Robotics4EU

Boosting Wider Adoption of Robotics in Europe

D4.4

Responsible Robotics Advocacy Report

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Responsible Robotics Advocacy Report

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Table of Abbreviations and Acronyms

Abbreviation	Meaning
ADRA	AI, Data and Robotics Association
ADRF	AI, Data and Robotics Forum
AFL	AgriFood Lithuania
AI	Artificial Intelligence
CE	Civitta Estonia
CL	Civitta Lithuania
CoARA	Coalition for Advancing Research Assessment
CSO	Civil society organisations
DBT	The Danish Board of Technology
DIH	Digital Innovation Hub
DORA	Declaration on Research Assessment
EC	European Commission
EDIH	European Digital Innovation Hubs
ELSA	Ethical, legal, social aspects
ERA-LEARN	European Partnership Stakeholder Forum
EU-OSHA	European Union Organizational Safety and Health Association
GDPR	General Data Protection Regulation
GHG	Greenhouse gas
HPC	High performance computing
ICT	Information and communications technology
IEC	International Electrotechnical Commission
IP	Intellectual Property
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
LNE	The Laboratoire national de métrologie et d’essais
ML	Machine Learning
NGO	Non-governmental organization
NLF	New legislative framework
NTNU	Norwegian University of Science and Technology
R&D	Research and Development
RED	Radio equipment directive
RIA	Research and Innovation Actions
RRI	Responsible Research and Innovation
SDG	Sustainable Development Goals
SRL	Societal Readiness Level
SSH	Social Sciences and Humanities
TEF	Testing and Experimentation facilities
TVET	Technical and vocational education and training
UN	United Nations

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RESPONSIBLE ROBOTICS ADVOCACY REPORT

Summary

The Robotics4EU Responsible Robotics Advocacy report, informed by Robotics4EU activities, desk research, and stakeholder consultations, delineates an advocacy strategy for responsible robotics development in the EU. Policy recommendations, focused on EU policymakers, also hold value for national and regional policy stakeholders, as well as robotics industry and academia.

In this summary, 10 priority recommendations, endorsed by the robotics community and experts in ethics, law, and societal aspects, are presented alongside actionable steps to achieve them, identified by the Robotics4EU team.

Regulatory Framework for Responsible Robotics

Advance regulation coherence for responsible robotics
Form an EU expert group, advancing the coherent regulation for responsible robotics, in form of ethics and safety guidelines as annex to EU ethics guidelines for AI or Machinery and Product Safety Directives

Ensure that testing and experimentation leads to evidence-based policy recommendations
Develop testing and experimentation tools and methodologies for data generation and ensure that the data is used in evidence-based policy decisions

Update safety guidelines in light of new advancements in robotics
Elaborate safety-by-design approaches integrating a balance between safety, speed and versatility, as well, as reflecting on the trade-offs between safety standards, economic liability, regulatory guidelines and user experiences

Support for Robotics Community in creating Responsible Robotics

Provide roboticists, especially SMEs, with support for compliance with ethical and legal requirements
Improve the accessibility of consultations on ethics, legal and societal aspects of robotics, through, for example, (E)DIHs, TEFs, IP Helpdesk and other robotics-industry targeted EU initiatives. Support self-assessment tools that help robotics developers assess their compliance to responsible robotics principles and regulations

Amplify the focus on ELSA aspects in robotics R&D
Strengthen the requirements in the EU-funded robotics projects (i.e., Horizon Europe Cluster 4) to allocate the project position for the ELSA experts with integral and reiterative participation in the responsible robotics solution research and development

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Engagement

of stakeholders for the ethics, legal and social aspects deliberation and responsible robotics development

Showcase and discuss the realistic state of robotics
Invest in societal dialogue and awareness campaigns about capabilities, limits, risks and benefits of robotics through initiatives (i.e., exhibitions, science festivals, public lectures, etc.) and public media channels

Ensure EU citizens' views are heard in shaping EU robotics visions
In the upcoming EU facilitated consultations for the programming periods of Horizon/Digital Europe, include questions on responsible robotics Also, consider the citizen engagement work done by the EU-funded projects

Ensure multi-stakeholder representation in robotics life-cycle
Enhance multi-stakeholder engagement in EU-funded robotics projects, and incorporate engagement facilitation services in Testing and Experimentation Facilities to integrate diverse multi stakeholders' inputs, focusing on responsible robotics aspects

Ensure collaborative dialogue for equitable workforce transition
To promote a smooth transition towards integration of robotics in workplaces, foster active discussions between industry, worker representatives, and policymakers. Facilitate sector-specific conferences to address the impact of automation and robotics, identifying emerging employment trends and developing action plans for adapting strategies and regulations to ensure a just transition for workers

Education

In skills for responsible robotics

Promote technology and engineering education with focus on responsible robotics
To foster a skilled workforce for responsible robotics development, incentivise technical education through scholarships and certification programmes. Implement mandatory technology ethics courses and collaborative projects with ethics/social perspectives in engineering and computer science curricula.

Full list of recommendations and measures, alongside with the presentation of the drivers and barriers for robotics acceptance in society, are presented in the report below.

The report aims to summarise Robotics4EU activities that can be followed in the www.robotics4eu.eu

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1 Introduction

1.1 The Robotics4EU project

The Responsible Robotics Advocacy Report is integral to the Robotics4EU[1] project, funded under the European Union's Horizon 2020 research and innovation programme. The project, aligning with the EU goal of supporting, developing and exploiting the opportunities brought by ICT progress to benefit its citizens, businesses and scientific communities[2] aims to contribute to more widespread adoption of (AI-based) responsible robots. Adoption can be achieved if there is a societal acceptance of robotics, which can be strengthened by implementing responsible robotics principles among the robotics community.

To increase awareness and adherence to responsible robotics principles, the project aims to 1) strengthen the understanding and knowledge of non-technical aspects of robotics deployment - legal, socio-economic and ethical issues among the robotics community and 2) provide opportunities, tools and platforms to enhance the development of responsible robotics. These tools include a responsible robotics self-assessment tool - RoboCompass[3], methodologies and opportunities for engagement through co-creation workshops, citizen and community engagement, and awareness-raising activities. As an integral part of these activities, a strategy for the policy action is proposed in this report that reflects the approaches and lessons learned in the project.

1.2 Responsible Robotics Advocacy Report approach

1.2.1 Target groups

Responsible Robotics Advocacy Report aims to translate the citizens' expectations, experts' and stakeholders' insights and the industry's needs into the advocacy strategy for responsible robotics development with a focus on actionable steps for the stakeholders in robotics policies.

The recommendations mainly focus on **EU-level policymakers**, as they play a crucial role in defining the regulatory frameworks and policy guidelines for the development of responsible AI-based robotics. EU policies steer the direction of research and industry by defining funding priorities and requirements, setting regulations, and promoting the guidelines for the assessments.

Standardisation committees may also find this document of great interest, enabling them to establish the broad outlines of their standardisation programmes, with a view to including technical tools for the design and verification of responsible robotics.

In terms of domains of interest, the recommendations primarily concern legislators for the **machinery sector,** which may be the most prominent actors in instilling the need for a framework for responsible robotics. They may also be of strong interest to policymakers in the **AI sector** since Robotics4EU ties the link between ELS recommendations for AI

[1] Robotics4EU Project. (n.d.). Retrieved from https://www.robotics4eu.eu/

[2] INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies - Information and Communication Technologies (ICT). (2014). https://cordis.europa.eu/programme/id/H2020-EU.2.1.1./en

[3] Responsible Robotic Compass - RoboCompass - was initially called the Maturity Assessment Model and is referenced accordingly in the Robotics4EU deliverables. https://robocompass.aiod.eu/

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and the domain of robotics, and also for policymakers in **EU-OSHA** when robots are used in a professional setting.

In addition, recommendations also tackle the following target groups that have a role in promoting responsible robotics principles:

- **National-level policymakers.** To promote the adoption of responsible robotics principles in national-level robotics project strategies and funding, it is essential for national policymakers to play a central role in shaping social and educational policies.
- **Regional-level policy makers.** To ensure alignment with local peculiarities, it is important to include regional-level policymakers due to their close proximity to affected communities.
- **Robotics associations.** As key stakeholders in the development of robotics strategies, robotic associations also play a pivotal role in advocating for and promoting the adoption of responsible robotics principles.
- **Robotics industry.** The focus is on promoting responsible product development, manufacturing, and deployment practices.
- **Universities and research institutions.** Recommendations emphasise the importance of educational and research entities in advancing responsible robotics through curriculum development and research initiatives

1.2.2 Responsible Robotics: definitions

International Organization for Standardization (ISO) defines the term “robot”, as a **“programmed actuated mechanism with a degree of autonomy to perform locomotion, manipulation or positioning**”[4]. In other words, robots are machines able to move and act with some degree of autonomy[5]. It is rather a broad term under which vastly different solutions qualify - from machines inspecting oil pipes to conducting autonomous surgeries. A common distinction often used by practitioners to further classify the otherwise broad term is the distinction between service/social/domestic/collaborative robots and industrial robots. While industrial robots are optimised for efficiency and precision in industrial settings, service/social/domestic/collaborative robots are designed to interact with humans and work together. Generally, both classifications press on unique aspects of responsible robotics. While industrial robotics often lean heavier on socioeconomic and worker rights aspects, service/social/domestic/collaborative robots relate more to human experience and privacy.

Robotics4EU project has focused its activities on four priority areas[6] - agrifood, agile production, healthcare and inspection and maintenance of infrastructure. The initial list of recommendations stemmed from the project work in these areas, but further reiterations of the report aimed to translate these recommendations into overarching ones to cover all domains where AI-driven robotics may raise concerns and gaps in relation to responsible robotics principles.

[4] ISO 8373:2021(en), Robotics — Vocabulary. (n.d.). Retrieved from https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-3:v1:en

[5] Drukarch, H., Calleja, C., & Fosch-Villaronga, E. (2023). An iterative regulatory process for robot governance. Data & Policy, 5, e8. https://doi.org/10.1017/DAP.2023.3

[6] Priority Areas were defined by the call for proposal ICT-46-2020 and integrated in the Robotics4EU project approach

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In the context of the Robotics4EU project, **responsible robotics refers to robots whose design takes into account values and expectations of society**. This concept plays an important role in Robotics4EU as safer, more considerate, durable, affordable, and practical robotics solutions – responsible robots – are the central component in avoiding, limiting, and/or removing non-technological barriers that are currently in the way of the widespread adoption of robots.

Our devotion to responsible robotics draws upon **Responsible Research and Innovation (RRI) principles**, which aim to promote science and innovation that would foreground, first and foremost, societal value. It is no surprise that certain innovations might sometimes be unpredictable, if not disruptive, for the social good. As per the philosopher Bernard Stiegler,[7] technology is our *pharmakon*, a medicine that can at once potentially be a poison and a remedy. Inspired by RRI principles, the responsible robotics approach **aims to make it curative by keeping in mind societal needs, values and expectations at all levels of technology development.** RRI acknowledges the unpredictable nature of novelty and aspires to promote creativity alongside a deep concern for the social value of research and innovation. It is an approach that seeks to **anticipate and assess potential implications of research and innovation so as to gear it towards a socially responsible, ethical, and sustainable trajectory.**

More specifically, RRI aims to promote research and innovation that consider the values of the European Union, including respect for human dignity, freedom, democracy, equality, the rule of law, and respect for human rights, including minorities[8]. Horizon 2020 scheme also places emphasis on the “informed engagement of citizens and civil society in research and innovation matters by promoting science education, by making scientific knowledge more accessible, by developing RRI agendas that meet citizens’ and civil society’s concerns and expectations and by facilitating their participation in Horizon 2020 activities.”[9] Hence, taking measures to ensure public engagement in research and innovation also falls under the scope of RRI principles.

European Partnership Stakeholder Forum (ERA-LEARN) includes the principles below within the scope of RRI[10]:

- **Equality and non-discrimination: Promotion** of equality and non-discrimination in all EU policy, acknowledging unconscious bias
- **Ethics:** Guidelines on research integrity for responsible conduct of research
- **Inclusiveness and public engagement:** Openness and transparency of partnerships & public engagement of citizen
- **IPR & GDPR:** IPR rules and GDPR respected
- **Open Science:** Openly available research outputs: Open access to Publications & Open Data
- **Responsible evaluation and decision-making:** DORA, CoARA & responsible use of research metrics, no bias in evaluation
- **SDGs and EC priorities:** Taking into consideration UN Sustainable Development Goals and European Commission priorities 2019-2024

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[7] Stiegler, B. (2013). What makes life worth living: on pharmacology. Cambridge, UK: Polity

[8] Rome Declaration on Responsible Research and Innovation in Europe . (2014). https://digital-strategy.ec.europa.eu/en/library/rome-declaration-responsible-research-and-innovation-europe

[9] Strand, R. (n.d.). Responsible Research and Innovation” as an Emerging Principle in European Research and Innovation Policy. Retrieved from https://www.uib.no/sites/w3.uib.no/files/attachments/strand_rri_lecture.pdf

[10] Responsible Research & Innovation. (n.d.). Retrieved from https://www.era-learn.eu/support-for-partnerships/governance-administration-legal-base/responsible-research-innovation

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The project employs various methods to promote responsible robotics in different fields of robotics, including but not limited to

- The **creation of a maturity assessment model** named Responsible Robotics Compass (RoboCompass)[11]
- **Citizen, end user and stakeholders involvement** in robotics development[12];
- **Awareness-raising in robotics community** through capacity building activities and information dissemination[13]
- **Responsible Robotics Advocacy report** (present document) and policy recommendations

1.2.3 AI-based Responsible Robotics: situating Responsible Robotics in relation to Trustworthy AI

The focus of the Robotics4EU project and this report revolves around **AI-based robotics - robots** integrated with AI programs/algorithms that allow autonomous functioning, enhancing their adaptability and functioning across various applications. The research and advocacy in the trustworthy AI area comprehensively map the ethical, legal and social issues and potential solutions. There is a great overlap between these issues in AI-based robotics.

However, various experts interviewed for the expert consultations (See Section 2) noted that as AI is developing and becoming integrated into robotic solutions, **there is a trend to subsume robotics within the AI discourse**, affecting attention to ELSA, problem definitions, strategies, and legal frameworks. Nonetheless, it's crucial to recognise that robotics, being physical and actuated mechanisms, fundamentally differ from software and data systems. A few important differences to be mentioned:

- **REGULATION |** As a robot is an assembly of various hardware and software components (sensors, actuators, motors, etc.), it requires a holistic approach relative to many different sectors: electronics, mechatronics, mechanics, computer sciences, etc. Part of these sectors are already well covered by specific regulations (e.g. machinery regulation, RED directive), but the regulations for intelligent robotic systems has not yet been fully addressed.
- **SAFETY |** The direct interaction of robots with the real world can have a substantial impact on both individuals and equipment, thereby giving rise to concerns, particularly in the context of safety.
- **PRIVACY |** While AI primarily deals with data processing and algorithmic decision-making, robotics introduces a layer of physicality through the different sensors, amplifying considerations related to surveillance, physical proximity, and unauthorised access.
- **CYBER-SECURITY |** Keeping software up-to-date, for example, when a vulnerability is detected, only requires downloading a newer version. In the case of robotics, vulnerabilities relative to hardware cannot be so easily patched; in

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[11] Responsible Robotics Compass: https://robocompass.aiod.eu/

[12] Robotics4EU conducted the following consultations:
- GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns
- Citizen Consultation For The Validation Of Robotics Business Ideas
- Robotics Community Needs Analysis
- Co-creation workshops to test robotics applications (deliverable to be published on www.robotics4EU.eu)

[13] The knowledge transfer and capacity building activities were conducted in the 4 priority verticals: healthcare; agrifood: Agile production (deliverable to be published on www.robotics4EU.eu); Inspection and maintanance of infrastructure.

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addition, vulnerabilities in software can be patched but need to take into account the interoperability with the hardware.

- **SUSTAINABILITY |** The use of resources for AI raises many questions relative to its ecological impact (big data, HPC, Generative AI, etc.). Massive adoption of robotics would also require considering the ecological impact covering the production chain, energy consumption and waste recycling chain for the physical parts (batteries, materials, etc.).

The report aims, building on the regulatory landscape and frameworks and instruments for trustworthy AI[14], **to suggest directions towards advancing responsible robotics and tackling the ELSA specific to robotics**. Through the activities of the project, the impact of the regulatory developments and frameworks for trustworthy AI (GDPR, AI Act, etc.) were analysed with a focus on the impact on robotics. However, since the agreement of the AI Act has been reached during the last iterations of the report, the recommendations should be read as a reiterating of the directions of the AI Act instead of overlapping where it is the case.

1.2.4 Scope and limitations

Considering the extensive list of non-technical barriers to adopting robotics, it is important to note that the presented policy recommendations and measures should not be viewed as an exhaustive list. The recommendations build on the common approach of the community, emphasising the directions of policy action where the focus is needed. Further in-depth research and discussion are necessary for comprehensive policy and regulatory action, positioning the recommendations in the context of the robotics application domains and considering the specifics of various robotics categories.

Structure of the report

Chapter 1 introduces the goal of the report, main concepts, scope and limitations.

Chapter 2 presents methods for information collection and for the design of the recommendations.

Chapter 3 outlines the recommendations for policymakers, following the structure of 4 main sub-sections based on the overarching problems/advocacy directions. Each recommendation in the 4 sub-sections is coupled with proposed measures for the potential actions to implement the recommendation.

Chapter 4 provides the conclusions and next steps for the implementation of recommendations.

[14] Thiebes, S., Lins, S. & Sunyaev, A. Trustworthy artificial intelligence. Electron Markets 31, 447–464 (2021). https://doi.org/10.1007/s12525-020-00441-4

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2 Methodology

In order to design a list of policy recommendations aimed at enhancing the uptake of responsible robotics, based on a comprehensive range of sources, information was collected through:

- Desk research
- Group consultations
- Survey
- Expert interviews.

Desk research

In January - February 2023, project partners CL, CE, LNE, DBT, NTNU, and AFL conducted the primary desk research, analysing the results of the Robotics4EU deliverables[15] and presenting the findings on the main gaps and barriers for responsible robotics adoption that could be tackled by the policy action.

Additionally, a continuous desk research study was conducted analysing the outputs of the EU-funded projects and initiatives working on the non-technical aspects of robotics. The main sources (the list is not exhaustive) that informed the work are:

SIENNA	Stakeholder-informed ethics for new technologies with high socio-economic and human rights impact Coordination and Support Action funded under Horizon 2020. 2017-2021
INBOTS	Inclusive Robotics for a better Society). Coordination and Support Action funded under Horizon 2020. 2018-2021
TechEthos	Ethics for Technologies with High Socio-Economic Impact). Coordination and Support Action funded under Horizon 2020. 2021-2023
HubIT	The HUB for boosting the Responsibility and inclusiveness of ICT enabled Research and Innovation through constructive interactions with SSH research Coordination and Support Action funded under Horizon 2020. 2017-2021.
REELER	Responsible Ethical Learning with Robotics Research and Innovation Action funded under Horizon Europe. 2017-2019.

Table 1 EU-funded projects working on non-technical aspects of robotics

Group consultations

The initial outcomes of the desk research were discussed with the stakeholders - robotics research and industry representatives, experts in ethical, legal and social aspects of

[15] D1.2 "Robotics community, citizens and policy makers needs analysis"; D1.4. "Responsible robotics maturity assessment model (final)"; D3.2 "Knowledge transfer and capacity building in healthcare"; D3.3 "Knowledge transfer and capacity building in agri-food"; D3.4 "Knowledge transfer and capacity building in inspection and maintenance of infrastructure"; D3.5 "Knowledge transfer and capacity building in agile production"; D4.1 "Citizen consultations report"; D4.2 "Robotics business ideas validation"; D4.3 "Co-creation workshops to test robotics applications" (deliverables to be published in www.robotics4EU.eu)

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robotics - in 4 different group consultations, happening in the span of March - November 2023. Group consultations were led by Civitta Lithuania. The goals of these consultations were the following:

a) To discuss how identified gaps and barriers could be tackled by policy action
b) To discuss and prioritise initial recommendations, gathering feedback on their feasibility and accurateness

Robotics4EU expert group | On March 13th, 2023, in Copenhagen, the meeting was organised with 10 experts[16] from Robotics4EU expert group, with a focus on policy recommendations. The discussion outputs were prioritising and clarifying the non-technical barriers and the definition of the approach to recommendations. A first draft list of recommendations was designed after the discussion with the expert group. This list was further deliberated in the following group consultations.

Responsible Robotics Policy Lab | Robotics4EU organised the 'Responsible Robotics Policy Lab' workshop to facilitate discussions, gather inputs, and validate the initial recommendations among stakeholders, including robotics and Social Sciences and Humanities (SSH) experts. The workshop was held on the 14th of June 2023, with 8 participating experts. The output of the discussions was:

- New recommendations were suggested
- Most important recommendations identified
- Some recommendations were questioned as not relevant or not feasible
- Background and insights were provided for several recommendations.

The overview of the discussions can be found in the Robotics4EU article "Enhancing responsible robotics development and societal acceptance: what should policy priorities focus on?"[17].

Based on the Policy Lab outcomes, the recommendations were refined and compiled into the draft brief "Promoting Responsible Robotics. Recommendations for Policy Makers"[18] with initial priority policy recommendations.

euRobotics Topic Group Summit | On October 26th, 2023, Robotics4EU presented initial policy recommendations to the euRobotics community in their annual Topic Group Summit[19]. 55 people participated in the online Zoom workshop, with 25 of them contributing to a Miro board (an online platform for collaborative brainstorming). Participants were asked to prioritise recommendations and provide their feedback on the Miro board on the following questions:

- What is the most important thing the EC or national policymakers can do to support the development and uptake of responsible robotics?
- Are presented recommendations and measures feasible to implement?

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[16] An overview of the meeting is presented here.
[17] Robotics4EU. (2023, June 26). Enhancing responsible robotics development and societal acceptance: what should policy priorities focus on? https://www.robotics4eu.eu/news-articles/enhancing-responsible-robotics-development-and-societal-acceptance-what-should-policy-priorities-focus-on/
[18] Promoting Responsible Robotics- Recommendations for Policy Makers. (n.d.). Retrieved from https://www.robotics4eu.eu/wp-content/uploads/2023/10/BookletPolicyRecomendations_Robotics4eu_SG_20231025.pdf
[19] The 2023 Topic Group Summit. (2023). https://events.eu-robotics.net/event/the-2023-topic-group-summit/

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- How might the implementation of this recommendation affect the industry?
- What measures are missing?

The insights and feedback on the recommendations were incorporated into the draft brief that was published in the following event as a call for public feedback and further stakeholders' validation.

AI, Data and Robotics Forum (ADRF) | To discuss the recommendations, Robotics4EU organised a workshop at the AI, Data, Robotics Forum in Versailles, France, on November 9th, featuring experts from policy, industry, and academia:

- Prof. Dr. Philip A.E. Brey, professor of philosophy and ethics of technology at the University of Twente
- Cem Gulec, Programme and Policy Officer – Artificial Intelligence and Robotics, at the European Commission
- Dr. Susanne Bieller, General Secretary at the International Federation of Robotics
- Prof. Dr. Juha Röning, Professor of Embedded System at the University of Oulu

The goal of the workshop was to discuss the ethical and social dimensions of AI-based robotics and transform these discussions into actionable directives for policymakers and industry leaders, illustrating how ethical and societal considerations can be integrated into the entire robotics life cycle. Speakers' presentations and discussions with the audience revolved around the topics of robotics and AI integration and the importance of the dimension of physicality and building trust beyond safety through engagement and education[20].

The drafted brief of the initial recommendations was announced in the workshop, inviting participants to review and provide their feedback either online or in personal feedback sessions at the Robotics4EU booth at ADRF.

Survey

The drafted brief "Promoting Responsible Robotics - Recommendations for Policy Makers"[21] was also disseminated through Robotics4EU social media and direct email marketing channels. The dissemination of the brief was coupled with the invitation to provide feedback on recommendations in the survey. The survey questions focused on prioritising the most important recommendations and identifying the gaps (the full list of the questions is provided in Annex 3). However, over the period of November 9 to December 9, 2023, only eight responses were received, providing qualitative insights on the topic.

Expert interviews

Along with the desk research, survey and group consultations, the task also involved individual consultations with stakeholders. The stakeholders included SSH experts working on the ELSA (ethicists, psychology, law, and sociology experts), policymakers

[20] Robotics4EU. (2023, November 16). Insights from the Robotics4EU Workshop: Shaping Responsible Robotics in Europe through Policy and Industry Collaboration. https://www.robotics4eu.eu/news-articles/insights-from-the-robotics4eu-workshop-shaping-responsible-robotics-in-europe-through-policy-and-industry-collaboration/

[21] Promoting Responsible Robotics- Recommendations for Policy Makers. (n.d.). Retrieved from https://www.robotics4eu.eu/wp-content/uploads/2023/10/Preview_BookletPolicyRecomendations_Robotics4eu_SG_20231107.pdf

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and representatives of robotics research and industry. Seventeen expert consultations were held in the span of March 1st - December 14th, 2023 (see the list in Annex 4).

Interviews were conducted in two rounds:

I. Initial discussion on recommendations, aiming to discuss the approach and direction the recommendations should take, identifying main barriers. The meetings were held with David Bisset (euRobotics) on March 1st, Fredrik Heintz, Juha Röning, Nabil Belbachir and Philip Piatkiewic (ADRA) on June 13th, 2023.

II. Final expert validation calls, receiving detailed feedback on the recommendations, sent in the form of the draft brief in advance, and elaborated insights on the specific topics. The standard questions asked were:
   - Do the proposed recommendations identify the correct direction of solving the societal barriers to robotics adoption?
   - Are the measures feasible and implementable?
   - What are the missing gaps/emphasis needed?

   Based on the expertise of stakeholders, the discussion would shift to the specific recommendation. Experts from Robotics4EU Expert Group, SIENNA, TechEthos, INBOTS, Collaborative Robotics, euRobin, and organisations like the International Federation of Robotics were invited, along with contacts established at the European Robotics Forum 2023.

The consultations with experts provided significant guidance on finalising the policy recommendations presented in the following report. We are grateful to all experts participating in the interviews and providing their feedback.

Designing the structure of the report

The collected recommendations, covering various non-technological aspects of robotics uptake, were assembled under 4 overarching themes. These themes were selected as ones encompassing and communicating the core advocacy directions of Robotics4EU work:

- Focusing on the societal acceptance of robotics through engagement and awareness-raising (**ENGAGE**)
- Advancing the development and uptake of responsible robotics solutions through support to the robotics community (**SUPPORT**)
- Promoting Responsible Robotics principles as a way of ensuring the adherence to societal acceptance and uptake of robotics (**ENSURE**)
- Looking into the socio-economic impacts of responsible robotics (**FORESEE**)

The next chapter presents the overview of these 4 directions and dwells into each of them by outlining the problems, recommendations and proposed actions for implementing the recommendations.

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3 Advancing Responsible Robotics: Recommendations

The following section of the Responsible Robotics Advocacy report presents an elaborate list of recommendations that tackle the non-technical aspects of robotics adoption and societal acceptance. The recommendations are structured under 4 sub-sections that emphasise the overarching directions of the recommendations:

ENGAGE **a wide array of actors in the formulation of robotics policies and the development of robotic solutions**

The direction for policy action revolves around the need to ensure the comprehensive multi-stakeholder engagement in robotics - starting from the citizen engagement in the dialogues for strategic policy directions to the end-user engagement in the research and development.

SUPPORT **the robotics community in the development of responsible robotics**

The direction for policy actions emphasises the need for support for the robotics community in navigating the regulatory landscape and guidance on incorporating the responsible robotics principles from the conception to the deployment and reiterative evaluation of the robotics solutions

ENSURE **adherence to the responsible robotics principles in safety, data, ethics, and sustainability**

The challenges in robotics development and adoption, spanning safety, privacy, representation, liability, and sustainability, necessitate immediate policy action. Policymakers are urged to establish robust regulations, guidelines, and ethical frameworks to address these multifaceted concerns effectively.

FORESEE **and mitigate the socio-economic challenges**

The recommendations propose foresight, analysis and policy measures for a fair transition to automation at the local level, acknowledging the impact on workers. They emphasise fostering dialogue among industry stakeholders, including workers and policymakers. The broader, long-term impact is sought through aligning the industry and education system and implementing economic measures to address inequality risks.

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3.1 ENGAGE A WIDE ARRAY OF ACTORS IN THE FORMULATION OF ROBOTICS POLICIES AND THE DEVELOPMENT OF ROBOTIC SOLUTIONS

The rapid technological advancement and uptake of robotics and AI-based solutions are already changing the way we live, work, and interact. These new and powerful technologies have the potential to transform society in the near future. However, such transformation also brings along numerous **difficulties as well as known and unknown barriers from a societal perspective that need to be addressed and discussed with the wider public.**

Robotics4EU engagement activities with citizens, end users, and robotics community representatives[22] (engineers and researchers, developers and deployers) show that currently, **a broad stakeholder engagement in robotics development, including policy levels, is lacking**.

The Robotics4EU Citizen Consultations highlighted that many people generally have a positive view of robotics but that there are important barriers to more widespread adoption of robotic solutions that need to be understood better[23]. First of all, **citizens expect to be engaged in the development of the field** – this is crucial whenever implementing new and novel technologies that change the regular ways of being and functioning within a society. Robotics4EU citizen engagement activities showed that citizens are eager to be heard and included in the debate about robot technology. Furthermore, citizens think it is important to consider their inputs to introduce robots into society smoothly. Although citizens may not possess the technical knowledge required to build or control a robot, they can contribute with an additional understanding of the social world in which new technologies will be implemented.

On the path of introducing new and emerging technologies, one **should uncover what potential barriers might obstruct the adoption and acceptability by users and impacted stakeholders.** Inclusivity of a wide array of citizens and stakeholders in the technology design, development and deployment process ensures that robotics solutions encompass and include in an anticipatory manner a great plurality of perspectives[24], needs and abilities. Additionally, citizens can help reveal as much as to understand the actual worries and wishes that come along with automation, which in turn helps overcome barriers and establish trust in the industry's technology and business models.

Furthermore, the Robotics4EU team believes **it is important to engage in these discussions early on to help steer robotics development towards the desired paths – thereby also away from the unwanted scenarios** – and to ensure an ethical development of technology that is broadly accepted by society.

The prevalent lack of dialogue between roboticists and the general public led to widespread misconceptions, unfounded fears and reduced trust regarding robotics. As

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[22] Robotics4EU. Robotics community, citizens and policy makers needs analyses. https://www.robotics4eu.eu/publications/deliverable-1-2-robotics-community-citizens-and-policy-makers-needs-analyses/

[23] Robotics4EU. GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns. https://www.robotics4eu.eu/publications/globalsay-on-robotics-citizen-consultations-on-wishes-and-concerns

[24] Umbrello, S., Bernstein, M. J., Vermaas, P. E., Resseguier, A., Gonzalez, G., Porcari, A., Grinbaum, A., & Adomaitis, L. (2023). From speculation to reality: Enhancing anticipatory ethics for emerging technologies (ATE) in practice. Technology in Society, 74, 102325. https://doi.org/10.1016/J.TECHSOC.2023.102325

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noted in the REELER policy recommendations, the exaggerated images of the universal, human-like, well-functioning and scary robots presented by the mainstream media need to be counterbalanced by the public debate and political action that would **encourage the conversation on the actual effects and foreseen and unintended consequences of the robotics integrations**[25]. The REELER project advocates for the engagement and awareness-raising tools that **tackle the imaginaries** that hinder the acceptance of robotics, i.e., misguided perceptions of robots can generate fear or fascination, leading to disappointment among citizens. Prevalent misconceptions can also impact policymakers and shape policy directions. Policymakers may allocate funds based on unrealistic expectations, impacting robot developers[26]

To bridge the gap between roboticists and the general public, it is important to prioritise **inclusive dialogue with citizens and stakeholders**. Establishing open channels of communication and fostering a more comprehensive understanding between the industry, policymakers, and the general public will both contribute to a more informed and constructive public discourse on robotics. Involving a variety of actors across government, industry, academia and civil society, such as citizens, end users and CSOs can help to steer the development in correlation with societal expectations. Also, the dialogue should be based on the attempt to understand general public concerns, even if fears are not based on a factual understanding of the current-day capabilities of robotics technologies. It is important to not only state that robots will not take over but also to identify the root causes of these fears rather than relying solely on presenting facts.

The following recommendations present policy-related measures that could strengthen the two-way dialogue between the robotics community and the general public. The recommendations focus on three directions:

- Awareness-raising initiatives
- Inclusive discussions for robotics development strategies and policies;
- Multistakeholder representation in the robotics life-cycle

By definition, recommendations require the involvement of research and academia, industry and its associations, regional, national and EU-level policymakers.

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[25] Policy recommendations from Responsible Ethical Learning in Robotics (REELER). (n.d.). Retrieved from https://responsiblerobotics.eu/wp-content/uploads/2019/12/PolicyRecommandations_for-reading-online.pdf

[26] ibid

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Terms and definitions

Citizens
Citizens, referred to in this report, mean two things: 1) **The general public** that should be informed of robotics advancements and benefits, risks and capabilities, even though they do not express interest in the deliberation of robotics-related questions 2) **Citizens that feel directly concerned** and should have the opportunity to express their view through the measures defined in section 3.1.2.
Stakeholders
Beyond direct actors in the robotics field (robotics researchers and developers, regulators, deployers and end-users), the important stakeholders could be listed (however, the list is not exclusive): ● NGOs and civil society organisations ● Labour organisations ● Consumer advocates ● Environmental organisations ● Local community representatives ● Ethicists ● Lawyers ● Sociologists, anthropologists, etc. The elaborate mapping of the robot makers and stakeholders can be accessed in REELER project[27]
End users
The end users are individuals in the environment the robot will be functioning in, sometimes knowledgeable about the task that is to be performed autonomously when the robot is deployed in a professional context, and likely to monitor the robot's activities and be impacted by the results of its actions. It is important to note, that in the context of this report, end users are not referred to as the entities (companies, public institutions, etc.) buying the robot or where the robot will be deployed, but as the individuals that will be directly interacting with the robot.

Table 2 The definitions of citizens, stakeholders, and end users

3.1.1 Increase awareness of the robot's capabilities, limits, risks and benefits

Robots and AI systems have first been described in works of fiction before the technology caught up[28]. These fictional portrayals of robots and their behaviour have influenced our understanding of robots and the development of the industry - the advancements, capabilities, associated risks, and limitations of robotic technologies have been exaggerated in the public narrative. Consequently, exaggerated images of robotics amplify both fears of robotics and expectations as well.

[27] REELER: https://responsiblerobotics.eu/
[28] AI Armageddon and the Three Laws of Robotics. https://www.cs.memphis.edu/~tmccauly/ai_armageddon-McCauley.pdf

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While the **fear of limitless automatisation and human unemployment due to technological advancements** is widely prevalent among the general public[29], the **expectations for robots, especially for specific tasks, are also inflated.**

A **gap in expectations** is often observed for autonomous, particularly for “smart” systems. When a role traditionally held by a person is automated (such as care roles or other service providers), users' expectations are unpredictable and go beyond the fulfilment of operational specifications – all of which can be identified in observation and consultation. For example, a robot working at a social or medical centre may be expected to show empathy as this is part of the usual human interactions. It has been shown that humans attribute emotional intelligence to systems based on their pre-programmed answers or actions, if these actions change depending on the situation. On the contrary, a surveillance or inspection robot may be perceived as threatening and dangerous when it is not at all the case. The robot's physical appearance may also affect the expectations: humanoid robots would be expected to have human-like capacities; machine-like robots would be expected to have high precision and high computational power, etc.

This mismatch in expectations impacts not only the attitudes and acceptance of robotics in the general public but, more importantly - adopters: industry, SMEs, and public bodies. For instance, consider a scenario where a manufacturing enterprise, spurred by exaggerated portrayals of advanced robotic functionalities, harbours expectations of seamless and comprehensive automation within its production processes. The ensuing reality, marked by the nuanced limitations of existing robotic technologies, may result in substantial discrepancies between anticipated outcomes and the actual capacities of the deployed robotic systems.

Thus, both fear of robotics and disappointment in their capabilities stem from unrealistic imaginaries of robotics. **The general population should be made aware of the limits of the robot’s capabilities, both to avoid overreliance and to limit fears of a so-called “robot revolution”. On the other hand, the investment in creating a more positive, although still realistic, narrative is crucial**[30].

This can be done by including realistic robots in modern works of fiction, communicating openly about the limits of automation and exposing real robots to the public in situations where it is possible to interact with them and discover their limitations. The national level actors should take up the practical implementation, ensuring that the real questions are answered, and misconceptions and fears tackled in the specific societal contexts.

Measures:

- Invest in societal dialogue and awareness-raising campaigns about capabilities, limits, risks and benefits of robotics through European-wide initiatives (e.g., through synergies with European Researchers' Night, Science Cafe’s), national initiatives (i.e., science festivals, public lectures, etc.) and media channels (e.g., podcasts like “Future Europe”, TV shows, documentaries, etc.) *EU and national level, in cooperation with robotics associations*

[29] Robotics4EU. GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns. https://www.robotics4eu.eu/publications/globalsay-on-robotics-citizen-consultations-on-wishes-and-concerns

[30] Key Takeaways. (n.d.). Retrieved from https://adrforum.eu/key-takeaways

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- Ensure real-life opportunities for engaging with robots, such as exhibitions and testing of robotic solutions in public spaces (children's robotics competitions, science fairs, such as RoboCup[31], Robotex[32])
  National and robotics industry level

- Establish a comprehensive set of guidelines for the deployment of robots in public spaces, such as autonomous delivery robots, focusing on ensuring transparency, accurate representation, informed consent, safety protocols, and providing clear communication and behavioural guidelines for citizens. These guidelines should be developed through participatory approaches, employing real-case scenarios and learning-based formats (i.e., Living Labs)
  EU level

3.1.2 Engage citizens in the discussions on the mission and vision of robotics development in the EU

Awareness raising and public dialogue, aimed at discussing robotics' capabilities and risks, also should spiral to the citizen engagement in creating policies, strategies and development directions related to robotics. Involving society in robotics policy development is important to ensure its trust and acceptance and to align the EU's robotics vision with societal expectations.

Citizen involvement rests on the core democratic notion that technology that changes (or has the potential to change) the lives of people and makes substantial changes in society should not only be decided and discussed by businesses, policy-makers, stakeholders, etc., but also by those that are directly or indirectly affected by these developments on a daily basis, namely, citizens.

Several platforms/initiatives run by the European Commission attempt to gather public opinions on the direction of robotics development. Eurobarometer studies on robotics reveal opinions on the impact of digitisation and automation on daily life. However, the Eurobarometer studies on public opinion of robotics are not periodic, with the most recent ones dating to 2020, 2017, 2015 and 2012[33].

European Commission holds consultations with stakeholders and the general public on policy developments, including deliberation on priorities for EU Research and Innovation[34] and Digital Europe[35] programmes. The open stakeholder consultations are held, coupled by the Citizen Panels[36] and a dedicated platform for Europeans discussing

[31] RoboCup Federation official website. (n.d.). Retrieved from https://www.robocup.org/
[32] Competitions - Robotex International. (n.d.). Retrieved from https://robotex.international/roboticscompetitions/
[33] Surveys.(n.d.). Retrieved from https://europa.eu/eurobarometer/surveys/browse/all/series/3971
[34] Directorate-General for Research and Innovation. (2023, April). The results of the public consultation on the future of EU Research and Innovation programmes are now public. https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/results-public-consultation-future-eu-research-and-innovation-programmes-are-now-public-2023-04-19_en
[35] Consultations | Shaping Europe's digital future. (n.d.). Retrieved from https://digital-strategy.ec.europa.eu/en/consultations
[36] European Citizens' Panels: https://citizens.ec.europa.eu/index_en

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EU policies - Futurium[37]. Also, a notable example of citizen engagement in defining the future policy directions was The Conference on the Future of Europe (CoFE) in 2023. However, these initiatives do not explicitly cover the topics related to robotics development and funding priorities.

Therefore, it is recommended that broad citizen engagement in the development of robotics policies is encouraged through facilitated citizen consultations, surveys, focus groups and online discussions.

Engagement activities should ensure that participants are well-equipped and informed to deliberate the questions, while consultations and discussions are well-facilitated. Activities should address crucial questions about development priorities, acceptable sectors and application cases for robotics, and deliberate societal impacts from robotics uptake.

Measures:

- Looking forward to the next programming periods for Horizon Europe and Digital Europe, ensure that established formats of citizen consultations (i.e., European Citizens' panels) include the questions on priorities of robotics and include the existing work done[38]. This would help to understand public opinion on desired spheres/levels of automation, acceptable and non-acceptable robotics applications, especially on controversial robotics, such as social, care, law enforcement, robots, and autonomous vehicles
  EU level

- Strengthen the role of Technology Assessment (TA) organisations in the robotics policy development on the national level and address TA continuously as an integral mechanism for informing policies, regulation and funding for robotics research and development at the EU level
  EU and National level

- Link the robotics dimension to the New European Bauhaus[39] initiative to ensure that robotics is not left out of the interdisciplinary discussion but rather included in the deliberation of the creative and sustainable future of Europe (for example, including sessions on Responsible Robotics in New European Bauhaus 2024 festival)
  EU level

- Establish strategic initiatives, including research, projects, and events, fostering collaboration between ADRA and citizen representative and technology assessment (TA) organisations in forming collective stances on the key priorities in robotics development. Citizen-representative organisations should be invited to collaborate through an open, public call.
  EU level, in cooperation with robotics associations

[37] European Commission. (n.d.). Your Voice, Our Future | Futurium. Retrieved from https://futurium.ec.europa.eu/en/about-futurium
[38] For example, Robotics4EU conducted GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns or SIENNA D4.5 Public views on artificial intelligence and robots across 11 EU and non-EU countries
[39] New European Bauhaus: beautiful, sustainable, together. - European Union. (n.d.). Retrieved from https://new-european-bauhaus.europa.eu/index_en

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3.1.3 Ensure representation of citizens, experts, stakeholders and end users in the robotics research, development, and deployment

Ensuring societal inclusivity in robotics, beginning with high-level policy objectives, should be mirrored in the practical phases of the robotics life cycle. Involving a diverse range of citizens and stakeholders in the design, development, and deployment processes guarantees that robotics solutions proactively incorporate a broad spectrum of perspectives, needs, and abilities.

Despite the nature of robotics being autonomous machines, **humans often control, monitor and collaborate with them**, as seen with the emergence of co-bots, which are dependent on human interaction. It is, therefore, essential to explore how robots are perceived and received by those who are and will be using robotic solutions, working with them or in the close vicinity of robots, or in any way impacted by the outputs of the robotic activity. A comprehensive understanding of the impact on various groups is essential for developing robots that seamlessly integrating into their intended environments, operating effectively and safely alongside human interactions.

The literature emphasises the **normative role of the robotics designer**[40] - designers and developers, focusing on the technical perspectives, which might be limited in reflecting the variety of perspectives of contexts of users, including the physical body features or skills and the risk of “importing their own normative understandings”[41]. The misalignment between the creators’ perspective and end users' or stakeholders’ understanding creates a condition that can support the societal refusal of robotics.

Involving citizens, end users and stakeholders, including trade and labour unions, social partners, CSOs and NGOs, representing affected workers and vulnerable groups in early-stage robot design, development, and deployment could enhance the alignment with users' needs, fostering fair representation and potentially increase societal trust and acceptance of robots by considering inputs and concerns of affected groups comprehensively.

Target group: citizens

Involving a broad and diverse assortment of citizens in the processes of robotics development is a crucial step towards making technology better suited for society and aligning the needs and expectations between society and the robotics community. Doing so enables the creation and implementation of human-centred technology.

Based on data collected in the citizen engagement activities carried out in Robotics4EU[42] it is recommended that citizen engagement is prioritised in the development of new technologies, such as robotics and AI-based solutions. The gap between the general public and research and development was also noted across the expert interviews[43].

Citizen engagement is crucial for home / urban / service robots. For example, citizen interaction with urban delivery robots is beyond that of the end worker-robot relationship

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[40] Policy recommendations from Responsible Ethical Learning in Robotics (REELER). (n.d.). https://responsiblerobotics.eu/wp-content/uploads/2019/12/PolicyRecommandations_for-reading-online.pdf
[41] Ibid
[42] Robotics4EU. GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns. https://www.robotics4eu.eu/publications/globalsay-on-robotics-citizen-consultations-on-wishes-and-concerns
[43] Robotics4EU. Robotics community, citizens and policy makers needs analyses. https://www.robotics4eu.eu/publications/deliverable-1-2-robotics-community-citizens-and-policy-makers-needs-analyses/

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in the work setting. While interacting in public spaces, even if not actively, but passively (bypassing, reacting to the robot's presence by altering their routes and actions), citizens are impacted in unique ways that need to be deliberated and considered by the technology producers and deployers.

Engaging citizens can be achieved through several approaches. It can be done by recruiting individuals randomly from the general population and/or by identifying and collaborating with organised societal actors such as civil society organisations (CSOs) already working collectively toward specific goals.

Target group: end users

Engaging end users is an important step toward creating responsible robotics. As end users are the ones operating in close contact, operating the robots and affected by their introduction to their environments, their engagement is paramount to ensure that robot developers, designers, and manufacturers are better equipped to make informed decisions about their products' design and functioning and avoid costly mistakes that may render their solutions(s) unfit for the environment in which they operate.

Also, engaging them in the development stages of the robot can further increase trust from the users of the technology if they feel that their inputs have been represented in the final design of the robot.

A stronger emphasis on user involvement and user-driven innovation has occurred as concepts such as design thinking, co-creation, and user experience have influenced many companies' innovation models[44]. Many of these concepts stem from the same ground idea of involving external actors, such as users' perspectives in the development process of new products, applications, services or systems. "If we are to design the futures we wish to live, then we need those whose futures they will be to actively participate in their design"[45]. It has also been found that usability is one of the key factors in increasing trust in new technology together with operational safety, cognitive compatibility and trialability[46].

The involvement of end users is indispensable for crafting solutions rooted in genuine societal needs, as opposed to assumptions or technology-centric research and development pathways. Through meaningful collaboration with end users, the robotics community not only refines its understanding of contextual challenges but also aligns its limited resources and efforts with the most pressing needs identified by the users. However, this process of end user engagement has to be well designed, paying attention to the complexities of work. There must be a facilitated dialogue to uncover the real needs and challenges in their work, aligning the expectations and technical capabilities.

Target group: stakeholders and representative groups

Along with general public and end-user engagement, it is also important to reflect upon other kinds of stakeholders or representative groups that could have a stake in the development of robotics. Engaging stakeholders is crucial for the successful adoption of

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[44] Wise, E., & Hoegenhaven, C. (2008). User-Driven Innovation - Context and Cases in the Nordic Region. (Innovation Policy). Nordic Innovation Centre. http://www.nordicinnovation.net/prosjekt.cfm?id=1-4415-246

[45] Robertson, T. and Simonsen, J. (2013): Participatory Design – Introduction. I Routledge International Handbook of Participatory Design, ed. Simonsen, J. page 1.

[46] Hengstler, M., Enkel, E., & Duelli, S. (2016). Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices. Technological Forecasting and Social Change, 105, 105-120. Summary can be found free here: https://hbr.org/2017/04/to-get-consumers-to-trust-ai-show-them-its-benefits

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robotics. It involves identifying, understanding and involving people who have a stake in the outcome of the development, both in the short and long run. For example, the head of the Hospital Human Resources Manager might be an important stakeholder in revealing the drivers and barriers to the acceptance of robotics in the health sector. Through stakeholder engagement, it is possible to identify groups that may not support robotics development and understand the barriers and fears behind these concerns. These perspectives are essential to be aware of when making regulatory policies for robotics and in the general development of the technology. Stakeholders can overlap with the categorisation of end users and the general public, but there will also be additional actors to include, such as unions, researchers and academia, standards associations, insurance companies, etc.

Stakeholder engagement, a well-established approach, must gain heightened importance in robotics development. While it is commonly used, a forward-thinking mindset is crucial to identify stakeholders beyond the usual suspects. Allocating extra time for diverse stakeholder inclusion, considering both immediate and long-term perspectives, becomes essential.

Overall, citizen, end-user and stakeholder engagement under the EU's Open Science Policy and as a priority for the European Research Area, is well-established. It is reflected in Horizon Europe as a recommended practice[47] of involving all relevant actors in the co-creation of R&I content, with tools and methodologies provided. However, a challenge lies in ensuring that these practices are not dismissed and conducted in high quality (not as a "check-list" activity), alongside tailoring the methods and tools to the context and application specificities in robotics.

Measures:

- Include new project calls in Horizon Europe and Digital Europe programmes, focused on citizen and end-user engagement in the domain-specific robotics fields, to analyse the impacts of technology on various societal groups and individuals and to create replicable and open-source tools and proven methodologies for future engagement management[48]
  EU level

- Expand the requirements for involving end users and stakeholders in EU-funded robotics projects (IA or RIA) to ensure the engagement is integrated from the outset of the robotics life-cycle (from defining requirements to deployment) and focuses on the ethical, societal aspects, as well as on functionality and safety
  EU level

- Expand the offer of Testing and Experimentation Facilities to include existing validated multistakeholder engagement methodologies to allow clients to assess the societal acceptance of their robotics solutions (See Table 3)
  EU level

- Communicate and promote the value and best practices of end-user and stakeholders' engagement in industry events (such as IEEE, ERF, ADRF).
  EU and industry level

[47] EU Grants: HE Programme Guide. (2023). https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/programme-guide_horizon_en.pdf
[48] An example of successful project in a (field)s, such as EUPATI: https://cordis.europa.eu/project/id/115334

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Tools and Methodologies

Co-creation tools
Facilitating collaboration between developers and end users and stakeholders. Look for inspiration from free online resources such as the co-creation guide on how to engage citizens in the process of developing responsible, innovative technologies from the SocKETs project: https://guide.sockets-cocreation.eu/
The Robotics4EU discussion game
The discussion game is a board game that can be played in a group setting to discuss non-technological barriers to robotics adoption. It can be downloaded for free from the Robotics4EU website https://www.robotics4eu.eu/
REELER project
Reeler project tools provide a roadmap with different waypoints for navigating your way through responsible robotics, including methods for engaging with different stakeholder groups: https://responsiblerobotics.eu/

Table 3 Examples of multistakeholder engagement methodologies

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3.2 SUPPORT ROBOTICS COMMUNITY IN DEVELOPMENT OF RESPONSIBLE ROBOTICS

The implementation of the core responsible robotics principle - the consideration of values and expectations of the society - is diffused throughout the various dimensions: from the bottom-up voluntary action, such as considering stakeholders' points of view in the concept stage, to strictly regulated aspects of ensuring human rights - such as safety, data and privacy regulations. The evolving landscape of the "hard" regulation and the wide array of the "soft" aspects that need to be considered in the design, development and implementation process is rather complex. Through the robotics community engagement activities[49], the following emerged: 1) aspects of the regulation landscape that could be enhanced towards more coherent and relevant frameworks; 2) a lack of awareness of the regulation and expected responsible robotics practices; 3) a lack of the capacities and resources to ensure the compliance and conduct the meaningful societal and ethical evaluation and integration of ELSA from the first steps of the robotics life cycle.

Robotics4EU activities aimed to assist the robotics community by organising capacity-building workshops, providing a self-assessment tool for ethical, social and legal considerations, and creating and disseminating methodologies and practises of stakeholder and citizen engagement. However, **it was identified there is a need for regulatory improvements, with a focus on advancing coherence, wide support for the robotics community in navigating the regulatory landscape, and guidance on incorporating responsible robotics principles from the conception to the deployment and reiterative evaluation of the robotics solutions.**

3.2.1 Advance coherence of regulations and standards for robotics

One of the recurring issues slowing robotics adoption in Europe noted throughout the Robotics4EU *Robotics and Policy Makers Needs Analysis*[50] and capacity-building workshops was unharmonised regulation. 57% of the Robotics community needs analysis respondents have prioritised the unharmonised regulation among the 3 most important legal issues for adoption[51].

The absence of a universally defined term for "robot" in the current regulatory landscape creates complexities and uncertainties. Numerous legal documents and regulation pieces need to be combined and interpreted to cover specific robotic categories[52]. While ISO standards aim to provide clarity (for example, defining standards for personal care robots), they remain non-binding.

To address these challenges, it is recommended to introduce new overarching legal categories specific to types of robotics. This approach would replace reliance on multiple legal acts and promote a more unified and responsible regulatory framework. Addressing uncertainties in existing acts, such as potential overlaps and conformity

[49] Knowledge transfer and capacity building workshops in 4 priority verticals of Robotics4EU: agri-food; agile production; healthcare; inspection and maintenance of infrastructure

[50] Robotics4EU. Robotics community, citizens and policy makers needs analyses. https://www.robotics4eu.eu/publications/deliverable-1-2-robotics-community-citizens-and-policy-makers-needs-analyses/

[51] ibid

[52] Kapeller, A., Felzmann, H., Fosch-Villaronga, E., & Hughes, A. M. (2020). A Taxonomy of Ethical, Legal and Social Implications of Wearable Robots: An Expert Perspective. Science and Engineering Ethics, 26(6), 3229–3247. https://doi.org/10.1007/S11948-020-00268-4/

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assessments, which are crucial to ensuring effective and coherent regulations for the responsible development and use of robotics.

It is crucial to acknowledge that the EU is advancing greatly towards establishing a coherent legal framework for trustworthy AI (AI Act, Ethics Guidelines for Trustworthy AI). One should note that in the context of the European New Legislative Framework and as specifically pointed out in the explanatory memorandum of the AI Act, regulatory intervention on trustworthy AI matters should not consist in a sectoral, "ad-hoc" approach, but rather tend towards a standardised approach across sectors, seeking common paradigms.

The overarching principles for responsible robotics could also be established in line with this approach. Even though Trustworthy AI regulations and guidelines cover most of the ELSA in AI-driven robotics, there is a need to advance these guidelines and approaches with the specifics for robotics, accounting for the unique challenges raised by the physicality of robotics: physical harm, cybersecurity of connected systems, embedded surveillance, biases in design, etc (covered in the section 3.3 of this report). **There is a need to develop coherent, responsible robotics regulation that would serve as overarching legislation, bringing coherence and focus to these aspects.**

Moreover, coherence is required not only among the parts of the legal frameworks in the EU but also across the EU member states. There are significant **gaps in harmonisation related to the different requirements across borders in robotics application domains.** The SIENNA report emphasises this gap as one of the most urgent recommendations[53].

With the national legislative frameworks differing in various application domains, the robotics developers and deployers, aiming to bring their solutions to different markets, have to investigate and comply with different rules and receive approval from each country's notified bodies.

UNHARMONISED REGULATION IN INSPECTION AND MAINTENANCE

The importance of harmonised regulation in the EU has been emphasised by the Inspection and maintenance community in capacity-building workshops, conducted by Robotics4EU. It was noted that different legislation and regulations across borders hinder the adoption of robotics solutions in I&M, as for each country, inspection must be performed by local certified inspectors following the specific rules and procedures.
The absence of a unified approach complicates the development and deployment of robotic systems and impedes collaboration and knowledge sharing among industry stakeholders.

Measures:

- Create a group of experts (representing industry, experts in ethics, social and legal aspects of robotics, representatives of stakeholder, end-user and citizen organisations) at the EU level (similar to HLEG-AI) on responsible robotics, aiming to advance the coherence of the responsible robotics regulations, advancing one of the possible scenarios[54], including: a) creating special ethics guidelines for robotics as annexes to EU Ethics guidelines for AI and AI Act;

[53] Konrad Siemaszko. (2020). D5.6: Recommendations for the enhancement of the existing legal frameworks for genomics, human enhancement, and AI and robotics. 70. https://www.sienna-project.eu/digitalAssets/894/c_894270-l_1-k_sienna_d5.6_recommendations-for-the-enhancement-of-the-existing-legal-frameworks-for-genomics--human-enhancement--and-ai-and-robotics_www.pdf
[54] Brey, P. (2023). How is responsible robotics different from responsible AI? https://adrforum.eu/sites/default/files/2023-12/How%20is%20responsible%20robotics%20different%20from%20responsible%20AI.pdf

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b) Annexing Machinery Directive and General Product Safety Directive.
EU level

- Encourage national and European competent authorities to engage collaboratively[55] on addressing responsible robotics, especially where societal acceptance raises significant concerns, for example, law enforcement robots, social robots, and care robotics
EU and national level

- Establish a framework for machinery, allowing regular review and adaptation of regulations regarding the new legislative issues created by emerging AI-driven technologies (for example, analysing the implications of the AI Act on the different robotics application domains)
EU level

3.2.2 Develop testing and experimentation facilities and fund experiments to advance standardisation

Testing and experimentation are crucial steps to ensure performance, safety, interoperability and compliance with the standards of robotic solutions. Testing and experimentation frameworks, through the lowered regulatory barriers (legal "sandbox" settings) in the controlled environment, allow the unfolding of robotics' unforeseen consequences and exploring modes of engagement with end users[56]. Advanced testing technologies and facilities provide environments for enhancing the efficiency and accuracy of the testing process. Also, the testing facilities can be instrumental for responsible robotics development in the following ways:

- **Serve as instruments for innovation governance**[57]. The regulatory lag has been one of the main 3 hurdles identified in Needs Analysis[58]. This lag is associated with the information disparity[59]. To tackle this gap, the robotics community emphasises the need for policymakers to be involved in the experimentation and testing, to use that as knowledge-generating tools that are relevant for regulation, bringing policymakers closer to research[60]. This collaboration in the testing can evaluate compliance with regulatory norms, anticipating risks and deliberating on the appropriate safety requirements. This enables policymakers to respond more swiftly to technological advancements and formulate or reiteratively adjust regulations in a timely manner, based on evidence-based mechanisms. SAFE & SOUND[61] - is a notable example of

[55] Konrad Siemaszko. (2020). D5.6: Recommendations for the enhancement of the existing legal frameworks for genomics, human enhancement, and AI and robotics. 70. https://www.sienna-project.eu/digitalAssets/894/c_894270-l_1-k_sienna_d5.6_recommendations-for-the-enhancement-of-the-existing-legal-frameworks-for-genomics--human-enhancement--and-ai-and-robotics_www.pdf
[56] Engels, F., Wentland, A., & Pfotenhauer, S. M. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. Research Policy, 48(9), 10. https://doi.org/10.1016/J.RESPOL.2019.103826
[57] ibid
[58] Needs Analysis reference; 52% of respondents choosing this among top 3 legal problems;
[59] Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12
[60] Ibid
[61] LAIDEN. (n.d.). ERC StG Safe & Sound Towards Evidence-based Policies for Safe and Sound Robots. Retrieved from https://www.laiden.org/projects/erc-stg-safe-sound

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supporting research toward an evidence-based regulatory model for robots that guides rather than catches up with robot (r)evolution.

- **Advance standardisation**. Testing and experimentation are vital for developing the "best practices" essential for robust standards, a crucial aspect in the context of the current Safety-AI-Robotics challenge. Relying solely on industry-led initiatives for standardisation is time-consuming. Public financial support for experiments is a key strategy for expeditious standard development, also, ensuring the responsible robotics aspects are included in the development of standards.
- **Consider ELSA and sociotechnical environments**. As presented in Chapter 3.1., engaging the wide array of actors in the robotics life-cycle is a vital step for advancing responsible robotics. The involvement of end users, focusing on the testing of functionalities and safety of the products, should also be advanced with integrating the social and ethical evaluation of solutions. Currently, the lack of settled methodologies for testing methods for aspects such as trust, dignity, and privacy is identified in different application domains, for example, exoskeletons[62]. Also, the physical testing facilities allow not only the engagement of actors but also the evaluation of the real-world environments and the interaction of actors in the environments.

Summing up, testing and experimentation frameworks and facilities, with the elaborate engagement strategies of policy-makers and wider societal representation and evaluation, allows granting the innovation “broader democratic legitimacy, than purely top-down, expert driven forms of technology introduction”[63].

Drawing on the feedback from the engagement with the robotics community, identifying the lack of a developed and comprehensive approach to testing, and emphasising the instrumental role of testing in the advancement of responsible robotics, the recommendation is to **advance robust testing frameworks that integrate controlled testing facilities and real-world environments**. As the Testing and experimentation facilities (TEFs) are implementing this recommendation to some extent, investment is required in the broader application fields and continuously providing better accessibility to the technology providers. Additionally, testing frameworks and facilities should include the methodologies for citizens' and end users’ involvement, focusing on the societal acceptance aspects, such as perceived safety, and impact on the well-being and human experience.

Measures:

- Continue investing in research and development of advanced testing technologies and experimentation facilities (i.e., expansion of TEFs to robotics solutions)
  EU level

- Encourage and facilitate the development of operational regulatory sandboxes dedicated to responsible robotics, meant to check the adaptability of the principles of the AI Act to specific critical AI-driven robotic application

[62] Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12
[63] Engels, F., Wentland, A., & Pfotenhauer, S. M. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. Research Policy, 48(9), 103826. https://doi.org/10.1016/J.RESPOL.2019.103826

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EU and national level

- Encourage integration of social and ethical evaluation and stakeholder engagement in the testing procedures conducted by manufacturers, by providing guidelines and supporting the creation, maintenance and dissemination of tools on how to assess the responsibility of the robot
EU level

- Create a funding mechanism that would focus on creation, development and validation of replicable data generation methodologies to be included during experimentation[64]. These methodologies should be based on the scientific method, and the outcomes would inform the policy level and standards development of responsible robotics.
EU level

3.2.3 Support translating technology-neutral responsible robotics principles into actionable application-specific guidelines

The attention to integrating ELSA from the outset of the technology development is gaining more importance. For example, "Ethics by Design" approach is established in the discourse of consideration of the ethical principles in the technology development process, ensuring that the principles are addressed from the early stages of the research, such as specification of objectives, and followed through the development[65]. Practically, these considerations are implemented in the newest regulatory frameworks, such as GDPR, AI Act, AI Ethics Guidelines, and the Assessment List for Trustworthy AI.

However, this principle-based, technology-neutral approach to regulation and guidelines does not provide the necessary empirical grounding to guide technology developers' practices[66]. These principles must be articulated in concrete, actionable recommendations that allow consideration of specifics of robotics solutions and their context of use[67].

The development, maintenance and reiterative evolution of practical tools/checklists/methodologies are crucial to allow research and industry to approach the ethical, societal and legal requirements through clear, straightforward assessment procedures. Also, there should be advancements in the legislation mandating industries to undergo ethical assessments[68].

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[64] Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12

[65] European Commission. (2021). Ethics By Design and Ethics of Use Approaches for Artificial Intelligence. https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

[66] Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12

[67] Kapeller, A., Felzmann, H., Fosch-Villaronga, E., & Hughes, A. M. (2020). A Taxonomy of Ethical, Legal and Social Implications of Wearable Robots: An Expert Perspective. Science and Engineering Ethics, 26(6), 3229–3247. https://link.springer.com/article/10.1007/s11948-020-00268-4

[68] Andrea Bertolini, Nicoleta Cherciu, & Francesca Episcopo. (2021). INBOTS WP5. D2.1. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5dee9ee77&appId=PPGMS

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Measure:

- Fund projects, based on interdisciplinary collaboration between industry and ELS experts, creating frameworks and guidelines for operationalising responsible robotics principles in application domains, with an aim to incorporate these guidelines into standard
EU-level, in dialogue with ADRA

3.2.4 Establish and mainstream interdisciplinary collaboration

While the development of ethical guidelines and assessment tools in AI and robotics is necessary for the aim of standardising ethical evaluation, it is important to emphasise as well the limitations of these tools and approaches. Each ethical assessment is unique and based on research type, varying risks at different robotic solutions development stages, technical parameters, and socio-technical environments. Standard tools and formal evaluations should be coupled with tailored approaches and facilitated deliberation to ensure meaningful integration of ELSA into the robotics life-cycle.

In other words, formal guidelines or checklists have their limitations if practised as self-assessment by the roboticists. They are rather meant as a starting point for the reiterative ethical reflection in technology development[69]. **For an ethical and societal evaluation to have meaning and reiterative impact on the solution development, continuous, integrated, interdisciplinary collaboration must be ensured between technicians and SSH experts,** specialising in ELSA - ethicists, legal experts, sociologists, anthropologists, psychologists, cybersecurity, and communication experts.

Stemming from the essence of the moral inquiry, it is essential to emphasise that ethical deliberation becomes meaningful only in the dialogue and through reflection. Two-sided conversation between technicians and SSH experts allows the translation of formal guidelines into mature, meaningful discussions. The SSH expert can explain and situate the ethical concepts (such as autonomy) in a meaningful application.

Secondly, the technical specifics of the solution and the local and specific socio-technical environments of the application solution **create the need for original approaches to ethical and societal evaluation**. The ethical principles need to be translated into concrete situations where they face the situatedness of technology, impacted by human lifestyles, culturally embedded values and expectations[70]. Thus, to some extent, the tool and method can only serve with the competencies needed to adapt the tools and methods to specific environments. As emphasised in the HubIT project policy recommendations, the inclusion of SSH experts in technology development plays a crucial role in studying the impacts of technology on stakeholders and identifying the unwanted impacts[71]. The project REELER defines this role as “alignment experts”, who are intermediaries seeking to align robot makers' views and the affected stakeholders[72]. The earlier mentioned tools in the hands of the SSH experts become useful as starting

[69] Cawthorne, D., & Robbins-van Wynsberghe, A. (2020). An Ethical Framework for the Design, Development, Implementation, and Assessment of Drones Used in Public Healthcare. Science and Engineering Ethics, 26(5), 2867–2891. https://doi.org/10.1007/S11948-020-00233-1

[70] Umbrello, S., Bernstein, M. J., Vermaas, P. E., Resseguier, A., Gonzalez, G., Porcari, A., Grinbaum, A., & Adomaitis, L. (2023). From speculation to reality: Enhancing anticipatory ethics for emerging technologies (ATE) in practice. Technology in Society, 74, 102325. https://doi.org/10.1016/J.TECHSOC.2023.102325

[71] Olena Nedozhogina, & Hans Hõrak. (2021). D5.4 Policy recommendations. https://www.hubit-project.eu/public-results/21

[72] REELER. (n.d.). Responsible Robotics. Retrieved from https://responsiblerobotics.eu/

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points, a common platform for SSH experts and technicians to meet and go through the tool by engaging in meaningful, context-sensitive deliberation.

Integral participation of experts from the ethics/social/humanitarian field is necessary to ensure that the definition of requirements, design choices, risk mitigation, evaluation and implementation of responsible robotics principles are done responsibly and create impact.

Further, the deliberation of ethical issues between technicians and SSH experts should be embedded in the project design, allowing for the continuous feedback of these deliberations into the design, rather than engaging with ELSA only at the last development phase - validation and testing.

To establish the broader role of the SSH experts in the robotic solution design, development and deployment, policies should create incentives for value-oriented design, as opposed to only revenue orientation[73]

The need to promote interdisciplinary collaboration is prevalent on the various levels, alongside already existing EU efforts to include SSH experts in robotics calls:

- **In nationally-funded robotics projects.** Establishing the role of SSH experts in R&I projects, funded by national programmes and mechanisms, ensuring the clear criteria for the outcomes and eligibility of a wide array of actors
- **In academia.** Establishing funding and collaboration mechanisms between departments in research, as well as in teaching.
- **In industry.** Creating best practices of the process of interdisciplinary collaboration respecting the economic constraints of the robot producers, and integrating well in the company's production dynamics. The SSH experts could support the established roles of the data, privacy and compliance officers.

Measures:

- Strengthen the requirements in the EU-funded robotics research and development projects (i.e., Horizon Europe Cluster 4) to allocate the project position for the ethics/social/humanitarian experts with integral and reiterative participation in the robotics solution development
EU level

- Where applicable, ensure that national or regional robotics R&I funding calls are defining the role of ethics/social/humanitarian experts, ensuring that funding mechanisms and eligibility conditions include the representatives of these organisations (academia, NGOs, CSO, etc.) not limited to university or research institutions
National level

- Include SSH expert services (for robotic solution evaluation, etc.) into the commercial offering of TEF and (E)DIH to ensure that technologies being developed and tested by SSH experts
EU level

[73] ibid

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3.2.5 Include ethical and societal evaluation dimensions in the curricula of robotics/engineering education

To ensure human-centric technology development in the long run, it is crucial to educate the students in engineering on the importance of the ELSA and develop knowledge and skills to develop robotics responsibly. The SIENNA report supports the recommendation by emphasising that "higher education institutions and industry should invest in education and training for engineers and other technology actors to analyse, assess and address ethical issues, and to utilise specialised tools, such as research ethics assessment, Ethics by Design, technical standards, regulations, and Corporate Social Responsibility (CSR) policies."[74]

Good-practice examples are researchers/PhD students in robotics engineering incorporating the ethical dimension (value-sensitive design or approach on sustainable robots) in their engineering projects. For example, the project MARBLE by the TU Berlin[75], aiming to optimise energy consumption and avoid the carbon dioxide emission produced while emptying garbage bins by municipal waste management, included in-depth research on social and environmental sustainability. The project resulted in the development of the methodology for integrating sustainability in the design process of urban service robots[76].

However, integrating the ELS aspects in robotics research in academia is based on individual interest rather than on a strategic approach to enhancing collaboration. **Thus, educational approaches and practical collaboration opportunities between engineers and technology ethicists must be developed.**

Measures:

- Develop a coherent curriculum that includes mandatory classes and collaboratory projects on ethics of technology (or general integration of RRI approaches[77]) in engineering, IT, and other technology-focused degrees to integrate approaches of human-centred design from the first steps of the robotics-related education
  National level with a focus on higher education institutions

- Fund cross-disciplinary PhD and research projects that integrally encompass engineering (and software development) and ELSA research, in national programmes and EU Marie Curie-Sklodowska actions
  EU and National level with a focus on research and academia

3.2.6 Ensure the accessibility of support for roboticists, especially SMEs, in compliance and ethical and legal evaluation

The complex regulatory framework, including standards and regulations, poses a toll on

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[74] Ethics & human rights for new and emerging technologies: SIENNA project Policy Brief #4. (2021). https://doi.org/10.5281/ZENODO.4590094
[75] Mobile Autonomous RoBot for Litter Emptying (MARBLE). (n.d.). Retrieved from https://www.tu.berlin/en/mpm/research/projects/murmel
[76] van der Schoor, M. J., & Göhlich, D. (2023). Integrating sustainability in the design process of urban service robots. Frontiers in Robotics and AI, 10, 1250697. https://doi.org/10.3389/FROBT.2023.1250697
[77] Olena Nedozhogina, & Hans Hõrak. (2021). D5.4 Policy recommendations. https://www.hubit-project.eu/public-results/21

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small and medium-sized enterprises to navigate the landscape and ensure their solutions comply with the requirements[78]. Additionally, adherence to the responsible robotics principles and incorporating them from the concept and design stage requires resources and competencies. Thus, complex support measures are needed to ease the load or help navigate the requirements.

Responsible Robotics Compass

The Responsible Robotics Compass developed by Robotics4EU will help to assess and determine the maturity of non-technological aspects of a robot in development, regardless of its area of application. It focuses on Legal, Data, Socioeconomic, Human experience, and Sustainability markers, considering how the technology is developed, which internal and external processes are in place, how it interacts with its user, and other relevant risks and risk mitigation measures.

https://robocompass.robotics4eu.eu/

Measures:

- Establish standardised certification processes for AI robotics systems that incorporate both GDPR and AIA criteria to provide a clear path towards compliance.
  EU level in cooperation with the robotics industry

- Develop and continue to support easy-to-use online self-assessment tools that enhance the capacity for responsible robotics practices among robot developers, academics, and policymakers, and can adapt to evolving regulatory landscapes and industry norms. These tools can be employed by robotics developers, innovators, and academics to proactively self-validate their creations' compliance with EU regulations.
  EU level

- Strengthening the accessibility of consultations on ethics, legal and societal aspects of robotics through the (E)DIHs, TEFs, IP help desk and other robotics-industry targeted EU initiatives
  EU level

- Continue awareness-raising campaigns to inform SMEs on the availability of ELSA related support services, establishing ties with the industry associations

  EU-level in cooperation with the robotics industry

[78] Drukarch, H., Calleja, C., & Fosch-Villaronga, E. (2023). An iterative regulatory process for robot governance. Data & Policy, 5, e8. https://doi.org/10.1017/DAP.2023.3

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3.3 ENSURE ADHERENCE TO THE RESPONSIBLE ROBOTICS PRINCIPLES IN SAFETY, DATA, ETHICS AND SUSTAINABILITY

The Robotics4EU project, centring its efforts on exploring the perspectives on robots of citizens, end users, and the robotics community, aims to identify risks related to non-technical aspects of robotics, which need to be tackled to strengthen the trust of robotics in society. Some perceived risks of the development and use of robotics stem from complexities of safety, privacy, representation, liability and sustainability issues. Each of these categories consists of a range of risks, from safety concerns to issues surrounding data access and management, biases, the representation of marginalised groups, and sustainable governance of robotics. We propose a non-exhaustive list of recommendations for policymakers, targeting some of the most pressing challenges within these risk areas.

3.3.1 Ensure the updates on safety guidelines in light of new advancements in robotics

The discussion on the safety of robotics is one of the central issues when discussing the societal impact and acceptance of robotics. Automation in the workplace is generally known to contribute to the safety of the workers, with machines taking over Dull, Dirty and Dangerous work (3D)[79]. These “3Ds of work” for robotics signify undesirable work when performed by humans. Automating these tasks “has led to improved working conditions and is a natural evolution for workplace productivity and safety”[80], and it has become a significant driver for the wider adoption of robots.

The landscape of safety standards (ISO and IEC) and other domain-specific regulatory frameworks are elaborate and encompass various applications, from the well-established industrial to emerging personal care robots or autonomous vehicles. These standards and regulations assure the industry and citizens that the machines are in line with the safety requirements and can be trusted.

However, with the advancements in robotics (smarter, smaller, collaborative, softer), **continuous investments in the development of the safety standards and creating new approaches to new risks are crucial**, ensuring the standards encompass the diverse environments, industries and multi-purpose use cases of applications[81].

The approaches to safety are heavily application-domain and context-dependent. Particular safety standards do not apply from one application case to another. Thus, the specific measures for the recommendation application will be discussed further with examples of the manufacturing and healthcare domains.

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[79] Takayama, L., Ju, W., & Nass, C. (2008). Beyond dirty, dangerous and dull: What everyday people think robots should do. HRI 2008 - Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction: Living with Robots, 25–32. https://doi.org/10.1145/1349822.1349827
Ask, K., & Søraa, R. A. (2023). Digitalization and Social Change: A Guide in Critical Thinking. Digitalization and Social Change: A Guide in Critical Thinking, 1–304. https://www.taylorfrancis.com/books/mono/10.1201/9781003289555/digitalization-social-change-kristine-ask-roger-andre-s%C3%B8raa

[80] Fishel, J. A., Oliver, T., Eichermueller, M., Barbieri, G., Fowler, E., Hartikainen, T., Moss, L., & Walker, R. (2020). Tactile Telerobots for Dull, Dirty, Dangerous, and Inaccessible Tasks. Proceedings - IEEE International Conference on Robotics and Automation, 11305–11310. https://doi.org/10.1109/ICRA40945.2020.9196888

[81] Devitt, S. K., Horne, R., Assaad, Z., Broad, E., Kurniawati, H., Cardier, B., Scott, A., Lazar, S., Gould, M., Adamson, C., Karl, C., Schrever, F., Keay, S., Tranter, K., Shellshear, E., Hunter, D., Brady, M., & Putland, T. (2021). Trust and Safety. https://arxiv.org/abs/2104.06512v1

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Safety for collaborative robotics in manufacturing

A current trend in the field of industrial robotics is the use of cobots, or collaborative robots, which are able to interact with people and the environment and autonomous guided vehicles (AGVs). One advantage of this development is higher speed and flexibility of production while retaining the worker's expertise[82], [83].

Nevertheless, one disadvantage of this shift is the increased safety risks associated with robots' physical vicinity with workers and enhanced autonomous manoeuvre capabilities. This leads to **heightened collision risk** and regulations to increase collision control in the work environment, with several deaths caused by robot accidents or wrongful use reported[84]. Traditionally, workers' safety has been ensured by means of cages around production cells where robots operate; however, this solution requires a considerable amount of space, as well as training for employees on how to interact with robots In 2016, ISO issued safety requirements to create a safer environment for human-cobot interactions[85].

Nonetheless, **the lack of standards suitable for cobots** stands out as a significant impediment to the wider adoption of collaborative industrial robots, according to the 2020 MIT Report on the state of industrial robotics[86]. The existing safety standards mostly rely on limiting a robot's overall velocity and the force with which a robot may interact with a person. Yet, the report maintains that companies are reluctant to implement these technologies because speeds are affected by these safety standards. Hence, **reduced speed** stands out as a limitation to the wider adoption of cobots. It is also recorded that "traditional approaches, such as speed and payload limitations, are less applicable with new and emerging safety systems."[87] An example is smaller, payload-limited robotics arms which abide by safety standards that can nevertheless restrict the force they can apply. Improving the robot's design, rather than regulating its speed or strength, can also increase safety; for example, by equipping robots with sensors or sensor pads that can detect humans in their vicinities and avoid collision, such as Scaraflex pressure-sensitive safety skin[88].

From the safety perspective in collaborative robots, the above-mentioned recommendation on ensuring the relevance of the standards might encompass the following: **developing alternative safety approaches which do not rely on restrictions on the speed and force of the cobots**.

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[82] Halim, J., Eichler, P., Krusche, S., Bdiwi, M., & Ihlenfeldt, S. (2022). No-code robotic programming for agile production: A new markerless-approach for multimodal natural interaction in a human-robot collaboration context. Frontiers in Robotics and AI, 9, 1001955. https://doi.org/10.3389/frobt.2022.1001955

[83] Howard, J. (2019). Artificial intelligence: Implications for the future of work. American Journal of Industrial Medicine, 62(11), 917–926. https://doi.org/10.1002/AJIM.23037

[84] Søraa, R. A. (2019). Mecha-Media: How Are Androids, Cyborgs, and Robots Presented and Received Through the Media? Rapid Automation: Concepts, Methodologies, Tools, and Applications, 12–30. https://doi.org/10.4018/978-1-5225-8060-7.CH002

[85] International Organization for Standardization. ISO/TS 15066:2016. Robots and Robotic Devices—Collaborative Robots. https://www.iso.org/standard/62996.html.

[86] Julie Shah, Christopher Fourie, & Lindsay Sanneman. (2020). The State of Industrial Robotics: Emerging Technologies, Challenges, and Key Research Directions. https://www.therobotreport.com/wp-content/uploads/2021/01/2020-Research-Brief-Sanneman-Fourie-Shah.pdf

[87] Ibid.p. 13

[88] Scaraflex. (n.d.). Retrieved from https://www.scaraflex.com/?lang=en

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Measures:

- Ensure that safety-by-design is a mandatory approach in the EU-funded robotics research and development, aimed at integrating a balance between safety, speed and versatility, as well, as reflecting on the trade-offs between safety standards, economic liability, regulatory guidelines and user experiences.

- Ensure continuous collaboration between policymakers and communities of research and practice of industrial robots to identify safety challenges and barriers in current safety regulations, hindering the uptake of robotics and engage in collaborative discussions to explore solutions (i.e., workshops, working groups, etc.)

These measures necessitate EU-level engagement of the industry, the scientific community and policy-makers.

Safety for robotics in healthcare

Safety considerations hold paramount importance within the healthcare domain, where the well-being of vulnerable individuals is at stake. The introduction of robots into healthcare settings introduces an additional layer of complexity in ensuring the utmost safety. Unlike other environments, healthcare facilities cater to individuals with diverse health conditions, including those with limited mobility, mental illnesses, compromised immune systems, and belonging to various risk groups. Consequently, the safety standards for robots in healthcare are some of the highest of all industries with complex health context[89]. Healthcare settings, such as hospitals and home services, pose distinctive challenges for the integration of robots due to the stringent regulatory landscape. In these environments, robots are not solely interacting with healthy individuals but are also entrusted with the care and well-being of those who are medically fragile. This necessitates a meticulous approach to safety, characterised by adherence to rigorous safety standards. Some scholars argue for acceptance if "properly assessing the needs of the human user and then matching the robot's role, appearance and behaviour to these needs" are done"[90].

Within healthcare, numerous regulations and guidelines govern the use of technology and robotics. Robots are not necessarily easily adapted to current safety regulations in healthcare regulations. These encompass patient security laws, stringent healthcare data protection regulations, and institutional barriers that encompass a wide spectrum of considerations, from ethical concerns to the intricacies of care delivery processes, as well as multiple legal ramifications[91]. **To successfully implement robots in healthcare settings while upholding the highest standards of safety, it is imperative to navigate regulatory and institutional frames.** This involves not only meeting the legal requirements but also ensuring that the integration of robotics technology aligns with the ethical principles and values that underpin healthcare delivery.

[89] Fosch-Villaronga, E. (2019). Robots, healthcare, and the law: Regulating automation in personal care. Routledge. AND Kim, J., Gu, G. M., & Heo, P. (2016). Robotics for healthcare. Biomedical Engineering: Frontier Research and Converging Technologies, 489-509.
[90] Broadbent, E., Stafford, R., & MacDonald, B. (2009). Acceptance of healthcare robots for the older population: Review and future directions. International Journal of Social Robotics, 1(4), 319–330. https://link.springer.com/article/10.1007/s12369-009-0030-6
[91] Fosch-Villaronga, E. (2019). Robots, healthcare, and the law: Regulating automation in personal care. Routledge.

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Measures:

- Reinforce transparency principles by requiring the highest attainable level of traceability of data for robotics solutions to ensure backtracking (in line with the AI Act's recommendations).
EU-level in cooperation with the robotics industry

- Ensure that safety aspects are mapped in various possible ways through multistakeholder engagement activities in robotics design phases (see section 3.1.), focusing on lived experiences from healthcare workers, patient groups, and technology developers.
Robotics industry-level

3.3.2 Ensuring that machine operators and workers are properly informed about the reliability of human-robot collaboration systems.

There are several ways to raise awareness on the safety of technology, focusing e.g. on software, hardware, integration systems, testing and validation of the technology, or on end-user expertise, training and perceptions. Focusing on the physical safety of humans is important for boosting wider acceptance of human-robot collaboration systems, but also "soft safety" on how robots are *perceived* by their users is important.

For example, the physical collision risk can be significantly reduced to levels deemed 'acceptable', but the **lack of trust** among employees or workers could still serve as a barrier to adopting cobots in workplace settings[92]. Fletcher and Webb (2017) raise questions about the psychological impact of the possibility of 'safe' collisions with robots on employees. In this scenario, it is of utmost importance to properly inform machine operators and workers regarding the reliability of the human-robot collaboration systems. **The lack of comprehensive information on the possible repercussions of human-robot collaboration in the workplace could indeed be an obstacle to the wider adoption of robots in the workplace**.

The Sienna project policy brief similarly recommends "reinforcing requirements for manufacturers on instructions and warnings for users of AI and robotics products"[93] This measure has the additional advantage of addressing the soft safety aspects discussed above. **Workers and machine operators need to be informed about the level of real safety risks involved in working in collaboration with robots**. This will enhance technical safety measures to be duly implemented while at the same time preventing the propagation of safety perceptions that do not align with reality.

Measures:

- Encourage technology providers, integrating collaborative robots in the workplaces, to organise training for workers, focusing on current real-life safety risks, robots' capabilities and limitations, and guidelines for safe usage
Robotics industry-level

[92] S. R. Fletcher and P. Webb. "Industrial robot ethics: The challenges of closer human collaboration in future manufacturing systems." In M. I. A. Ferreira, J. S. Sequeira, M. O. Tokhi, E. E. Kadar and G. S. Virk (eds.) A world with robots, (pp. 159-171), International Conference on Robot Ethics: ICRE 2015

[93] Trilateral Research. (2020). Enhancing EU legal frameworks for AI & robotics: SIENNA project Policy Brief #1 (1.0). Zenodo. https://doi.org/10.5281/zenodo.4332661

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3.3.3 Promote Ethics by Design principles to ensure privacy and cybersecurity

Data privacy and security issues are crucial factors in shaping the societal acceptance of robots. Maintaining **data protection** emerges as an ongoing concern. The risk of information leaks, breaches, and the **safeguarding of personally identifiable information** all present substantial hurdles to the broader adoption of robotics. Existing data protection regulations, such as GDPR, extend their coverage to this domain.

While the GDPR primarily focuses on protecting individuals' privacy rights and the lawful processing of personal data, the AIA complements the GDPR by introducing regulations tailored to the unique aspects of AI, ensuring that personal identifiable information handled by AI systems receives specialised attention. This intersection is generally beneficial, as it provides a more comprehensive regulatory framework. However, potential challenges may arise in terms of clarity and consistency, necessitating robotics developers to become extremely aware of the implications of processing personal data in the context of robotics and the need for careful alignment to avoid confusion and ensure harmonious compliance. This is especially complex for researching robotic systems in public domains due to the different requirements and the large amount of personal identifiable information used.

The issue in robotics, data, and privacy lies beyond increasing users‘ control over data collected or ensuring transparency. It necessitates a shift in responsibility, strengthening the responsibility of robotics designers and developers to ensure users' privacy. Beyond compliance with the legal frameworks, the approach to privacy in robotics shall be tackled from the design stage. Following the Ethics By Design approach, privacy concerns shall be a part of the concept, design and development of robotics solutions.

The Ethics by Design approach concerning privacy aims to create robotics systems with built-in privacy measures and user-friendly interfaces. This ensures that **users, regardless of their expertise, can navigate the system without facing unnecessary complexities**, contributing to a more equitable and secure digital environment. This is in line with the Digital Europe initiative's focus on promoting ethical standards and ensuring a secure digital environment to advance a digital transformation that prioritises user trust, privacy, and security in the adoption of emerging technologies.

Data privacy concerns are closely intertwined with **cybersecurity** considerations, which in turn pose formidable challenges to the successful implementation of robotics solutions. Cyberattacks, such as malware, ransomware, and phishing attempts, can not only compromise data integrity but also disrupt manufacturing processes and compromise the safety of robotic systems[94]. Consequently, the integration of robust cybersecurity protocols and technologies is essential to mitigate these risks and ensure the reliable and secure operation of robotics in Industry 4.0. **This includes continuous monitoring, threat detection, and proactive response strategies to address emerging cyber threats effectively.**

[94] Yaacoub, J. P. A., Noura, H. N., Salman, O., & Chehab, A. (2021). Robotics cyber security: vulnerabilities, attacks, countermeasures, and recommendations. International Journal of Information Security 2021 21:1, 21(1), 115–158. https://doi.org/10.1007/S10207-021-00545-8

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Measures:

- Provide guidelines and educational resources for robot developers and implementors for data containment in the robots operating in private and public environments
  Robotics industry and research level

- Ensure that investments available for researching, enhancing and promoting cyber security are accessible for robotics-specific needs[95] (encryption, authorisation/authentication, physical security[96])
  EU level in cooperation with universities and research institutions

3.3.4 Establish evaluation and testing procedures to detect machine biases

A system that does not display intelligent behaviour and only acts in an automated, repeated manner is rarely a source of bias. Therefore, the issue of biases in robotics is mostly relevant to systems including AI capability. For example, an automated door-opening system that does not recognize people with darker skin tones or of a different body type/ability would cause discrimination. In addition to software biases, robotic systems are subject to “physical biases” - that is, design choices that can lead to discrimination. For example, the control and command may require a minimal force or height to operate, or be inaccessible to people with health limitations such as mobility, hearing or sight impairment. This is most critical if safety features rely on a biased perception of capacity (e.g emergency stop button requiring force or a human presence sensor calibrated at an average male height, not detecting females or smaller people. Overall, whether they are physical or software, biases are known to impact the trust that users place in the system[97].

Intelligent robotic systems may be perceived as “intelligent”, but they do not possess a moral compass and solely rely on subjective training with the data they have been provided[98]. The data used to train, test and evaluate learning-based systems is generated by human actors, some of whom may be familiar with the task - but due to the cost, most data is annotated by subcontractors without a particular competence in the area. For data describing aspects of human life, the collection of data is usually done in the same socio-economic area as the company developing the product, so usually, the data is collected in a developed country but often annotated in poorer countries, which leads to a new geopolitical landscape and challenges in data ownership and privacy[99]. Overall, data annotation practices pose new ethical questions[100] that need to be

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[95] ibid

[96] Botta, A., Rotbei, S., Zinno, S., & Ventre, G. (2023). Cyber security of robots: A comprehensive survey. Intelligent Systems with Applications, 18, 200237. https://doi.org/10.1016/J.ISWA.2023.200237

[97] Howard, A., & Borenstein, J. (2019). Trust and Bias in Robots. American Scientist, 107(2), 86. https://doi.org/10.1511/2019.107.2.86

[98] Tsamados, A., Aggarwal, N., Cowls, J., Morley, J., Roberts, H., Taddeo, M., & Floridi, L. (2021). The ethics of algorithms: key problems and solutions. AI & SOCIETY, 37(1), 215–230. https://doi.org/10.1007/S00146-021-01154-8

[99] Gomart, T., Nocetti, J., & Tonon, C. (2018). Europe: Subject or object in the Geopolitics of Data?https://www.capgemini.com/wp-content/uploads/2019/08/Europe_geopolitics_data_2018_IFRI-1.pdf

[100] Neha Panchal. (2023, April 14). Ethical Considerations in AI Data Annotation. https://www.damcogroup.com/blogs/understanding-ethical-considerations-in-ai-data-annotation

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addressed in the near future by additional studies and enforcement of existing regulations.

Additionally, for continuous machine learning systems, the behaviour will change[101] depending on the situations the system is exposed to in its lifetime, which poses particularly difficult ethical questions[102][103]. Robotic systems in particular, could easily implement continuous learning based on embedded sensors, so this issue requires particular attention.

Because of this, existing societal inequalities or unconscious biases in perception or interpretation (in particular, based on gender, ethnicity or culture) are reproduced in the datasets. AI solutions learn from these datasets and, therefore, perpetuate human discrimination and biases. This can be especially critical in spheres such as medical care, employment or banking. For example, wearable robots such as exoskeletons, while greatly improving life quality and enhancing equality, may have critical consequences[104]. if bias is not considered in the development and testing of the system. For robots where a close interaction with humans is expected, some design choices may make the system harder or impossible to use to people with different body types or capabilities. For example, a button may be inaccessible to users with smaller hands, or voice commands not understood if the person has an accent.

The biases based on personal characteristics such as gender, race and minority can be embedded in the data used to train, test and evaluate intelligent systems. This issue stems from the environment in which the data is collected, the way this data is sorted, annotated, and augmented for learning, the weights put on minority groups in testing, and the lack of hardcoded principles[105]. The design of the robotic system must be chosen taking into account inclusivity and validated by testing with explicitly constructed diverse groups of users. Consultation of diverse groups should start at early design stages, in order to keep the ability to change the implementation of physical interfaces.

To tackle discriminatory biases, evaluation designed to detect biases should be mandatory for AI systems whose operation may impact human equality. The training and testing of systems based on data should use datasets augmented for the inclusion of minority groups or a weighting that enhances the performance of the system for minorities. **Accountability for discrimination by robots against certain groups of people, which is either built into the design or a by-product of the robot's algorithms, should be guarded against by law and ethical standards.**

[101] Salem, M., Lakatos, G., Amirabdollahian, F., & Dautenhahn, K. (2015). Towards safe and trustworthy social robots: Ethical challenges and practical issues. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9388 LNCS, 584–593. https://doi.org/10.1007/978-3-319-25554-5_58

[102] Howard, A., & Borenstein, J. (2019). Trust and Bias in Robots. American Scientist, 107(2), 86. https://doi.org/10.1511/2019.107.2.86

[103] Kok, B. C., & Soh, H. (2020). Trust in Robots: Challenges and Opportunities. Current Robotics Reports 2020 1:4, 1(4), 297–309. https://doi.org/10.1007/S43154-020-00029-Y

[104] Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12

[105] von Braun, J., Archer, M. S., Reichberg, G. M., & Sorondo, M. S. (2021). AI, robotics, and humanity: Opportunities, risks, and implications for ethics and policy. Robotics, AI, and Humanity: Science, Ethics, and Policy, 1–13. https://doi.org/10.1007/978-3-030-54173-6_1

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The AI Act requires[106] that AI systems be designed in a way that allows natural persons to effectively monitor, control, and intervene in their operations. This is necessary in particular because supervision is the only reliable way to control the ethical functioning of an intelligent system. This principle should also be applied to intelligent robotic systems, in order to verify whether physical or software bias is present. However, it is necessary to stress the importance of specific training for supervisors - an untrained person may not be able to recognise bias or overly rely on AI once it has shown good performance on some topics. Over-reliance on AI or autonomous systems is a global issue, but particularly poignant when potential outcomes include discrimination or harm to protected categories.

Measures:

- Enforce the human-in-control principle for all automated systems via regulations, whether or not based on AI.
- Develop the guidelines for the training of robot operators and supervisors, tackling the risk of over-reliance and over-confidence in AI-based robotics systems
- Enhance the ongoing development of bias testing guidelines in the AI domain to encompass robotics, specifically addressing the nuances of real-time data acquisition

  These measures necessitate EU-level policy action

3.3.5 Develop liability frameworks for autonomous systems

The behavior of AI-based systems is often inscrutable due to their complex interconnectedness of parameters. Their decision-making processes are not governed by explicit rules but rather by the patterns they recognise within the training and testing data. As a result, it is challenging to pinpoint the exact reasons behind specific decisions, making it difficult to assign blame for negative outcomes. This opacity in decision-making, often referred to as a "black box" problem, poses significant risks beyond the underlying bias issues.

In the context of AI-based autonomous robots, this lack of transparency can translate into even greater consequences. If an autonomous robot were to engage in discriminatory behaviour, the physical manifestation of that decision would have a more tangible impact on individuals or groups. This heightened impact underscores the importance of addressing the interpretability challenges in AI-based systems to ensure accountability and responsible deployment.

To mitigate these risks, it is crucial to develop interpretable AI systems that can explain their decision-making processes. This transparency will not only facilitate accountability but also allow for a better understanding of the system's behaviour and potential biases. By making the "black box" more transparent, we can better safeguard against undesirable outcomes and promote a more responsible and accountable approach to AI-powered robotics.

[106] Key Issue 4: Human Oversight - EU AI Act. (n.d.). Retrieved from https://www.euaiact.com/key-issue/4

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European Union is already active in the development of a liability framework for robotic systems, as was advised in the Resolution on Civil Law Rules on Robotics in 2017[107] and as this is one of the EU's current legislative priorities[108]. In particular, a common EU approach[109] was proposed for connected and autonomous vehicles. However, the approach to regulation stays sector-specific, which may cause an issue in such a multidisciplinary and multi-sectorial area of development as robotics. Indeed, independently focusing the development of liability frameworks on autonomous driving systems, industrial robotics, home robotics, etc., creates dead spots in less active or less critical areas, which may cause later issues.

Measures:

- Form an EU-level working group, including industry experts in law and ethics, aiming to develop a common liability framework for robotic systems, focusing on the potential level of impact, for example, a risk-based approach adopted by AI Act
- Expand the EU liability rules for artificial intelligence, to cover robotics[110]
- Include safeguarding measures for operators in liability frameworks. In particular, the developer should bear some responsibility if the fault was caused by an excessively cumbersome or not digitally enforced operating procedure.

  These measures necessitate EU-level policy action in coordination with EU member states

3.3.6 Advocate for reusability and repairability in robotics manufacturing

The role of robotics in the efforts made towards sustainability is becoming more discussed and established. In many cases, robotics introduce opportunities to advance SDGs and, more specifically, reduce greenhouse gases. Most notably by: (1) replacing heavy machinery and inspection equipment with drones; (2) disaster relief robots specialised in search and rescue; and (3) precision farming. By enhancing operational efficiency, replacing heavy vehicles, and reducing greenhouse gas (GHG) emissions, robotic solutions promise to have a significant positive impact on the environment and align with SDGs. There are, however, also many aspects of robotics that still deserve care and attention. Robotics production is a resource-intensive process that often uses rare earth minerals as its basis - and without a considerable aftermarket, it eventually contributes towards electronic waste (e-waste).

The production of robotics requires a wide range of raw materials, including rare earth metals, specialised plastics and other critical components. The mass extraction of these materials can lead to scarcity, particularly when drawn from environmentally sensitive areas. The depletion of such resources not only poses economic challenges but can also

[107] Civil Law Rules on Robotics. (2017). https://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_EN.html
[108] Joint Declaration on the EU's legislative priorities for 2018-19. (n.d.). Retrieved from https://commission.europa.eu/system/files/2017-12/joint-declaration-eu-legislative-priorities-2018-19_en.pdf
[109] European Parliament. (2018, February 28). A common EU approach to liability rules and insurance for connected and autonomous vehicles. https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU(2018)615635
[110] Liability Rules for Artificial Intelligence. (n.d.). Retrieved from https://commission.europa.eu/business-economy-euro/doing-business-eu/contract-rules/digital-contracts/liability-rules-artificial-intelligence_en

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threaten the ecosystem and biodiversity (e.g. processing raw materials often requires destructive practices such as chemical-intensive refining, which can lead to water pollution and environmental degradation).

Further, the development of robotics systems often leads to the introduction of new models, and as a result, older robots are discarded and contribute to the increasing global problem of e-waste. Because these systems can contain hazardous materials, including heavy metals and other potentially toxic components, the improper disposal of robotics can significantly hurt the environment.

To address these concerns, it is vital to **promote responsible production and consumption as well as lifecycle management, including efficient recycling practices and a secondary marketplace.** Also, policy actions should encourage the opportunities to reuse and repair robots by defining the maintenance standards/solutions manufacturers.

Measures:

- Advance the current right-to-repair guidelines to include clearly defined roles and responsibilities of stakeholders within the repair ecosystem (manufacturer, seller, repairer, buyer) to ensure future alignment with the evolving landscape.
  EU-level
- Address the current lack of uniformity in component specifications and interfaces, emphasising interoperability and compatibility by facilitating an industry-led consortium, composed of leading manufacturers, researchers, and relevant regulatory bodies. The consortium would define and maintain standardised protocols for critical components in electronic and robotic systems.
  EU-level in cooperation with industry
- Encourage the development of guidelines and open-source documentation for repairing, refurbishing and reusing robotic systems
  EU-level in cooperation with industry
- Establish incentives or tax breaks for businesses investing in refurbishing or pre-owned robotic systems
  National level
- Include and promote robotics into existing support measures for circular economy objectives.
  EU and national level

3.3.7 Encourage the robotics industry to evaluate the environmental impact of their business

In the pursuit of developing cutting-edge robots, it is imperative to instil a heightened sense of environmental responsibility throughout the entire process, from conceptualisation to production. While robotics are rightfully considered a force for positive change, the integral aspect of sustainability is regrettably often overlooked[111].

[111] Haidegger, T., Mai, V., Mörch, C. M., Boesl, D. O., Jacobs, A., Rao R, B., Khamis, A., Lach, L., & Vanderborght, B. (2023). Robotics: Enabler and inhibitor of the Sustainable Development Goals. Sustainable Production and Consumption, 43, 422–434. https://doi.org/10.1016/J.SPC.2023.11.011

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To address this oversight, it is recommended that the European Commission promotes the impact assessment of robotics projects to include social and ecological factors in line with SDGs. This assessment should extend beyond the mere acknowledgement of robotics as a force for positive change and delve into the specific ecological implications of their production[112], considering aspects such cradle-to-cradle lifecycle, waste generation, and the re-use of materials. An in-depth scrutiny of the resources consumed during the manufacturing process is crucial. This scrutiny should not only encompass the quantification of GHG emissions and pollutants released but also include a thorough evaluation of waste generation indicators. Additionally, the European Union should consider funding projects that research the impact of robotics on the environment and collect best practices on how robots can be used to achieve the set-out sustainability goals.

Measures:

- Ensure that EU-funded project proposals incorporate environmental evaluation and life-cycle analysis in the expected impacts part in addition to the positive impact robotics have. This can include the energy and raw, rare and toxic materials needed to produce, deploy and use robots, and can feature aspects of the circular economy as mitigation steps, such as: using less, using longer (repair, warranty, component market), using again (secondary market place), and recycling.
  EU-level

- Develop regulations, standards, and directives that enforce energy-efficient practices in the robotics industry by putting forward specific calls for proposals focused on encouraging the development and implementation of low-energy-use robotics, providing a more structured and regulatory approach. Simultaneously, raise awareness and educate the robotics industry on the current best practices and standards for ensuring energy efficiency and sustainability of their products and processes, such as using renewable energy sources, reducing waste and emissions, and recycling materials
  EU-level in cooperation with industry and research

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[112] Giordano, G., Murali Babu, S. P., & Mazzolai, B. (2023). Soft robotics towards sustainable development goals and climate actions. Frontiers in Robotics and AI, 10, 1116005. https://doi.org/10.3389/FROBT.2023.1116005

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3.4 FORESEE AND MITIGATE THE SOCIO-ECONOMIC CHALLENGES

The macroeconomic benefits of automation are widely recognised – enhanced productivity and quality contribute to more affordable goods, making them accessible to a larger population. The rising demand creates opportunities for increased consumption and employment[113] which drives economic growth. Also, the widespread integration of robotics is expected to bring shifts in the employment landscape, including changes in the demand for certain skills and impacts on the welfare systems. While some jobs are displaced by industrial robots, new positions and service sectors are created that include jobs that are directly connected with (handling) the new technologies[114].

The impact of automation on the labour market depends on complex factors such as market structure, institutional norms, regulations and consumer preferences[115]. OECD report presents that around 14% of jobs might be automated in the next 10 to 20 years, with 32% being at risk of the changed nature/tasks of the positions. Future of Jobs Report 2020 compiled by the World Economic Forum, states that 43% of companies believe that automation will reduce the current workforce, while 29% think it would expand the workforce. The different evaluation reports hardly agree on foreseeing the loss/gain of workplaces due to automation. However, **even if the total number of jobs increases as new tasks and occupations are created, there are nevertheless occupations (i.e., assembly lines) where the risk of displacement is an important issue, which calls for proactive action.**

The **economic predictions of changes** in the labour market should be complemented by the **societal perception of labour market disruption. Namely, 60% of the 1232 respondents in the Robotics4EU needs analysis marked technological unemployment[116] as a primary barrier to adopting robots**. This fear of technological unemployment should be understood on a macro level. Automation first impacts the particular worker, who is exposed both to the benefits and to the tensions that come along with the transition to new ways or forms of working. On a personal level, impacts range from job displacement and the changed nature of work (different demand for skills, human interaction level, autonomy, etc.) to the sense of well-being at work, but it also affects the community as a whole through the local workers' quality of life.

The risk of any negative impacts on the people at the frontline needs to be mitigated beforehand, on the policy level. This **includes ensuring that the benefits brought by automation are fairly distributed to a variety of groups and that the economic growth reaches the citizens most closely affected by the transition.** Policies should focus on ensuring that the most vulnerable groups (low-skill and low-wage workers) are supported and able to experience the benefits of the technology first-hand. On the macro level, policies should enable the development of skills, ensure a fair share of benefits and manage the risks of the transition thoughtfully.

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[113] Mark Muro, Robert Maxim, & Jakob Whiton. (2019). How machines are affecting people and places.https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_Automation-AI_Report_Muro-Maxim-Whiton-FINAL-version.pdf
[114] Haapanala, H., Marx, I., & Parolin, Z. (2022). Robots and Unions: The Moderating Effect of Organised Labour on Technological Unemployment. https://docs.iza.org/dp15080.pdf
[115] Chapter 5. Ensuring good jobs for all. (2019). Going Digital: Shaping Policies, Improving Lives. https://doi.org/10.1787/9789264312012-EN
[116] Technological unemployment can be defined as "unemployment due to our ability to find ways to save the use of work be greater than the ability to find new uses for work" [23]. Keynes, J. Essays in Persuasion; Springer: Berlin/Heidelberg, Germany, 2016.

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The following recommendations, present the policy-related measures that could be strengthened in a fair transition to automated solutions on the local level, considering the impact of automation on a worker. The recommendations are focused on building a dialogue between industry stakeholders, including workers and policymakers, for foresight and mitigation. Further recommendations that would have broader and long-term impact include industry and education system alignment and the uptake of economic measures that would address risks associated with inequality.
Recommendations mainly revolve around national-level policies. Due to the scope of the report, the comparative analysis of the EU member states' social and education policy responses to robotics integration and automatisation is not conducted. Thus, the recommendations should be taken as emphasising the directions to be taken and strengthened in further robotics development.

3.4.1 Ensure dialogue between industry, worker representatives and policymakers

To ensure that as many possible scenarios and worries are being considered before workplace automation takes up its full speed, all related parties need to meet and discuss the matter: worker representatives, employers and policymakers. The trilateral dialogue is necessary to create a system for mitigating the possible negative effects that come along with automated tasks, collaborative workplaces and hybrid work forms with robots. With new kinds of co-employees and new work-related structures coming into play, **workers' rights, needs and responsibilities must be reviewed to ensure the positive change also benefits the regular employee**.

A well-functioning labour negotiation structure and the involvement of all three parties is necessary for all of the stakeholder representatives brought to the table – industry representatives who are responsible for diversifying product lines and job opportunities, workers' and local community representatives (unions) who stand for the interests of those whose lives will be most affected, and policy-making bodies that can address the regulatory mechanisms and social benefits that are needed to be put in place.

Active negotiation between industry, worker representatives and policymakers is, therefore, a basis for ensuring long-term societal acceptance of robotics that is supported by the positive experience and benefits of automation among all societal groups.

Measures:

- Further define workers' rights policies related to job displacement, work condition violations, and invasion of privacy, specifically caused by automation and robotics. These policies should receive proper auditing procedures and working condition assessments in collaboration with labour unions. The EU can play an important role in sharing best practices between member states and ensure compliance with regulations from other domains (GDPR, AIA, Machinery Directive)
  EU and national level

- Encourage the organisation of regular regional sector-specific conferences, bringing together representatives from employers, employees' unions, and relevant policymakers, aimed at discussing issues in specific sectors affected by automation and the introduction of robotics, deliberating future tendencies and action plans, informing the adaptation of labour laws, strategies and regulations at both the national and EU levels
  All levels

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3.4.2 Implement and promote industry-driven upskilling and reskilling schemes

The changing demand for skills needs to be addressed in order to make sure that people do not lose their jobs. The long-term alignment between industry needs and the technical expertise available can be aligned with proper training programmes. As shifts in tasks and the eliminating of some automated jobs pose a direct risk to individual workers, immediate responses are required to address the risk of unemployment. It is, however, essential to acknowledge that in certain areas, the goal might be to replace jobs that involve high risks, such as dangerous maintenance or inspection tasks, with automated solutions for the sake of worker safety. Balancing the need for job retention with the aim of eliminating risky roles should be a key consideration in shaping workforce strategies.

Both the analysis of the necessary training needs and the suitable mechanisms for reskilling or upskilling need to be put into place on the first possibility, before the fact, not to keep people waiting for solutions once their job or task list is delegated to robots. The necessary upskilling or re-skilling schemes prepared in response to this challenge should be facilitated by the industry and supported with partial compensation for the transition period. The decision as to which party should co-fund the programmes is to be discussed.

Measures:

- Adapt sector-specific and/or region-specific fiscal policies that would incentivise retraining of staff. For areas in which a consensus on what skills and knowledge to transfer in the reskilling programme, the European Commission is advised to develop blueprints for impactful training modules as done with "Digital Skills: New Professions, New Educational Methods, New jobs"[117]
  National and municipal level

- Align EU and national level policies in collaboration with industry and unions, adding reskilling activities into the employee's rights to benefits list.
  *EU and national le*vel

3.4.3 Promote technology, engineering and robotics education

As the demand for skilled professionals in robotics, including engineers, developers, integrators, maintainers, and operators, continues to escalate, the emphasis on practical technological and engineering skills becomes increasingly critical. To ensure that the demand for technical skills is met, technical education should be promoted and accessible at all levels of education and to all societal groups

Alongside awareness raising in order to increase the general understanding of the population of the robotics capabilities, limitations and risks (see Recommendation 3.1.1), the education for the skills relevant to the robotics shall be ingrained in from the early age school curriculum to the formal and informal life-long learning facilities. This recommendation assumes an understanding of how to teach robotics at different levels of education so that it sparks interest and positive experiences in people of all age groups.

On the level of professional and higher education, notably, a discrepancy exists between the appeal of technical and vocational education and training (TVET) programs and the

[117] European Commission, Directorate-General for Communications Networks, Content and Technology, (2019). Digital skills : new professions, new educational methods, new jobs: executive summary, Publications Office. https://data.europa.eu/doi/10.2759/036695

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specific needs of the robotics industry. Promoting an application-oriented education system becomes crucial to address this gap. Such an approach not only aids in bridging the current skills gap but also facilitates the upskilling of individuals with lower skill levels.

Measures:

- Encourage and sponsor the creation of robotics clubs and participation in robotics competitions in schools and pre-schools, local municipalities, public libraries, universities, and other educational or cultural institutions. These clubs and training materials could be created or sponsored by or together with regional industry leaders.
  National and municipality level in cooperation with industry associations

- Include robotics in general education topics as a part of ICT and digital methods integration in primary and secondary education curricula
  National level

- Facilitate more widely accessible and funded internships in the framework of different levels of education (high-school, TVET, university), to encourage practical learning opportunities
  Municipality and industry level

- Promote TVET technology and engineering education by providing incentives like scholarships and certification programs
  National and industry level

3.4.4 Evaluate and mitigate the risks of technological unemployment and inequality

Automation, bringing overall positive effects to the economy, poses specific risks to the social and economic structure of the society:

1) **Risk for social welfare systems.** With the current tax systems charging labour more than capital[118], the companies are directed towards prioritising automation. The potential reduction of the workforce and the increased toll on the social welfare systems might bring consequences to the European Social model[119] and national welfare systems[120].
2) **Capital concentration and reduced competition.** Lack of resources needed for the investment in automation on the SMEs side might significantly affect their ability for technology adoption and, consequently, competitiveness[121], leading to increased capital concentration and oligopolistic or monopolistic tendencies[122] on the side of established players.

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[118] Ionescu, L. (2019). Should governments tax companies' use of robots? Automated workers, technological unemployment, and wage inequality. Economics, Management, and Financial Markets, 14(2), 64–69. https://doi.org/10.22381/EMFM14220195
[119] EIT Digital. (n.d.). Digital Transformation of European Industry. Retrieved from https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/Digital-Transformation-of-European-Industry-Summary.pdf
[120] Lima, Y., Barbosa, C. E., dos Santos, H. S., & de Souza, J. M. (2021). Understanding technological unemployment: A review of causes, consequences, and solutions. Societies, 11(2). https://doi.org/10.3390/SOC11020050
[121] ibid
[122] EIT Digital. (n.d.). Digital Transformation of European Industry. Retrieved from https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/Digital-Transformation-of-European-Industry-Summary.pdf

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Thus, it is crucial to consider these potential risks of automation and consider the appropriate regulation and fiscal policies that combine a labour-friendly environment and innovation, leading to economic growth and social cohesion[123]. The proposals for the labour regulation policies span from providing social security and flexibility to serve as safety nets during transitions and safeguarding the rights and security of workers in new work arrangements to advocating for unconditional basic incomes and introducing taxation policies like a robot tax to address the balance of tax burdens between workers and machines or prioritise "humanised" production[124].

Also, the focus should remain on SMEs, supporting them in the uptake of robotics, thus ensuring and promoting the diverse adoption of the technology and diversified benefits of the transformation.

The strategies for achieving this goal spread across the different policy intervention domains, including InvestEU, Horizon Europe, Digital Europe, and related social welfare and cohesion programmes[125]. The in-depth analysis of the solutions and strategies, with the well-established collaboration between the policy sides representing technology innovation and social cohesion, should be further encouraged and aimed for. Since the effects of automation on unemployment and inequality are quite ambiguous, **it is crucial to evaluate and analyse the impact of the automation sector by sector, region by region per member state to inform policy decisions.**

Measures:

- Initiate regular studies on the potential labour market impacts of emerging robotics technologies that are expected to enter the European market in the next three years to inform EU and national-level policy directions *EU level*

- Support ongoing studies that examine the potential impact of automation on wealth distribution (EU-level and regionally) and explores the role of fiscal policies to mitigate the possible effects of rising inequalities. *EU and national level*

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[123] Ibid

[124] Kim, Tae Wan & Scheller-Wolf, Alan (2019). Technological Unemployment, Meaning in Life, Purpose of Business, and the Future of Stakeholders. Journal of Business Ethics 160 (2):319-337.

[125] EIT Digital. (n.d.). Digital Transformation of European Industry. Retrieved from https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/Digital-Transformation-of-European-Industry-Summary.pdf

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4 Conclusions

This study, conducted as part of the Robotics4EU project, has delivered a set of policy recommendations informed by a thorough desk research, survey, and expert consultations with robotics research and industry representatives, experts in technology ethics, law, policy, and social sciences. These recommendations, summarised in the main conclusions below, can serve as a valuable guide for responsible robotics development and adoption policy decisions.

As the overarching approach, a comprehensive multi-stakeholder engagement, encompassing citizens, users, and stakeholders such as labour representatives, is required across the entire robotics value chain, from design to deployment and utilisation, to ensure that AI-based robotics are responsible.

A significant part of the recommendations for responsible robotics are targeted at **EU-level policymakers** and could be summarised in the following advocacy messages:

- Recognise the fundamental differences between robotics and AI systems, particularly in areas such as safety, privacy, cyber-security, and sustainability, underscoring the need for a comprehensive and distinct approach to address the unique of physically embedded intelligent systems into robotics solutions
- Develop a coherent regulation on robotics that harmonises various regulatory directions (AI Act, Machine Directive, etc.) and policy instruments and provides a clear framework for the development, use, and operation of robots
- Enhance the development of guidelines that interpret regulations and principles for robotics application sectors

Integrating responsible robotics approaches into the life-cycle of robotics depends on **policy support and cooperation with industry**. The main recommendations for the roboticists are:

- Advance responsible robotics development focusing on democratic engagement and multi-stakeholder representation, including citizens, end-users, labour unions, and representatives of affected groups.
- Ensure that in the normative essence of the robotics design and development process, experts in ethics, law and social sciences support roboticists to ensure the adherence of their solution to responsible robotics principles

This approach should involve a diverse range of stakeholders - from citizens and end-users to experts in ethics, law, and social sciences, to ensure that robots are designed and used in a way that is consistent with the values and needs of society. The EU and national policy instruments, such as regulations or funding requirements, should encourage or require engagement.

The role of **university and research institutions** is to ensure that robotics-related education and research integrally incorporate ethical, legal and social dimensions, from post-secondary education to cross-disciplinary PhD and research projects.

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The **national-level policy frameworks** are crucial in creating a supporting scene for responsible robotics development, including:

- Fostering technology and engineering education with a focus on responsible robotics
- Ensuring the evaluation of the consequences of automation and robotics adoption on the social and economic fabric of local communities, mitigating the potential risks of rising inequalities

To further advance these recommendations for promoting responsible robotics in Europe, policymakers should engage in ongoing discussions with the robotics community through established frameworks like ADRA, ensuring the participation of diverse stakeholders, including experts from ethical, legal, and social domains.

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5 References

AI Armageddon and the Three Laws of Robotics. https://www.cs.memphis.edu/~tmccauly/ai_armageddon-McCauley.pdf

Andrea Bertolini, Nicoleta Cherciu, & Francesca Episcopo. (2021). INBOTS WP5. D2.1. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5dee9ee77&appId=PPGMS

Ask, K., & Søraa, R. A. (2023). Digitalization and Social Change: A Guide in Critical Thinking. Digitalization and Social Change: A Guide in Critical Thinking, 1–304. https://www.taylorfrancis.com/books/mono/10.1201/9781003289555/digitalization-social-change-kristine-askroger-andre-s%C3%B8raa

Botta, A., Rotbei, S., Zinno, S., & Ventre, G. (2023). Cyber security of robots: A comprehensive survey. Intelligent Systems with Applications, 18, 200237. https://doi.org/10.1016/J.ISWA.2023.200237

Brey, P. (2023). How is responsible robotics different from responsible AI? https://adrforum.eu/sites/default/files/202312/How%20is%20responsible%20robotics%20different%20from%20responsible%20AI.pdf

Broadbent, E., Stafford, R., & MacDonald, B. (2009). Acceptance of healthcare robots for the older population: Review and future directions. International Journal of Social Robotics, 1(4), 319–330. https://link.springer.com/article/10.1007/s12369-009-0030-6

Calleja, C., Drukarch, H., & Fosch-Villaronga, E. (2022). Harnessing robot experimentation to optimize the regulatory framing of emerging robot technologies. Data & Policy, 4(9566), e20. https://doi.org/10.1017/DAP.2022.12

Cawthorne, D., & Robbins-van Wynsberghe, A. (2020). An Ethical Framework for the Design, Development, Implementation, and Assessment of Drones Used in Public Healthcare. Science and Engineering Ethics, 26(5), 2867–2891. https://doi.org/10.1007/S11948-020-00233-1

Chapter 5. Ensuring good jobs for all. (2019). Going Digital: Shaping Policies, Improving Lives. https://doi.org/10.1787/9789264312012-EN

Civil Law Rules on Robotics. (2017). https://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_EN.html

Competitions - Robotex International. (n.d.). Retrieved from https://robotex.international/roboticscompetitions/

Consultations | Shaping Europe's digital future. (n.d.). Retrieved from https://digital-strategy.ec.europa.eu/en/consultations

Devitt, S. K., Horne, R., Assaad, Z., Broad, E., Kurniawati, H., Cardier, B., Scott, A., Lazar, S., Gould, M., Adamson, C., Karl, C., Schrever, F., Keay, S., Tranter, K., Shellshear, E., Hunter, D., Brady, M., & Putland, T. (2021). Trust and Safety. https://arxiv.org/abs/2104.06512v1

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Directorate-General for Research and Innovation. (2023, April). The results of the public consultation on the future of EU Research and Innovation programmes are now public. https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/results-public-consultation-future-eu-research-and-innovation-programmes-are-now-public-2023-04-19_en

Drukarch, H., Calleja, C., & Fosch-Villaronga, E. (2023). An iterative regulatory process for robot governance. Data & Policy, 5, e8. https://doi.org/10.1017/DAP.2023.3

EIT Digital. (n.d.). Digital Transformation of European Industry. Retrieved from https://www.eitdigital.eu/fileadmin/2022/ecosystem/makers-shapers/reports/Digital-Transformation-of-European-Industry-Summary.pdf

Engels, F., Wentland, A., & Pfotenhauer, S. M. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. Research Policy, 48(9), 10. https://doi.org/10.1016/J.RESPOL.2019.103826

Ethics & human rights for new and emerging technologies: SIENNA project Policy Brief #4. (2021). https://doi.org/10.5281/ZENODO.4590094

EU Grants: HE Programme Guide. (2023). https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/programme-guide_horizon_en.pdf

European Citizens’ Panels: https://citizens.ec.europa.eu/index_en

European Commission, Directorate-General for Communications Networks, Content and Technology, (2019). Digital skills: new professions, new educational methods, new jobs: executive summary, Publications Office. https://data.europa.eu/doi/10.2759/036695

European Commission. (2021). Ethics By Design and Ethics of Use Approaches for Artificial Intelligence. https://ec.europa.eu/digital-single-market/en/news/ethics-guidelines-trustworthy-ai

European Commisson. (n.d.). Your Voice, Our Future | Futurium. Retrieved from https://futurium.ec.europa.eu/en/about-futurium

European Parliament. (2018, February 28). A common EU approach to liability rules and insurance for connected and autonomous vehicles. https://www.europarl.europa.eu/thinktank/en/document/EPRS_STU(2018)615635

Fishel, J. A., Oliver, T., Eichermueller, M., Barbieri, G., Fowler, E., Hartikainen, T., Moss, L., & Walker, R. (2020). Tactile Telerobots for Dull, Dirty, Dangerous, and Inaccessible Tasks. Proceedings - IEEE International Conference on Robotics and Automation, 11305–11310. https://doi.org/10.1109/ICRA40945.2020.9196888

Fosch-Villaronga, E. (2019). Robots, healthcare, and the law: Regulating automation in personal care. Routledge.

Giordano, G., Murali Babu, S. P., & Mazzolai, B. (2023). Soft robotics towards sustainable development goals and climate actions. Frontiers in Robotics and AI, 10, 1116005. https://doi.org/10.3389/FROBT.2023.1116005

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Gomart, T., Nocetti, J., & Tonon, C. (2018). Europe: Subject or object in the Geopolitics of Data? https://www.capgemini.com/wp-content/uploads/2019/08/Europe_geopolitics_data_2018_IFRI-1.pdf

Haapanala, H., Marx, I., & Parolin, Z. (2022). Robots and Unions: The Moderating Effect of Organised Labour on Technological Unemployment. https://docs.iza.org/dp15080.pdf

Haidegger, T., Mai, V., Mörch, C. M., Boesl, D. O., Jacobs, A., Rao R, B., Khamis, A., Lach, L., & Vanderborght, B. (2023). Robotics: Enabler and inhibitor of the Sustainable Development Goals. Sustainable Production and Consumption, 43, 422–434. https://doi.org/10.1016/J.SPC.2023.11.011

Halim, J., Eichler, P., Krusche, S., Bdiwi, M., & Ihlenfeldt, S. (2022). No-code robotic programming for agile production: A new markerless-approach for multimodal natural interaction in a human-robot collaboration context. Frontiers in Robotics and AI, 9, 1001955. https://doi.org/10.3389/frobt.2022.1001955

Hengstler, M., Enkel, E., & Duelli, S. (2016). Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices. Technological Forecasting and Social Change, 105, 105-120. Summary can be found free here: https://hbr.org/2017/04/to-get-consumers-to-trust-ai-show-them-its-benefits

Howard, A., & Borenstein, J. (2019). Trust and Bias in Robots. American Scientist, 107(2), 86. https://doi.org/10.1511/2019.107.2.86

Howard, J. (2019). Artificial intelligence: Implications for the future of work. American Journal of Industrial Medicine, 62(11), 917–926. https://doi.org/10.1002/AJIM.23037

International Organization for Standardization. ISO/TS 15066:2016. Robots and Robotic Devices—Collaborative Robots. https://www.iso.org/standard/62996.html.

Ionescu, L. (2019). Should governments tax companies' use of robots? Automated workers, technological unemployment, and wage inequality. Economics, Management, and Financial Markets, 14(2), 64–69. https://doi.org/10.22381/EMFM14220195

ISO 8373:2021(en), Robotics — Vocabulary. (n.d.). Retrieved from https://www.iso.org/obp/ui/#iso:std:iso:8373:ed-3:v1:en

Joint Declaration on the EU's legislative priorities for 2018-19. (n.d.). Retrieved from https://commission.europa.eu/system/files/2017-12/joint-declaration-eu-legislative-priorities-2018-19_en.pdf

Julie Shah, Christopher Fourie, & Lindsay Sanneman. (2020). The State of Industrial Robotics: Emerging Technologies, Challenges, and Key Research Directions.https://www.therobotreport.com/wp-content/uploads/2021/01/2020-Research-Brief-Sanneman-Fourie-Shah.pd

Kapeller, A., Felzmann, H., Fosch-Villaronga, E., & Hughes, A. M. (2020). A Taxonomy of Ethical, Legal and Social Implications of Wearable Robots: An Expert Perspective. Science and Engineering Ethics, 26(6), 3229–3247.

Key Issue 4: Human Oversight - EU AI Act. (n.d.). Retrieved from https://www.euaiact.com/key-issue/4

Key Takeaways. (n.d.). Retrieved from https://adrforum.eu/key-takeaways

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Kim, J., Gu, G. M., & Heo, P. (2016). Robotics for healthcare. Biomedical Engineering: Frontier Research and Converging Technologies, 489-509.

Kim, Tae Wan & Scheller-Wolf, Alan (2019). Technological Unemployment, Meaning in Life, Purpose of Business, and the Future of Stakeholders. Journal of Business Ethics 160 (2):319-337.

Kok, B. C., & Soh, H. (2020). Trust in Robots: Challenges and Opportunities. Current Robotics Reports 2020 1:4, 1(4), 297–309. https://doi.org/10.1007/S43154-020-00029-Y

Konrad Siemaszko. (2020). D5.6: Recommendations for the enhancement of the existing legal frameworks for genomics, human enhancement, and AI and robotics.70. https://www.sienna-project.eu/digitalAssets/894/c_894270-l_1-k_sienna_d5.6_recommendations-for-the-enhancement-of-the-existing-legal-frameworks-for-genomics--human-enhancement--and-ai-and-robotics_www.pdf

LAIDEN. (n.d.). ERC StG Safe & Sound Towards Evidence-based Policies for Safe and Sound Robots. Retrieved from https://www.laiden.org/projects/erc-stg-safe-sound

Liability Rules for Artificial Intelligence. (n.d.). Retrieved from https://commission.europa.eu/business-economy-euro/doing-business-eu/contract-rules/digital-contracts/liability-rules-artificial-intelligence_en

Lima, Y., Barbosa, C. E., dos Santos, H. S., & de Souza, J. M. (2021). Understanding technological unemployment: A review of causes, consequences, and solutions. Societies, 11(2). https://doi.org/10.3390/SOC11020050

Mark Muro, Robert Maxim, & Jakob Whiton. (2019). How machines are affecting people and places. https://www.brookings.edu/wp-content/uploads/2019/01/2019.01_BrookingsMetro_AutomationAI_Report_Muro-Maxim-Whiton-FINAL-version.pdf

Mobile Autonomous RoBot for Litter Emptying (MARBLE). (n.d.). Retrieved from https://www.tu.berlin/en/mpm/research/projects/murmel

INDUSTRIAL LEADERSHIP - Leadership in enabling and industrial technologies - Information and Communication Technologies (ICT). (2014). https://cordis.europa.eu/programme/id/H2020-EU.2.1.1./en

Neha Panchal. (2023, April 14). Ethical Considerations in AI Data Annotation. https://www.damcogroup.com/blogs/understanding-ethical-considerations-in-ai-data-annotation

New European Bauhaus: beautiful, sustainable, together. - European Union. (n.d.). Retrieved from https://new-european-bauhaus.europa.eu/index_en

Olena Nedozhogina, & Hans Hõrak. (2021). D5.4 Policy recommendations. https://www.hubit-project.eu/public-results/21

Policy recommendations from Responsible Ethical Learning in Robotics (REELER). (n.d.). Retrieved from https://responsiblerobotics.eu/wp-content/uploads/2019/12/PolicyRecommandations_for-reading-online.pdf

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Promoting Responsible Robotics- Recommendations for Policy Makers. (n.d.). Retrieved from https://www.robotics4eu.eu/wp-content/uploads/2023/10/BookletPolicyRecomendations_Robotics4eu_SG_20231025.pdf

Promoting Responsible Robotics- Recommendations for Policy Makers. (n.d.). Retrieved from https://www.robotics4eu.eu/wp-content/uploads/2023/10/Preview_BookletPolicyRecomendations_Robotics4eu_SG_20231107.pdf

REELER. (n.d.). Responsible Robotics. Retrieved from https://responsiblerobotics.eu/

Responsible Research & Innovation. (n.d.). Retrieved from https://www.era-learn.eu/support-for-partnerships/governance-administration-legal-base/responsible-research-innovation

Robertson, T. and Simonsen, J. (2013): Participatory Design – Introduction. I Routledge International Handbook of Participatory Design, ed. Simonsen, J. page 1.

RoboCup Federation official website. (n.d.). Retrieved from https://www.robocup.org/

Robotics4EU. (2021, May 31). Robotics community, citizens and policy makers needs analyses. https://www.robotics4eu.eu/publications/deliverable-1-2-robotics-community-citizens-and-policy-makers-needs-analyses/

Robotics4EU. Knowledge transfer and capacity building in inspection and maintenance of infrastructure - Robotics4EU. https://www.robotics4eu.eu/publications/knowledge-transfer-and-capacity-building-in-inspection-and-maintenance-of-infrastructure/

Robotics4EU. (2023, June 26). Enhancing responsible robotics development and societal acceptance: what should policy priorities focus on? https://www.robotics4eu.eu/news-articles/enhancing-responsible-robotics-development-and-societal-acceptance-what-should-policy-priorities-focus-on/

Robotics4EU. (2023, November 16). Insights from the Robotics4EU Workshop: Shaping Responsible Robotics in Europe through Policy and Industry Collaboration. https://www.robotics4eu.eu/news-articles/insights-from-the-robotics4eu-workshop-shaping-responsible-robotics-in-europe-through-policy-and-industry-collaboration/

Robotics4EU. GlobalSay on Robotics: Citizen Consultations on Wishes and Concerns. (2022, April 28). https://www.robotics4eu.eu/publications/globalsay-on-robotics-citizen-consultations-on-wishes-and-concerns/

Rome Declaration on Responsible Research and Innovation in Europe . (2014). https://digital-strategy.ec.europa.eu/en/library/rome-declaration-responsible-research-and-innovation-europe

S. R. Fletcher and P. Webb. "Industrial robot ethics: The challenges of closer human collaboration in future manufacturing systems." In M. I. A. Ferreira, J. S. Sequeira, M. O. Tokhi, E. E. Kadar and G. S. Virk (eds.) A world with robots, (pp. 159-171), International Conference on Robot Ethics: ICRE 2015

Salem, M., Lakatos, G., Amirabdollahian, F., & Dautenhahn, K. (2015). Towards safe and trustworthy social robots: Ethical challenges and practical issues. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Lecture Notes in Bioinformatics), 9388 LNCS, 584–593. https://doi.org/10.1007/978-3-319-25554-5_58

Scaraflex. (n.d.). Retrieved from https://www.scaraflex.com/?lang=en

Søraa, R. A. (2019). Mecha-Media: How Are Androids, Cyborgs, and Robots Presented and Received Through the Media? Rapid Automation: Concepts, Methodologies, Tools, and Applications, 12–30. https://doi.org/10.4018/978-1-5225-8060-7.CH002

Stiegler, B. (2013). What makes life worth living: on pharmacology. Cambridge, UK: Polity

Strand, R. (n.d.). Responsible Research and Innovation" as an Emerging Principle in European Research and Innovation Policy. Retrieved from https://www.uib.no/sites/w3.uib.no/files/attachments/strand_rri_lecture.pdf

Surveys.(n.d.). Retrieved from https://europa.eu/eurobarometer/surveys/browse/all/series/3971

Takayama, L., Ju, W., & Nass, C. (2008). Beyond dirty, dangerous and dull: What everyday people think robots should do. HRI 2008 - Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction: Living with Robots, 25–32. https://doi.org/10.1145/1349822.1349827

The 2023 Topic Group Summit. (2023). https://events.eu-robotics.net/event/the-2023-topic-group-summit/

Thiebes, S., Lins, S. & Sunyaev, A. Trustworthy artificial intelligence. Electron Markets 31, 447–464 (2021). https://doi.org/10.1007/s12525-020-00441-4

Trilateral Research. (2020). Enhancing EU legal frameworks for AI & robotics: SIENNA project Policy Brief #1 (1.0). Zenodo. https://doi.org/10.5281/zenodo.4332661

Tsamados, A., Aggarwal, N., Cowls, J., Morley, J., Roberts, H., Taddeo, M., & Floridi, L. (2021). The ethics of algorithms: key problems and solutions. AI & SOCIETY, 37(1), 215–230. https://doi.org/10.1007/S00146-021-01154-8

Umbrello, S., Bernstein, M. J., Vermaas, P. E., Resseguier, A., Gonzalez, G., Porcari, A., Grinbaum, A., & Adomaitis, L. (2023). From speculation to reality: Enhancing anticipatory ethics for emerging technologies (ATE) in practice. Technology in Society, 74, 102325. https://doi.org/10.1016/J.TECHSOC.2023.102325

van der Schoor, M. J., & Göhlich, D. (2023). Integrating sustainability in the design process of urban service robots. Frontiers in Robotics and AI, 10, 1250697. https://doi.org/10.3389/FROBT.2023.1250697

von Braun, J., Archer, M. S., Reichberg, G. M., & Sorondo, M. S. (2021). AI, robotics, and humanity: Opportunities, risks, and implications for ethics and policy. Robotics, AI, and Humanity: Science, Ethics, and Policy, 1–13. https://doi.org/10.1007/978-3-030-54173-6_1

Wise, E., & Hoegenhaven, C. (2008). User-Driven Innovation - Context and Cases in the Nordic Region. (Innovation Policy). Nordic Innovation Centre. http://www.nordicinnovation.net/prosjekt.cfm?id=1-4415-246

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

Yaacoub, J. P. A., Noura, H. N., Salman, O., & Chehab, A. (2021). Robotics cyber security: vulnerabilities, attacks, countermeasures, and recommendations. International Journal of Information Security 2021 21:1, 21(1), 115–158. https://doi.org/10.1007/S10207-021-00545-8

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101017283

6 Annexes

Annex 1. Responsible Robotics Policy Lab

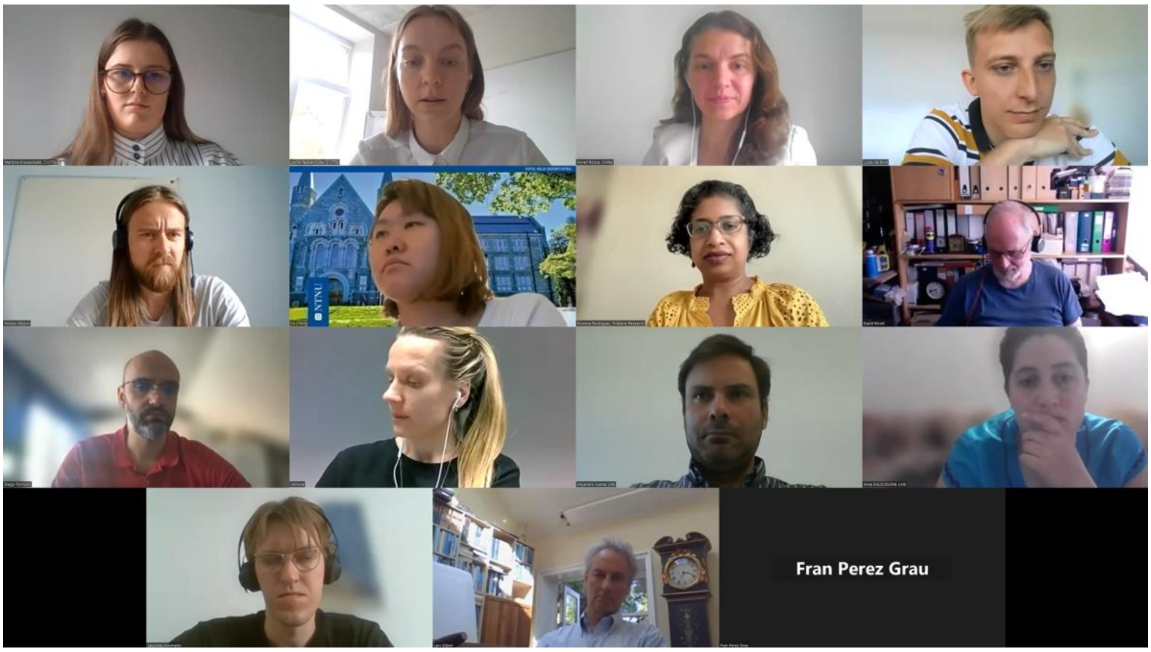

Figure 1 Screenshot of the Responsible Robotics Lab participants

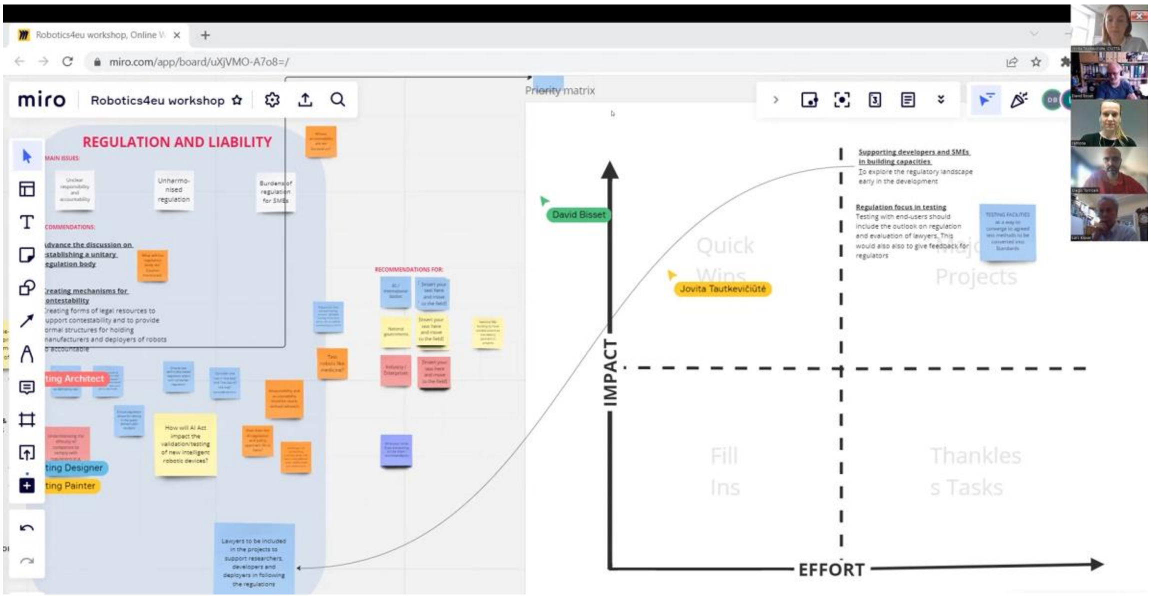

Figure 2 Screenshot of the Zoom session with participants working in the MIRO platform

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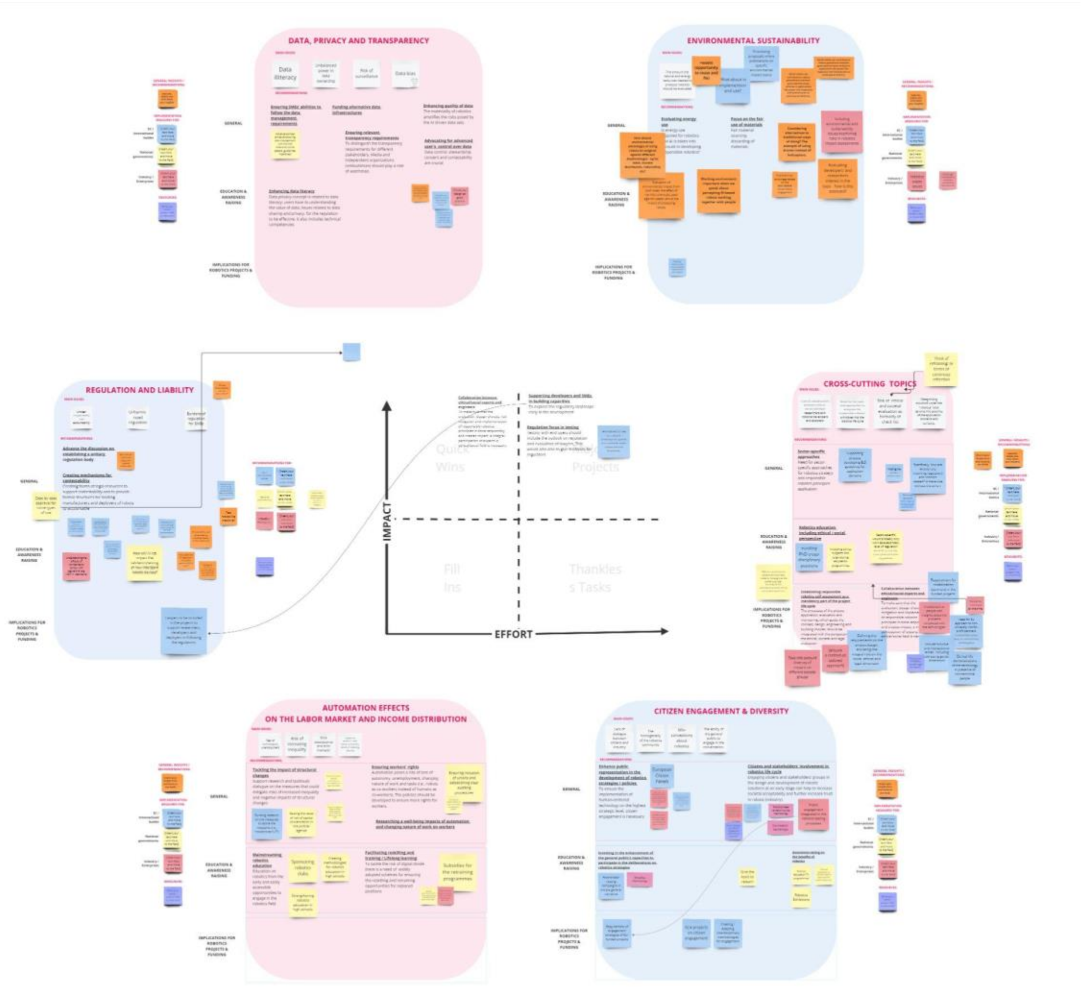

Figure 3 Screenshot of the MIRO board with the inputs from the participants

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Annex 2. euRobotics Topic Group Summit

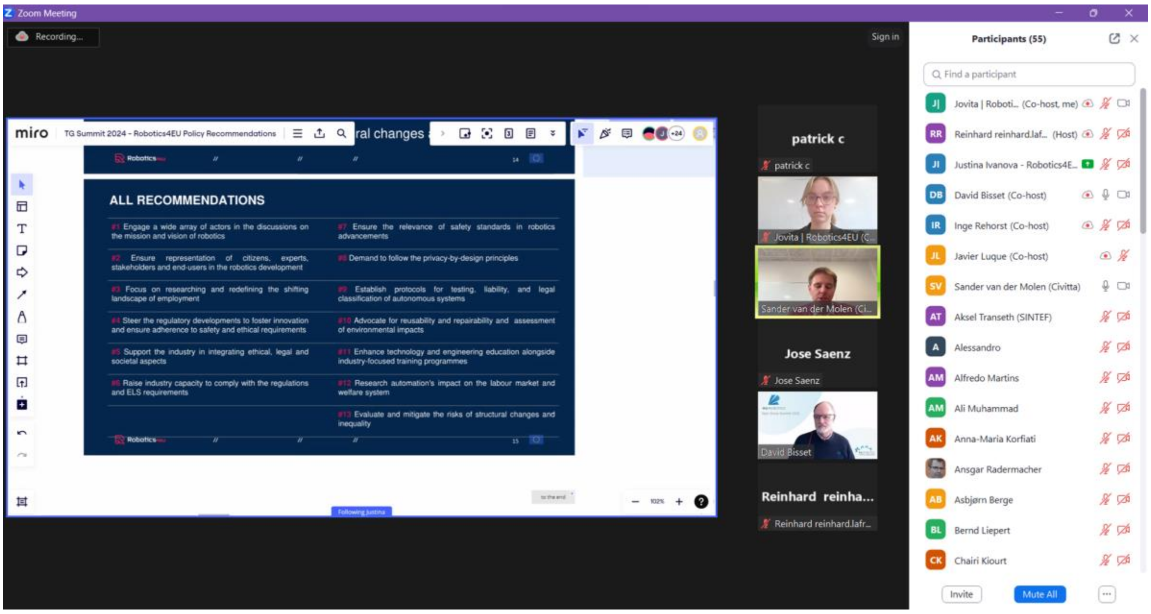

Figure 4 Screenshot form the Zoom Workshop in euRobotics Topic Group Summit

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Figure 5 Screenshot of the euRobotics Topic Group Summit participants MIRO board contributions

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Annex 3. Promoting Responsible Robotics – Recommendations for Policy Makers. Survey questions

Promoting Responsible Robotics: Recommendations for Policy Makers

What should be the priorities of policies aimed at enhancing responsible robotics development and societal acceptance of robotics?

We invite you to share your insights on how the development of responsible robotics could be supported and what could be done by EU- and national-level policy actions!

Please complete the survey by **December 4, 2023**

The survey is conducted by the EU-funded project Robotics4EU (Grant Agreement Number: 101017283), aimed at applying responsible robotics principles amongst the EU robotics community and envisaging the societal acceptance of robotics solutions. The survey responses will be used to develop the Responsible Robotics Advocacy Report. The report aims to provide recommendations for the EU and national-level policymakers on enhancing the adoption of responsible robotics.

We will use your anonymized responses in a report we are writing. Approval from the respondent will be sought if any direct quotations are to be used.

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Please indicate the organisation you represent *

Your answer

Please indicate your affiliation to robotics field: *

- ◯ Researcher in Robotics
- ◯ Robotics Engineer / Developer
- ◯ Robotics Deployer / Integrator
- ◯ Robotics Operator
- ◯ Robotics End-user
- ◯ General Public
- ◯ Social/humanitarian sciences expert
- ◯ Policy maker / government representative
- ◯ Legal expert
- ◯ Representative of NGO (incl. labour/trade unions)
- ◯ Other: ______

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Industry practices in responsible robotics

Responsible robotics *refers to the field of robotics that takes into account societal values and expectations, encompassing ethical, legal, and socio-economic considerations.*

How do you engage end-users and stakeholders in improving responsible robotics technologies in your field?

Your answer

Are there regulations or standards your expertise area supports or contributes to for promoting responsible robotics?

Your answer

Gaps and recommendations

What do you think are the most important ethical/societal/legal issues in the robotics?

Your answer

What is the key action the European Commission or national policymakers can take to support responsible robotics development and adoption?

Responsible robotics *refers to the field of robotics that takes into account societal values and expectations, encompassing ethical, legal, and socio-economic considerations.*

Your answer

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Here is the list of initial policy recommendations compiled by the Robotics4EU project. Do you think each of them are relevant in advancing responsible robotics? *

The elaborated list and descriptions can be found here.

	Not relevant	Slightly relevant	Moderately relevant	Relevant	Very relevant
Engage a wide array of actors in the discussions on the mission and vision of robotics development in the EU	○	○	○	○	○
Ensure representation of citizens, experts, stakeholders and end-users in the robotics research, development and deployment	○	○	○	○	○
Focus on researching and redefining the shifting landscape of employment	○	○	○	○	○

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Steer the regulatory and policy developments to foster innovation while ensuring adherence to necessary safety and ethical requirements	○	○	○	○	○
Support the industry in integrating ethical, legal and societal aspects from the outset of product development	○	○	○	○	○
Ensure the relevance of safety standards in robotics advancements	○	○	○	○	○
Demand to follow the privacy-by-design principles	○	○	○	○	○

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Establish protocols for testing, liability, and legal classification of autonomous systems	◯	◯	◯	◯	◯
Advocate for reusability and repairability in robotics manufacturing, alongside assessment of environmental impacts	◯	◯	◯	◯	◯
Enhance technology and engineering education alongside industry-focused training programmes	◯	◯	◯	◯	◯
Research automation's impact on the labour market and welfare system	◯	◯	◯	◯	◯
Evaluate and mitigate the risks of structural changes and inequality	◯	◯	◯	◯	◯

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Do you have any further insights on the suggested recommendations?

For more context on the Robotics4EU recommendations, we invite you to take a look at the booklet.

Your answer

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Annex 4. Expert Interviews

Expert	Position	Date of the interview	Main topics discussed:
Alejandro Suarez	Assistant Professor at the University of Seville, and Researcher at the GRVC Robotics Lab	22/11/2023	- Importance of managing expectations on what robots can and cannot do across general society, as well as in companies employing solutions - Importance of defining coherent liability frameworks and certification processes
Duska Rosenberg	Professor Emeritus at University of London	23/11/2023	- The importance of comprehensive, widely applicable testing, with the inclusion of SSH experts - Importance of partnership models in equipping the SMEs (as subcontractors), education institutions and research towards
Lars Klüver	Senior Advisor at The Danish Board of Technology	23/11/2023	- Considering cognitive skills needed for the changing labor demand - Focus on the fair negotiations and well-functioning labour negotiation market - The biggest social issue: the consequences on the local communities of companies moving out of established place due to automation - Responsibility of companies on the local level: plan the transition! - Pro-actively (locally) anticipate future trends and risks
Michel Joop van der Schoor	PhD student at TU Berlin	23/11/2023	- The need for tools for social impact and risk assessments for autonomous robotics, especially in public settings - The importance of exposing engineering students to social risks/impacts - the need of social sciences in engineering - The social acceptability is a core dimension in socially assistive robots and through this domain could spill over to other robotics application domains

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Deividas Petrulevičius	Program Coordinator at Research Council of Lithuania	24/11/2023	- The issues in the field of responsible robotics are geographically dependent. Depending on the strength of industry - Further SSH expert inclusion needs to be specified through the requirements and value promotion - The role of universities in including SSH experts in the engineering domains - For the support of SSH integration, the use of existing structures is important. For example, initial consultations with SSH experts should be available
Cecile Campbell	Head of ALV (Arena for learning about welfare technology)	27/11/2023	- The development of robotics need to be grounded in the concrete, specific need discovered by the customers / end-users - Attention to supporting end users in managing privacy and data security via standards and checklists.
Dylan Cawthorne	Associate Professor at the Drone Center at the University of Southern Denmark in Odense	24/11/2023	- Questioning the premise that “societal acceptance is desirable” - Emphasising the need to put human values, nature first, before technological development goals - Emphasising the need for regulation to ensure the standard and rewards for companies to go beyond the minimal standard - Emphasised the need for a more structured way of doing experiments in the public: role of public consent - Importance of the structures of universities in promoting the interdisciplinary collaboration between roboticists and SSH experts: mechanisms for payment needed
Egil Petter Stræte	Senior Researche at Ruralis - Institute for Rural and	30/11/2023	- The need to ensure the communication of the responsible robotics principles to industry, as ones at the front-lines of engaging with the responsible

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	Regional Studies		robotics - The importance of supporting SMEs in navigating the complex landscape of regulation and requirements
Laurynas Adomaitis	AI Ethics Researcher at CEA	30/11/2023	- Discussed Anticipatory Technology Ethics adoption - Original ELS analysis is required for each project, as issues are context and solution-depended - Presented the ethicists and roboticists collaboration good practice. Ethicists coming with tools gives credibility
Maja Karovic Hadžiselimović	Robotics and mechatronics engineer	01/12/2023	- Noted the subjective nature of the safety standards (for example, the threshold for hurt) - Big industry players could include the responsible robotics approaches into their future plans and procedures. This is the level that supports thinking in these terms should be provided. Integrate it into the futuristic approaches.
Juan C. Moreno	Spanish Council for research | Direct a Lab on neuroreabilitation; robotics and neurotechnologies for healthcare	30/11/2023	- Emphasising the need for the funded projects to be embedded in the bottom-up approach, promoting innovation based on the real needs rather than futuristic vision of the technicians
Federico Manzi	Researcher in Developmental and Educational Psychology, Università Cattolica del Sacro Cuore	04/12/2023	- Trust in robotics depends on the trustworthiness of the companies developing them, concerning questions of the well-being of their workers, data management, etc. - Importance of democratisation of development of solutions and promoting long-term responsible robotics research vs short-term results driven
Diane	Principal	04/12/2023	- Recommendations provided for

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Whitehouse	Ehealth policy consultant		the achievability of recommendations - Noted the general tendency for robotics to be descending in policy priority lsits
Susanne Bieller	General Secretary at International Federation of Robotics IFR	11/12/2023	- Emphasised the wide spread of misconceptions on what robotics is and what are the current capabilities - Differentiation is crucial between social spheres and industrial application spheres. - ELSA is approached differently during design&development and deployment - Importance of involvement of European actors in international standard development - Ensuring the correct distribution of liability - Ensuring the upskilling of workers in the service sector
Eduard Fosch Villaronga	Associate Professor at Leiden University	14/12/2023	- Testing zones can work as data generating tools for identifying inconsistencies between regulation and technical solutions - New legal categories need to be considered for robotics (for example, delivery robotics in road traffic laws). New legal categories give more clarity in the regulation landscape - The need for diversity in standard bodies - Safety should be encompassed not only as physical, but also concerning, for example, mental health - Testing spaces should be organised more coherently and defined more clearly

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