PRO-RES

PROmoting ethics and integrity in non-medical RESearch

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Executive Summary

Following the series of interviews conducted by NTUA (Task 5.2), as part of WP5 activities of PRO-RES, and the resulting report D5.1 “Report on the interview outcomes with experts from science, policy making and from Research Ethics Committees”, the aim of D5.2 report is to present the ethical requirements that have already emerged or are about to become part of the relevant discussion regarding the impact (personal, socioeconomic) and the consequences that the application of these technologies has. The technologies or groups of technologies that have been taken into consideration are those which were identified as significant by the experts interviewed within the WP5 series of interviews, and they have been presented in D5.1. In this report the aim is to further elaborate the ethical challenges discussed with the interviewees and identify common ethical considerations and disputes that apply to most of the technologies discussed. This list of technologies has, also, been compared and enriched with further input provided in the report “100 Radical Innovation Breakthroughs for the future” (2019) published by the European Commission.

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List of abbreviations

AI	Artificial Intelligence
ALM	Autonomous Learning Machine
CSA	Coordination and Support Action
D	Deliverable
DIY	Do it yourself
DoA	Description of Action
EC	European Commission
EDPB	European Data Protection Board
ELSI	Ethical, Legal and Social Implications
GA	Grant Agreement
GDPR	General Data Protection Regulation
HET	Human Enhancement Technology
ICT	Information and Communication Technology
NTUA	National Technical University of Athens
PRO-RES	Promoting ethics and integrity in non-medical research
RECs	Research Ethics Committees
RIBs	Radical Innovation Breakthroughs
RRI	Responsible Research and Innovation
SDGs	Sustainable Development Goals
SwafS	Science with and for society
WP	Work Package

1. About PRO-RES

PRO-RES (PROmoting integrity in the use of RESearch results - in evidence-based policy: a focus on non-medical research) aims to produce a guidance framework helping to deliver Responsible Research and Innovation (RRI). PRO-RES is a Horizon 2020 project coordinated by the European Science Foundation (ESF), involving 13 different partners across Europe. The main aim of the project is to encourage policymakers and their advisors to seek evidence for their decisions from research that has been conducted ethically and with integrity.

The guidance framework includes the following elements:

1) A statement – The Accord – which lays out the principles for ethical research which we hope all stakeholders can sign up to.

2) The Accord is supplemented with a Toolbox for policy makers and advisors to help them identify ethical evidence for their decision-making processes.

3) Additional supportive resources that complement the Accord and the Toolbox are provided on the PRO-RES website (http://prores-project.eu/) and include Foundational Statements on the values, principles and standards behind ethical research, a Glossary of Terms and Concepts and a pool of supplementary information such as on other existing Ethics Codes and Guidelines, available Education/Training on ethical research practice, illustrative Case Examples, a List of Ethics/Integrity Advisors, and much more.

The entire framework aims to:

- cover the wide spectrum of non-medical research and
- offer practical solutions for all stakeholders, that will comply with the highest standards of research ethics and integrity.

In terms of post-2020 European strategic funding policy, this offers a strong and sustainable contribution to RRI via a comprehensive ethics and integrity framework, similar to Oviedo/ Helsinki, which will have been constructed in negotiation with relevant stakeholders.

1.1 About WP5 'Sustainability of the framework /Road-mapping'

Research, technology and policy are not static, but, in certain areas, they advance quite rapidly. Hence any guidance framework created to support these fields of knowledge and action needs to be both sustainable, but, also, flexible enough to meet anticipated future needs; it needs to be adaptable by design. As the PRO-RES framework will be covering the non-medical scientific field, which is wide and non-uniform, it is important to identify the particularities of the various sub-fields and take into consideration the cross-correlation of interests, needs and approaches to issues related to ethical frameworks for different scientific communities.

In this context, WP5 has been aiming at maximizing the potential sustainability of the PRO-RES framework and at developing the necessary conditions for this framework to remain updated and in use after the end of the project. It includes road mapping activities and interaction with different types of interested stakeholders that will boost visibility of the project and provide valuable input regarding current research strategies while envisaging incipient ethical risks.

More particularly, sustainability is considered as substantive and technical. Substantive sustainability of the PRO-RES framework will essentially be based on its ability to grasp current trends on the non-medical fields covered by the project, encounter incipient risks and codify possible measures, that should be proposed pre-emptively, or suggested procedures that will aid the continuous updating of PRO-RES framework. To that direction, road mapping has been applied so as to smoothly integrate the above considerations effectively into the PRO-RES activities.

As part of WP5 activities and in particular Task 5.2, the National Technical University of Athens (NTUA) conducted a series of interviews within 2019 regarding current research trends and strategies in the non-medical field covered by the project, as well as stimulating approaches on possible ethical issues and risks which are expected to arise in the near future following the progress of the respective scientific fields. The interviewees' list included three types of stakeholders, namely research experts, research integrity experts (members of

Research Ethics and Deontology Committees /RECs), and policy makers. The background of the interviewees varied and covered a range of disciplines in the non-medical fields of research. The relevant results and the analysis of the conclusions deriving from these interviews were presented in D5.1 "Report on the interview outcomes with experts from science, policy making and from Research Ethics Committees".

1.2 About D5.2 Report on future ethical requirements

Following the series of interviews conducted by NTUA (Task 5.2) and the resulting D5.1, the aim of D5.2 is to present the ethical requirements that have already emerged or are about to become part of the relevant discussion. The technologies or groups of technologies that have been taken into consideration are those which were identified as significant by the experts interviewed within the WP5 series of interviews, and they have been presented in D5.1. In this report the aim is to further elaborate the ethical challenges discussed with the interviewees and identify common ethical considerations and disputes that apply to most of the technologies discussed. Its further aim is to provide a concise narrative of the needs and the RE & RI promoting 'measures' that a framework like the one introduced by PRO-RES can cover and offer, while fostering RRI. The list of technologies has been enriched by the input given thoroughly in the report "100 Radical Innovation Breakthroughs for the future"[1] by EC. In this report there is, also, an overview of three relevant *Science with and for Society (SwafS)* projects (SIENNA, SHERPA and PANELFIT,) and their publicly available input on ethical challenges.

The main areas of interest identified can be grouped under the following major topics, which are, also, correlated:

1. Big data analytics / big data governance
2. Surveillance/security versus privacy/human rights etc.
3. Environment
4. Advancements in molecular biology/genomics/biotechnology and health impact

[1] 100 Radical Innovation Breakthroughs for the future (Foresight), European Commission, Directorate-General for Research and Innovation, Directorate A — Policy Development and Coordination, Unit A.2 — Research & Innovation Strategy, May 2019 (https://ec.europa.eu/info/sites/info/files/research_and_innovation/knowledge_publications_tools_and_data/documents/ec_rtd_radical-innovation-breakthrough_052019.pdf).

2. Connections to the report "100 Radical Innovation Breakthroughs for the future" – An overview of the ethical requirements

This report has provided insights on 100 emerging developments, i.e. the Radical Innovation Breakthrough (RIBs) and the Radical Societal Breakthrough (RSBs), that may exert a strong impact on global value creation and offer important solutions to societal needs. Through this work[2] the EC has identified a set of emerging developments through a mixed-methods procedure that combined machine learning algorithms and human evaluation. The study aimed to identify potentially important, disruptive innovations over the coming 15 to 20 years. It used an identification model called the Radical Innovation Breakthrough Inquirer, which combines foresight on future value-creating structures in the world economy, with a scan of cutting-edge developments in science and technology worldwide. After successive waves of selection and refinement, the resulting 100 emerging topics were subjected to several assessment procedures, including expert consultation and analysis of related patents and publications. Having analysed the potential importance of each of these innovations for Europe, their current maturity and the relative strength of Europe in related R&D, the report includes recommendations that can influence policy. Here, we have enriched the content of D5.2, by drawing connections between the EC's comprehensive report and the technologies with significant impact that were recognized through the set of expert interviews conducted within the context of WP5 study.

The RIBs are grouped in the following 8 thematic groups:

1. Artificial Intelligence and Robots
2. Biohybrids
3. Biomedicine
4. Breaking Resource Boundaries
5. Electronics & Computing
6. Energy
7. Human-Machine Interaction & Biomimetics

[2] https://ec.europa.eu/info/research-and-innovation/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/foresight/activities/horizon-scanning-study-future-radical-innovation-breakthroughs_en

8. Printing & Materials

In the following table, we have combined the results of D5.1 list of technologies and corresponding ethical challenges with the Radical Innovation Breakthrough list, and we present the relation between the two lists:

Technology (D5.1 list)	**Consequences - Ethical challenges**	**Foresight** (presence in Radical Innovation Breakthroughs)	**Foresight Group**
Nanotechnology	Safety (health and environment), handling of materials, nano-divide, materials by design, ethics dumping	Carbon nanotubes, Flexible electronics, Nanowires, Nano-LEDs	Electronics & Computing
Materials Science, materials engineering		2D Materials, Bioplastic, Metamaterials, Self-healing materials	Printing & Materials, Breaking Resource Boundaries
Molecular biology	Handling of data (big data, personal data), targeted therapies, rare diseases therapies	Bioinformatics	Biohybrids
Genetics -human genome modification – genetic engineering		Gene editing, Gene therapy, Genomic vaccines, Microbiome, Reprogrammed human cells, targeting cell death pathways	Biomedicine
Biotechnology, CRISPR			
AI	Decision making: self-determination and free will data mining techniques for AI, ethics washing	Artificial Intelligence	Artificial Intelligence and Robots
Organ donation and transplantation, technology for IVF	Differences regarding organ types: e.x. uterus transplantation (research) is not allowed in some countries. Dual Use issues	Regenerating medicine	Biomedicine
Technologies involving handling of data: e.x. additive manufacturing, MbD	Datasets creating discriminatory routes, reverse engineering, copyrights/patents, text matching techniques for plagiarism violate the contracts between authors and repositories	-	-
Blockchain technology – Data analytics		Blockchain	Artificial Intelligence and Robots
Electronics – Communication systems (telephone systems, copper base lines)	As physical location might not be identified this affects emergency services	Graphene transistors, Optoelectronics	Electronics & Computing
Profiling – surveillance – facial recognition	Privacy and security, Individual security-group security, control of data	Emotion recognition	Human-Machine Interaction & Biomimetics
Nuclear technology and data	Use and storage of energy	-	-

Hydrogen technologies		Hydrogen fuel	Energy
Quantum technologies – 2nd Quantum Revolution – Quantum computing	Creation of even bigger databases	Quantum computers, Quantum cryptography	Electronics & Computing
Oil extruding from stones for electricity	Environmental issues	-	-
Covert research – subject-specific research	Retrospective consent, biomedical approach to ethics (Biomedical Ethics and its translation over into Humanities and Social Sciences), the morality of individual researchers	-	-
Citizen Science	Ensuring research ethics, data collection and analysis	-	-
Animal welfare	Synthesis of genetic material, implanting tracking devices without standard procedures, clinical research in veterinary practice, euthanasia	-	-
Agriculture – new crops - GMF		Gene editing	Biomedicine

Table 1. Matching of D5.1 list with the "100 Radical Innovation Breakthroughs" list

Additionally, the following figure included in the report summarizes the results of all 100 Radical Innovation Breakthroughs[3]:

[3] Ibid, pp. 15-17.

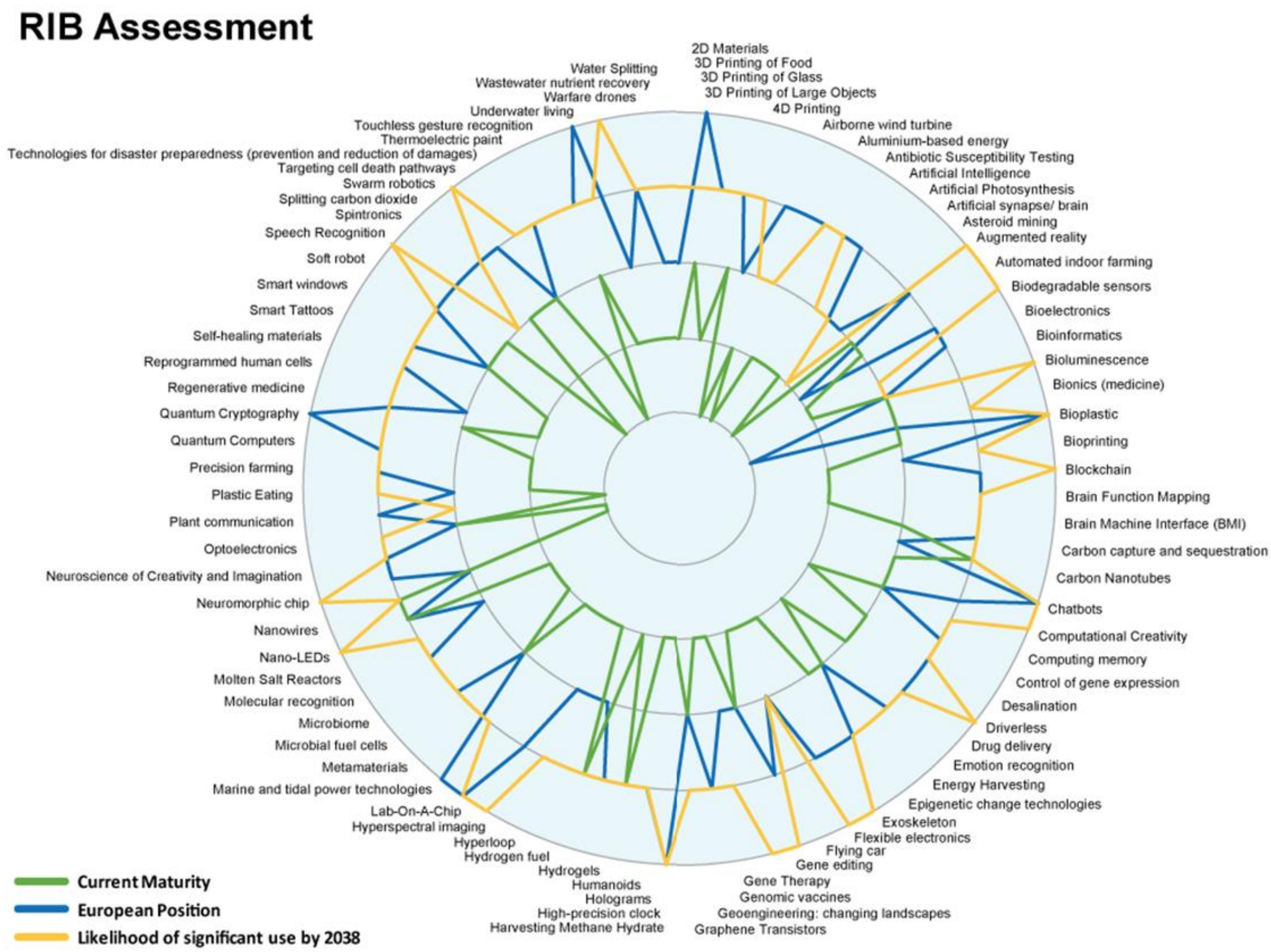

Figure 1. The results of all 100 Radical Innovation Breakthroughs as presented in the report

The main ethical challenges that need to be addressed and resolved are the following:

- Safety issues for human health and the environment resulting from material handling and use/storage of energy.
- The handling/control of data, whether personal data or big data etc. This includes privacy and ownership issues.
- Issues that relate to personalised medicine and targeted therapies (types of consent, data handling, equal opportunities and access to these therapies).
- The problems of autonomy/ decision-making abilities and free will as related to open possibilities for AI applications (ex. autonomous vehicles).

- The debate ‘privacy versus security’ which is, also, related to the storage and use of various data.
- The extent and purpose of intervention to the human genome and of human enhancement.

These issues have been addressed by all experts during the interviews, and they are common in all relevant discussions. Most of them are already known ethical issues that have been raised in the past in some cases, during previous stages of development of these technologies that we focus on. However, as these technologies emerge now, the ethical issues are set either in a different dimension or in a more emphatic way. At this point, it should be mentioned that there is a kind of ‘meta-‘ discussion regarding the types and nature of the ethical issues that are raised, and, in particular, on whether new emerging technologies raise novel ethical issues, which require new ethical approaches, or simply represent different contexts for application of familiar ethical themes.[4] There are arguments supporting the idea that emerging technologies may raise unique ethical problems that set them apart from earlier technological developments, due to factors such as convergence, embeddedness, malleability, and human transcendence.[5] However, even these unique ethical problems can be addressed within the frame that classic Ethics provide, namely through the routes of assessment and evaluation that deontology, consequentialism and virtue ethics suggest. [6]

[4] See, Herkert, J., “Ethical Challenges of Emerging Technologies”, in Marchant, Gary & Allenby, Braden & Herkert, Joseph, *The Growing Gap Between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem*, Springer Netherlands, 2011.
[5] See ibid, pp. 35-44.
[6] On a contemporary approach on the matter, see Brey, P., Ethics of Emerging Technologies, in S. O. Hansson (Ed.), *Methods for the Ethics of Technology*, Rowman and Littlefield International, 2017, in particular his ‘anticipatory ethics’ approach.

2.1 Across the Atlantic: The U.S. point of view

In October 2020, the White House released the *National Strategy for Critical and Emerging Technologies*, developed by the National Security Council of U.S.A.[7]. The strategy includes the *United States Government Critical and Emerging Technologies List*, which “reflects the 20 technology areas that United States Government Departments and Agencies identified to the National Security Council staff as priorities for their missions”[8]. The technologies, presented in alphabetical order, are the following:

1. Advanced Computing
2. Advanced Conventional Weapons Technologies
3. Advanced Engineering Materials
4. Advanced Manufacturing
5. Advanced Sensing
6. Aero-Engine Technologies
7. Agricultural Technologies
8. Artificial Intelligence
9. Autonomous Systems
10. Biotechnologies
11. Chemical, Biological, Radiological, and Nuclear (CBRN) Mitigation Technologies
12. Communication and Networking Technologies
13. Data Science and Storage
14. Distributed Ledger Technologies
15. Energy Technologies
16. Human-Machine Interfaces
17. Medical and Public Health Technologies
18. Quantum Information Science
19. Semiconductors and Microelectronics
20. Space Technologies

Although this list reflects the technological priorities of the National Security Council and, as expected, it includes defense/ military related technologies, it, also, has a lot of similarities with the merged list presented in the previous chapter, which, to a great extent,

[7] https://bit.ly/3blJ16P
[8] Ibid p. 13 (A-1)

provides the European perspective. In Annex 1[9] of our report, there is a 'list of lists' issued by some American universities and other organisations/issuing entities, which we identified during our research, including various 'top technologies' lists, some of them for 2020 and some of them 2021. The direct comparison and contrast of all these lists is beyond the scope of this report. However, it is worth mentioning that these lists, whether "top 10" or "top 20", focus on the same technologies or families of technologies as described in Table 1 of this report and as grouped in the 8 thematic groups of the 100 Radical Innovation Breakthroughs report.

[9] See pp. 32-33.

3. Overview from relevant SwafS projects

During our research, we identified as relevant the results of similar research studies deriving from the work completed by three other SwafS projects and made publicly available. The first project is SIENNA (*Stakeholder-Informed Ethics for New technologies with high socio-economic and human rights impact*), which has developed ethical frameworks, recommendations for better regulation and operational tools for the ethical management of human genomics, human enhancement and AI & robotics.

The second project is SHERPA (*Shaping the Ethical Dimensions of Smart Information Systems*) which analyses how AI and big data analytics impact ethics and human rights, while developing novel ways to understand and address these challenges to find desirable and sustainable solutions that can benefit both innovators and society.

The third project is PANELFIT (*Participatory Approaches to a New Ethical and Legal Framework for ICT*), which, among other things, is committed to facilitate the adaptation process regarding the changes in the regulation of IDT research and innovation by producing a set of editable, open access Guidelines, validated by two data protection agencies.

3.1 SIENNA (*Stakeholder-Informed Ethics for New technologies with high socio-economic and human rights impact*)

3.1.1. Ethical Analysis of Human Genetics and Genomics (Genetic research ethics)

The SIENNA approach for ethical analysis can be defined as: foresight-orientated and empirically informed, requiring stakeholder engagement. An interesting nuance may be brought up considering two distinct areas of technology development – technologies looking at the genome and technologies modifying the genome – since those are not at the same stage of development at the moment. Ethical, Legal and Social Implications (ELSI) referring to sequencing technologies rather question the limits and accommodations surrounding their implementation and use in different areas in society. ELSI referring to genome editing are still formulated in terms of drastic interdictions and raise the question of a research moratorium. Indeed, based on the analysis of ethical issues pertaining to germline gene editing there remains serious ELSI to be addressed before widespread use of this approach should be used, especially in the clinic, but also in research. Among others, one has been under addressed in a potentially vulnerable group, namely, the burden and risk of harm to women who donate oocytes for experiments that would be needed to even attempt to verify if gene editing could be used in the clinic.

(i) Prenatal genome

On the theme of prenatal genome sequencing, the group did not opt for specific country and time but created two scenarios:

- In Dystopia: the test is not proposed to pregnant ladies but it is mandatory: there is no right to choose, no right not to know. It raises unsolvable ethical issues that are not debated socially. The system decides and it is coercive. The data gathered through the tests are used both for healthcare purposes but for other purposes (known and unknown). Regarding other uses, the test is used for social control, biological weapons and forensics – leading to generalized effects of stigmatisation. There is an unregulated commercial use of the information, particularly highlighted in its aggressive marketing.
- In Utopia: there is sufficient funding for screening, counseling and related healthcare. The law ensures freedom for participants by allowing ample room for personal choices and through ethical guidelines such as the right to be forgotten and to leave at any time. There would be continuing and engaging societal debate. Individuals would have access to their sensitive information in a secure way. Professionals would also be appropriately educated. Genomics would be conceived as one (among others) form of knowledge that affects your health and the risk of genetic determinism would be kept in check.

(ii) DIY sequencing

The scenario here takes place in ten years' time in the US. This location was selected because DIY sequencing was conceived here as a development of current consumer trends, which are particularly well implemented in the US where the principle of liberty is strongly valued both in conservative and libertarian thinking. The idea of using DIY technology in one's household raises issues as to how people would manage that type of technology by themselves, how its use should be regulated, and more generally how to empower people while minimising (illegitimate) dual use or misuse. Another clear concern would be related with the technological divide between those who have access to these technologies and those who have not. Finally, one can ask how data would be shared with other parties, whether health data or other types of data. The group thus tried to identify risks and benefits of having such a sequencer in every household.

- Benefit: Quick, cheap and personal access to genetic information; extension of individual freedoms; benefits for research with a massive generation of data that could possibly be easily accessed to. Such devices could also increase individual interest in genomics and healthcare.
- Risks: Misinterpretation of genetic information; problems in sharing genetic information and unintended data sharing (accessed by third parties, and hacking); potential for social and health inequalities, depending on who uses this information. The generalization of genomic data might also increase discriminatory actions and enhance the role of genomics in framing discussions about identity and reproduction. Financial issues are also relevant (financial gains in reselling the info) – risk of exploitation when someone is asked to share information for money.

(iii) Germ line gene editing

If, in a given country such clinical trials were authorised, the national government could set up an expert committee that would supervise the evolution of the field so as to give the green light to use of the technology. However, the composition and functioning of this committee would have to be open to public scrutiny and oversight.

3.1.2. Ethical Analysis of Human Enhancement Technologies (HETs)

As a result of mapping the ethical issues of HET, we find that there remain conceptual problems over the characterisation of HETs. For example, in the same way that a prosthetic limb may be spoken of as replacing a "body part", so too might a pharmaceutical be described. After all, a drug may be utilised to replace missing chemicals that promote homeostasis. While presently we do not talk of drugs as prostheses, the human enhancement debate may clarify how these different technologies are similar, requiring a new language through which to discuss the ethics of such interventions. There is one singular thread which dominates the ethical debates about HETs and that has to do with the speculative content of the inquiries. Both advocates and critics rely heavily on multi-factorial speculations about potential scenarios that may develop as a result of embracing HETs and many of these conditions are extremely difficult to predict with any certainty.

In this respect, the ethical debate over HETs may hinge on the willingness to embrace uncertainty and to suffer the consequences, but this applies also to rejecting HETs. In the future, it may transpire that an enhanced population is best able to confront the challenges of an increasingly toxic environment, which may require biological modifications in order for life to thrive. Alternatively, humanity's seemingly always fragmented knowledge of living systems may mean that interventions are made that reveal themselves to be catastrophic and irreversible for human life in the long-run. Indeed, this is the criticism often leveled at germ line genetic interventions. For while we may have some certainty over the removal of genetic dysfunction for an individual who experiences the suffering, the broader impact on the species by removing all forms of genetic dysfunction may yet be unknown.

The problem, however, is that societies must elevate the interests of those presently alive over the lives of those who are yet to exist and this is where it becomes a difficult matter to resolve ethically.[10] Buchanan *et al*. [11]describe a situation where the human population through its employment of technology, moves from "chance to choice", but the latter may not bring about a more desirable set of circumstances, even if it is characterised by the elevation of

[10] See, also, on this report chapter 4 on Intergenerational Ethics and Justice.
[11] See, Buchanan et al., From Chance to Choice: Genetics and Justice, Cambridge University Press, 2000.

autonomy. In one crucial sense, humanity's willingness to explore new scientific solutions for human problems is to embrace the idea that lives are best determined by choice, rather than chance, but it is necessary to dispel the idea that the individual's experience of a better life is commensurate with the species also flourishing.

3.1.3. Ethical Analysis of AI and Robotics Technologies

It was found, amongst others, that the aims of efficiency, productivity and effectiveness improvement through AI and robotics are inherently tied to the replacement of human workers, which raises ethical issues. It was, also, found that the aim of mimicking of social behaviour in AI and robotics is associated with risks of deception and of diminished human-to-human social interaction. Further, it was identified that the aim of developing artificial general intelligence and super intelligence raises issues of human obsolescence and loss of control, and raises issues of AI and robot rights. The aim of human cognitive enhancement, finally, was found to bring risks to equality, human psychology and identity, human dignity and privacy.

In relation to algorithms, the discussion focused on how they can be value laden and contain biases. In relation to knowledge representation, the focus was on how inaccuracy, misrepresentation and bias can raise ethical issues. How automated scheduling and planning can raise issues of trustworthiness and responsibility, and how they could decrease human capabilities were issues also discussed.

In relation to machine learning, the discussion included many ethical issues, such as the issues of transparency and explainability, fairness and discrimination, reliability, privacy and accountability. Machine ethics was analysed to have many pitfalls, including the difficulty of implementing human morality in AI systems, the potential for failure and corruptibility, equality of access to ethical AI, the undermining of human moral responsibility, and the possibility that we want to grant such systems moral status and rights.

The issues with robotics techniques and approaches were the following. For robot sensing, issues of reliability of error were discussed, as well as risks to privacy and safety associated with some sensor types. In relation to robot actuation, issues of safety, privacy, and psychological impacts proved to be relevant. For robot control systems, it was discussed how robots can have different degrees of autonomy, as well as the associated issues of safety, responsibility and accountability, transparency, and privacy.

Finally, a number of general implications and risks were described and associated with the development and use of AI and robotics. For AI, these included potential negative implications for autonomy and liberty, privacy, justice and fairness, responsibility and accountability, safety and security, dual use and misuse, mass unemployment, transparency and explainability, meaningfulness, democracy and trust. For each value or issue, the aim was to come to a precise determination of it, then to discuss different general ways in which AI might impact it, and to analyse the moral considerations involved. For robotics, the general implications and risks included loss of control, autonomy, privacy, safety and security, dual use and misuse, mass unemployment, human obsolescence, human mistreatment, robot rights, and responsibility and accountability. These issues were analysed in a similar way as in the corresponding part on AI.

At this point, it should be mentioned that in order any discussion on the aforementioned issues like autonomy, rights, responsibility and accountability, to be applicable to robots or AI applications or any other autonomous learning machine (ALM), we cannot avoid the deeper and broader discussion on the notion of agency, and in particular, on the development of moral agency. In other words, it is necessary to examine if and to what extent ALMs have the "potential to become 'moral beings' and/or 'persons', and to make ethical decisions about their actions and interactions with humans "[12] This discussion is even broader and involves examining the property of 'personhood' attributed to ALMs and all other notions entailed, such as self-awareness, consciousness and conscience.[13] Even if this potential cannot be fully verified by the current stages of development of these technologies, it is important, at the level of design and regulating research and the level of policymaking, to make provisions and anticipate such possibilities.

[12] Iphofen, R and Kritikos, M. (2019) Regulating artificial intelligence and robotics: Ethics by design in a digital society, *Contemporary Social Science*, Taylor and Francis online: https://doi.org/10.1080/21582041.2018.1563803, p. 171.

[13] See ibid, pp. 173-176, 180.

3.2 SHERPA (*Shaping the Ethical Dimensions of Smart Information Systems*)

3.2.1. Ethical issues in AI

(i) Machine Learning

Some ethical issues are directly related to AI in the narrow sense, most prominently to machine learning, which is currently often implemented through neural networks. This type of AI is characterised by opacity, unpredictability and, typically, the need for large data sets for training and validation. Ethical issues linked to this type of AI include

- bias
- discrimination
- security breaches
- data protection issues

(ii) Socio-Technical Systems

This understanding of AI points to ethical issues arising from living in a digital world. These socio-technical systems appear to act autonomously, structuring the way humans can act, and have significant social impact. They lead to ethical issues such as:

- unequal access to power and resources
- unfair distribution of the costs and benefits of technology
- impact on warfare, and the killing of humans by machines

(iii) Artificial General Intelligence

Currently no AI exists that can be described as artificial general intelligence, i.e. it has human cognitive capabilities. However, these systems figure prominently in the literature and in people’s imagination. Such systems would potentially raise ethical issues such as:

- hostility towards humanity by superintelligent machines
- changing perceptions of humans based on close interaction with machines (e.g. neural implants)

3.3. PANELFIT (*Participatory Approaches to a New Ethical and Legal Framework for ICT*)

3.3.1. Ethical issues in ICT technologies

(i) Informed consent in the context in ICT research and Innovation

It is unclear whether consent should always be the preferred legal basis for data processing activities, regardless of the area or field where the processing shall take place. Article 6 of the GDPR prescribes that data processing must have at least one legal basis, but it does not oblige data controllers to prefer one over another. For example, the Irish supervisory authority, the Irish Data Protection Commission (IDPC), has indicated that "there is no hierarchy or preferred option within this list, instead each instance of processing should be based on the legal basis which is most appropriate in the specific circumstances". In particular, regarding the importance of consent, the IDPC indicates that "it is important to note that 'consent', whilst perhaps the most well-known, is not the only legal basis for processing – or even the most appropriate in many cases".

(ii) Data Commercialisation in the Context of ICT research and Innovation

The issues and gaps were identified through an expert workshop and later refined through several rounds of feedback. The legal background and relevance of the issues and gaps for ICT research have been discussed. To solve the identified problems, mitigation measures have been proposed.

1. Whether counter-performance practices, the monetisation of data in exchange for services, is lawful. This prevents not only the emergence of markets and commons of personal data, but also the development of new services, making an official position by legislators necessary.
2. It is unclear whether a primary controller can collect consent for a yet unidentified recipient. Without clarification by the EDPB, research and innovation based on consent, for

instance in health science or open access research, is restrained. Multiple unclarities with regards to shared controllership have been discussed. It has to be determined when and under what conditions a processor becomes a (joint) controller, how rights and responsibilities are shared in a joint controllership and whether data subjects can and should become data controllers. Until the issues are clarified through an authoritative interpretation of the GDPR, contracts and agreements may be utilised between (joint) controllers and processors to determine rights and responsibilities. The lack of an established pricing mechanism for data was established as a gap in the current regulation. Determining the value of data is necessary in order to achieve a fair and transparent commercialisation of data and the development of regulated data markets. Research on suitable pricing mechanism is required to overcome this gap.

3. The lack of a standard for the provision of privacy practices, possibly in a machine readable format, is necessary to develop systems that give individuals the opportunity to effectively manage privacy preferences. The development and implementation of such a standard through research projects would counteract consent fatigue and would benefit data subjects and ICT researchers alike.

(iii) Issues and gaps analysis on security and cybersecurity ELI in the context of ICT research and innovation

Security objectives may be in conflict with other human rights and values, a fact that also became visible during the debate on the use of surveillance technologies in the context of the COVID19 pandemic. The identified topics reached therefore from the need of more clear definitions and debates to the complex relationships between the sometimes conflicting values, impacts of ICTs on humans and the economic, political and social systems they live in, over security threats related to global shifts in ICT related economic powers to ethical and legal issues related to emerging ICTs.

1. Definition of Security and Cybersecurity: The ambiguity of the term security and the difficulty or impossibility to achieve consensual definitions of security causes related legal uncertainties.
2. Security over privacy? The complexity of the relation between privacy and security and the manifold impacts of this relation on the individual enjoyment and exercise of human rights and on shaping democratic and societal development requires broad debates and political dialogue.
3. Conflict between stable principles and "liquid" situations: Political developments in which stability provided by written or unwritten law is neglected or losing in importance also weaken the meaning and the weight of existing legislation and rules.
4. Surveillance effects on humans: The risks of surveillance are manifold. It does not only affect individuals' privacy, the chilling effect may also change society by threatening fundamental rights such as the freedom of speech, of assembly and association.
5. The dominance of big US companies: Big US based tech companies not only dominate ICT markets but they also dominate research in the field of AI. This might lead to a corresponding dominance in AI products in the future.
6. Information and power asymmetries: Power asymmetries caused by unequally distributed information or unequal access to information raise several issues, ranging from potential competitive advantages to losses of autonomy and sovereignty.
7. Future impacts on democracy: Individual freedoms, social cohesion, democratic achievements and traditions are at risk. The multitude of threats and the magnitude of issues at stake calls for strong interventions to stop and reverse the antidemocratic impacts of existing and future ICTs.
8. Freedom of expression: Freedom of expression is a central building block of democracy; measures against the abuse of new media for hate speech or the distribution of fake information are endangering this freedom.
9. Biometrics and ICT for emotion detection: Biometric analysis based on audio-visual data is often opaque for data subjects; this may lead to discriminatory treatment based on the analysis results, of which affected persons may not even be aware about.

10. AI and Security: Decision-making process of AI is usually based on complex mathematical algorithms, making it difficult or impossible to obtain explanations understandable by humans.
11. AI for predictive policing: Using predictive policing technologies threatens to undermine the presumption of innocence and, therefore, can disrespect human dignity as well as fundamental rights of individuals.
12. Security standards for IoT devices: Security standards for IoT devices are largely a legal gap. No mandatory requirements for IoT security exist; at least not as long as no personal data are used.
13. Insufficient guidance to participants in open science: The current governance of open science and particularly open access to scientific research data in Horizon 2020 provides insufficient and misleading guidance to researchers on how to deal with personal data.
14. Sharing of Personal Data in Open Science Fails to Be Considered to Its Full Potential: How to share personal scientific research data is currently not sufficiently understood. Legal mechanisms for such sharing are missing.
15. Intelligent machine autonomy and the implications of the possibility of development of moral agency and personhood: Although this issue has not been discussed as such within the scope of the project, it should be taken into consideration, particularly in view of further developments and applications of ICT.

4. Intergenerational Ethics and Justice, and the harmonization with United Nations' 17 goals for sustainable development

At this point, it is necessary to refer to the notion of Intergenerational Ethics, as it seems appropriate to combine the ethical issues that people at present face, or they will be facing very soon, with potential challenges that will emerge in the near future or later. Intergenerational Ethics is this particular area of Ethics that is related to the moral obligations that people of the present have towards future generations. Existing concepts of moral duties, political legitimacy, and human rights face special and fundamental challenges when expanded to cover obligations to future generations. The challenges include the non-reciprocity and power asymmetry between present and future generations, the temporal complexity of cause and effect, the uncertainty about the effects of our actions and about future needs, the indefinite number of future people, and the difficulty of identifying bearers of future harm. However, in particular in the context of climate change and environmental degradation more generally, future-oriented duties are high on the agenda of the global public.[14]

The natural environment and the consequences of human activity, both short-term and long-term, shape a field of interest that gives rise to various ethical challenges. In this scope there has been the development of the so-called 'sustainability science[15]', as a particular research field evolved into a vibrant discipline, focusing on "examining the interactions between human, environmental, and engineered systems to understand and contribute to solutions for complex challenges that threaten the future of humanity and the integrity of the life support systems of the planet, such as climate change, biodiversity loss, pollution and land and water degradation."[16] As the environmental impacts become more and more prominent in a negative way, and climate change is a fact, certain policies have been

[14] See Fritsch, M., Taking Turns with the Earth. Phenomenology, Deconstruction, and Intergenerational Justice, Stanford University Press 2018, and "Discourse Ethics and Intergenerational Justice", in *Habermas Now*, Eduardo Mendieta (ed.), Polity press, Cambridge Mass., 2015

[15] See Spangenberg, J. (2011). Sustainability science: A review, an analysis and some empirical lessons. Environmental Conservation, 38(3), 275-287. doi:10.1017/S0376892911000270. See, also, Sustainability Science (unesco.org) and Broadening the Application of the Sustainability Science Approach (unesco.org) .

[16] https://en.wikipedia.org/wiki/Sustainability_science

developed and updated in order to promote a climate –neutral economy and protect the environment while ensuring that such a transition happens in a fair way.

The most prominent initiative taken on a global level is the compilation of the 17 Sustainable Development Goals (SDGs) as central in *The 2020 Agenda for Sustainable Development*, which was adopted by all United Nations Member States in 2015 and provides a "shared blueprint for peace and prosperity for people and the planet, now and into the future".[17] To that direction, EC has developed a strategy with the so-called Green New Deal as its integral part in order to implement the Agenda and the SDGs.[18]The 17 SDGs are the following:

1. No poverty
2. Zero hunger
3. Good health and well-being
4. Quality education
5. Gender equality
6. Clean water and sanitation
7. Affordable and clean energy
8. Decent work and economic growth
9. Industry, innovation and infrastructure
10. Reduced inequalities
11. Sustainable cities and communities
12. Responsible consumption and production
13. Climate action
14. Life below water
15. Life on land
16. Peace, Justice and strong institutions
17. Partnerships for the goals

[17] See https://sdgs.un.org/goals
[18] See https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_el , https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX:52019DC0640 , https://eur-lex.europa.eu/legal-content/EL/TXT/?qid=1596443911913&uri=CELEX:52019DC0640#document2 , https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism_en , The Just Transition Mechanism: making sure no one is left behind | European Commission (europa.eu) .

The various developments and the progress of science are an indispensable part of the promotion and implementation of the SDGs, serving science's core purpose, namely the advancement of human knowledge (explaining, understanding, predicting) aiming at improving people's lives, their health, their prosperity and their growth within society, while preventing harm. As it is elaborated in the Agenda, "[s]cience itself establishes the factual basis, anticipates future consequences, generates and assesses evidence, and thus contributes towards finding pathways to sustainability transformations. […] Technological innovation has long been recognized as crucial to achieving development objectives. Scaling up applications of existing scientific knowledge and technological innovation – in both the natural and social sciences – while pursuing further research, can enable shifts away from business-as-usual actions and address development challenges across many sectors. Often the technology already exists and the task is to identify and address the obstacles to widespread deployment. […] In the context of the Sustainable Development Goals, technology can be central to resolving trade-offs that can arise if individual Goals and targets are addressed in isolation. For example, target 2.3 (*increased productivity as part of Goal 2- Zero hunger*) requires a doubling of agricultural productivity, which could be achieved by prioritizing productivity gains over everything else, but that could then negatively impact a myriad of other targets, including those related to livelihoods, health, climate change mitigation, biodiversity and water. However, those issues can be minimized through the strategic deployment of new technologies – from advanced water use sensors to climate-smart agriculture, to renewable energy technologies. In another example, advances in gene-editing technologies, notably Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR), can improve the prospects for gene therapy at the individual level with gains in productivity and control vector-borne diseases such as malaria, and facilitate the precision breeding of plants and animals. Deploying advanced technologies like artificial intelligence could also play a major role in achieving the Sustainable Development Goals. Many such applications are under development but need careful assessment of potential broader consequences before deployment."[19]

[19] https://sustainabledevelopment.un.org/content/documents/24797GSDR_report_2019.pdf, p. 36.

Conclusions

The technologies presented in this report compile a complex and dynamic field covering all major sectors of human life and activity, which are important for personal and societal prosperity. Some of them are the development/progress of previous stages of certain technologies, and some of them constitute a totally new direction to various scientific enterprises. Regardless of the particular scientific field they belong to, these emerging or not-yet-achieved technologies give rise to various ethical debates that have to do with the purpose they serve, but, mostly, with the consequences they bring. These consequences relate to the agents involved, the direct users of these technologies, but, also, the indirect recipients of their results, as well as the scientists and the people involved in these technologies' designs and developments, such as funders and investors. Furthermore, the natural and cultural environment is always central in these debates as it always shares certain burdens of these consequences. Nowadays, more than ever, the protection of environment is crucial and demands immediate action. Finally, any discussion on ethical challenges, and any design of regulating frameworks should always leave room, not only for 'known unknowns', but, also, for the 'unknown unknowns'.

As far as the PRO-RES framework is concerned, the mapping and assessing of future ethical requirements is important to be updated regularly and follow closely the developments of emerging technologies, as it is particularly this field of scientific progress that provides policy making with new ideas and socio-economic challenges. A properly informed framework by cutting edge research at this level will be able to support effectively evidence based policy.

Annex 1

'Top technologies' lists issued by American universities and other organisations/entities:

Issuer	Links
USA Government	https://2017-2021.state.gov/united-states-releases-national-strategy-for-critical-and-emerging-technologies/index.html
	National strategy for Critical and Emerging Technologies (https://bit.ly/3blJ16P)
Berkeley University of California	https://www.betr.berkeley.edu/
	https://cstms.berkeley.edu/working-groups/past/emerging-technologies-and-their-ramifications/
Boston University	http://www.bu.edu/research/reports/2019/
Caltech (California Institute of Technology)	https://breakthrough.caltech.edu/magazine/the-caltech-effect-september-2020/#article-Sense-of-Re-Purpose
Columbia University	https://etc.cuit.columbia.edu/
Johns Hopkins University	https://www.centerforhealthsecurity.org/news/center-news/2018/2018-10-09_technology-global-catastrophic-biological-risks.html
MIT (Massachusetts Institute of Technology)	https://www.technologyreview.com/10-breakthrough-technologies/2020/
Other issuing entity	https://www.nextgov.com/emerging-tech/2020/10/white-house-strategy-names-20-emerging-technologies-crucial-national-security/169293/
	https://www.rstreet.org/2020/10/26/conspicuously-absent-from-the-recent-u-s-national-strategy-for-critical-and-emerging-technologies-any-actionable-strategy/
	https://onlinelibrary.wiley.com/doi/10.1002/hbe2.237

	https://www.weforum.org/reports/top-10-emerging-technologies-2020
	https://www2.deloitte.com/content/dam/insights/articles/6730_TT-Landing-page/DI_2021-Tech-Trends.pdf
	https://www.scientificamerican.com/article/top-10-emerging-technologies-of-20201/
	https://www.scientificamerican.com/report/top-10-emerging-technologies-of-20202/
	https://www.nature.com/articles/d41586-020-00114-4
	https://www.gartner.com/en/newsroom/press-releases/2020-08-18-gartner-identifies-five-emerging-trends-that-will-drive-technology-innovation-for-the-next-decade
	https://www.gartner.com/smarterwithgartner/how-digital-twins-simplify-the-iot/
	https://www.gartner.com/smarterwithgartner/gartner-top-strategic-technology-trends-for-2021/
	https://www.comptia.org/blog/emerging-technologies-impact-2020
	https://www.comptia.org/content/infographic/2020-emerging-technology-top-10-list
	https://investingnews.com/daily/tech-investing/emerging-tech-investing/top-emerging-technologies/