. And level 2 (partial automation) means that aspects of both steering or acceleration/deceleration can be taken over by driver assistance system. At SEA levels 3, 4 and 5, the human driver no longer has to monitor the environment. At level 3 (conditional automation), all aspects of the driving task are taken over by the automatic driving system, with the expectation that the human driver will respond in an appropriate manner to requests to intervene. At level 4 (high automation), the automatic driving system also fully executes the driving task, but here the vehicle can pull over safely through a guiding system if a human driver does not respond appropriately to requests to intervene. And at level 5 (full automation), the vehicle can drive itself under all roadway and environmental conditions that can be managed by a human driver. Autonomous car software at SAE levels 1 and 2 is currently being used in consumer vehicles. Car software at SAE levels 3, 4 and 5 is under development and being tested and used in specific environments and for specific purposes.

In **step 4**, we describe the likely and possible impacts of the technological developments described in the previous step, along with the stakeholder groups consisting of the populations that will be affected by these impacts. So, for autonomous car software, we find that stakeholder groups include drivers, other road users, designers and sellers. And in terms of potential socio-economic impacts of the operating software we find that there is a (future) potential for both safety improvement and safety issues, massive job losses and unemployment among professional drivers (taxis, truckers, etc.), and economic growth in certain sectors (lessened need for expensive human drivers, and more efficient spending of time as drivers can focus on other tasks), amongst others.

In **step 5**, we identify and describe all the ethical issues relevant to the subject, including those that pertain to the (potential) impacts uncovered in Step 4. For autonomous car software, these can be found to include:

- *Issues of safety and AI decisions.* There may be situations where the software is unreliable and poses safety issues for vehicle occupants and other road users. And the decisions a car is to make right before a potentially fatal crash can present difficult dilemmas where it is hard for the software to the right thing.
- *Issues of moral, financial, and criminal responsibility.* It may be difficult to figure out who, if anyone, is responsible for car crashes and breaches of law.
- *Privacy issues.* There is a potential for mass surveillance through data collection and sharing by the autonomous car software.
- *Issues of wellbeing.* There is a potential for massive job losses and unemployment among drivers.
- *Issues of autonomy and de-skilling.* Vehicle users may lose their independence and driving skills.
- *Issues of security.* The autonomous car software may expose itself to exposure to hacking and malware, with associated consequences.
- *Issues of power.* Certain global conglomerates involved in AI may gain significant market and data power. They may potentially successfully lobby governments to facilitate the shift of liability onto others.

In **step 6**, we further analyse the ethical issues that were identified in Step 5. We conduct a comprehension-oriented ethical analysis, which is an analysis that is directed at an understanding of ethical issues as well as possible ways of resolving moral dilemmas. For autonomous car software, we find that there exists a conflict between the purported benefits, which include potential improvements in safety, economic efficiency and well-being, and the issues outlined in step 5. For a morally justified mass introduction of vehicles with (near) full autonomy (SAE level 4 and 5), a carefully considered trade-off necessary. It seems that instituting proper policy safeguards in terms of preventing data misuse, preventing abuses of power by manufacturers of autonomous AI systems, and compensating for job losses among professional human drivers would go a long way in justifying the mass introduction of fully autonomous vehicles on public roads. In contrast to vehicles with full autonomy, the mass introduction of vehicles with more limited autonomy (SAE 1 and 2), may be easier to justify.

Tensions should be noted in relation to solutions to the issue of AI decision procedures: autonomous car occupants want their car to always prioritise their own safety at the cost of other road users', while people in general prefer cars with utilitarian decision-making mechanisms, in which least harm for any road users is preferred.

Furthermore, in resolving the issue of moral responsibility for decisions taken by the software, it seems two of the most likely solutions are to place responsibility with the owner(s) of the vehicle or with its designers or manufacturers.

In **step 7**, we conduct solution-oriented ethical analysis. We assess arguments and competing considerations regarding ethical issues examined in preceding steps, to reach evaluations and possibly recommendations. Here we could compare arguments and find that, indeed, the mass introduction of autonomous vehicles is permissible on the condition that policy safeguards are put in place which prevent data misuse, prevent abuses of power, and compensate professional human drivers. In addition, we could argue that autonomous cars should strictly use utilitarian decision-making mechanisms, and that moral (or at least legal) responsibility the vehicle's actions lies with the designers.

8. Relation to other types of assessment

This section details the relations of ethical assessment with other prominent types of assessment, namely, socio-economic impact assessment (SEIA) (subsection 8.1) and human rights impact assessment (HRIA) (subsection 8.2). For each, similarities and differences with ethical assessment are outlined, as well as things that need to be considered going forward.

8.1 Ethical assessment and socio-economic impact assessment

In our approach, we see socio-economic impact assessments (SEIAs) as a critical aspect of, and support to ethical analysis and ethical impact assessment. In SIENNA, SEIA was already closely linked with ethical analysis and ethical impact assessment. It preceded and fed into the ethical analysis, the assessment of ethical impacts and the legal analysis carried out in the project.

Ethical principles and social values are deeply connected and integrated. Any examination of ethical issues and impacts cannot be distanced or disconnected with the social and economic environment, realities and challenges it operates under. Understanding impacts on people's lives, culture, communities, health and well-being and politics cannot be an after-thought. In relation to new and emerging technologies, this connection becomes even more critical to address socio-economic and ethical considerations, and would help avoid the trap of missing contexts and the wider implications.

We next outline some key differences and similarities focussing on some key aspects such as aims and scope, legal foundations, methods, frameworks, values and principles, steps and challenges. Finally, we discuss what we need to consider going forward.

8.1.1 Differences between ethical assessment and SEIA

Aims and scope: As defined in SATORI, ethics assessment refers to "any kind of institutionalised assessment, evaluation, review, appraisal or valuation of practices, products and uses of research and innovation that primarily makes use of ethical principles or criteria. The objects of research or innovation that are assessed may be research or innovation goals, new directions, projects, practices, products, protocols, or new fields. There are many organisations engage in some form of ethics assessment of R&I."[76] Ethics assessment is a key element of Responsible Research and Innovation (RRI). A SEIA has different aims, scope and positioning. Generally, it is a tool used to identify, evaluate the socio-economic impacts of a proposed change, development, project or intervention on people, groups, or society. Depending on scope, it may include the identification of mitigation actions to reduce the negative/adverse impacts identified. As further outlined by SATORI, "Ethics assessment is, overall, different from impact assessment since, as argued, a large part of ethics assessment is not concerned with impacts of research and innovation but with ethical issues within research and innovation practices"[77] (except of course where an ethical impact assessment is carried out). An ethical impact

[76] Shelley-Egan, Clare et al, "Ethical Assessment of Research and Innovation: A Comparative Analysis of Practices and Institutions in the EU and selected other countries", SATORI project, Deliverable 1.1, June 2015. https://satoriproject.eu/media/D1.1_Ethical-assessment-of-RI_a-comparative-analysis.pdf
[77] Ibid.

assessment is the "process of judging the ethical impacts of research and innovation activities, outcomes and technologies that incorporates both means for a contextual identification and evaluation of these ethical impacts and development of a set of guidelines or recommendations for remedial actions aiming at mitigating ethical risks and enhancing ethical benefits, typically in consultation with stakeholders" - I.e., it is a process of ethical impact identification, analysis and evaluation.[78]

Legal foundations: Ethical assessments generally do not have legal foundations or scope for recourse, except where they are either instrumentalised, including via obligations as set out by funders or in other negotiations and contracts, or where they are connected to other legal instruments. Consideration of socio-economic factors has been included in some impact assessment legislation.[79] Where the law requires that a project, initiative or technology provides socio-economic benefits for society, a SEIA would be a good way of demonstrating socio-economic benefits.

Difference in methods: There exist a large number of methods for ethical assessment in different domains and fields. E.g., principle-based ethics, discourse ethics, casuistry, ethical guidelines, ethical risk analysis, ethical matrix, consensus conferences, focus groups, ethical Delphi, scenarios and others.[80] Many specifically directly differ from the methods employed in SEIAs. SEIA studies come with a variety of methods for assessment. E.g., as cost-effectiveness, cost-benefit analysis, risk analysis, econometric models, sectorial models or Computable General Equilibrium (CGE) and others. In contrast with ethical assessment tools, these methods are generally qualitative or quantitative research methods that come along with requirements and recommendations for the measurement and evidence-gathering.[81] Additionally, and as opposed to ethical assessment, SEIA research methods heavily rely on the use of indicators and/or (primary or secondary) data. These indicators might differ across studies, but they usually refer to the following categories: jobs and earnings, human capital, health, education, labour markets among others.

Frameworks: There is diversity of frameworks and their use in ethical assessment and SEIAs.[82] Variations may occur by geography (international, regional, national, local), fields (e.g., ICT) or even professions. Ethical assessments and SEIA frameworks show significant differences. First, the conceptual framework of a SEIA builds upon the idea that evidence is a key aspect that should guide the assessment. Meanwhile, ethical assessments are driven by values. Second, SEIAs have in the centre

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[78] CEN Workshop Agreement, "Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework", CWA 17145-2, May 2017. https://satoriproject.eu/media/CWA17145-23d2017.pdf

[79] See for example, Canada's Impact Assessment Act (S.C. 2019, c. 28, s. 1), section 22 (1). https://laws-lois.justice.gc.ca/eng/acts/I-2.75/page-4.html#h-1160335

[80] See Shelley-Egan, Clare et al, "Ethical Assessment of Research and Innovation: A Comparative Analysis of Practices and Institutions in the EU and selected other countries", SATORI project, Deliverable 1.1, June 2015. https://satoriproject.eu/media/D1.1_Ethical-assessment-of-RI_a-comparative-analysis.pdf; also https://www.forskningsetikk.no/en/resources/the-research-ethics-library/systhematic-and-historical-perspectives/ethical-assessment/

[81] European Commission, "Better Regulation Toolbox-19". https://ec.europa.eu/info/files/better-regulation-toolbox-19_en

[82] Shelley-Egan, Clare et al, "Ethical Assessment of Research and Innovation: A Comparative Analysis of Practices and Institutions in the EU and selected other countries", SATORI project, Deliverable 1.1, June 2015. https://satoriproject.eu/media/D1.1_Ethical-assessment-of-RI_a-comparative-analysis.pdf

of the framework the society or the economy, whereas ethical assessments focus on ethical research and innovation practices.

Values and Principles: As per the CWA 17145-1,[83] general ethical principles for ethics assessment for all of the major fields of scientific research and (technological) innovation include the following: research integrity, social responsibility, protection of and respect for human research participants, protection of and respect for animals used in research, protection and management of data and dissemination of research results, protection of researchers and the research environment, avoidance of and openness about potential conflicts of interest. Based on the guiding principles noted by European Commission and other authors[84], SEIA studies should be: comprehensive in relation with the dissemination of results and the assumptions taken, unbiased, of high-quality, flexible and equitable. By comparing both sets of principles, it becomes evident that there are certain differences among ethical assessment and SEIA. First, equity considerations are a fundamental element of a SEIA. In contrast with ethical assessments, SEIAs should clearly identify who will benefit, who might be disadvantaged and emphasise vulnerability and under-represented groups. Second, ethical assessment considers the protection for animals used in research, whereas SEIAs do not usually account for it. Third, SEIAs specifically include the use of evidence as a guiding principle and recommends setting a limit to the tools and instruments that can be employed in the assessment (principle of proportionality).

Challenges: As pointed out in SATORI, ethical assessment faces various challenges such as: lack of unity; recognised approaches; professional standards and proper recognition in some sectors; lack of shared vocabularies, standards, approaches, and methodologies; no clear methodology or frameworks; lack of quality assurance and accreditation procedures; dominance of principlism, which is based on the four ethical principles of autonomy, beneficence, non-maleficence and justice.[85] SEIAs face challenges of a different sort – e.g., data quality and availability, access to resources (expertise, personnel, budgets), finding consensus on indicators and methodologies, results accessibility etc.[86]

8.1.2 Similarities between ethical assessment and SEIA

Aims and scope: Both ethical assessments and SEIAs share common aims of identification and evaluation. Their scope can similarly be broad or limited. However, any examination of ethical impacts cannot be distanced or disconnected with the social and economic environment, realities and challenges it operates under. The criteria/indicators used in both forms of assessment might overlap (an ethical concern might be a social concern). Furthermore, both ethical assessments and SEIAs share common underlying goals such as aiming to protect vulnerable groups, increasing social responsibility and fostering respect for human rights.

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[83] CEN Worshop Agreement, Ethics assessment for research and innovation - Part 1: Ethics committee, CWA 17145-1, May 2017. https://satoriproject.eu/media/CWA_part_1.pdf

[84] European Commission "Impact Assessment Guidelines",2009.
Mackenzie Valley Environmental Impact Review Board (MVEIRB), *Socio-Economic Impact Assessment Guidelines,* Mackenzie Valley Environmental Impact, 2007.

[85] See SATORI, "Outline of an Ethics Assessment Framework. Main results of the SATORI project", September 2017.
https://satoriproject.eu/media/D4.2_Outline_of_an_Ethics_Assessment_Framework.pdf

[86] See GSMA, "Using socio-economic impact assessments", 2019. https://www.gsma.com/betterfuture/wp-content/uploads/2019/05/Using-Socio-Economic-Impact-Assessments.pdf

Methods: As in ethical assessment, there are a range of methods for carrying out SEIAs.[87] There is some overlap between some of the methods used in ethical assessment and SEIAs, e.g., ethical assessment and SEIAs both might use multi-criteria analysis, matrices, or qualitative methods such as focus groups.

Steps: The SIENNA six steps to ethical analysis[88] (i.e., 1. Specification of subject, aim and scope of analysis 2. Description of subject of analysis 3. Identification of stakeholders and (potential) impacts 4. Identification and specification of ethical issues 5. Analysis and evaluation of ethical issues 6. Optional: Recommendations and options for ethical decision-making) have a lot in common with the steps involved in a SEIA. Steps used in some other ethics assessment processes might also have common elements where the underpinning method is the same. Generally, the steps in a SEIA include an initial stage of scoping and planning of analysis, a second step of screening or analysis of the baseline scenario, followed by an impact identification and impact assessment stages and the formulation of recommendations. Depending on the scope of the SEIA, studies might also include a stage for the identification of mitigation and/or monitoring actions. It can be noted, that both procedures follow a similar logic: 1. Scoping and planification of the analysis where the identification of stakeholders and subject of analysis take place; 2. Identification and evaluation of the impacts; 3. Optional formulation for recommendations.

Frameworks: Where ethical assessment and SEIA conceptual frameworks might be similar are the overlaps in some underpinning principles (e.g., sustainability or social responsibility).The operational framework might also be very similar among ethical assessments and SEIA.

Values and Principles: Based on the principles previously described, we can identify several similarities among ethical assessment and SEIAs. First, both assessments consider concepts related to research integrity and comprehensiveness. Ethical assessments might frame this idea as the avoidance of and openness about potential conflicts of interest. SEIA principles recommend studies are unbiased and not letting political decisions influence the results, and considering all relevant impacts. Second, both assessments are engaged with the transparency of their results and the inclusiveness and respect towards stakeholder's opinions and research participants. Apart from the set of principles included, there are other similarities on the values guiding ethical assessments and SEIAs. As mentioned previously, SEIA studies are grounded in the use of indictors, and in the process by which these indicators are defined certain values play an important role. In that sense, ethical assessments share a common value with SEIA, as both assessments consider social responsibility.

Challenges: Both ethical assessment and SEIAs face several challenges. Similar challenges include having a clear methodology or framework for carrying out the assessment, and diversity in approaches and terminologies in different organisations, countries, and scientific fields. Also, the difficulties of setting the scope of analysis are shared in both types of assessment.

[87] Australian Government Bureau of Rural Sciences, "Socio-economic Impact Assessment Toolkit. A guide to assessing the socio-economic impacts of Marine Protected Areas in Australia", 2005. https://www.environment.gov.au/system/files/resources/27b104ce-ff21-43d8-9a7f-2c51cbe821bd/files/nrsmpa-seia.pdf

[88] See Rodrigues, Rowena, Stearns Broadhead, Philip Brey, Zuzanna Warso, Tim Hanson, Lisa Tambornino, & Dirk Lanzerath, " SIENNA D1.1: The consortium's methodological handbook (Version V0.6)", 2018. https://doi.org/10.5281/zenodo.4247384

8.1.3 What we need to consider going forward

A SEIA strengthens ethical analysis and ethical impact assessments and help broaden the vision and understanding of impacts taking into account diverse perspectives and particularly that of socio-economic vulnerable groups in society. It also helps widen the net of understanding the risks and threats and addressing value conflicts. SEIAs combined with ethical analysis and ethical impact assessments will support responsible research and innovation and socially desirable shaping of new and emerging technologies. It will also improve the relevance and value of ethical analysis and ethical impact assessments. In relation to new and emerging technologies this connection becomes even more critical to address socio-economic and ethical considerations and would help avoid the trap of missing contexts and the wider implications.

Ethical assessment can draw the following from SEIAs. First, ethical assessments can increase the flexibility of the studies and adapt the procedures according to the results found in the research process, i.e., the introduction of new stakeholders to the discussion. Second, ethical assessment can adopt some of methods from SEIAs and aim to increase the use indicators in the analysis and adopt the resolution to be an evidence-based science. In turn, SEIAs can improve their practice by extending its guiding principles, e.g., towards the protection of animals or further considering the concept of social responsibility as a key value in the definition of indicators or research practices.

8.2 Ethical assessment and human rights impact assessment

Human rights impact assessment (HRIA) offers a way to measure how policies and other interventions by business enterprises, NGOs, governments and other stakeholders impact on human rights.[89] This includes both that of existing policies as well as the potential impact of future policies.[90] HRIAs may consider the impacts on rights such as: the right to a fair wage; the right to health care and other social services; the right to family life; the right to take part in the cultural life of a community; and the right to freedom from racial, gender, age and other types of discrimination. They are found in a variety of guidance and toolkits, and can have a variety of steps and stages, which may include: screening, planning and scoping, data collection and baseline development, analysing impacts, impact mitigation and management, monitoring, reporting and evaluation.[91] In terms of methods, HRIA methodologies often use quantitative and qualitative approaches for evidence gathering and make liberal use of stakeholder consultation.

Differences between instruments can typically be described in terms of whether they focus on impacts that are: positive or negative; intended or unintended; direct or indirect; ex ante or ex post HRIAs.[92] HRIAs are also valued in terms of their suitability and effectiveness. Criticisms of HRIAs considered not fit for purpose tend to include that the instrument: (1) is considered too long or too general; (2) offers

[89] Harrison, J. (2011). Human rights measurement: reflections on the current practice and future potential of human rights impact assessment. *Journal of Human Rights Practice*, *3*(2), 162-187.
[90] de Beco, G. (2009). Human rights impact assessments. *Netherlands Quarterly of Human Rights*, *27*(2), 139-166.
[91] Götzmann, N. (2019). Handbook on Human Rights Impact Assessment. https://www.researchgate.net/publication/337558738_Handbook_on_Human_Rights_Impact_Assessment
[92] de Beco, 2009, op. cit.

limited examination of the specific values that inform the process; and (3) privileges some actors as participants over others.[93]

The Danish Institute for Human Rights lists the following 10 criteria as essential for HRIA: 'meaningful participation; non-discrimination; empowerment; transparency; accountability; use of human rights standards; analysis of actual and potential impacts (caused, contributed to and directly linked to); assessment of severity of human rights impacts; inclusion of impact mitigation measures; and focus on access to remedy'. Each criterion includes complexity and difficulty. For instance, the issue of *non-discrimination* includes taking into account where conflicts and tensions arise between, on the one hand, legitimate prediction-based analysis that results from experience and expertise, and on the other, misplaced assumptions that rely on generalisations about groups separated problematically or unnecessarily by characteristics such as gender, class and race.[94]

8.2.1 Differences between ethical assessment and HRIA

Aims and scope: HRIA aims to identify, evaluate and respond to the potential human rights impacts of policies and other interventions by business enterprises, NGOs, governments and other stakeholders. Ethical assessment, on the other hand, aims to identify, evaluate and respond to potential ethical issues associated with practices, products and uses of research and innovation.

Whereas HRIA assesses adherence to legally sanctioned human rights, ethical assessment evaluates adherence to ethical principles. These ethical principles may contain human rights principles but also many principles unrelated to human rights, and the human rights principles in ethical assessment have moral rather than legal foundations. Moreover, unlike HRIA (and ethical impact assessment), ethical assessment does not limit itself to the evaluation of *impacts* (on society, the environment, etc.), and also considers issues internal to a particular practice (e.g., issues of "playing god" in relation to genetic engineering). Finally, ethical assessment has as its subject practices, products and uses of research and innovation, whereas HRIA can cover this as well as government policies and business activities outside of the research and innovation domain.

Legal foundations: Efforts to apply human rights principles for evaluative methods focus on legal rights and obligations, as well as measures for positive and negative outcomes. Legal rights are connected with legal obligations, all of which offers a structure for legal recourse in the event where human rights are ignored or abused. Ethical assessments rarely have such foundations or scope for recourse, except where they are either instrumentalised, including via obligations as set out by funders or in other negotiations and contracts, or where they are connected to other legal instruments. The fact that there are concrete propositions to which the HRIA can refer is both an advantage and a disadvantage. On the one hand it offers a foundation for discussion, consultation and implementation. Legal implications also ensure that specific rights will not be ignored. On the other, it requires that each participant has shared knowledge and understanding. Yet, human rights standards may not be widely understood,[95] and as we note below, there might not be widespread agreement, especially globally.

[93] Harrison, 2011, op. cit.
[94] Gostin, L., Mann, J. M. (1994). Towards the development of a human rights impact assessment for the formulation and evaluation of public health policies. *Health and Human Rights, 1*(1), 58-80.
[95] Harrison, 2011, op. cit.

Global differences: Human rights rely on national and international legal instruments. On the one hand these may be globally recognisable, yet on the other they rely on culturally circumscribed moral and ethical foundations. On an international level, challenges emerge when discussion of human rights are

> forbidden or inhibited, governance frameworks are weak, corruption is high, human rights awareness is low, and/or where civil society activism is constrained by the state. In these jurisdictions, stakeholders may be unaware of their rights under law, and may not frame issues in a rights language, even where issues may relate directly to human rights.[96]

Human rights as legal instruments that rely on what are considered 'universal' rights may also face challenges in cultures where 'rights' are defined more broadly and where they are related to values, issues, and agreements that arise from, or are resolved according to, custom, social exchange, or group interaction.[97] While ethical analysis is similarly affected by culturally specific differences (content or context), their impact may be less sweeping, since ethics is broader than human rights and the very concept of practicing ethics is mostly not contested. For instance, governmental or cultural restrictions may entail limitations to the kinds of discussion that may be had on culturally sensitive ethical topics, rather than to an outright ban of ethics discussion *per se*.

Difference in methods: Ethics assessments tend to be, or at least to include as best practice, discursive elements, whereas HRIA methodologies tend to prioritise quantitative and qualitative research methods.[98] For HRIA this includes formalised requirements for certain kinds of evidence and for the measurement of actual as well as potential human rights impacts through 'evidence-based analysis'.[99] Given these, and given the legal foundations for HRIA, the primacy of rational arguments is clear.[100] While ethical discussions also make liberal use of argumentation, this is threaded within a complex tapestry of individual as well as shared values and beliefs, all of which have rich cultural and experiential bases. It is also to be expected that the analysis may include emotions such as empathy and compassion. Such values tend not to feature as heavily in legal instruments such as HRIAs. Similarly, while 'normative standards' form necessary *benchmarks* for all participants or actors affected by HRIA, the same expectation does not hold true to the same extent for ethical assessment. Whereas it is acceptable and necessary for human rights to consider the rights of all, it would be problematic and exclusionary for an ethics assessment to claim that it offers some kind of universal ethical account. Indeed, inclusionary good practice in ethics seeks to avoid propagating or reifying majority views or an historical status quo, and instead seeks to encourage plurality of perspectives. To that end, ethics assessment can offer comprehensive lists ethical principles, issues, and guidelines as tools, while allowing for subjective selection/interpretation/weighing of these items.

Authority: The question of authority in any assessment process is key, especially where assessors are external and/or where guidance is not binding. For HRIA, Kemp and Vanclay[101] suggest that assessors will need sufficient familiarity with the context so as to identify and use 'effective levers for change' and 'calculate the tactical concessions that they may need to make in order to effectively raise human rights issues of significant concern'. This includes the need to avoid isolating themselves and losing

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[96] Kemp, D., & Vanclay, F. (2013). Human rights and impact assessment: clarifying the connections in practice. *Impact Assessment and Project Appraisal*, *31*(2), 86-96.
[97] Ibid.
[98] Harrison, 2011, op. cit.
[99] Ibid.
[100] de Beco, 2009, op. cit.
[101] Kemp and Vanclay, 2013, op. cit.

influence. That this can conflict with how ethical issues are treated is noted by the authors. While the requirement to carefully manage these relations is not limited to HRIA, and ethical assessment also includes pragmatic considerations, there are differences to be found in the priorities and methods that arise from being external/internal to a process. In other words, while balancing values in value conflicts (i.e., making trade-offs between them) is a perfectly acceptable part of ethics assessment, it would not be as easy to compromise any one ethical value in the pursuit of other more 'important' ethical values for political reasons (e.g., tactical concessions), given that this would itself be unethical.

8.2.2 Similarities between ethical assessment and HRIA

Aims and scope: As previously stated, HRIA aims to identify, evaluate and respond to the potential human rights impacts of policies and other interventions by business enterprises, NGOs, governments and other stakeholders. Ethical assessment, on the other hand, aims to identify, evaluate and respond to potential ethical issues associated with practices, products and uses of research and innovation. It is clear that both can evaluate impacts on human rights, be it from different perspectives; one from a legal viewpoint, and the other from a moral viewpoint. In addition, there is some overlap in their ability to assess innovation activities.

Processes: There is some overlap between the processes for both types of assessment, including that each benefit from early preliminary assessments, such as screening, as well as full assessments. Successful transition between the varying levels of assessment will rely on a rigorous process, staffed by those with sufficient expertise, as well as robust tools, which includes well prepared and defined questions to aid such analysis. In all instances, it is key to ensure that such processes are rigorous, transparent, and independently verifiable, with prescribed outcomes (predicted, predictable and unexpected), as well as agreed timelines. It is important to be aware that transparency in assessments may not be prioritised, especially if it is in someone's interests not to share information (whether material is confidential or not). It has been suggested that the limited availability of 'corporate-commissioned HRIAs' suggests 'confidentiality, rather than transparency, is standard practice',[102] and the same sometimes applies in other competitive industries, including in research, especially as it pertains to funding and to poor or corrupt ethical practice.

Procedures: The procedure for HRIA suggested by de Beco[103] includes three crucial steps: analytical, deliberative, monitoring and evaluation. For each there needs to be sufficient flexibility in the steps so as to meet specific needs, circumstances, situations and issues as they arise,[104] though in each case flexibility should not compromise the quality and reliability of the process. As summarised by Reijers et al.,[105] Abrahams and Wyss[106] suggests the following phases in HRIA: '(i) the preparation stage during which the societal context is established, (ii) the screening stage during which the range of technologies is narrowed down, (iii) the scoping stage during which options and scenarios are depicted, (iv) the evidence gathering stage during which data is gathered to support claims of impacts (v) the

[102] Ibid.
[103] de Beco, 2009, op. cit.
[104] Kemp and Vanclay, 2013, op. cit.
[105] Reijers, W., Brey, P., Jansen, P., Rodrigues, R., Koivisto, R., & Tuominen, A. (2016). A Common Framework for Ethical Impact Assessment. *SATORI Deliverable D4.1.*
[106] Abrahams, D., & Wyss, Y. (2010). Guide to Human Rights Impact Assessment and Management (HRIAM). *International Business Leaders Forum and the International Finance Corporation in association with UN Global Compact* https://www.unglobalcompact.org/library/25 [accessed 18/01/20].

consultation stage during which stakeholders are consulted, (vi) the analysis stage aimed at verifying the depicted impacts, (vii) a conclusion and recommendation stage and (viii) a monitoring and evaluation stage during which the outcomes are juxtaposed with stakeholder expectations.' These steps and phases fit fairly well with ethical assessment procedures. For example, SATORI's main steps for ethical impact assessment include: the EIA threshold analysis stage, the preparation stage, the ethical impact identification stage, the ethical impact evaluation stage, the remedial actions formulation stage, and the review and audit stage.[107] Notably, in SATORI, stakeholder consultation is carried out at several of these steps.

Application of frameworks: Each assessment tool stands to offer more impact if they are utilised at a point when policies and practices can be changed. In these ways, early adoption or implementation offers a better chance of influencing the methods and design of processes and outcomes. It can also offer more time for thorough analysis, which can offer wider detection of neglected issues as well as potentially unintended consequences, as well time to scrutinise justifications for policies and actions and to ensure wide dissemination of information for appropriate consultation. Where possible, carrying out assessments at different intervals of a process can 'capture not only short but also medium and long-term impact'.[108] For both instruments, a toolkit of short-term and long-term impact assessment can be beneficial, since the former may be used to address urgent matters, while long-term impact assessment can help to track more complex or systemic changes.[109] Where toolkit and methodological frameworks fail, this will affect the outcomes of an assessment. As such, each assessment relies on *indicators* that can measure success and impact, and each suffers where there is a lack of agreement about what those indicators are and how these should be applied and understood in practice.

Integration or separation: Whether assessments are 'dedicated, integrated or issue-specific approach',[110] and incorporated into existing instruments, or not, needs to be carefully considered. Each method has benefits and limitations. De Beco[111] suggests that incorporating HRIAs into existing impact assessments.

> creates two problems. First, there is a risk that HRIAs are only developed in certain areas. Human rights impact would only be considered limitedly, depending on the kind of impact with which it is jointly assessed. Second, human rights might be diluted in the impact assessments into which they are incorporated, with the risk that policy-makers forget that human rights entail obligations, because other issues dealt with do not have this consequence. When HRIAs are incorporated into environmental, social or economic impact assessments, human rights could be considered as mere aspirations. It is therefore critical to remind States that human rights provide for legal standards.

There are similar risks for ethical assessment incorporation, especially given the tendency for ethics to be viewed as a box ticking exercise. All such decisions impact on the 'scope, resourcing, expertise and methodology' of the HRIA,[112] and the same is true for ethics assessment.

[107] Ibid.
[108] de Beco, 2009, op. cit.
[109] Ibid.
[110] Kemp and Vanclay, 2013, op. cit.
[111] de Beco, 2009, op. cit.
[112] Kemp and Vanclay, 2013, op. cit.

Values, norms and risk of deception: Both HRIAs and ethical assessments rely on norms and standards that in turn rely on there being sufficient shared values for normative foundations.[113] Yet both are vulnerable to what might be called *rights* or *ethics 'washing'*, whereby a company or organisation adopts the terminology of impact assessment so as to further their own agenda, including with outcomes that stand in stark contrast to the aims of either HRIA or ethics assessments. It can also happen that companies show willingness to follow standards with 'limited enforcements mechanisms and subsequently benefit in terms of reputation credits' or where they seek to 'offset human rights harm by doing good deeds elsewhere'.[114] In these kinds of circumstances, the washing can be achieved by offering impact-appropriate rhetoric without transparency or without tangible, concrete outcomes. In either assessment process this can include using simplistic tick boxes or codes to achieve minimum compliance.[115] In the case of both ethics and human rights, such tactics can help to reify existing priorities and decisions and can aid in circumventing meaningful consultation and discussion. This occurs, for instance, where actors in bad faith are not required to act on the outcome of a consultation yet they may benefit by publicising the existence of the consultation, especially as indicative of inclusive engagement processes. Another outcome, whether intentional or not, is where insufficient or inappropriate stakeholders are consulted, especially if these are selected on the basis of desired responses. Not all policies or outcomes will affect all populations and communities in the same way, or even at all: 'While all stakeholders are in some way rights-holders, not all human rights of all stakeholders are put at risk in every circumstance'.[116] For these reasons, it is recommended that a 'distributional impact' needs to be assessed in HRIA[117] so as to consider how the consequences of a policy or outcome will affect diverse populations, and thereby ensure proportional input regarding benefits and the reduction of harms. The same can be applied to ethical assessment.

8.2.3 What we need to consider going forward

Ethics assessment can adopt some of the proposals as outlined in HRIA:

- Education is key in both areas. As well as general education on HR and on ethics, it is also recommended that we foster 'better understanding of evidence gathering techniques that are appropriate to different forms of assessment, and the development and application of context-specific indicators that actually drive assessment processes'.[118]
- The difficulty of managing complexity is common to both assessment instruments. On the one hand, information needs to be made accessible without oversimplifying the instrument. In HRIA data is taken from previous implementation to further refine such processes and try to resolve such tensions, and these techniques of regular refinement can be adopted for ethical assessment (see below).
- Both fields require clearly defined aims and objectives, transparency of intentions and methods, sharing of data to ensure best practice, and robust monitoring of processes at theoretical and applied levels. Guidance should also be dynamic and regularly updated. It is essential to foster dialogue at all stages of assessment, and to include relevant actors and stakeholders in these dialogues.

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[113] Harrison, 2011, op. cit.
[114] Kemp and Vanclay, 2013, op. cit.
[115] Harrison, 2011, op. cit.
[116] Kemp and Vanclay, 2013, op. cit.
[117] de Beco, 2009, op. cit.
[118] Harrison, 2011, op. cit.

- Though consensus may be desired and sought, in any case where definitive answers cannot be found, or disagreements remain, decisions must yet be made, and as such there should be transparency about the processes for resolving or closing disagreements in advance of consultation.

Importantly, ethics assessment and HRIA can be complementary instruments:

- Especially in the area of human rights, it can be helpful to have assessments from both an ethical and legal perspective. This way, one can gain knowledge about what ought to be done from a strictly moral viewpoint, and what can be enforced through legal recourse, and thus potentially about how legal frameworks for human rights may need to be amended.
- In situations where stakeholders tend to be less willing to voluntarily adhere to ethical standards concerning human rights (e.g., in situations where business interests are counter to human rights interests), conducting HRIAs is to be preferred, given the easier route towards enforcement.

9. Conclusion

9.1 Summary

This report has provided a methodology for the ethical analysis of emerging technologies. *Ethical analysis* was defined the process by which ethical issues associated with a situation, action, process or thing are studied in a systematic manner. We distinguished two types of ethical analysis that each have different aims. *Comprehension-oriented ethical analysis* is directed at an understanding of ethical issues as well as possible ways of resolving moral dilemmas, whereas *solution-oriented ethical analysis* is directed at solving moral dilemmas and providing courses of action. We provided a methodology for both.

First, in section 2, we described the goals, assumptions, and applicability of our approach. We have made the following assumptions about the projects for which this method is suitable: (1) Ethical analysis is desired for a particular emerging technology, emerging field of technology, or technological development; (2) A systematic approach is sought for comprehensive identification of a range of ethical issues arising from different aspects of the technology at different levels; (3) The ethical analysis spans both current technology and its use, as well as the foreseeable or potential future technology and its use; (4) The analysis is intended to be responsive to the needs and concerns of stakeholders involved in the development and use of the technology, as well as the interests of those stakeholders affected by the technology; (5) The analysis can constitute a basis for normative recommendations and resulting early-stage interventions in the innovation process.

Next, in sections 3 and 4, we detailed SIENNA's 7-step approach to ethical analysis. In section 3, we provided a detailed description of our methods for conceptual analysis and descriptive studies in preparation for ethical analysis. These methods are covered in steps 1 to 4 of SIENNA's general approach to ethical analysis. The results of these steps constitute input for steps 5 to 7 (covered in section 4), where the focus is on substantive ethical analysis. In step 1, we identify the subject of the analysis (i.e., technology or area of emerging technology in question), and we specify other aspects of the analysis to be performed, including its aims and constraints. The aims may range from more exploratory, perhaps mapping the various ethical issues, or more prescriptive, issuing frameworks or guiding decision-makers. In step 2, we undertake a more thorough scoping exercise by stratifying the subject of analysis into the different levels at which the analysis will take place. The *technology level*, the most general level of description, specifies the technology in general, its subfields, and its basic techniques and approaches. The *artefact* or *product* level gives a systematic description of the artefacts and processes that are being developed for practical application outside the field. The *application* level defines particular uses of these products, in particular contexts and domains, by particular users. In step 3, we describe the subject of the ethical analysis, including its likely future developments. At each of the three levels of description, the relevant objects should be catalogued and described in detail, with clarity and conceptual rigor. In step 4, we describe the likely and possible impacts of the technological developments described in the previous step, along with the stakeholder groups consisting of the populations that will be affected by these impacts. For this step, we have devised a comprehensive approach to social impact assessment, which was outlined in subsection 3.5.

In section 4, we provided a detailed description of our methods for ethical analysis. In step 5, we identify and describe all the ethical issues relevant to the subject, including those that pertain to the (potential) impacts uncovered in Step 4. Specifically, we identify issues, principles and values that may be affected or challenged by a given technology, due to its applications and impacts that were described in the earlier steps. As with the preceding steps, this should take place at the three levels of description for the technology in question. In step 6, we identify and describe all the ethical issues relevant to the subject, including those that pertain to the (potential) impacts uncovered in Step 4. Specifically, we identify issues, principles and values that may be affected or challenged by a given technology, due to its applications and impacts that were described in the earlier steps. As with the preceding steps, this should take place at the three levels of description for the technology in question. Finally, in this step 7, we assess arguments and competing considerations regarding ethical issues examined in preceding steps, to reach evaluations and possibly recommendations. Evaluation entails making and defending moral judgments regarding the moral desirability or undesirability of particular actions, persons, things, events, and outcomes, including environmental and all that entails. Depending on the scope of the overall ethical analysis, this may yield various forms of ethical guidance. Guidance may include recommendations about particular decisions or policies, frameworks for assigning responsibilities to different actors, development or revision of codes of ethics, etc.

In section 5, we identified foresight methodologies which are especially suited to each step in the research process detailed above where foresight could play a significant role. It was not the purpose of this section to provide detailed instructions on how to perform any methodology, merely to suggest some foresight methodologies which are especially suited to the requirements of each step. For step 1 (*Specification of subject, aim and scope of ethical analysis*), the recommended methodology was *environmental scanning*. For step 2 (*Specification of subject, aim and scope of ethical analysis*), *environmental scanning* and *relevance tree* were recommended. For step 3 (*Description of the subject of ethical analysis*), *roadmapping* and *multiple perspectives* were recommended. For step 4 (*Identification of potential impacts and stakeholders*), *roadmapping* and *relevance tree* were recommended. And for step 5 (Identification of ethical issues), *roadmapping*, *relevance tree*, and *future visions* were recommended.

In section 6, we described how stakeholders can be engaged at each stage, their potential impact and methods of engagement. In addition, we presented recommendations on how to improve stakeholder engagement. It was concluded that: (1) Each technology area can pose its own challenges to the process and way stakeholders can be incorporated in ethical analysis. This should be adequately addressed during stakeholder analysis; (2) Transparency and clear communications should exist between and within external and internal stakeholder groups; (3) When the need arises to outsource parts of the project, attention should be paid to robustness of methodologies used; (4) Never exclude a stakeholder because of the potential risk of bias or lobbying, however always ensure that stakeholders are transparent about their affiliations and declare all their conflict of interests; (5) When possible widen the scope and type of stakeholders engaged to encompass civil society and human rights organisations, patient groups and stakeholders of disfranchised backgrounds; (6) Vulnerable populations such as non-EU citizens (residents, refugees, migrants) should be stakeholders.

In section 7, we showed, by looking at cases, how our approach can be applied. We discussed the application of our approach in the SIENNA project, in our ethical analyses of AI and robotics, human enhancement, and human genomics, and we demonstratde application in a case study of autonomous vehicles.

In section 8, we briefly described the relations of ethical assessment with other prominent types of assessment, namely, social impact assessment (SIA) and human rights impact assessment (HRIA). For each, similarities and differences with ethical assessment are outlined, as well as things that need to be considered going forward.

9.2 Limitations and suggestions for future research

The methodology that we propose possibly constitutes most extensive methodology for ethical analysis of emerging technologies that has been published to date. It is based on previous methodologies with a proven track record, notably anticipatory technology ethics and ethical impact assessment, and it is supported by extensive studies of three emerging technologies in the SIENNA project, in which a precursor of the approach has been applied. Nevertheless, it should be observed that the approach, in its various incarnations, has only been applied to a limited number of technologies. It has been applied to artificial intelligence, robotics, human enhancement, and human genomics, and its precursors, anticipatory technology ethics, and ethical impact assessment, have mostly been applied to information technologies, nanotechnology and selected biomedical technologies. This is already a fairly broad range of technologies, but more case studies, involving other technologies and involving the latest version of our approach, would allow for further testing and refinement of the approach.

One area of attention in future development is that for the anticipation of future developments and assessment of impacts, the approach now rests heavily on foresight analysis and social impact assessment, but does not draw heavily from the fields of technology assessment and science and technology studies. These fields have much to offer, and better inclusion of them could help in further improvements to the approach. In particular, the mentioned fields have a less linear and more evolutionary understanding of research and innovation and of the interaction between technology and society than do foresight analysis and social impact assessment, and including them could avoid an overly technological determinist conception of technological innovation and social impacts.

There is still significant room, also for further development of foresight analysis and social impact assessment methods in relation to ethical analysis. We have, so far, only succeeded in a partial integration of methods from these fields with methods of ethical analysis, and more innovative work is possible at this intersection, for example in the development of methods for combining ethical analysis with scenario studies or with Delphi studies.

Further work is also needed on the relation of this and similar ethical impact assessment approaches to other impact assessment approaches, including social impact assessment and human rights impact assessment, and on ways of integrating this approach into processes of responsible research and innovation (RRI) and technology policy. [FN though see 6.3] Much more work needs to be done, also, on methods for the inclusion of stakeholders in ethical analysis. Stakeholder inclusion raises important methodological issues regarding proper representation of interests and viewpoints, addressing issues of power imbalance, the relation between stakeholders and ethics experts, the inclusion of members of the general public, and the reliability of methods for surveying and eliciting viewpoints and opinions from stakeholders.

Notwithstanding these limitations and points for further research, we hope to have presented here an approach for the ethical analysis of emerging technologies that is clear, comprehensive, applicable, flexible, and effective. We do believe it is the most detailed and comprehensive approach to date, and hope that it will prove its utility in the years to come.

References

Abrahams, D., & Wyss, Y. (2010). Guide to Human Rights Impact Assessment and Management (HRIAM). *International Business Leaders Forum and the International Finance Corporation in association with UN Global Compact* https://www.unglobalcompact.org/library/25 [accessed 18/01/20].

Alqatawneh, Omayma, Alex Coles, and Ertu Unver, "Towards the Adoption of Self-Driving Cars", *Smart Trends in Computing and Communications*, Springer, 2020, pp. 455–461.

Asveld, L., & Roeser, S. (Eds.). *The Ethics of Technological Risk*. London: Earthscan Publishers, 2009.

Bezold, Clem, Jonathan Peck, Craig Bettles, and Bob Olson, "Using Vision in Futures", in Theodore J. Gordon and Jerome C. Glenn (eds.), *Futures Research Methods*, 3rd ed., The Millenium Project, 2009.

Bezold, Clement, "Anticipatory Democracy and Aspirational Futures", *Journal of Futures Studies*, Vol. 15, No. 2, 2010, pp. 167–170.

Bray, Olin H., and Marie L. Garcia, "Technology Roadmapping: The Integration of Strategic and Technology Planning for Competitiveness", *Innovation in Technology Management. The Key to Global Leadership. PICMET'97*, IEEE, 1997, pp. 25–28.

Brey, P., "Anticipatory Ethics for Emerging Technologies", *Nanoethics*, Vol. 6, 2012, pp. 1–13. https://doi.org/10.1007/s11569-012-0141-7

Brey, P., "Ethics of Emerging Technologies", in S. O. Hansson (ed.), Methods for the Ethics of Technology, Rowman and Littlefield International, 2017.

Brey, P., Jansen, P., Lundgren, B. and Resseguier, A. (2020). An Ethical framework for the development and use of AI and robotics technologies. Deliverable D4.4 of the SIENNA project. https://www.sienna-project.eu/publications/. 93 pp.

Boenink, M., T. Swierstra, and D. Stemerding, "Anticipating the Interaction between Technology and Morality: A scenario Study of Experimenting with Humans in Bionanotechnology", *Studies in Ethics, Law and Technology*, 4(2), 2010.

Cardwell, D., *The Fontana History of Technology*, Fontana, London; New York, 1994.

CEN, CEN Workshop Agreement, "Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework", CWA 17145-2, June 2017. http://satoriproject.eu/publication_type/standards/

Cotton, M. *Ethics and Technology Assessment: A Participatory Approach.* Berlin: Springer-Verlag. 2015.

Dainow, B., "173 Rules for Improving Your Google Listings", *IMedia Connection*, 13 January 2011. http://thinkmetrics.com/wp/digital-marketing-articles/173-rules-for-improving-your-google-listings/

Dainow, B., "Threats to Autonomy from Emerging ICTs," *Australasian Journal of Information Systems,* vol. 21 November 26, 2017. https://doi.org/10.3127/ajis.v21i0.1438.

Dainow, B., "Threats to Autonomy from Emerging ICTs", *Australasian Journal of Information Systems*, Vol. 21, No. 0, 2017. http://journal.acs.org.au/index.php/ajis/article/view/1438.

De Beco, G. (2009). Human rights impact assessments. *Netherlands Quarterly of Human Rights*, *27*(2), 139-166.

European Commission, *Stakeholder consultation guidelines 2014, public consultation document*, 2014. https://ec.europa.eu/smart-regulation/impact/docs/scgl_pc_questionnaire_en.pdf.

Fusch, Patricia I., Lawrence Ness, "Are we there yet? Data saturation in qualitative research", *The qualitative report*, Vol. 20, No. 9, 2015.

Gianni, R., J. Pearson, B. Reber (eds.), *Responsible Research and Innovation: From Concepts to Practices*, Routledge, 2018.

Gomes, Lee, "When Will Google's Self-Driving Car Really Be Ready?", *IEEE Spectrum*, Vol. 53, No. 5, 2016, pp. 13–14.

Gordon, Theodore J., and Jerome C. Glenn, "Environmental Scanning", in Theodore J. Gordon and Jerome C. Glenn (eds.), *Futures Research Methods*, 3rd ed., The Millenium Project, Washington, DC, 2009.

Gostin, L., Mann, J. M. (1994). Towards the development of a human rights impact assessment for the formulation and evaluation of public health policies. *Health and Human Rights, 1*(1), 58-80.

Götzmann, N. (2019). Handbook on Human Rights Impact Assessment. https://www.researchgate.net/publication/337558738_Handbook_on_Human_Rights_Impact_Assessment

Hansson, S. O. (ed.), *Methods for the Ethics of Technology*, Rowman and Littlefield International, 2017

Harrison, J. (2011). Human rights measurement: reflections on the current practice and future potential of human rights impact assessment. *Journal of Human Rights Practice*, *3*(2), 162-187.

Heimerl, Florian, Steffen Lohmann, Simon Lange, and Thomas Ertl, "Word Cloud Explorer: Text Analytics Based on Word Clouds", *2014 47th Hawaii International Conference on System Sciences*, 2014, pp. 1833–1842.

Horling, Brian, and Matthew Kulick, *Personalized Search for Everyone*, Google Inc., 2009. https://googleblog.blogspot.com/2009/12/personalized-search-for-everyone.html.

Hoven, J. van den, Doorn, N., Swierstra, T., Koops, B., Romijn, H. (Eds.) (2014). *Responsible Innovation 1: Innovative Solutions for Global Issues*. Dordrecht, The Netherlands: Springer.

Ikonen, Veikko, Minni Kanerva, and Panu Kouri, *D.1.1 Heuristics & Methodology Report - Final*, ETICA Project, 2009.

Jansen, P., Brey, P., Fox, A., Maas. J., Hillas, B., Wagner, N., Smith, P., Oluoch, I., Lamers, L, Van Gein, H., Resseguier, A., Rodrigues, R., Wright, D. and Douglas, D. (2019). SIENNA D4.4: *Ethical Analysis of AI and Robotics Technologies* (Version V1.1). Zenodo. 226 pp.

Jansen, P., Broadhead, S., Rodrigues, R., Wright, D., Brey, P., Fox, A., and Wang, N. (2018). SIENNA D4.1: *State-of-the-art Review: AI and Robotics* (Version V.04). Zenodo. 102 pp.

Jensen, Sean R., Heidi C. Howard, Alexandra Soulier, Emilia Niemiec, Rowena Rodrigues, Stearns Broadhead and David Wright, 2019, SIENNA D1. 1: *The consortium's methodological handbook*, SIENNA D1.1: The consortium's methodological handbook (Version V0.6). Zenodo.

Kelly, Heather, "Self-Driving Cars Now Legal in California", *CNN, Update*d 30 October 2012. https://www.cnn.com/2012/09/25/tech/innovation/self-driving-car-california/index.html.

Kemp, D., & Vanclay, F. (2013). Human rights and impact assessment: clarifying the connections in practice. *Impact Assessment and Project Appraisal*, *31*(2), 86-96.

Kim, Young Gil, Jong Hwan Suh, and Sang Chan Park, "Visualization of Patent Analysis for Emerging Technology", *Expert Systems with Applications*, Vol. 34, No. 3, 2008, pp. 1804–1812.

Koops, B., Oosterlaken, I., Romijn, H., Swierstra, T., & Van den Hoven, J. (Eds.). (2015). *Responsible Innovation 2: Concepts, Approaches, and Applications.* Dordrecht, The Netherlands: Springer.

Linstone, Harold, "Multiple Perspectives", in Jerome C. Glenn and Theodore J. Gordon (eds.), *Futures Research Methods*, 3rd ed., The Millenium Project, 2009.

Lucivero, F., Ethical Assessments of Emerging Technologies. Appraising the moral plausibility of technological visions, *International Library of Ethics, Law and Technology*, Springer, 2016

Lucivero, F., T. Swierstra, M. Boenink, "Assessing Expectations: Towards a Toolbox for an Ethics of Emerging Technologies", *NanoEthics*, 5(2), 2011, pp. 129–141.

Palm, E., & Hansson, S. O. The case for ethical technology assessment (eTA). *Technological Forecasting and Social Change*, 2006, 73, 543–558.

Reijers, W., Brey, P., Jansen, P., Rodrigues, R., Koivisto, R., & Tuominen, A. (2016). A Common Framework for Ethical Impact Assessment. *SATORI Deliverable D4.1. http://satoriproject.eu/media/D4.1_Annex_1_EIA_Proposal.pdf*

Reijers, W., D. Wright, P. Brey, K. Weber, R. Rodrigues, D. O'Sullivan, B. Gordijn, "Methods for Practising Ethics in Research and Innovation: A literature Review, Critical Analysis and Recommendations", *Science and Engineering Ethics*, 2017. https://doi.org/10.1007/s11948-017-9961-8

Renfro, William L., *Issues Management in Strategic Planning*, Quorum Books, 1993. https://books.google.ie/books?id=5LATAQAAMAAJ.

Ritchey, Tom, "Morphological Analysis", in Theodore J. Gordon and Jerome C. Glenn (eds.), *Futures Research Methods*, 3rd ed., Washington, DC, 2009.

Rodrigues, Rowena, Stearns Broadhead, *D1.2: Stakeholder analysis and contact list*, SIENNA project, 2018.

Sandelowski, Margarete, "Combining qualitative and quantitative sampling, data collection, and analysis techniques in mixed-method studies", *Research in nursing & health*, Vol. 23, No. 3, 2000, pp 246-255.

Schmeer, Kammi, "Stakeholder analysis guidelines", *Policy toolkit for strengthening health sector reform*, Vol. 1, 1999.

Schwartz, Barry, "Google: We Never Index All Your Pages", *Search Engine Roundtable*, 2015. https://www.seroundtable.com/google-index-all-pages-20780.html.

Stahl, Bernd Carsten, "ETICA Report Summary", *European Commission : CORDIS : Report Summaries: Report Summaries*, January 18, 2013. http://cordis.europa.eu/result/report/rcn/56066_en.html.

Stahl, B. C., R. Heersmink, P. Goujon, C. Flick, J. van den Hoven, K. Wakunuma, M. Rader, "Identifying the Ethics of Emerging Information and Communication Technologies", *International Journal of Technoethics*, 1 (4), 2010, p. 27. http://doi.org/10.4018/jte.2010100102 42

Stahl, B. C., "IT for a better future: How to integrate ethics, politics and innovation", *Journal of Information, Communication and Ethics in Society*, 9(3), 2011, pp. 140–156. doi:10.1108/ 14779961111167630

Stilgoe, Jack, “Self-Driving Cars Will Take a While to Get Right”, *Nature Machine Intelligence*, Vol. 1, No. 5, May 2019, pp. 202–203.

Soulier, Alexandra , Emilia Niemiec and Heidi Carmen Howard, *D2.4: Ethical analysis of human genetics and genomics*, SIENNA project, 2019. https://zenodo.org/record/4068016.

The Danish Institute for Human Rights (2020) https://www.humanrights.dk/business/tools/human-rights-impact-assessment-guidance-toolbox/introduction-human-rights-impact [accessed 15/01/20]

The Futures Group International, “Relevance Trees”, in Theodore J. Gordon and Jerome C. Glenn (eds.), *Futures Research Methods*, 3rd ed., The Millenium Project, 2009.

Van de Poel, I. An Ethical Framework for Evaluating Experimental Technology. *Science and Engineering Ethics*, (online article) 1–20. http://link.springer.com/article/10.1007%2Fs11948-015-9724-3#/page-1, 2015.

Van de Poel, S. and Royakker, L., *Ethics, Technology and Engineering: An Introduction,* Wiley, 2011.

Von Schomberg, R. Prospects for technology assessment in a framework of responsible research and innovation, M. Dusseldorp and R. Beecroft (eds). *Technikfolgen abschätzen lehren: Bildungspotenziale transdisziplinärer Methoden*, Springer, 2012, p. 50.

Wright, D., “A framework for the ethical impact assessment of information technology”, *Ethics and Information Technology*, Vol. 13, 2011, pp. 199–226. http://doi.org/10.1007/s10676-010-9242-6

Wyatt, Sally, “Technological Determinism Is Dead; Long Live Technological Determinism”, in Edward J. Hackett (ed.), *The Handbook of Science and Technology Studies*, Vol. 3, MIT Press, Cambridge, Mass., 2008, pp. 165–180.

Annex 1 - Proposal for generalised socio-economic impact assessment (SEIA) methodology

This section presents a proposal for a generalised socio-economic impact assessment (SEIA) methodology for new and emerging technologies, drawing insights from SIENNA work. This section first reviews the SEIAs carried out in SIENNA and then presents its proposal for a generalised methodology.

1. Review of SEIA work in SIENNA

The research team reviewed the work carried out in Tasks 2.1, 3.1 and 4.1 (state of the art reviews and SEIA of the three technology areas i.e., human genomics (HG), human enhancement technologies (HET) and AI and robotics (AI & R). The SIENNA SEIAs are documented in Deliverables D2.1[119], D3.1[120] and D4.1[121]. The table below documents the results of the review.

Review criteria	D2.1 (HG)	D3.1 (HET)	D4.1 (AI & R)
Lead partner	Uppsala University	Trilateral Research	Trilateral Research
Resources allocated	The overall task on state-of-the-art review (including SEIA) had 6 person months (PMs). How much was allocated to the SEIA was not documented.	The overall task on state-of-the-art review (including SEIA) had 6 PMs. TRI had 1.75 PM for the SEIA.	Overall task on state-of-the-art review (including SEIA) had 6 PMs. TRI had 3 PMs for the SEIA.
How defined/conceptualised	General; and not strictly formal SEIA of current and expected social and economic impacts of human genomic technologies.	SEIA was defined as "a systematic analysis used to identify and assess the socio-economic impacts of HETs on society. Impacts refer to the	SEIA defined as "an analysis used to identify and assess the social, economic and environmental impacts of AI and robotics on society. Impacts refer to

[119] Howard, Heidi, Emilia Niemiec & Alexandra Soulier, "SIENNA D2.1: State of the art review of human genomic technologies", 2019. https://doi.org/10.5281/zenodo.4067912
[120] Jensen, Sean R., Saskia Nagel, Philip Brey, Tanne Ditzel, Rowena Rodrigues, Stearns Broadhead, & David Wright, "SIENNA D3.1: State-of-the-art Review: Human Enhancement", 2018. https://doi.org/10.5281/zenodo.4066557
[121] Jansen, Philip, Stearns Broadhead, Rowena Rodrigues, David Wright, Philip Brey, Alice Fox & Ning Wang, "SIENNA D4.1: State-of-the-art Review: Artificial Intelligence and robotics", 2019. https://doi.org/10.5281/zenodo.4066571

Review criteria	D2.1 (HG)	D3.1 (HET)	D4.1 (AI & R)
		potential changes caused – directly or indirectly, in whole or in part, for better or for worse – by the technologies under consideration."[122]	the potential changes – whether positive or negative, direct or indirect, in whole or in part caused by or associated with the technological field under consideration".[123]
Approach	Qualitative (desk research)	Qualitative, participatory	Qualitative, participatory
Level	Pre-Basic	Basic	Basic
Steps/Process	1- Planning 2- Identify and assess impacts	1- Planning 2- Identify impacts 3- Assess impacts and consult stakeholders 4- Formulate recommendations 5- Review	1- Planning 2- Identify impacts 3- Consult stakeholders 4- Assess impacts 5- Formulate conclusions 6- Review
Tools/methods used	Literature review, market analysis	Literature review, survey, criteria evaluation	Literature review, interviews, criteria evaluation
Why were such tools/methods chosen?	Resources available, time constraints, topic	Resources available, time constraints, lack of data	Resources available
How and what types of stakeholders were engaged ?	Stakeholders were not engaged during the assessment.	Stakeholders were consulted via a mini-survey on the significance of the impacts identified. They included human enhancement experts in academia, industry, civil society, media representatives. Note, a separate task on stakeholders' identification was previously conducted.	11 semi-structured interviews were conducted with experts on AI and robotics to supplement the literature review. This group of experts was selected to reach professionals in different fields and from different locations. They included an economist, academic researchers from AI, ethics and robotics, regulators, journalists,

[122] Jensen et al, op.cit., 2018.
[123] Jansen et al, op.cit., 2019.

Review criteria	D2.1 (HG)	D3.1 (HET)	D4.1 (AI & R)
			legal experts and representatives from a European consumer-protection Organisation.
Data collection process, sources of information	External sources: desk-based review	External sources: desk-based review on online databases from academic papers; mini survey	External sources: desk-based review; stakeholder interviews
Categories of impact identified and their target population (if any)	A. Economic: industry and society level B. Social: groups and society level	A. Social: individual, groups, society level B. Economic: individual and society level C. Environmental: individual, animals and society level	A. Social: group and society level. B. Economic: group and society level. C. Environmental: group and society level.
Challenges or weaknesses	a) Nature of the task: limited time allocated to the task, large scope of genomics to be addressed and range of technologies and possible applications, lack of access to specific data b) Technologies of genome sequencing: lack of economic investigation and data gathering on the matter c) Expertise in impact assessment d) No stakeholder consultation	a) Nature of the topic: broad and fuzzy topic with unclear subject delimitations. b) Not enough coverage on human enhancement technology both from the academia and public: scarcity of resources available, challenge to find scientists, public view on human enhancement has not been assessed enough c) Survey: small simple size, no	a) Impact identification: lack of consensus among authors of existing studies, bias from institutional motivations or opinions. b) Timelines of impacts: literature does not address this adequately (or at all). Thus, questions on this were included at the interviews to shed some light on the matter.

Review criteria	D2.1 (HG)	D3.1 (HET)	D4.1 (AI & R)
		statistical significance test.	
Unique elements (compared to other SEIAs)	Not obvious.	Included environmental explicitly	- Included environmental explicitly - It explores which applications generate the most positive/negative impacts. - Distinct insights from literature review and interviews. - Analysis on the effects of impacts on values.
Team's overall assessment of effectiveness based on above and/or use in SIENNA work that followed it (e.g., ethical analysis, legal and HR analysis and WP5 results)	The SIENNA SEIA work was part of the third step (Identification of stakeholders and potential impacts) in its ethical analysis process and was designed to feed into it directly. The work in *D2.4 Ethical analysis*[124] which identified issues and values that may be affected or challenged by genomic technology relied on the description of	SIENNA SEIA work was part of the third step (Identification of stakeholders and potential impacts) in its ethical analysis process and was designed to feed into it directly. *D3.4 ethical analysis*[127] identified issues, principles and values that may be affected or challenged by a given technology, partly based on its	SIENNA SEIA work was part of the third step (Identification of stakeholders and potential impacts) in its ethical analysis process and was designed to feed into it directly.[129] The ethical analysis method in D4.4[130] cross-referenced ethical issues with the results of the SIENNA D4.1 report on the state of the art of AI and robotics technology.[131] Impacts

[124] Soulier, Alexandra, Emilia Niemiec & Heidi Carmen Howard, "SIENNA D2.4: Ethical Analysis of Human Genetics and Genomics", 2019. https://doi.org/10.5281/zenodo.4068016
[127] Jensen, Sean R., "SIENNA D3.4: Ethical Analysis of Human Enhancement Technologies", 2020. https://doi.org/10.5281/zenodo.4068071
[129] See p.23, D4.4.
[130] Jansen, Philip, et al, "SIENNA D4.4: Ethical Analysis of AI and Robotics Technologies", 2020. https://doi.org/10.5281/zenodo.4068083
[131] See p. 25, D4.4.

Review criteria	D2.1 (HG)	D3.1 (HET)	D4.1 (AI & R)
	innovative technologies in genomics and the identification of related social and ethical impacts provided in D2.1.[125] D2.4 also referenced the ELSI challenges of genomic sequencing in the clinic faces similar ELSI challenges as those involved in research.[126] Impacts and concerns highlighted in D2.1 were taken up in D2.4 (e.g., health disparities, genetic discrimination, risk of misrepresentation etc). The SIENNA Foresight Workshop Genomics: Future impacts and ethical issues (18 January 2019) also drew upon work in D2.1.	applications and impacts described in D3.1.[128] Some of the SEIA work was touched upon in the SIENNA Foresight Workshop: Social and Ethical Issues of Human Enhancement (16-17 January 2019, London).	highlighted in SEIA were engaged in D4.4. SEIA work was used in the SIENNA Foresight Workshop: Social and Ethical Issues of AI and Robotics (15-16 January 2019, London). A social impacts checklist was distributed to participants and social impacts were very much a core part of the discussion. The legal analysis (D4.2)[132] mapping part of the legal research began with a literature review and included the relevant analysis of findings and results of SIENNA D4.1. D4.2 also cross-references the issues in drawing its conclusions.

Table 7: Review of SEIA work in SIENNA

2. Proposal for a generalised methodology for SEIA of new and emerging technologies

Based on our use of SEIAs in SIENNA for human genomics, human enhancement technologies and AI and Robotics and the review and evaluation of this work, this section presents a generalised method

[125] D2.4, p.98.
[126] p.108.
[128] See p.25, D3.4.
[132] Rodrigues, Rowena, Konrad Siemaszko, & Zuzanna Warso. "SIENNA D4.2: Analysis of the legal and human rights requirements for AI and robotics in and outside the EU", 2019. https://doi.org/10.5281/zenodo.4066812

for carrying out a SEIA of new and emerging technologies. The guidance provided here is primarily meant to facilitate researchers in carrying out a SEIA of new and emerging technologies in research projects but could also be useful more generally.

2.1 Concept and definition

Impact assessment (IA) is an overarching term for concepts, processes, methods, and tools to analyse, evaluate and manage the intended and unintended positive and negative consequences of planned interventions[133]. Specific methods have been developed, each of them focused on the study of specific types of impacts and/or applications. The method here presented will contribute to this branch of studies and will propose a method for SEIA specific to new and emerging technologies.

We define SEIA as a tool used to identify and assess the economic and social impacts of new and emerging technologies. The resulting analysis allows us to understand and assess how new and emerging technologies will evolve in the society and the economy and affect different social groups. The benefits of a SEIA for new and emerging tech include, but are not limited to:

- Assisting parties to identify and address significant and adverse impacts of such technologies early-on.
- Helping find ways to reduce, remove, or prevent these impacts from happening.
- Providing a dialogue platform or springboard for planning how to maximise beneficial impacts.

2.2 Objectives, scope and challenges

The objective of a SEIA is to explore, identify and assess expected social and economic impacts of new and emerging technologies.

Given the nature of the topic (new and emerging technologies) and its limitations, we recommend following a qualitative rather than quantitative approach. The scope of the SEIA would be determined on a case-by-case basis – in some cases it might be more limited than others. However, these types of SEIAs should not be interpreted as a comprehensive empirical examinations.

The proposed SEIA aims to answer the following research questions:

- How does the specific technology impact the economy and the society?
- What population/which groups does the technology target?
- Who are the other stakeholders that might be unintentionally or marginally impacted?
- How can we measure its impact?
- How can the negative impacts be mitigated and positive impacts be maximised (taking resource constraints into account)?

There are several challenges that might be encountered in carrying out SEIAs of new and emerging technologies. One key challenge that affects SEIAs of new and emerging technologies is the lack of data for its assessment. This relates to the scarcity of expertise on the matter and the general lack of prior research on the topic. Having the right expertise to carry out the SEIA is also a challenge. SEIAs are also affected by the selection of a broad topic for assessment. SEIA studies usually refer to a particular technology, targeted at a particular population. Defining a common framework for all new and

[133] Vanclay, F., "International Principles for Social Impact Assessment" *Impact Assessment and Project Appraisal*, vol 21, No. 1, March 2003, pp. 5-11.

emerging technologies is a challenging task as there are many technologies, with different applications and sectors involved that need to be taken into consideration.[134] Another might be that impacts are not always observable when the assessment is carried out. This means that the assessment will need to be re-visited and reviewed. Existing ambiguity about how the target technology will affect the values that determine the criteria and framework for evaluating their impact is yet another challenge. Also challenging is the complexity of the synergistic effects of emerging technologies on socio-economic structures. Finally, and significantly, resource availability (finance, time, personnel) and timing the SEIA right so it can have greatest value also remains an ongoing challenge.

2.3 Operational framework

This sub-section outlines the approach and key steps of the SEIA. Based on previous SEIAs and adapting the process to the study of new and emerging technologies, we have recommended a six-step method (see Figure 1). Steps two and five (*) might not always apply. The final decision on whether to include them will depend on project's capacity and the technology studied.

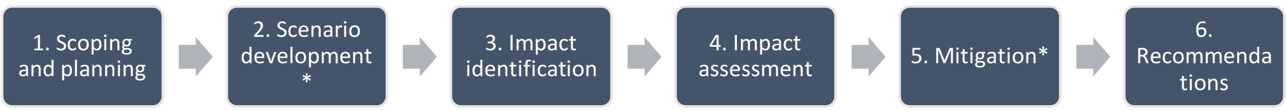

Figure 6: Steps in the SEIA

Elaborated below are the each of the steps, their objectives, process, results, tools and methods and resources and expertise required. *Steps are steps that might not be present in all SEIAs depending on their level and type.

2.3.1 Scoping & planning

Objective: To plan and conduct a preliminary scoping analysis that identifies SEIA considerations and required information or knowledge. At the end of this step, researchers should have a deep understanding of the technology to be assessed and should have identified the users, stakeholders and the socio-economic forces at play. Additionally, other specifics of the assessment should be planned. One, the boundaries of the scope of the assessment process need to be identified. Two, case-specific indicators and significance criteria should be determined. Three, team composition, resource allocation and the time-line for the SEIA must be outlined.

Process: In order to more fully grasp the consequences of new and emerging technologies, some preliminary questions should be answered. Examples of relevant questions include:

- What is the intended purpose of the technology?
- What are the typical applications of the technology?
- In which sector does it operate? Which other sectors might it affect?
- Does it offer new services?
- Does it replace an already existing technology?
- Who are the target users?

[134] Other factors that explain this challenge are the lack of a commonly agreed definition of the target technologies or the fact that many of the technologies are under development and we do not know the direction in which they will evolve.

- Who are the affected stakeholders?
- Who might be affected by unintended uses of the technology (e.g., accidents or misuse)?

Once these questions have been answered, researchers should start thinking about the possible sources of data (if available) to identify and assess impacts, the accessibility of users and stakeholders identified, and the steps further required. The approach of the SEIA will depend on these factors. Thus, here key decisions about the methods, tools and the scope, should be taken.

Result: This step will result in a plan for the SEIA that will, inter alia, help understand the functioning of the target technology and its impact flows.

Tools and methods: Internal team discussion, desk-based research, literature review and consultations with expert, stakeholders, or general public (if required).

Resources and expertise required: To proceed with the next steps of the SEIA, a good understanding of the state of the art of the technology to be studied is key. It is also important to have a general level understanding of the processes by which the technology is developed. If the team lacks expertise, consultations with experts or an extended literature review might be desirable.

2.3.2 Scenario development

To envision future impacts, using scenario thinking to foresee the development of new and emerging technologies is helpful. Scenario thinking is defined as "a description of a possible set of events that might reasonably take place"[135] It is a very useful tool to envision possible future outcomes that cannot be currently observed.[136] Its importance must be emphasised particularly in the context of the advent of new technology, which brings its own complexities and implications for society, and potential alternatives of future impact whose understanding needs to be deepened and broadened.

Despite this being a very valuable step, scenario development is very demanding in terms of efforts, resources, and expertise. Additionally, the benefits derived from it depend on the type of technology being assessed. For instance, futuristic technologies[137] may highly benefit from scenario thinking, while other technologies that are further advanced in terms of piloting, might not. Thus, this step is not proposed as critical to the SEIA methodology but one that could highly add value to it. We recommend conducting it when the resources, team expertise and type of target technology allow it.

Objective: The main objective of developing scenarios is to stimulate thinking about possible occurrences, assumptions related to these occurrences, possible opportunities and risks, and courses of action.[138] Additionally, it allows stakeholders to engage in the assessment and explore issues expected to influence the development and uptake of new technologies.

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[135] Kwon, Heeyul, Jieun Kim and Youngtae Park, "Applying LSA text mining technique in envisioning social impacts of emerging technologies: The case of drone technology", *Technovitation,* 2017. http://dx.doi.org/10.1016/j.technovation.2017.01.001
[136] Schoemaker, P., and M. Mavaddat, "Scenario Planning for Disruptive Technologies", *Wharton on Managing Emerging Technologies,* 2000, pp. 206-241.
[137] By 'futuristic technology' we refer to innovative or revolutionary technology that is still in research and design phases and not yet in use.
[138] Schoemaker, P., and M. Mavaddat, "Scenario Planning for Disruptive Technologies", *Wharton on Managing Emerging Technologies*, 2000, pp. 206-241.

Process: There are many different types of scenarios, each of them with their own construction process.[139] Outlined here is a broad recommendation on how to build scenarios. Please note, that this description should be adapted according to the technology under assessment and the resources available.

First, we recommend organising a brainstorming session. This meeting should be coordinated by the impact assessment team and led by a scenarios expert who will usually develop a general briefing version of the scenarios based on the desk-based research with the aim of scoping the exercise. The scenarios be time limited to a five to seven years' timeframe to enable predictions based on existing knowledge and at the same time, to take into account the timescales of policy change and investment cycles. At the end of the first session, participants should have identified several factors relating to the drivers of technology innovation, potential barriers to and inhibitors of technology adoption and a list of social and economic positive and negative impacts attached to each scenario. Depending on the scenario approach, participants may be asked to weigh the impact of each factor and the likelihood of effecting the anticipated impact. The findings of this initial session should be synthesised into a draft scenario. This is an intensive and skilled writing process as conflicting views emerging from a participatory group process need to be reflected into a coherent story.

Second, we recommend a validation session in which the results and initial scenario are shared with the participants of the brainstorming session for their review. This is important for many reasons: to ensure that all views are captured and represented accurately, cross-check assumptions, give participants an opportunity to revise their views and include any afterthoughts, gather comments and recommendations, and reassess the scenarios.

This step should be repeated as many times as groups of stakeholders, users or affected parties until the scenario is stable, i.e., researchers have resolved most if not all stakeholder comments and issues, and the remaining stakeholders have no or few minor comments.

Result: At the end of this step, researchers should have developed a list of possible scenarios including main drivers, barriers and potential impacts. Scenarios should be formulated in a clear manner.

Tools and methods: Each type of scenario has its own construction methods. For the visioning, we recommend using creative tools such as diagrams, decisions trees or mental maps. For the consultation and validation of scenarios with stakeholders we recommend using participatory methods such as workshops or the Delphi method (when resources and expertise permit).

Resources and expertise required: Developing scenarios is an intense activity and requires good resources and expertise. Scenario building requires visionary and creative experts and the collaboration of different types of expertise – e.g., foresight analysis experts, scenario building professionals, creative thinkers, technology developers and experts from different backgrounds to provide useful insights e.g., science and technology, social sciences, environmental sciences, economics, demography, etc.[140] Team members with experience in participatory methods are also required. Adequate time and human resource must be devoted to the scenario building and validation process.

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[139] European Foresight Platform, "Scenario method", 2010. http://www.foresight-platform.eu/community/forlearn/how-to-do-foresight/methods/scenario/
[140] European Foresight Platform, "Scenario method", 2010. http://www.foresight-platform.eu/community/forlearn/how-to-do-foresight/methods/scenario/

2.3.3 Impact identification

Objective: Impact identification requires a logical and systematic approach. The goal is to consider all important impacts. There should be a differentiation between, and clarification of, direct and indirect impacts,[141] and ensuring that indirect effects, which may be potentially significant, are not missed out.

Process: We propose a two-fold approach. First, desk-based research should be carried out using specialist technology futures resources (see examples in Table 2). Here two factors should be taken into consideration. First, the resource must cover the target new or emerging technology, and experts and public should actively discuss the target technology. Second, a future-oriented context is necessary, i.e., opinions should be mainly about the future development of that technology and its potential implication for society.[142]

Resource	Content/Areas of focus	URL
Future Timeline	AI & robotics, home & leisure, society & demographics, space, etc.	http://www.futuretimeline.net
MIT Technology Review	Biomedicine, computing, energy, materials, robotics, etc.	http://www.technologyreview.com
World Future Society	Social, economic, technology, science, etc.	http://www.wfs.org
Wired	Design, science, security, entertainment, design, etc.	http://wired.com
io9	Science fiction, futurism, science, technology, etc.	http://io9.com

Table 8: Example of websites specialised in futures of new and emerging technologies [143]

When identifying impacts, researchers should first consider direct impacts of the technology target by referring to the following suggested categories of potentially affected groups: individuals, consumers, workers, enterprises, public authorities, members of the public and vulnerable groups. Depending on the target technology, the potentially affected (including vulnerable) groups will differ. Second, to understand indirect or second-order effects, insights from multi-sectoral analysis and the scenarios should be considered. Researchers should categorise impacts by macro, meso and micro-level and associate them to one or more of the scenarios, sectors or groups identified in the previous steps.

Second, researchers will need to identify which of these impacts are likely to be relevant. To carry out this task, we recommend a combination of technical and participatory approaches. Once each impact has been captured by a scenario (if previously identified), experts should assess its relative relevance against the following factors[144]:

- The direction of the impact: who is affected and in what way (i.e., positive or negative sign of the impact)

[141] Direct impacts are these which are a direct consequence of the technology under assessment on the socio-economic environment. In contrast, indirect impacts are these which are not a direct result of the technology, often produced away from, or as a result of a complex impact pathway.
[142] Kwon, Heeyul, Jieun Kim and Youngtae Park, "Applying LSA text mining technique in envisioning social impacts of emerging technologies: The case of drone technology", *Technovitation*, 2017. http://dx.doi.org/10.1016/j.technovation.2017.01.001
[143] Ibid.
[144] European Commission, "Better Regulation Toolbox-19". https://ec.europa.eu/info/files/better-regulation-toolbox-19_en

- The magnitude of the expected impacts: consider impacts with the greatest impact.
- The relative size of expected impacts for specific stakeholders: consider impacts that despite being of small range in absolute terms, may be significant for some specific group due to:
    - The relative size of the latter (example of micro and small enterprises)
    - The concentrated nature of the impacts on specific regions or industry; and the cumulative impact.

Next, the analysis should be shared with experts or stakeholders for validation. Consultations via surveys, focus groups or interviews could be carried out. During these consultations, researchers should assess together with stakeholders and users' the relevance of the impacts.

Result: A stakeholder validated mapping of all potentially relevant impacts connected to affected parties and sectors of relevance of the technology being studied.

Tools and methods: The most common tools and methods used for impact identification are checklists, matrices, and professional judgement. Selection of these tools and methods depends on target of evaluation and sector. However, given the nature of the topic, literature review and professional judgement via surveys or interviews are expected to be the most appropriate tools (and have been proven to function well when used).

Resources and expertise required: The impact identification stage could take a long time given the lack of resources on new and emerging technologies. Teams with mixed of expertise are very beneficial at this stage as many fields and sectors might be implicated. Experts such as social scientists, economists, experts from key sectors of relevance, ethical and legal experts are critical to involve.

2.3.4 Impact assessment

Objective: Once impacts are identified; they should be evaluated to determine their significance. Thus, the main purpose of this step is to assess the magnitude or extent of the impacts identified.

Process: When data is available, quantitative assessments should be prioritised. Analytical methods such as cost-effectiveness, cost-benefit analysis, risk analysis, multi-criteria analysis or quantitative tools as econometric models, sectorial models or Computable General Equilibrium (CGE) could be used. Despite being highly valuable, using these methods could be a challenging task given the nature of new and emerging technologies as a subject of socio-economic analysis. Thus, we believe that for new and emerging technologies, qualitative assessments might be more suited or desirable. Among the existing qualitative methods, participatory tools as dialogue or Delphi methods are useful.

We recommend following an impact significance methodology. Impact significance analysis is a common practice in impact assessments that makes judgments about what is important, desirable, or acceptable. It also interprets degrees of importance. In general terms, an impact significance is determined by the joint consideration of its characteristics: magnitude, duration, and likelihood.[145] Each of these is described below:

- *Magnitude*: for each impact being evaluated, researchers should determine its magnitude. Magnitude could refer to different aspects depending on the study, such as the extent or

[145] Terrapon-Pfaff, Julia, Thomas Fink, Peter Viebahn and El Mostafa Jamea, "Determining significance in social impact assessments (SIA) by applying both technical and participatory approaches," *Environmental Impact Assessment Review*, Vol. 66, 2017, pp. 138-150

spatial scale of the impact, the severity of the impact, or the number of persons or units of study affected.[146]

- High: within the limits of the highest order of imaginable impacts.
- Medium: Impact is real but not substantial in relation to other impacts that might take effect within the bounds of those that could occur.
- Low: Impact is of a low order and therefore likely to have little real effect.

- *Duration*: for each impact, the assessment should decide if it will be short-term, medium-term, long-term.
  - Short-term impact: impacts that can occur over a few months or for a defined period. So, short-term impacts may be of minor importance in the long-time frame.
  - Medium-term impact: impacts that can be measured in months or few years (e.g., up to ten years).
  - Long-term impact: impacts that last for over ten years.
- *Likelihood of occurrence*: For each impact being evaluated, researchers should decide if it will be unlikely to occur, will possibly occur, or will probably occur.[147]
  - Unlikely to occur: These are impacts that have a very low chance of occurring now or in the future.
  - Possibly will occur: These are impacts that are possible, but not likely occur.
  - Probably will occur: These are impacts that are very likely to occur.

In order to determine the level of magnitude, duration and likelihood, the study should design significance criteria during the scoping stage. These criteria will help researchers have a common approach and assess impact uniformly.

Results: Assessment of each of the impacts according to its characteristics. The analysis could be organised as indicated in the table below.

Scenario	Impact	Magnitude	Duration	Likelihood
#1	#a	High	Medium-term	Unlikely to occur
	#b	Medium	Long-term	Probably will occur

Table 9 Impacts significance by scenario

Tools and methods: There are different approaches to conducting significance analysis. In general, these can be divided into technical approaches and participatory approaches. Technical methods use technical tools and depend primarily on expert assessments, technical details, and interpretation of data. Participatory methods concentrate on the relative significance given to an effect by a person or a group. The decision of which approach to follow will depend on the resources available, the expertise or the data availability, and should be set at the scoping stage.

When the team has enough resources, we recommend using a mixed methodology. First, the impact assessment team will assess the significance based on their expertise or secondary data. Second, the

[146] Rossouw, N., "A review of Methods and Generic Criteria for Determining Impact Significance", *African Journal of Environmental Assessment and Management,* Volume 6, June 2003, pp. 44-61.

[147] Terrapon-Pfaff, Julia, Thomas Fink, Peter Viebahn and El Mostafa Jamea, "Determining significance in social impact assessments (SIA) by applying both technical and participatory approaches", *Environmental Impact Assessment Review*, Vol. 66, 2017, pp. 138-150.

conclusions derived should be validated with stakeholders. However, we do not define this validation step as compulsory. Furthermore, it will depend on resources and time available.

Resources and expertise required: The resources and expertise needed for conducting the impact assessment stage will depend on the final approach taken. For instance, if the SEIA includes a quantitative assessment, there should be provisions for adequate time, finances (to obtain the data), and expertise on such methods. A SEIA that follows the impact significance methodology could be less time and resource intensive.

2.3.5 Mitigation of impacts

One of the most significant and critical steps in a SEIA is the identification of mitigation measures and mitigation of impacts, which is carried out based on the assessment of the impacts. Mitigation involves design changes and/or other interventions to overcome socio-economic impacts. The SEIA team analyses what are the options for mitigate the negative impacts identified. However, given the nature of the topic here discussed, this step might not be included in all SEIAs as mitigation itself might not be within the control of the research project carrying out the SEIA. The decision on whether to include this step and its extent (identification of measures might be possible in all cases but actual mitigation responsibility might lie elsewhere) depend on several factors such as the nature and type of technology studied, its purpose and scoping and whether such a step is able to be implemented by the organisation commissioning the SEIA. Outlined below is a general recommendation for this step, which will need to be tailored to each case.

Objective: The objective here is to identify and take mitigating measures to manage, reduce or eliminate adverse socio-economic impacts.

Process: To identify and refine appropriate mitigation actions, researchers should collect information on measures (e.g., by looking at what measures have been taken by similar technologies, related research projects) and discuss these with potentially impacted groups, policy-makers and other stakeholders and implement appropriate measures (as feasible). The impact identification, assessment and mitigation steps should be conducted in an iterative fashion and there should be a constant feedback loop between these steps. This process should be repeated until the possible effects are no longer significant or the implementation of additional mitigation actions becomes financially unfeasible.

Results: Mitigation plan, including identification and implementation of mitigation measures and responsibilities and review provisions.

Tools and methods: There is no specific method for identifying and implementing mitigation actions. However, when designing mitigation actions, the following guidelines could be helpful:[148]

- Researchers should concentrate on minimizing the possible major negative effects.
- Instead of merely reducing adverse impacts, mitigation should improve the long-term beneficial socio-economic effects.
- Mitigation should concentrate on removing causal factors and impact-related mechanisms, eliminating the root of the effect rather than controlling the result.

[148] Mackenzie Valley Environmental Impact Review Board (MVEIRB), *Socio-Economic Impact Assessment Guidelines,* Mackenzie Valley Environmental Impact, 2007.

Resources and expertise required: Developing a strong mitigation action plan requires time and resources. The participatory approach here suggested requires several sessions with stakeholders and users and a constant validation process. It also requires the right expertise on the team. For instance, experts on participatory methods will be needed, and team members with knowledge on how to construct mitigation plans and deal with different types of stakeholders whose interests might not be compatible or come into direct conflict.

2.3.6 Recommendations

In some SEIAs, this is the final step (and this step might also immediately follow the impact assessment step where the mitigation step is not carried out).

Objective: To analyse the main opportunities and risks attached to each impact and formulate recommendations

Process: Here, researchers should look back at the analysis conducted and draw conclusions from it. Following previous steps, researchers should work upon the scenario planning (if any) and impact assessment tables and analyse them. Researchers should consider both positive and negative impacts identified and think how they will evolve. By doing so, opportunities attached to positive impacts, and the risks that come along with negative effects would be identified. Once, this have been identified final recommendations can be formulated.

Results: Insights on opportunities and risks (Table 4) and/or a list of recommendations (Table 5).

Scenario	Impact	Assessment	Opportunities	Risk
#1-	#a			
	# b			

Table 10 Opportunities and Risks

Time-frame	Recommendation	Responsible actor/stakeholder
Short term		
Medium term		
Long term		

Table 11 SEIA recommendations

Tools and methods: Although a participatory approach should we taken, we recommend following a technical approach and basing recommendations on team expertise and the mitigation actions formulated (if any). By doing so, we ensure that final recommendations are not biased toward personal interests or judgments from a specific group. We suggest framing the recommendations on different time terms i.e., the short, medium and long term.

Resources and expertise required: This final step does not require a specific expertise on the part of the team.

2.4 Levels of a SEIA

This section provides guidance on how to categorise impacts according to unit level and to define SEIA's scope level.

A. Categorisation of impact levels

As previously mentioned, impacts should be categorised into macro, meso or micro level:[149]

- *Macro Level:* this level covers country-level or aggregated impacts. This level usually represents the general environment within the economy or the society that influences the well-being, decision making or working performance among others, of all members of the society at the same time. For instance, some key dimensions of the macro environment are:
  - Political and legal environment,
  - Economic environment,
  - Socio-cultural and demographic environment
  - Technological environment.
- *Meso level*: this level refers to intermediate unit levels of decision making. These could refer to industry sectors or certain social groups. In contrast with the macro level, the meso-environment comprises forces closer to the individual or the firm and greatly influence decisions made at the micro level. Examples of dimensions of the meso-environment are:
  - Health structures
  - Community development
  - Competitors
  - Stakeholders
- *Micro level*: this level refers to the environment which is in direct contact with the individual or the organisation. This level gathers all forces that are in direct contact with the individual or organisation and influences them in the short-term. In contrast with the macro or meso environment, these forces are controllable but to some extent only. Some key dimensions of the microenvironment are:
  - Access to basic services
  - Local development structures

B. Categorisation of SEIAs levels:

At the planning stage, researchers should define the scope of the SEIA, identify its possibilities and limitations, and the resources available. Based on these insights, researchers can identify the assessment level of the SEIA[150] (see Table 12).

Level	**Information expectation**	**Recommended content**	**Focused on…**
Basic SEIA	Mainly qualitative information from secondary sources	Scoping Scenario planning Impact identification	Specific impacts only: specific population or sector. Indicators are pre-defined, and they are not a product of the impact identification stage.

[149] Serpa, Sandro Carlos Miguel Ferreira "Micro, Meso and Macro Levels of Social Analysis" *International Journal of Social Science Studies,* Vol. 7, No. 3, May 2019, pp. 120-124. https://heinonline.org/HOL/LandingPage?handle=hein.journals/ijsoctu7&div=36&id=&page=

[150] Adapted from *Socio-Economic Impact Assessment Guidelines,* Mackenzie Valley Environmental Impact, 2007

Moderate SEIA	Secondary research requiring either no primary research or a moderate amount of primary research	Scoping Impact identification Impact assessment	Identified and defined impacts. Acquiring basic information about the socio-economic environmental context.
Comprehensive SEIA	Primary and secondary research required	Scoping Impact prediction Impact assessment (qualitative and quantitative) Mitigation	Every area of possible impact. A detailed understanding of socio-economic environmental and context.

Table 12: SEIA levels

2.5 Indicators for use in assessment

Specific indicators should be set out for assessment of the new or emerging technology depending on the industry or sector involved and the target population. Below is a preliminary list of economic and social indicators:[151]

A. Economic:

Level	Dimension	Indicator (s) (examples)
Macro Level	Industry	Value added of the ICT sector and sub-sectors Changes in labour productivity Changes in production costs
	Jobs and earnings	Percentage of ICT driven jobs in other sectors Percentage of persons employed using computers connected to the Internet in their normal routine Job destruction/creation by sector
	Trends	ICT goods and services in manufacturing exports by economy or region Country or sector competitiveness Public or private investment
Meso Level	Savings	Time and money saved

[151] OECD, "Key ICT Indicators". https://www.oecd.org/digital/ieconomy/oecdkeyictindicators.htm; OECD, *How's life in the Digital Age? Opportunities and Risks of the Digital Transformation for People's Well-being*, OECD Library, 2019.

Micro Level	Income and Wealth	Labour markets returns to ICT Number of people using internet services for online Consumption
	Jobs and earnings	Changes in wages relative to labour productivity

Table 13: Economic indicators

- Social:

Level	Dimension	Indicator (examples)
Macro Level	Industry	Extent of job polarisation driven by digital skills and job automation
	Trends	Number of lives saved, increase/decrease in life expectancy
	Governability	Threats to democracy Open government applications
Meso Level	Health	Diffusion of health monitoring tools
	Industry	Extent of job polarisation driven by digital skills and job automation
	Equal treatment & access	Households with using a broadband connections-urban and rural Level of Internet access for households
	Social inclusion	Digital exclusion
	Job	Effects on health or security of workers Jobs at risk from automatisation
	Civic engagement and governances	Exposure to disinformation online Percentage of individuals who used Internet for interaction with public authorities
Micro Level	Health	Extreme internet use of children
	Education and Skills	Digital skills gap, digital resources at school, digital skills gap, online education
	Work-life balance	Tele-working and job stress
	Social connections	Children experience cyberbullying
	Personal security	Data protection concerns
	Subjective Well-being	Causal effect of internet use on subjective well-being

Table 14: Social Indicators

When developing case specifics indicators and to the extent possible, all indicators should be "RACER", i.e.,[152]

- **Relevant**, closely linked to the objectives to be reached.
- **Accepted** by stakeholders and users.
- **Credible** for non-experts, unambiguous and easy to interpret.
- **Easy to monitor**.
- **Robust** against manipulation.

2.6 General principles for SEIAs

Outlined below is a list of principles that should be followed by all SEIAs of new and emerging technology based on SIENNA and our own research[153]:

- **Comprehensive**
  - All relevant economic, social, and environmental impacts should be considered.
- **Open and inclusive of affected stakeholders-view**
  - Expert and public opinion should be included and well-reflected in the assessment process.
  - Local knowledge and experience, and acknowledgment of different local cultural values should be incorporated in the assessment.
- **Proportionate**
  - Tools and instruments employed in the assessment should be used in a way that is proportionate to the type of intervention or initiative, the importance of the problem or objective, and the magnitude of the expected or observed impacts.
- **Evidence-based**
  - Assessments should be based on the best available evidence; or provide a transparent explanation of why some evidence is not available and why it is appropriate to act in the absence of evidence.
  - Collect qualitative and quantitative social, economic, and cultural data sufficient to usefully describe and analyse all reasonable alternatives to the action.
- **Transparent**
  - The assessment process should be clearly described along with what assumptions are used and how significance is determined.
  - Results of evaluations, impact assessments, consultations and stakeholder responses should be widely disseminated.
- **Unbiased**
  - Evidence should inform political decisions - not the other way around.
- **High-quality**
  - The assessment should deal with issued and socio-economic concerns that really count, not those that are just easy to count.
  - It should use the right combination of expertise that provides the best results.
- **Flexible**

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[152] European Commission, "Better Regulation Toolbox-41" https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-41_en_0.pdf
[153] European Commission, "Better Regulation Guidelines", https://ec.europa.eu/info/sites/info/files/better-regulation-guidelines-impact-assessment.pdf European Commission, "Better RegulationToolbox-1" https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-1_en_0.pdf
Vanclay, F., "International Principles for Social Impact Assessment" Impact Assessment and Project Appraisal, vol 21, No. 1, March 2003, pp. 5-11.

- The SEIA process should be flexible to adapt to the technology/sector being assessed and any challenges posed
- If new considerations appear, the framework should be re-considered, and changes should be implemented.

- **Equitable**
  - Equity considerations should be a fundamental element of the SEIA.
  - The SEIA should clearly identify who will benefit, who might be disadvantaged and emphasise vulnerability and under-represented groups.

2.7 Added value of the proposed methodology and potential for integration with ethical analysis and ethical impact assessments

The specifics of new and emerging technologies as a topic of study pose a challenge to impact assessments. The SEIA presented here builds a specific method for SEIA of new and emerging technologies taking into consideration several challenges that their conduct encounters (e.g., the lack of data and resources has been overcome by presenting means to overcome this). Moreover, the futuristic view taken in the assessment process and the use of certain tools as scenarios are very valuable aspects of the methodology here proposed. By using these tools, we aim to minimise the uncertainty linked to the study of these technologies.

In this approach, we see SEIAs as a critical aspect of and support to ethical analysis and ethical impact assessment process, as exemplified in SIENNA, where it already included four steps (1) *Technological conceptualisation and foresight analysis,* (2) *Socio-economic impact assessment and foresight analysis* (3) *Ethical impact analysis* (4) *Ethical evaluation and recommendations.*

The CEN Workshop Agreement (CWA) 17145 defines an 'ethical impact' as **"**impact that concerns or affects human rights and responsibilities, benefits and harms, justice and fairness, well-being and the social good" and suggests that ethical impact assessment is a means of actioning social responsibility in research and innovation"[154].Further it outlines that the principle of 'social responsibility" - principle for raising awareness of the societal impacts of research and innovation, including taking appropriate remedial actions if deemed necessary.

Ethical principles and social values are deeply connected and highly integrated. Any examination of ethical impacts cannot be distanced or disconnected with the social and economic environment, realities and challenges it operates under. Understanding impacts on people's lives, culture, communities, health and well-being and politics cannot be an after-thought. In relation to new and emerging technologies this connection becomes even more critical to address socio-economic and ethical considerations and would help avoid the trap of missing contexts and the wider implications. A SEIA strengthens ethical analysis and ethical impact assessments and help broaden the vision and understanding of impacts taking into account diverse perspectives and particularly that of socio-economic vulnerable groups in society. It also helps widen the net of understanding the risks and threats and addressing value conflicts. SEIAs combined with ethical analysis and ethical impact assessments will support responsible research and innovation and socially desirable shaping of new and emerging technologies. It will also improve the relevance and value of ethical analysis and ethical impact assessments.

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[154] CEN Workshop Agreement, "Ethics assessment for research and innovation - Part 2: Ethical impact assessment framework" CWA 17145-2, June 2017. https://satoriproject.eu/media/CWA17145-23d2017.pdf