European Commission

Scientific Advice Mechanism

Successful and timely uptake of **Artificial Intelligence in science in the EU**

Group of Chief Scientific Advisors

Independent Expert Report

Corrected version

Scientific Opinion No. 15

March 2024

Research and Innovation

Successful and timely uptake of Artificial Intelligence in science in the EU

Group of Chief Scientific Advisors

European Commission
Directorate-General for Research and Innovation
Unit 02 — Science Policy, Advice & Ethics

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SCIENTIFIC ADVICE MECHANISM

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Scientific Opinion No. 15
March 2024

(Supported by SAPEA Evidence Review Report No. 13)

Brussels, 27 March 2024

2024 Directorate-General for Research and Innovation

Table of contents

ACKNOWLEDGMENTS 5
EXECUTIVE SUMMARY 6
Preamble 7
Overarching recommendation 1: 8
Recommendation 2: 9
Recommendation 3: 9
Recommendation 4: 10
1. Introduction 11
1.1 Background 11
1.2 Scope and objectives of the opinion 12
1.3 Summary of the Evidence Review Report 14
1.3.1 Introduction 14
1.3.2 Preliminary considerations 14
1.3.3 The landscape of AI research & innovation 16
1.3.4 Opportunities and benefits of AI in research 17
1.3.5 Challenges and risks of AI in research 19
1.3.6 Impact of AI on researchers' work environments 21
1.4 Summary of the policy landscape 23
1.4.1 Introduction 23
1.4.2 The European approach to AI 23
1.4.3 The European research and innovation landscape and AI 24
1.4.4 EU policies on the uptake of AI in R&I 26
1.4.5 The context worldwide 29
2. Recommendations 33
Preamble 33
Overarching recommendation 1: 33
Recommendation 2: 39
Recommendation 3: 42

Recommendation 4: 44
Annex 1 – Methodology....47
Annex 2 – Scoping Paper....49
Annex 3 – Policy landscape....60
Introduction 60
The European approach to artificial intelligence 60
The European research and innovation landscape and artificial intelligence 65
EU policies for the uptake of artificial intelligence in research and innovation....73
The context worldwide....84
Annex 4 - List of additional experts consulted and stakeholders 94
Annex 5 - References 97

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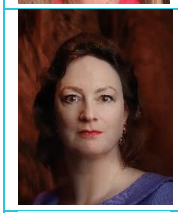	**Naomi Ellemers** Distinguished Professor of Social and Behavioural Sciences, Utrecht University
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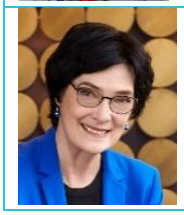	**Eva Zažímalová** Professor of Experimental Plant Biology at the Charles University in Prague and President of the Czech Academy of Sciences

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The Scientific Advisors in charge of preparing this Opinion were Nicole Grobert (co-lead), Alberto Melloni (co-lead) and Maarja Kruusmaa. This Scientific Opinion (SO) was endorsed by all seven Scientific Advisors.

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EXECUTIVE SUMMARY

The European Commission has prioritized the strategic development of artificial intelligence (AI) through funding, infrastructure, and a harmonised regulatory framework. The EU AI Act, the world's first comprehensive AI law, aims to ensure safe deployment of AI systems in the EU single market. The approach of the EU to AI centres on excellence and trust. AI has been identified as one of the six key areas that support Industry 5.0, the transformative model towards a sustainable industry. However, the challenge is to strike a balance between innovation and a responsible and human-centric AI deployment whilst taking transparency and accountability into account.

The Group of Chief Scientific Advisors (GCSA) was given the mandate to provide scientific advice on how the Commission can accelerate a responsible uptake of Al in science. The mandate requests recommendations on what impetus Al could give to scientific productivity and what benefits, incentives and challenges would Al-enabled research bring to the European innovation ecosystem and the society as a whole.

AI stands at the forefront of contemporary technological advancements. As a general-purpose technology, it is crucial for the EU to embrace any opportunities AI could bring, to confront its challenges, and to mitigate its risks. For the policymakers to be able to make informed decisions that foster responsible development and leverage the potential of AI in research, policymakers must understand the dynamics of research and innovation using AI.

The EU stands at a pivotal moment to shape the trajectory of AI in science. The use of AI in research and science is expanding, with a notable increase in AI-related publications across various fields. Successful applications include protein structure prediction by AlphaFold, new antibiotic discovery via AI, and improved weather forecasting through AI-driven models. To harvest the full potential of AI in science requires a nuanced understanding of its capabilities and constraints, responsible innovation, and a strategic approach to addressing its limitations. Poor data can lead to faulty AI models, thus perpetuating existing biases and discriminations. The potential for AI to monopolise innovation and unfairly appropriate scientific knowledge, especially through commercial large language models, is a growing issue. By fostering a responsible uptake of AI, the EU has the possibility to amplify its innovation capacity.

AI technologies, their use, and AI policies are evolving very rapidly. Uncertainties and opportunities of these rapid AI developments and their respective impacts on science and society are high.

This SO of the GCSA is informed by an evidence review report by experts of the Science Advice for Policy by European Academies (SAPEA) consortium, extensive literature reviews, and targeted workshops and interviews. In accordance with the objectives set by the Commission, this SO endeavours to provide a comprehensive and pragmatic approach to facilitating the uptake of AI in research and innovation across the EU, while respecting EU values and principles. It considers the diverse landscape of AI applications across various scientific disciplines and the heterogeneity of the research and innovation community in Europe. It acknowledges the importance of nurturing a favourable environment for AI adoption that not only includes technological advancements but also addresses the need for skills development, ethical considerations, legal frameworks, and public engagement. By providing a balanced assessment, this SO may be viewed as a guide for the Commission in developing and implementing policies that promote the responsible and effective integration of AI into research and innovation to respond to societal needs. This will ensure that Europe remains at the forefront of scientific excellence and innovation in the digital age.

Preamble

Artificial intelligence technologies, their use, and AI policies are evolving very rapidly. Uncertainties and opportunities of these fast AI developments and their impact on science and society are high. The recommendations are based on the scientific evidence addressing the specific scoping questions in the Scoping Paper, as well as knowledge, general scientific evidence, policies, and policy instruments available up until March 2024.

The recommendations in this document specifically address the uptake of AI in research as requested in the Scoping Paper, even though some of these recommendations can be applied to the uptake of AI more widely. The Group of Chief Scientific Advisors implicitly considers that all recommendations are based on European values and principles. Therefore, these are not explicitly restated in each recommendation.

Overarching recommendation 1:

Develop and deploy frameworks, including flexible dedicated funding mechanisms for research with AI, that evolve with the fast-paced and dynamic advancements of AI to support and strengthen the use of AI in research.

1.1 Support a publicly funded EU state-of-the-art distributed institute for research with AI (EDIRAS - European Distributed Institute for AI in Science) and, alongside this, create a European AI in science council (EASC) for all sciences with AI.

1.2 Ensure that European researchers from all disciplines (i.e, physical, life, social sciences and humanities) and Member States are aware of available AI-research infrastructure and tools (including EDIRAS, EASC), for AI in science.

1.3 Establish an EU node for continuous monitoring of AI developments and policies for the use of AI in research and development and innovation, assessing both the potential of AI to give impetus to research, and the threats and risks posed by AI in research.

1.4 Fund green AI initiatives and practices that measure and quantify the environmental impact of AI. Evaluate real affordable environmental costs by also considering economic, cultural, social, and environmental benefits in the long term.

1.5 Prioritise AI research with major benefits for EU citizens. Consider supporting the development of AI considering human values and specialised to address personalised health, advanced materials, social cohesion, the European Green Deal or the Destination Earth project.

1.6 Provide financial support for the development of AI tools and technologies specialised for scientific work (e.g., foundation models for science, scientific large language models, AI research assistants, and other ways to use AI technologies) to help scientists free up their time for their scientific work and enhance their overall efficiency.

1.7 Provide information, guidance and tools for researchers to support them in the handling of AI training for next generation scientists, legal requirements, social costs, ethical aspects, regulations and governance

of AI. Create tools for the transparent assessment, monitoring and reporting of potential misuse, such as bio-weapon developments, fraud, hacking, deep fake, and aggressive military AI applications.

Recommendation 2:

Improve quality standards of AI systems (i.e., data, computing, codes) and provide fair access for all researchers working on and with AI research.

2.1. Ensure data quality and representativeness.

2.2. Provide fair access to large high-quality research datasets.

2.3. Consider creative public-public and public-private partnerships to make private data available for research with AI for the public good.

2.4. Support epistemic evaluation of AI in science to improve the understanding of its limits in research.

Recommendation 3:

Protect and invest into efficient concerted actions between existing research infrastructures, Euro HPC (as computing power provider) and a future Institute for Research with AI (EDIRAS) – as they will play a key role in ensuring the EU's competitiveness in all scientific disciplines.

3.1 All aspects of AI systems (data, computing, and codes) managed by Research Infrastructures should be embedded in the infrastructure of the proposed EDIRAS by:

i) fostering the collaboration between AI technology developers and researchers to lead to the creation of more specialised and innovative AI tools tailored to Europe's specific research, societal, and industrial needs as well as cultural challenges; and

ii) preserving EU excellence and the EU's competitiveness for researchers in all scientific disciplines.

3.2 Support European companies, SMEs, and public-private partnerships which offer services to researchers to be able to compete with large

multinationals harvesting research results, code, and data from European researchers.

Recommendation 4:

Ensure that AI is driven by people (individuals and communities) living in an open society. Protect researchers, individuals, and communities from being driven by AI to only generate profit or be controlled by entities while ignoring or opposing EU core values and principles.

4.1 Build capacity, educate, and train people to meet the increasing demand for AI software, literacy, and proficiency, and preserve the results of such an effort.

4.2 Support interdisciplinary and transdisciplinary collaboration in order to detect in due time the new scientific and academic frontiers created by technological developments.

4.3 Retain, attract, and bring AI-research talent back by offering opportunities to work on high-impact societal challenges, quality of life, and a stimulating work environment.

4.4 Encourage attentive use of AI in the quality of assessment of research and people in academia and industry.

4.5 Use AI to foster social interaction between developers, teachers, peers and the broader community while acknowledging cultural and social factors in learning.

1. INTRODUCTION

1.1 Background

AI includes a series of high-performance predictive tools, the fruit of human research and scientific effort to generate knowledge capable of managing – with less uncertain predictions, the uncertainty of the future through the understanding and the interpretation of data. AI is having a growing impact on our everyday lives across a range of areas that include communication, entertainment, culture, navigation, healthcare or transport. While AI presents significant opportunities for democratic processes and civic engagement, its use also poses risks to citizens' rights, including privacy, freedom, and equality. All this is the subject of much debate: although AI offers remarkable time-saving opportunities, the knowledge process mostly takes place in a black box whose internal workings cannot currently be verified.

The capacity of AI to process vast quantities of data, recognise patterns, and generate insights offers unparalleled opportunities for advancing knowledge and addressing complex societal challenges. AI research is rapidly accelerating, and its use in science are growing even faster. AI technologies have been around for decades, but it is only in recent years that the advances in computing power, the availability of enormous quantities of data and new algorithms have led to major breakthroughs[1]. AI is, without doubt, a driver of innovation in all sectors of the economy.

That is why the Commission has prioritised the strategic deployment of AI, ensuring it aligns with European values such as trustworthiness, ethical standards, and human oversight. The Commission is supporting AI through funding, infrastructure, and a harmonised regulatory framework, by:

- allocating funding to AI research and development via the Horizon Europe and Digital Europe programmes;
- supporting the AI ecosystem by giving startups and researchers access to the necessary infrastructure and business support, and
- via the EU AI Act, providing regulatory clarity and guaranteeing trustworthiness.

The EU AI Act, the first-ever comprehensive AI law in the world, is intended to ensure the safe deployment of AI systems in the European single market

[1] What is artificial intelligence and how is it used? | Topics | European Parliament (europa.eu)

without hindering research and development. For this reason, EU lawmakers agreed that AI systems used for the sole purpose of research and innovation should be exempted from the regulation[2]. The EU currently has no dedicated and systemic policy to facilitate the uptake of AI in science; such a policy could connect and complement existing AI initiatives to boost the uptake of AI in science and provide for new, better targeted policies regarding its application.

In accordance Commission's objectives, this SO endeavours to provide a comprehensive and pragmatic approach to facilitating the uptake of AI in research and innovation across the EU. It gives an overview of the current state of AI, identifies the challenges and opportunities it presents, and offers evidence-based recommendations to policymakers.

This SO encompasses the wide variety of AI applications across various scientific disciplines and the diverse landscape of the research and innovation community in Europe. It acknowledges the importance of nurturing a favourable environment for AI adoption that incorporates technological advances without overlooking the need to address areas such as skills development, ethical considerations, legal frameworks, and public engagement.

With its balanced assessment, this document may be viewed as a guide for the Commission in developing and implementing policies that promote the responsible and effective integration of AI into research and innovation, thus ensuring that Europe remains at the forefront of scientific excellence and innovation in the digital age.

1.2 Scope and objectives of the opinion

The GCSA was given the mandate to provide scientific advice on how the European Commission can accelerate a responsible uptake of Al in science, in order to boost innovation and prosperity in the EU, strengthen the EU's position in science and ultimately contribute to solving Europe's societal challenges.

A Scoping Paper (see Annex 2) describes the issues at stake and the background to the questions to be addressed by the GCSA. In particular, the GCSA was asked to answer four questions:

[2] Artificial intelligence act: Council and Parliament strike a deal on the first rules for AI in the world - Consilium (europa.eu)

- What impetus could AI give to scientific productivity and what benefits, incentives and challenges would AI-enabled research bring to the European innovation ecosystem and the society as a whole?

- What is the impact of AI on the scientific process, and its potential to re-shape science and its governance practices?

- How can the EU best prepare for the impact and requirements of AI on the education and careers of the scientists and researchers of today and tomorrow, and what skills and competencies should education policies prioritise in this context?

- How should the Commission (through policy initiatives, regulation, communication, and outreach) facilitate responsible and timely AI uptake by the scientific and research communities across the EU?

Given the disruptive potential of AI as a technology applied to different fields, it can be expected that AI can also enhance research, thereby accelerating scientific discoveries, and bringing higher societal benefits faster, and transforming the scientific process. AI is increasingly used by scientists and in all fields of science. However, the EU has no dedicated, systemic policy to facilitate the uptake of AI in science, despite being among the most active global players in AI, and having a powerful and dynamic research community. Moreover, while the rewards of successfully adopting AI are promising, the threat of Europe lagging behind other global players is major.

The recommendations in this SO aim to guide and support the overall strategy for AI in research and innovation to be developed by the European Commission.

Such a comprehensive and targeted strategy, connecting and complementing various AI initiatives, would affect the uptake of AI in science both in research and in innovation.

The advice provided by the GCSA is based on a thorough assessment of the barriers that currently exist to a wider uptake of AI in science across domains at EU and national level, of the potential opportunities to be seized and of the risks to anticipate and mitigate.

1.3 Summary of the Evidence Review Report

1.3.1 Introduction

AI stands at the forefront of contemporary technological advancements, with the potential to revolutionise various sectors, including scientific research. As a general-purpose technology, it is crucial for the EU to embrace AI's opportunities, confront its challenges, and mitigate its risks. In alignment with the EU's regulatory framework, particularly the EU AI Act, there is a need to foster human-centric and trustworthy AI while protecting health, safety, and fundamental rights.

This Section is based on the evidence review report (ERR) produced by SAPEA (SAPEA 2024). The report provides a comprehensive synthesis of the state of the art of AI in research and responds to the questions addressed to the GCSA. Full references can be found in the ERR.

1.3.2 Preliminary considerations

Scientific research in the context of AI integration

Scientific research is a systematic pursuit of knowledge. It is characterized by collaboration across boundaries and is underpinned by freedom of inquiry and a commitment to epistemic integrity. The governance of research is primarily academic. It is guided by Merton's norms of universalism, communism (communalism), disinterestedness, and organised scepticism. These principles ensure that scientific knowledge remains a common heritage, free from biases and vested interests. This is critical when considering the integration of AI into scientific practices.

Diverse research partners and the role of AI

The landscape of research has **diversified beyond traditional academia**, with significant contributions from industry and private enterprises. This evolution has been shaped by historical trends. It varies regionally, with the EU traditionally focusing on independent basic research and the United States of America (US), for example, fostering a stronger industry-science nexus. It is essential to recognise the diverse nature of research communities to understand the multifaceted impact of AI on science.

Defining AI and its trajectory in science

AI, though lacking a universally accepted definition, can be broadly characterised as a machine-based system that interprets inputs to generate outputs that can affect physical or virtual environments. AI systems vary in

autonomy and adaptiveness. Recent advances suggest a move towards systems capable of emotional intelligence and multitasking. The **development of AI** is marked by breakthroughs in deep learning and natural language processing. It has set the stage for potential artificial general intelligence that could significantly enhance knowledge discovery across scientific domains.

The impact of AI on the scientific process

AI also has the **potential** to transform the scientific process by automating data analysis, enabling large-scale simulations, and fostering interdisciplinary collaboration. However, the integration of AI also raises **concerns** regarding research integrity, data privacy, and the reproducibility of results. One should envisage AI systems that align with the **ethos of science** and respect the principles of open and equitable scrutiny of scientific claims.

Preparing scientists for an AI-driven future

To prepare researchers for an **AI-driven future**, the successful uptake of AI in science necessitates equipping researchers with the necessary skills and competencies. This involves not only technical training in AI and data science but also fostering an understanding of AI's ethical implications. Investing in infrastructure, such as high-performance computing and data repositories, might also be critical to support AI-enabled research.

Policy design for timely and responsible uptake of AI in science

To facilitate the adoption of AI in science, there is a need to craft policies that encourage innovation while upholding **ethical standards**. Ideally, policies should promote transparent and responsible AI development, ensure **equitable access to AI resources**, and support **multidisciplinary** research initiatives. A **robust regulatory framework**, along with incentives for AI adoption, could indeed propel the EU towards a leading position in AI-enabled scientific research.

Intermediate conclusion

It is clear that the EU stands at a pivotal moment to shape the trajectory of AI in science. By fostering a **responsible uptake of AI**, grounded in the **foundational principles of scientific research** and tailored to the **diverse landscape** of all those involved in research, the EU has the possibility to amplify its innovation capacity and address pressing societal challenges. Policymakers, supported by researchers and innovators, would have to act with foresight and commitment if they want the EU to harness the

transformative power of AI for the advancement of European science and society.

1.3.3 The landscape of AI research & innovation

The rapid growth of AI

AI has experienced rapid growth, driven by **advancements in data availability**, **computational infrastructure**, and **algorithmic innovation**. This growth has profound implications for society, the economy, and the geopolitical landscape. Policymakers must understand the dynamics of AI research and innovation to make informed decisions that foster responsible development and leverage AI's potential.

The landscape of AI R & I

The evolution of AI is underpinned by increased **computational power**, **open-source software**, and b**ig data**. Generative AI, including language models like OpenAI's GPT-3, has escalated demand for both computational resources and skilled professionals. The generative AI field now encompasses multimodal capabilities, integrating text, image, audio, and video understanding.

Generative AI's breakthroughs stem from transformer architectures. They enable processing of large datasets and the scaling of language models. Despite their capabilities, AI models like GPT-3 require substantial investment in hardware and expertise. While initially, models were open-source, OpenAI transitioned GPT-3 to a closed, Application Programming Interface (API)-based commercial model, creating dependency and restricting access.

AI development predominantly uses open-source frameworks, but the increasing computational needs demand **specialised hardware and software**. This widens the gap between public and private research capabilities. Moreover, the consolidation of digital platform power by tech firms escalates concerns over competition dynamics and monopolistic tendencies.

Lastly, access to vast **datasets** is critical for AI development, yet **copyright laws** and **ethical considerations** constrain data accessibility. Future data needs are forecasted to outstrip supply. This poses challenges for training data-intensive AI algorithms.

The geopolitical economy of AI

AI's strategic significance is recognised, with implications for national competitiveness and research capabilities. The disparity in access to **AI resources** raises concerns over concentrated power and transparency.

The ascent of AI is reshaping the research landscape globally. Due to resource disparities, industry surpasses academia in producing significant machine learning systems. EU initiatives aim to bolster AI R&I, but they lag behind in private sector investment. The US leads in AI innovation and investment, with China and European countries trailing. Global AI research is geographically diverse, with significant contributions from the US, China, and the United Kingdom. The US dominates in **AI system development** and investment, reflecting the resources required for cutting-edge AI. **European** researchers do, however, play a notable role.

Private sector investment drives AI funding, outpacing public investment. European efforts to foster AI development include funding programmes like Horizon 2020 and **Horizon Europe** and **strategic initiatives** for startups and small and medium enterprises.

Intermediate conclusion

AI research and innovation are at a critical juncture, with significant economic, social, and geopolitical implications. Policymakers must navigate the complex interplay of technological advancement, industry dominance, data accessibility, and regulatory landscapes to ensure AI's responsible development and maximise its societal benefits.

1.3.4 Opportunities and benefits of AI in research

AI is increasingly used throughout science

The integration of AI into science and research has transformed the way knowledge is generated, discoveries are made, and data is analysed across various disciplines. This revolution, propelled nowadays by generative AI and machine learning tools, presents significant opportunities for scientific advancement, innovative research methodologies, and greater productivity.

AI can accelerate scientific discovery and innovation

The **use of AI in research and science** is expanding, with a notable increase in AI-related publications across various fields. AI tools are being used for data analysis, idea generation, and to address complex scientific questions.

Successful applications include protein structure prediction by AlphaFold, new antibiotic discovery via AI, and improved weather forecasting through AI-driven models.

AI plays an important role in **accelerating discovery and innovation**. AI technologies enable the automated generation of ideas from literature, speed up simulations, facilitate big data analysis, and promote new research methodologies. The use of AI in semantic analysis and pattern identification across disciplines from humanities to quantum physics exemplifies AI's transformative impact.

AI automation extends to experimental workflows. It reduces manual labour and increases efficiency. Autonomous laboratories and AI-driven experimental design tools are revolutionising materials science, biology, and drug discovery.

Research dissemination is enhanced by AI. AI's potential in academic publishing includes plagiarism checks, language enhancement, and content summarisation. While AI supports the publishing process, there is caution regarding over-reliance on AI without sufficient understanding and infrastructure.

As to the **future perspectives and technological advancements**, the continuous progress in AI technology is vital for maximising its benefits in research. Addressing AI's limitations, such as information accuracy and the cost of training large models, is crucial. Innovations like retrieval-augmented generation and systems that facilitate AI interactions point towards a future of semi-autonomous digital entities capable of complex tasks.

The impact of AI on research domains

There are many **innovative approaches in the humanities and social sciences**. Indeed, AI facilitates cross-disciplinary collaboration and introduces quantitative analysis into traditionally qualitative fields such as digital humanities and historical research. It facilitates **advanced control in experimental physics** too. AI systems employing reinforcement learning provide precise control in complex physics experiments, thereby improving outcomes in fields like nuclear fusion and quantum mechanics. Lastly, it is important to note **AI-driven discoveries from experimental data**: AI algorithms identify patterns in extensive datasets, enabling breakthroughs in astronomy, genetics, and high-energy physics, where manual analysis would not be feasible.

Intermediate conclusion

AI's integration into scientific research is undoubtedly reshaping the pursuit of knowledge. By accelerating discovery, automating workflows, and improving research dissemination, AI is becoming an indispensable tool across scientific disciplines. However, realising AI's full potential requires a nuanced understanding of its capabilities and constraints, responsible innovation, and a strategic approach to addressing its limitations. As AI continues to evolve, it offers an unprecedented opportunity to enhance scientific research and contribute to solving some of the most complex challenges faced by humanity.

1.3.5 Challenges and risks of AI in research

Reproducibility, interpretability, and transparency

The **opacity of AI algorithms** should not be overlooked. Many modern AI methods suffer from their opacity, where the lack of transparency hinders the interpretation, verification, and reproducibility of AI-generated results. Studies reveal numerous sources of reproducibility failures, such as data leakage, poor dataset quality, and inconsistent modelling and evaluation procedures.

The AI research landscape is dominated by private technology giants, leading to reduced accessibility for academic researchers to large datasets and computational resources. This **commercial opacity** also raises issues with reproducing results, benchmarking AI performance, and the potential for bias in AI safety and ethics evaluations.

Performance concerns in AI models

AI performance is heavily dependent on the **quality of input data**. Poor data can lead to faulty AI models, thus perpetuating existing biases and discriminations, such as gender-based wage disparities. Personal data protection, especially in health applications, is also a significant concern.

Another important point is that models must be updated. AI models require **periodic retraining** to stay current and effective, as outdated models can quickly become obsolete. There is also a challenge in ensuring that training data accurately reflects the diversity of real-world populations.

Lastly, there are **knowledge and training gaps**. Therefore, researchers need to establish cross-disciplinary expertise and ethical guidelines for AI

usage, addressing legal requirements and data governance to prevent misuse and ensure the responsible development and application of AI.

Fundamental rights and ethical considerations

AI fairness is a major concern, with **socio-cultural biases** and **discrimination** reflected in training datasets, which can influence outcomes in critical areas like housing, hiring, and education. New forms of machine bias arising from AI's decision-making processes may further exacerbate inequality and undermine trust in scientific findings.

Privacy-sensitive data, such as healthcare records, are often overused in research. This may lead to overfit models with limited generalisability. Besides, AI's reliance on copyrighted data without proper consent raises intellectual property rights concerns. **Security** must be guaranteed.

AI's unequal access and environmental costs, including its carbon footprint, raise **societal concerns**. The potential for AI to monopolise innovation and unfairly appropriate scientific knowledge, especially through commercial large language models (LLMs), is a growing issue.

Misuse and unintended harms

AI's ability to generate **fraudulent content** and **spread misinformation** at scale poses risks to scholarly communication and the integrity of the scientific record. AI capabilities can exacerbate predatory publishing, proliferation of low-quality research outputs, and research misconduct.

AI has limitations in accurately evaluating research quality, especially in the humanities and social sciences. This highlights the need for human expertise in the peer review process and cautions against over-reliance on AI for assessing scientific merit. In other words, AI brings **challenges in research assessment**.

AI's applications in **cybersecurity**, **bio-weapon development**, and **military uses** present significant **threats**. Strategies are needed to counteract malicious uses, ensure accountability, and engage in public discussions on the appropriate use of AI in sensitive domains.

Intermediate conclusion

AI's growing role in science brings substantial benefits but also significant challenges that must be addressed. Policymakers, researchers, and

stakeholders must work together to uphold ethical standards, ensure transparency, and mitigate the risks associated with AI's capabilities. It is essential to establish guidelines and infrastructures that support the responsible use of AI. This is to preserve scientific integrity and advance knowledge while safeguarding fundamental rights and societal values.

The integration of AI in research and science has not only propelled innovation. It also introduced a range of challenges and risks across various scientific domains. Addressing these issues is critical for the ongoing development of AI and its ethical, transparent, and beneficial application in scientific research.

1.3.6 Impact of AI on researchers' work environments

The impact of AI on research jobs and careers

Academics are under a **heavy pressure**. Current research careers face issues such as mental well-being concerns, unattractive career prospects with a decline in permanent positions, limited funding opportunities, and the need for a diverse skill set. The uptake of AI in research could further influence these dynamics, necessitating adaptation to new work environments.

AI is expected to **transform job roles and skill requirements** rather than replace a significant number of research positions. AI can automate repetitive tasks, allowing researchers to focus on complex intellectual activities that require creativity and critical thinking. As such, AI is seen rather as a supportive tool.

As to **public-private partnerships**, they could provide opportunities in AI education and infrastructure. They may also contribute to a brain drain from academia to industry. The private sector's involvement in AI research could affect career paths and the focus of public interest research.

Human-machine collaboration and co-creativity

AI can facilitate human-machine collaboration by executing tedious tasks, which will enable researchers to concentrate on intellectually stimulating activities. There is potential for co-creating **integrated solutions** that focus on upskilling and empowerment within an organizational context.

The impact of AI on researchers and the environment of research

While AI can increase efficiency, it may also lead to the **deskilling of workers** by automating tasks that maintain valuable skills. Researchers must adapt to ensure critical thinking and analytical skills remain sharp in the age of AI.

However, the proliferation of AI could exacerbate existing **gender, geographical, and disability-related disparities**. It appears crucial to ensure diversity in AI development teams and to address access inequalities to prevent the perpetuation of biases.

The digitisation of the workplace, including the adoption of AI, may affect researchers' **mental health**, as mentioned above. Concerns over job security, increased workplace surveillance, and the potential for unfair decision-making could contribute to stress and job dissatisfaction.

AI literacy and competencies

Researchers will need a **combination of skills** to integrate AI into their routine in the lab or in the field: foundational digital skills, domain-specific expertise, creative and critical thinking abilities to work with and develop AI systems. Ethical awareness and the ability to interrogate AI outputs are also essential. There is an **urgent and pressing need for AI-related skills training** to meet the growing demand for AI competencies in the workforce. It is critical for expanding the AI workforce.

Likewise, **AI literacy** encompasses understanding AI concepts, engaging with AI technology, and evaluating its trustworthiness. It also includes awareness of computing infrastructure and the ability to evaluate AI tools.

This is not all. Researchers also need **a variety of more general skills** in data management, communication, content creation, safety, and problem-solving to navigate the digital research landscape effectively. These skills are vital for responsible and ethical AI uptake.

Education and training in the digital era

Universities struggle to meet market and societal demands for information and communication technology skills, as there is indeed a shortage of digitally skilled workers. **Innovative education models**, like massive online open courses and vocational training, may help bridge the AI education gap. In fact, various AI training programmes across Europe, from online courses to specialised university curricula, already offer some opportunities for

developing AI skills. There are public initiatives and private sector courses that contribute to a growing ecosystem of AI education.

To address ethical and social concerns related to AI, strategies for **embedding AI education in scientific curricula** include providing foundational digital skills training and encouraging transdisciplinary approaches.

Intermediate conclusion

The integration of AI in the scientific research landscape is reshaping the work environments, career trajectories, required skill sets, and the education of scientists and researchers. Moreover, while AI offers opportunities for enhancing research processes, it also presents challenges that must be addressed to ensure the effective and ethical use of AI in research. From a scientific point of view, the influence of AI on scientists' careers and research environments has significant implications for job roles, skills, and mental well-being, and is clearly multifaceted.

1.4 Summary of the policy landscape

1.4.1 Introduction

In late January 2024, the Commission adopted a package to support AI start-ups and innovation, including a proposal to provide privileged access to supercomputers to AI start-ups and the broader innovation community. It also launched the setting up an AI Office and added some other support initiatives for the start-up ecosystem. The AI policy landscape, however, develops very fast. This section intends to be a brief and non-exhaustive summary at the time of writing (mid- March 2024) of the chronology of milestones of the construction of a European approach to AI, the European research and innovation (R&I) landscape and AI, the main EU policies for the uptake of AI in R&I and the context worldwide.

A longer overview – including all references and links to the documents and initiatives cited, can be found in Annex 3.

1.4.2 The European approach to AI

The common principles and values that underpin life in the EU are freedom, democracy, equality and the rule of law, and the promotion of peace and stability.

Rather than principles of values, research and technological developments are shared competences.

The EU's approach to AI is based on excellence and trust. It aims to boost research and industrial capacity while ensuring safety and fundamental rights. The European AI ecosystem is characterised by its complex, interlaced and highly cooperative environment. The challenge is to strike a balance between innovation and a responsible and human-centric AI deployment characterised by transparency and accountability. Policies such as the Regulatory framework on AI ('**EU AI Act**'), approved by the European Parliament in March 2024, propose regulatory frameworks to govern AI applications, especially those considered high-risk, but exclude research practices.

1.4.3 The European research and innovation landscape and AI

The purpose of the **European Research and Innovation Area (ERA)** is to establish an area in which researchers, scientific knowledge and technology circulate freely. Recent initiatives are intended to improve legal and technical conditions for accessing, sharing and reusing publications and data for scientific purposes, which, by ensuring a larger pool of data, will facilitate more efficient use of AI tools.

The Commission's current innovation policy is based on the **New European Innovation Agenda (NEIA)**, which aims to position Europe at the forefront of the new wave of deep-tech innovation and startups. Although progress has been made, there is still an innovation divide in the EU, which is primarily based on geography. It is a divide that must be closed by fostering equitable growth rates across the EU, and this is one of the goals of the NEIA. Tackling the innovation divide is a priority in EU policies such as cohesion and R&I. At the same time, EU research and innovation policy focuses on how the EU can develop its technological capacities and thus achieve technology sovereignty and strategic autonomy.

With its work programmes and close connection with the ERA, **Horizon Europe** is the key funding programme for research and innovation. The number of Horizon 2020 and Horizon Europe projects linked to AI increases year on year, with more than 1,000 projects that focus on AI or use AI tools, and over EUR 1.7 billion received in EU funding. The guidelines drawn up for all research activities involving the development or/and use of AI-based systems or techniques encourage grantees to adopt an ethical approach. There is also guidance on the use of generative AI tools for the preparation of

proposals. Further guidance to provide advice on how to achieve trustworthy AI research is also in preparation.

The **European Research Council (ERC)** also supports frontier research into and using AI. Since 2007, it has funded more than 1,000 projects across all scientific domains and grant types. The ERC Scientific Council acknowledges that researchers regularly seek input from AI and will renew its policies as needed. A foresight survey has been carried out among ERC grant beneficiaries that are using AI in their research.

The objectives of the **European Innovation Council (EIC)** include identifying, developing and scaling up breakthrough technologies and game-changing innovation. This most ambitious innovation initiative provides funding for activities across the spectrum of technological development, from early applied research into AI to support for companies in developing specific applications that use AI. In the period 2018-2023, it supported 97 R&I projects for developing AI-related software, hardware or both. The EIC also supported 273 deep-tech companies developing AI-based innovations. The current 2024 Work Programme includes a top-down EIC Accelerator Challenge call focusing on Human Centric Generative AI made in Europe.

Where the activities planned in **Marie Skłodowska-Curie Actions (MSCA)** involve the use and/or development of AI-based systems and/or techniques, applicants must provide details of the technical robustness of the proposed system(s). It is likely that AI will become a prominent and regular feature of the transferable-skills plan of MSCA projects at all career stages.

The **European Partnerships**, which bring together the Commission and public private and public sectors (or a combination of the two), are important implementation platforms for Horizon Europe. Partnerships with an AI component include EuroHPC Joint Undertaking, the AI, Data and Robotics Partnership, and Connected, Cooperative and Automated Mobility.

The **European Institute of Innovation and Technology (EIT)** and **Knowledge and Innovation Communities (KICs)** join forces to boost the EU's technological and industrial capacity in the field of AI. An EIT Community AI has been set up to 'foster collaboration in, education about, and uptake of AI by European enterprises and society'. The EIT also coordinates the Deep Tech Talent Initiative (DTTI), which will train 1 million Europeans by the end of 2025 in deep-tech fields such as AI.

The **Digital Europe Programme (DIGITAL)** provides strategic funding to projects in five key capacity areas: supercomputing, AI, cybersecurity, advanced digital skills, and ensuring widespread use of digital technologies across the economy and society as a whole.

Lastly, over 30 **EU decentralised agencies** contribute to the implementation of EU policies and share their concerns regarding AI. For example, the European Medicines Agency (EMA) has published an AI workplan covering the period up to 2028.

1.4.4 EU policies on the uptake of AI in R&I

The Commission supports the uptake of AI in scientific research, either directly or indirectly, through a variety of existing policies and initiatives.

Although it does not deal directly with research and innovation, the **European strategy for data** '**f**ocuses on putting people first in developing technology, and defending and promoting European values and rights in the digital world'. The **Digital Services Act** (DSA) and the **Digital Market Act** (DMA) form a single set of rules that apply throughout the EU. The twofold objective is to protect the fundamental rights of all users of digital services while fostering innovation, growth, and competitiveness. The **Common European data spaces** will ensure that more data becomes accessible for use in the economy and society, including for training machine learning and AI models, while ensuring that the companies and individuals who generate the data remain in control. The **Regulation on harmonised rules on fair access to and use of data** (**Data Act**) is aimed at making Europe a leader in the data economy. More specifically in research and innovation, Horizon Europe beneficiaries are required to manage digital research data in line with the **FAIR principles** (Findable, Accessible, Interoperable and Reusable). The EU Member States expressed their support for the FAIR principles in the Council conclusions on 'Research assessment and implementation of Open Science'.

Europe's **research infrastructures** are critical to the continent's ability to achieve scientific breakthroughs and drive innovation. They are also drivers for regional development, as they ensure that research skills and innovation talent focus on strategic scientific assets. AI is used and supported by data-intensive research infrastructures. The transformative potential of AI in building responsible research infrastructures for open science is also explored.

Open Science is another key policy priority of the EU. It involves open access to research publications, data and all digital objects produced during research;

it also promotes the reform of research assessment, and assesses equity – or the lack thereof. As open science enables widespread access to research publications, data and other outputs, it is a key component in boosting the uptake of AI in science.

The **European Open Science Cloud (EOSC)** is referred to in the European strategy for data as the Common European data space for science, research and innovation. A particular noteworthy initiative is the EU-funded project AI4EOSC, aimed at delivering an array of AI, machine-learning and deep-learning models, which are bundled for researchers and are customisable so that users can adapt them to their needs.

Given that access to and reuse of scientific publications and data are at the core of the EU open science policy, the research-related provisions relevant in **EU copyright and data legislation** present challenges for researchers and their organisations: for instance, differing interpretations of text and data-mining provisions across EU Member States that could put the EU in competitive disadvantage regarding AI developments. There is also a need to better understand and provide guidance on the interplay between AI-generated output and **intellectual property rights (IPR)**. Potential measures at EU level and actions in the ERA, which would impact AI, are under consideration.

Supercomputers are crucial for AI research. The **European High Performance Computing Joint Undertaking (EuroHPC)** aims to develop and maintain in the EU a world-leading ecosystem based on federated, secure and hyper-connected supercomputing, quantum computing, and service and data infrastructure. Researchers from European academic and research institutions, public authorities and public sector organisations, and industry and SMEs of participating states are given access to computing time on EuroHPC. Access is currently free of charge and should primarily be for the purpose of open access, public research and innovation. In January 2024, the Commission proposed an amendment to the EuroHPC Council Regulation to include a general-purpose AI perspective, establishing 'AI factories' to facilitate access for SMEs and AI startups.

The **Digital Education Action Plan** (2021-2027) outlines the Commission's vision for high-quality, inclusive, and accessible digital education in Europe. It emphasizes the need for coordinated efforts to bridge the digital competence and skills gap, which is crucial for effectively integrating AI into scientific research. The action plan also encourages educational systems to adapt with

a view to leveraging technological developments relating to fast-paced digital transformation, such as the ethical use of AI and data in learning. It is further supported by two Councils recommendations adopted in November 2023, and Action 13 of the ERA. The action plan also connects with education policy and the investment pathway the Commission is developing for the future **European Universities Initiative**. The EU's **digital skills strategy** is a comprehensive plan to achieve Europe's digital transformation. The **Digital Europe programme** provides strategic funding to support the development of a skilled talent pool of digital experts through specialised education programmes in key digital areas such as AI. The **European Digital Skills and Jobs Platform**, launched under the Connecting Europe Facility Programme, offers information and resources on digital skills, as well as training and funding opportunities. The digital skills strategy is linked to the **European Skills Agenda**, which also specifically mentions AI as a skill that bolsters the green and digital transitions. Through the Pact for Skills, the Commission supports an Erasmus+ Alliance for Innovation, ARISA (Artificial Intelligence Skills Alliance) with a view to developing a sectoral strategy for AI skills.

Following a proposal from the Commission to promote **attractive and sustainable research careers**, in December 2023 the Council adopted a Recommendation on a European framework to attract and retain research, innovation and entrepreneurial talents in Europe, and which includes the new Charter for Researchers. The European Competence Framework for Researchers covers the transversal skills researchers should have for successful careers across a variety of sectors, including some that could be considered relevant for AI. There are additional measures in the pipeline to improve the attractiveness of research careers in academia and beyond. Two further initiatives worth noting are the **Agreement on Reforming Research Assessment'** and the **Coalition for advancing research assessment (CoARA)**.

Academic freedom and **freedom of scientific research** are set as priorities in several European Parliament resolutions, the Horizon Europe Regulation, ERA actions (ERA Action 6 'Deepening the ERA through protecting academic freedom in Europe') and in a number of voluntary commitments by Member States.

The **EU Gender Equality Strategy for 2020-2025** considers AI an area of strategic importance and a key driver of economic progress in which women must play a role as researchers, programmers and users. It also refers to the

risks of AI reproducing, amplifying or contributing to gender biases. A project like the JRC's 'Diversity in AI' initiative is also aimed at ensuring inclusiveness and non-discrimination in AI systems, an area also covered in the EU AI Act.

AI has been identified as one of the six key areas that support **Industry 5.0**, especially in the context of the need to develop and implement human-centric technologies in the future. As semiconductor chips are crucial to key digital technologies, including AI, the **European Chips Act** is intended to strengthen Europe's place as technology leader in the field. Moreover, AI models for scientific discovery pose **standardisation challenges** for commonly agreed procedures, common safety rules especially in high-risk AI applications, and facilitating interoperability of results. In 2023, the Commission issued a request to the European Committee for Standardization (CEN) and the European Electrotechnical Committee for Standardization (CENELEC) to begin work on drafting harmonised standards to support the development of safe, trustworthy AI. The CEN and CENELEC have set up a Joint Technical Committee 21 'Artificial Intelligence'. In addition, in order to bring trustworthy AI to market more quickly and to improve its uptake, the Commission and the EU Member States are co-funding **sectorial AI Testing and Experimentation Facilities (TEF)** focusing on four sectors including health and agri-food. The **EU Guiding Principles for Knowledge Valorisation** aims to maximise the transformation of research and innovation results into solutions that benefit society.

1.4.5 The context worldwide

The international dimension is an essential component to ensuring the development of human-centric AI. In with the case of Horizon Europe in particular, the EU develops joint commitments with international partners based on reciprocal openness, ensuring a level playing field and reciprocity, and strengthening bilateral and multilateral partnerships.

Europe remains a scientific powerhouse. Although it has less than 7% of the world's population, it accounts for approximately a fifth of the world's publications, patents, and R&D. The EU has a higher level of technological diversification than other global innovators such as the US and China. However, it specialises in technologies that are easier to replicate such as transportation or machinery. The EU's capacity to be at the forefront of technological change in more sophisticated areas such as digital technologies is lower than that of the US and China. Despite recent improvements, the EU scientific ecosystem is experiencing a brain drain. The situation is rapidly

evolving, however. While the US initially took a laissez-faire approach to AI, calls for regulation have recently been mounting. The Cyberspace Administration of China is also looking into a proposal to regulate AI, while UK is working on a set of pro-innovation regulatory principles. The UK has taken a leading role in the global conversation on the risks of AI, especially at the cutting edge of development and how internationally coordinated action can mitigate those risks, and in November 2023 it hosted the UK **AI Safety Summit**. The resulting Bletchley Declaration on AI Safety, signed by the countries attending the Summit – including the EU, the US, and China – marked a commitment to a new global initiative focused on AI safety.

At international level, the following initiatives have taken place:

- The Organisation for Economic Co-operation and Development (OECD) has adopted a (non-binding) Recommendation on AI and developed a Framework for the Classification of AI systems,

- UNESCO has adopted documents such as Recommendations on the Ethics of Artificial Intelligence and Guidance for Generative AI in education and research,

- the Council of Europe is currently working on an international convention on AI

- the World Health Organisation (WHO) has updated its guidance to reflect the impact of generative AI technologies – 'Ethics and governance of artificial intelligence for health: guidance on large multi-modal models', and

- the Commission has pledged to continue engaging with like-minded partners and multilateral fora such as the G7 and G20 to build a consensus on international AI guidelines, in particular through the G7 Hiroshima process, which aimed to develop principles, guidelines, and best practices for the responsible use of AI.

In January 2022, the Commission published a toolkit on how to mitigate foreign interference in research and innovation. The Staff Working Document urges caution when opening up research data in particular with regard to the potential impact of the future deployment of machine learning and AI. In this context, and as set out in the **Communication on the European Economic Security Strategy**, the Commission is drawing a proposal for a Council

Recommendation on enhancing research security. Similarly, the Joint Communication on a **European economic security strategy** issued in June 2023 focuses on 'minimising risks arising from certain economic flows in the context of… accelerated technological shifts, while preserving maximum levels of openness and dynamism'. In October 2023, the Commission adopted a **Recommendation on critical technology areas,** identifying AI as one of 'four technology areas that are considered highly likely to present the most sensitive and immediate risks related to technology security and technology leakage'. Further activities and open dialogue will follow. Lastly, in January 2024, the Commission published a White paper on options for enhancing support for research and development involving technologies with dual-use potential.

As to stakeholders, research performing- and research funding-organisations have been calling for more investment in fundamental research on digital technologies and AI. They stress the need to strike a balance between guaranteeing safety for users and developers of AI systems and ensuring that the legal environment allows researchers to experiment and develop new applications. Some have expressed concerns about made-up 'facts' or how data is collected, and report that universities face challenges in terms of evaluating work produced with the help of AI. Others are keen to make more data available to enable AI applications and to enforce existing copyright laws. The latter is also a concern raised by academic publishers. Start-ups have broadly welcomed the creation of a harmonised framework for AI and the promotion of regulatory sandboxes.

Stakeholders across the AI community have also come together in groups such as the **Partnership on AI**, whose stated goal of sharing knowledge and fostering the responsible development of AI. The Commission itself has launched the **European AI Alliance** within the framework of its AI strategy in order to engage stakeholders such as the general public, civil society, business and consumer organisations, trade unions, academia, public authorities and experts. Other relevant stakeholder initiatives include the **Moonshot in Artificial Intelligence**, and the proposal '**CERN for AI**', a large-scale investment into publicly owned and operated AI infrastructure.

Box – The impact of AI on science for policy

The recent advances in AI, and especially the progress in the field of Large Language Models, are bound to have a profound impact not only on scientific research and the production of scientific evidence, but also on the practice of policymaking and science advice to policy (Tyler et al., 2023). AI models have the potential to enhance greatly the capacity to process and synthesise large volumes of data and scientific evidence, identify patterns that would be imperceptible to the human eye, and generate models that can predict future trends with a degree of accuracy that was previously unattainable. These features of AI can be leveraged to enable policymakers to get an overview of the state of knowledge on a specific topic rapidly and to respond swiftly to emerging challenges with policies that are both highly tailored to specific situations and adaptive to the needs of distinct locations and community groups. The prospect of seamlessly integrating AI within existing and burgeoning big data platforms could further enhance the decision-making process, ensuring that science advice to policy is underpinned by the most comprehensive, reproducible, and up-to-date information available.

However, the use of AI in science for policy is not without its challenges and limitations. AI models lack the contextual understanding which human expertise brings. The increasing reliance on AI-driven systems introduces complexities regarding transparency and accountability, as the "black box" nature of some algorithms does not allow to scrutinise why and how outputs are generated. This opacity becomes particularly problematic when considering the potential for ingrained biases within the data or the algorithms themselves, which may propagate existing inequities and/or false information. Ensuring that AI is employed responsibly when used to generate scientific insight to inform policy is therefore essential to avoid unintended effects and maintain public trust in policymaking.

While much of the application of AI within this context is in its early stages, policymakers, researchers, and practitioners should collaborate to shape responsible AI adoption in science for policy. Future developments for the use of AI in science advice might require:

- actions to develop AI and data literacy skills in scientists, intermediaries, knowledge brokers and policymakers to promote a better understanding of AI capabilities and limitations in order to make informed decisions about its use in policy development and implementation;
- the creation of guidelines and processes to ensure accountability and transparency;
- evaluating existing AI tools for their potential use for science for policy purposes;
- fostering interdisciplinary collaborations between AI experts, scientists, intermediaries, and policymakers to develop novel AI solutions specifically to

2. RECOMMENDATIONS

Preamble

Artificial intelligence (AI) technologies, their use, and AI policies are evolving very rapidly. Uncertainties and opportunities of these fast AI developments and their impact on science and society are high. The recommendations are based on the scientific evidence addressing the specific scoping questions in the Scoping Paper, as well as knowledge, general scientific evidence, policies, and policy instruments available up until March 2024.

The recommendations in this document specifically address AI uptake in research as requested in the Scoping Paper, even if some of these recommendations can be applied to the uptake of AI more widely. The Group of Chief Scientific Advisors implicitly consider that all recommendations are based on European values and principles. Therefore, these are not explicitly restated in each recommendation.

Overarching recommendation 1:

Develop and deploy frameworks, including flexible dedicated funding mechanisms for research with AI, that evolve with the fast-paced and dynamic advancements of AI to support and strengthen the use of AI in research.

The European Commission has played a major role in developing policies for preventing misuse of AI and data.

The Commission has also invested in AI start-ups (e.g., through the European Innovation Council – EIC), given researchers access to European High-Performance Computing (EuroHPC) Joint Undertaking, and created testing and experimentation facilities, and set-up common European data spaces to centralise European data in ways that could be more easily shared.

To accelerate the use of AI in research even more, the Commission needs to develop operational solutions whereby researchers from all disciplines understand, know how to use, and have access to AI-powered technologies.

A framework for interdisciplinary and transdisciplinary work combined with dedicated funding calls where AI technologies can be developed for specific scientific purposes can also incentivise researchers to create interdisciplinary teams aiming to solve larger societal challenges.

Europe's approach should include dedicated state-of-the-art AI technologies, systems, models, tools, specialised for scientific work. These elements are essential to help boost research speed, scale, and quantity, and increase the safety and security of European citizens. It should also enable the creation of public-private partnerships for faster and safer uptake of AI in science. Such support would enable European researchers and entrepreneurs to harvest the fruit of European research and for them to stay globally competitive and collaborative.

1.1 Support a publicly funded EU state-of-the-art distributed institute for research with AI (EDIRAS - European Distributed Institute for AI in Science) and, alongside this, create a European AI in science council (EASC) for all sciences with AI.

Evidence suggests that a possible way forward for the Commission is to invest in, establish, and provide ongoing funding for a state-of-the-art facility for academic research in Europe. Such a facility would provide the level of support necessary to enable public resources to engage in cutting-edge AI-powered research (SAPEA 2024).

This proposed EDIRAS would provide public scientists and researchers (those employed by publicly funded universities and research institutes operating on a not-for-profit basis) access to the infrastructures and inputs needed to undertake cutting-edge research with AI in all scientific disciplines.

EDIRAS would:

i) provide massive high-performing computational power;
ii) provide a sustainable cloud infrastructure;
iii) provide a repository of high-quality, clean, responsibly collected and curated datasets;
iv) provide access to interdisciplinary talent; and
v) have an AI scientific advisory and skills unit engaged in developing best practice research standards for AI and developing and delivering appropriate training and skills development programmes.

The SAPEA foresight exercise led to reflections that a 'CERN for AI' (the now-proposed EDIRAS) could undertake research with and into AI and ensure its robustness alongside conforming with European values including fairness (SAPEA Foresight Report 2023).

Big science projects can differ in centrality and can be structured in different ways and can be bound to a single infrastructure site (e.g., should it need a single physical instrument to attain its objective) or to geographically distributed networks (Rüland, A. 2023).

The GCSA recommends setting up a distributed institute for AI (a distributed 'CERN for AI in research') that complements, coordinates or liaises with existing bodies and develops new nodes depending on the changing needs. It should ensure distributed, collaborative research, development, and innovation, support the broader scientific community in developing and using AI, and be open to new nodes and research teams.

The focus should not be a single flagship objective. Instead, focus should be put on the support for researchers using AI for their research in any given field, and especially those in disciplines where AI is less frequently used. To bolster the cohesion and visibility of such distributed research institute, the proposed EDIRAS should be complemented by dedicated funding through a 'European Council' for AI in science (EASC). This funding should be flexible enough, for example, to respond rapidly to international developments and to incubate ideas and to support researchers less familiar with AI in science.

1.2 Ensure that European researchers from all disciplines and Member States are aware of available AI-research infrastructure and tools (including EDIRAS, EASC), for AI in science.

Evidence gathered for this SO showed that many scholars, including top AI experts, are barely or not at all aware of how to access and use available AI tools and existing infrastructures. EASC funding should be supporting European research labs and teams in all disciplines (including social sciences and humanities) working on diverse topics and in diverse research areas.

1.3 Establish an EU node for continuous monitoring of AI developments and policies for the use of AI in research and development and innovation, assessing both the potential of AI to give impetus to research, and the threats and risks posed by AI in research.

A dedicated facility should proactively monitor the use of AI in science. It should submit periodical reports and make recommendations, and if needed, guidelines, aimed at addressing risks related to this, e.g., related to limited reproducibility, interpretability, and transparency, misuse in scholarly communication, or unfair appropriation of scientific knowledge.

The monitoring mechanisms should be co-designed with the scientific community and research stakeholders, developers, and focus on transdisciplinary approaches, transparency, inclusivity, and the protection of individuals/communities living in an open society.

It should use foresight, continuous horizon scanning and technology assessment (including at global level) to identify evidence of future opportunities and challenges, as well as the positive and negative impacts of AI on research.

The assessment of harms should be integrated with the management of opportunities for European researchers, businesses and the public, while also monitoring such developments internationally.

AI is likely to increase productivity and spark new ideas. However, conclusive evidence is still lacking and evidence gathering is necessary to better understand the impetus AI may have on the quality, accessibility and productivity of the EU's research, development and innovation (SAPEA 2024).

The recently established European AI Office could contribute to this, as far as AI in general is concerned, but there is a need for monitoring specifically the use and development of AI in research.

1.4 Fund green AI initiatives and practices that measure and quantify the environmental impact of AI. Evaluate real affordable environmental costs by also considering economic, cultural, social, and environmental benefits in the long term.

Supporting the greenest high-performance computing and data centres is crucial to avoid creating new issues impacting further on already existing climate challenges society is facing. Therefore, it is necessary to stimulate research into green science and technology, and to provide incentives for researchers to work on sustainable solutions.

1.5 Prioritise AI research with major benefits for EU citizens. Consider supporting the development of AI considering human values and objectives and specialised to address personalised health, advanced materials, social cohesion, the European Green Deal or the Destination Earth project.

The use of AI is expected to make a big difference in sectors where large amounts of data are available, but difficult to interpret.

Currently, for example, researchers are using AI to analyse datasets of health information to develop diagnostic tools, to analyse genomic, epigenomic, and transcriptomic data, and to compare healthy to disease states and between disease states (ERC 2023).

AI may usher in a revolution in materials science. 'Materials science is central to new technologies needed to address climate change. Among many possibilities, new materials promise more efficient solar panels, better batteries, lightweight metal alloys for more fuel-efficient vehicles, carbon-neutral fuels, more sustainable building materials and low carbon textiles. Progress in materials science may also create substitutes for materials with fragile supply chains, including rare earth elements.'[3]

Climate science is another field where large amounts of data are available, but complex to analyse. The US-based Climate Change AI, a non-profit organisation aims to catalyse impactful work at the intersection of climate change and machine learning by building community, educating, and providing infrastructures.[4]

AI is also expected to be crucial for the Destination Earth (DestinE) flagship initiative of the Commission. It aims to develop a highly accurate digital model of the Earth on a global scale. This model will monitor, simulate, and predict the interaction between natural phenomena and human activities. It will contribute to achieving the objectives of the green and digital transitions as part of the Commission's European Green Deal and European Digital Strategy[5]. Such initiatives need to rely on innovative AI applications in climate research.

In the social sciences and humanities, significant progress can be expected in the topics covered by the roadmap of the European Strategy Forum on Research Infrastructures (ESFRI). Areas where more impact should be expected include, for instance, hermeneutic of cultural and historical data, preservation of cultural heritage, and linguistics in all its fields.

It is also important to support research that serves the public interest and that would otherwise be neglected because it is not lucrative for the private sector.

[3] a8d820bd-en.pdf (oecd-ilibrary.org)
[4] Climate Change AI | Tackling Climate Change with Machine Learning
[5] Destination Earth | Shaping Europe's digital future (europa.eu)

For instance, there are areas in research, e.g., patient treatment, health organisation, disabling diseases, with specific benefit for the public but which are not usually considered to be using AI (low intensity AI research).

1.6 Provide financial support for the development of AI tools and technologies specialised for scientific work (e.g., foundation models for science, scientific large language models, AI research assistants, and other ways to use AI technologies) to help scientists free up their time for their scientific work and enhance their overall efficiency.

Specialised AI tools and technologies for research in all disciplines need to be further developed to increase the usefulness of AI for research. For example, 'Retrieval-augmented generation is proposed as a remedy for the shortcomings of current LLMs. The tendency to "hallucinate", which is to generate seemingly random and irrelevant responses, is a major challenge. This generates misinformation without providing logical reasoning for the output. Retrieval-augmented generation suggests connecting any LLM to external databases and other symbolic engines, for additional data that the model can use to mitigate the generation of false information (Y. Gao et al., 2023; Lewis et al., 2020; Li et al., 2022).' (SAPEA, 2024).

If AI is to help scientists free-up their time for their scientific work, AI tools must be fit for purpose and such tools must meet the scientific needs, quality, and standards of relevant subject areas.

Invest in laboratory robotics while securing the interoperability and standards for AI facilitated experimental research, including research in social sciences and humanities.

1.7 Provide information, guidance and tools for researchers to support them in the handling of AI training for next generation scientists, legal requirements, social costs, ethical aspects, regulations and governance of AI. Create tools for the transparent assessment, monitoring and reporting of potential misuse, such as bio-weapon developments, fraud, hacking, deep fake, and aggressive military AI applications.

The *Ethics guidelines for trustworthy AI* published by the Commission in 2019 and the *Guidelines on the responsible use of generative AI in research*, published in 2024, must be updated and regularly adapted in view of new developments in AI, including generative AI. The guidelines must also be operationalised for the scientific community, for example by building on the existing operational guidelines *Ethics by Design and Ethics of Use Approaches*

for Artificial Intelligence and by making guidelines and harmonised standards openly accessible. Harmonised standards play an important role in EU legislation by turning what are sometimes vague essential requirements, for example in the AI Act, into concrete technical requirements[6], e.g., standards on data quality.

'Researchers developing AI systems are aware and somewhat monitoring AI threats (bio-weapon developments, fraud, hacking, deep fake, and aggressive military AI applications) but currently lack guidelines on regulations and governance.' (SAPEA, 2024).

Such information, guidance, and tools on AI for research are critical, and it is essential that it helps scientists to relieve rather than add additional administrative burden.

Recommendation 2:

Improve quality standards of AI systems (i.e., data, computing, codes) and provide fair access for all researchers working on and with AI research.

2.1 Ensure data quality and representativeness.

High-quality data is vital for the successful implementation of AI in science, but 'many current AI models perform poorly due to poor data used to train them. This is due to low input data quality, failure to update the model, and inherent differences between training data and real-world population.' (SAPEA, 2024).

Together with the research community, continue developing and applying standards, benchmarks, guidelines and best practices for high-quality datasets that comply with EU principles and goals for data privacy protection.

Help collect high-quality datasets that appropriately represent European education and cultural diversity (languages representing communities or their traditions, cultural patrimonies, educational tools for children, etc.) to facilitate an uptake of AI tools by social sciences and humanities.

Support scientific research for reaching consensus on standards for metadata and methods to track how data is collected, selected, documented, and

[6] Harmonising-AI-OXIL.pdf

processed. Ensure that researchers have access to those standards so that they can comply with them in their work.

Consider enforcing a watermark system to label AI-made work to distinguish raw data from AI-generated data. Ensure a clear and detectable division between data for training AI systems and data generated by AI systems.

Facilitate the development of benchmarks and standards for inclusiveness and representativeness in accordance with the EU instruments for protecting freedom of research (see European Parliament Resolution 17.1.2024 - 2023/2184(INL) and democratic principles.

Undertake research on standards and benchmarking of AI models, including estimates of their computational power and environmental impact (e.g., their CO2 footprint and water consumption).

Finance research initiatives of computationally low-cost AI models (also suitable for edge computing and the Internet of Things to advance those fields, too).

Finance the creation of datasets and models for purposes that have high social impact for EU citizens but are not necessarily lucrative from an economic point of view. Evidence points to commercial research tending to focus on a narrower range of topics. One role of public AI research would be to diversify research of AI itself and of AI for research.

Consider EU-wide initiatives of strategic data collection in areas that have a high impact for EU strategic autonomy, defence capacity, preserving European lifestyle and values, culture, environment, etc. Those datasets could have a purpose of finding alternative materials for rare earth metals, alternative pharmaceutics, language models of diverse European languages, etc.

2.2 Provide fair access to large high-quality research datasets.

Support AI-driven interdisciplinary research- that combines AI research with research in other domains. Among other initiatives, offer shared spaces for high-quality data repositories, computing power, and federated learning using high-quality datasets together with quality assessments of the research outcomes.

Keep building and developing large multipurpose interoperable datasets linked to European data spaces (e.g., European Open Science Cloud, DestinE), and develop interoperability standards.

Provide EU researchers with fair access to representative, high-quality datasets irrespective of their field of research, geographical area or affiliation while preserving privacy and ownership rights. Centralise public data and share it out for federated learning for research purposes. Invest in Europe's capacities to absorb this data that could drive the creation and development of these datasets.

The European Bioinformatics Institute (EMBL-EBI) at the European Molecular Biology Laboratory (EMBL), an intergovernmental research organisation funded by over 20 member states, prospect and associate member states, is a good example/model of how high-quality data can effectively be shared. 'AI is being increasingly used to push the frontiers of life science research and bring people together across disciplines to facilitate more effective collaborations and open new avenues for exploration.' (EMBL-EBI).

Address the lack of transparency associated with state-of-the-art AI models and systems. The opacity of the commercial AI sector prevents researchers from obtaining transparent and reproducible results and creates dependencies on AI models and services provided by industry. Transparency of public models helps among other things, to increase the trustworthiness of AI and to mitigate the reproducibility crisis in research.

Implement mandatory EU digital watermarks distinguishing scientific research and data produced through daily activities of EU citizens from data produced with AI.

2.3 Consider creative public-public and public-private partnerships to make private data available for research with AI for the public good.

Consider novel ways of procurement with private companies through dedicated EU fund (possibly supported by Member States and other players, like the European Investment Bank), for collecting data for public research, and/or for making data that is harvested as a side-product, available.

Novel types of public procurements could particularly be used for topics that do not have immediate high commercial value but are important for preserving European values, cultures, languages, lifestyle, well-being, and the safety and security of citizens.

Make data 'as open as possible and as closed as necessary' when researchers and scholars share data with the private sector and non-EU countries. Aim at reciprocity of data and sharing of algorithms, e.g., by using terms of legal contracts known as copyleft or share-a-like.

2.4 Support epistemic evaluation of AI in science to improve the understanding of its limits in research.

There is a need of a better understanding of AI as understanding how it works helps to perceive it as fair and just – 'in other words, of turning an opaque box into a glass box'. (Russo, 2023). However, the epistemic evaluation and explainability will be specific for each subject as they are not just technical but also philosophical concepts.

It is therefore important to 'incorporate values and other normative considerations, such as intersectoral vulnerabilities, at critical stages of the whole process from design and implementation to use and assessment' of the data (Russo, 2023) as and where applicable.

Recommendation 3:

Protect and invest into efficient concerted actions between existing research infrastructures, Euro HPC (as computing power provider) and a future Institute for Research with AI (EDIRAS) – as they will play a key role in ensuring the EU's competitiveness in all scientific disciplines.

3.1 All aspects of AI systems (data, computing, and codes) managed by research infrastructures should be embedded in the infrastructure of the proposed EDIRAS by:

i) fostering the collaboration between AI technology developers and researchers to lead to the creation of more specialised and innovative AI tools tailored to Europe's specific research, societal, and industrial needs as well as cultural challenges; and

ii) preserving EU excellence and the EU's competitiveness for researchers in all scientific disciplines.

Involve the scientific bodies and fora of research infrastructures (e.g., European Strategy Forum on Research Infrastructures (ESFRI); European

Open Science Cloud (EOSC), European Research Infrastructure Consortium (ERIC) forum, European Intergovernmental Research Organisation (EIRO) forum) for the establishment of the EDIRAS.

Provide a framework for matching Member States resources (given to research infrastructures) and Commission funding for the purpose of maximising the investments in research and technology, with a view to supporting transfer to the market, societal needs and the strategic defence policy.

Support the creation of European PhD schools dedicated to research with AI based at universities, other research infrastructures, and EDIRAS alike, in order to offer equal opportunities for accessing data, computing and codes, and to enable increased transnational access for the EU's next generation of researchers.

Consider a comprehensive EU policy for providing non-EU entities with access to European research infrastructures working with AI and to EDIRAS, taking into account compliance with and commitment to, fundamental rights, ethical principles and European values.

3.2 Support European companies, SMEs, and public-private partnerships which offer services to researchers to be able to compete with large multinationals harvesting research results, code, and data from European researchers.

Encourage and regulate the access of EU SMEs to public data spaces and data centres by offering better support services, collaboration with research institutions and better awareness about EDIRAS and EASC among SMEs.

Regulatory clarity and simplification in science with AI can support researchers in focusing on their main duties and in boosting the transfer into commercial applications that are 'EU regulation ready'. This will reduce the regulatory cost of start-ups adopting and exploiting the research findings of European researchers (see 1.5).

Rules for public venture capital and private capital must encourage new EU companies commercialising AI-based research results to profit from a better regulated market.

Recommendation 4:

Ensure that AI is driven by people (individuals and communities) living in an open society. Protect researchers, individuals, and communities from being driven by AI to only generate profit or be controlled by entities while ignoring or opposing EU core values and principles.

4.1 Build capacity, educate, and train people to meet the increasing demand for AI software, literacy, and proficiency, and preserve the results of such an effort.

Provide equitable access to AI systems and training for researchers from all research domains in all Member States to prevent inequality in education, and any loss of future European scientific talents and human capital, which can deprive future European research.

Ensure that educational sciences using AI declare as a verifiable goal the rights of individuals, personal fulfilment and dignity.

Prohibit the use of personal and research data concerning children – even if collected with parents' authorisation – for commercial profiling.

Consider education in 'AI literacy' as key for preventing the dispersion of future scientific talents. Use European Universities alliances and the European Alliance of Academies to start new networks and develop dedicated AI modules tailored to different disciplines, by creating joint EU doctoral schools. Promote research, for instance through specific funding calls, on philosophical, legal, and ethical issues on AI use in science and their impact on fundamental human rights, transparency and accountability.

4.2 Support interdisciplinary and transdisciplinary collaboration in order to detect in due time the new scientific and academic frontiers created by technological developments.

Create AI partnerships - both vertical and horizontal - that facilitate knowledge exchange between different scientific communities, encouraging the development of AI applications that address specific research needs in these fields, including a new role for the institutions mentioned in recommendation 3.1.

4.3 Retain, attract, and bring AI-research talent back by offering opportunities to work on high-impact societal challenges, quality of life, and a stimulating work environment.

Create academic benefits for retaining trained AI talents and attracting AI experts, providing them with tools to maximise the quality of their research, while caring for their well-being, and fostering their access to computing infrastructures and data.

4.4 Encourage attentive use of AI in the quality of assessment of research and people in academia and industry.

Aligned with the Research Quality Assessment Framework and the San Francisco Declaration on Research Assessment, foster an academic culture that values quality over quantity, and move towards qualitative and specialist assessment rather than quantitative evaluation, even though it is more expensive.

Reward validation and reproduction, and ethically sound research performed for the social good, not only the creation of AI models and model training.

Ensure research efforts in data collection, curation, and data validation are recognised by research assessments of both researchers and research institutions.

Support the development of strict guidelines limiting the use of AI tools in peer reviews or assessment of research grants. Evidence says that these tools add to the strain of scientific publishing through the generation of automated misinformation, in shadow organisations known as 'paper mills' and predatory journals.

4.5 Use AI to foster social interaction between developers, teachers, peers and the broader community while acknowledging cultural and social factors in learning.

Support linguistic, cultural and historical sciences with AI by offering to different clusters of EU populations tools for understanding themselves, their past and the others.

Exploit AI in the pedagogical sciences for a progressive bottom-up social constructivist approach (Howard Gardner), i.e., enabling a community to

design its learning objectives in contrast to the classical top-down transmissive approach.

Support, in the framework of existing exchange programmes, tools of trans-national access for local administrators, practitioners and teachers with the purpose of making visible and tangible the EU approach to AI for science.

ANNEX 1 – METHODOLOGY

The Group of Chief Scientific Advisors (GCSA) to the European Commission has been asked to provide a SO on the 'Successful and timely uptake of artificial intelligence in science in the EU'. The background to this request and the specific question to be answered by the advisors is laid down in the '**Scoping Paper**', prepared by the Commission services, to set out the request for advice (Annex 2). The recommendations presented here by the GCSA build upon the **Evidence Review Report** (ERR, SAPEA 2024) developed by SAPEA, additional literature, and expert and stakeholder consultation (see Annex 4).

The Scientific Advisors agreed to conduct the work as detailed in the Scoping Paper (July 2023). **Nicole Grobert** (co-lead), **Alberto Melloni** (co-lead) and **Maarja Kruusmaa** developed the SO on behalf of the Group of Chief Scientific Advisors. SAPEA organised **four expert workshops,** (attended also by other Advisors) covering Foresight, People, Policy and the Scientific process. These workshops included presentations and discussions to gather and synthesise scientific evidence. Each workshop was underpinned by a rapid literature review produced by the Specialist Unit for Review Evidence, Cardiff overseen by Academia Europaea, at the University of Cardiff. The Evidence Review Report (ERR) was supplemented with and further academic and 'grey' literature. SAPEA also invited independent scientific experts to peer review the ERR.

The SAM Secretariat supported the GCSA with the organisation of an elicitation exercise to gather further scientific evidence from additional experts in the field of technology governance, digital economy, innovation policy and open innovation, an expert **sounding board meeting** for scrutinising a draft of the recommendations of the SO, a discussion with **policy experts of the European Commission** on the scientific evidence and policy relevance, and a **stakeholder meeting**, where the preliminary outputs of the SAPEA Evidence Review Report and the areas under consideration for the SO were presented by the SAPEA Working Group chairs and the Scientific Advisors, respectively.

List of sources of evidence that informed this SO:

- Scoping Paper 'Successful and timely uptake of Artificial Intelligence in science in the EU' (SAM, 2023)

- SAPEA Expert workshops and related reports – October, November and December 2023, and January 2024
- An Evidence Review Report by SAPEA – (SAPEA, 2024), referred to as the ERR
- References
- Sounding Board Meeting – February 2024
- Stakeholder Meeting – March 2024

Meeting reports or summarising notes are published online.

ANNEX 2 – SCOPING PAPER

Scientific Advice Mechanism

European Commission's Group of Chief Scientific Advisors

Scoping paper:
Successful and timely uptake of Artificial Intelligence in science in the EU

4 July 2023

1. SCOPE

The present scoping paper outlines a request to the Group of Chief Scientific Advisors on how the European Commission can accelerate a responsible uptake of AI in science. Innovation holds the promise for economic prosperity and solution to global challenges. Science is at the heart of EU's research and innovation (R&I) policy, aiming to deliver new knowledge and breakthroughs for the benefit of society. Therefore, when referring to the global picture and outlook, this document uses the term R&I and when describing the particular request to the Group of Chief Scientific Advisors, we look more specifically at science as driver of innovation and the focus of our policy design.

2. ISSUE AT STAKE

Artificial Intelligence (AI) is one of the most disruptive sets of technologies our society has. AI has some characteristics of a 'General Purpose Technology', being applied in all sectors at high speed and in a disruptive manner, with the promise that it could achieve, and even surpass in some aspects, human abilities[1]. While science may serve as basis for developing AI-based applications, science is also to be considered as a specific field in which AI can be applied - some of the most complex scientific problems can be tackled with AI technologies (in general data-intensive ones, but not only). AI can be a big booster to research, accelerating scientific discoveries and bringing higher societal benefits faster.

AI is quickly becoming a transformative tool for the scientific processes, and already established new paradigms in diverse fields such as (but not limited to) biotechnology[2], material science[3], medical research[4], and social sciences[5], also in combination with other technologies (such as robotics)**.** While AI is itself a product of research, it has also been recognised as a powerful research tool, supporting scientists in their work. Its capabilities are very relevant to the process of scientific discovery[6] and innovation. For example, AI is already a key asset in the processing of scientific data on a large-scale and for the extraction and generation of patterns, predictions, or models. In addition, it is facilitating the understanding of scientific outputs (information retrieval, natural language processing or recommender systems in large repositories of scientific papers).

The use of AI is increasing among scientists and in all fields of science. The share of scientists using AI in their research increased from 12% in 2020 to 16% in 2021[7]. In the ERC, the use of AI is spread in almost in all fields, for instance in 'Geology, tectonics, volcanology'

[1] That is the case in some Narrow Artificial Intelligences that are focused on concrete tasks in which they could perform better than humans. i.e.: playing chess, finding patterns in data, etc.
[2] https://www.sciencedirect.com/science/article/pii/S1871678423000031
[3] https://www.nature.com/articles/s41524-022-00765-z
[4] https://www.nature.com/articles/s41591-021-01614-0
[5] https://link.springer.com/article/10.1007/s00146-022-01540-w
[6] Krenn, M., Pollice, R., Guo, S.Y. et al. On scientific understanding with artificial Intelligence, Nature (2022) .https://www.nature.com/articles/s42254-022-00518-3
[7] https://www.elsevier.com/connect/research-futures-2022

(18% of the projects have an AI component), linguistics (18%) or 'Sociology, demographics' (8%). Additionally, in the 2021-2022 work programme of the European Commission's Joint Research Centre (JRC), AI and its related technologies were present in around one quarter of the research projects[8]. This trend will likely accelerate in the coming years[9].

The application of AI in R&I would be a revolution rather than an incremental evolution. AI can be catalogued as a "general method of invention"[10] and its application in science and innovation is generating new paradigms. As such, it turbocharges the current trend of data-driven scientific discovery. It can reverse the slowdown in scientific productivity seen in recent years[11]. In particular AI can increase significantly the scientific production because it helps to accelerate the time to obtain results[12] (e.g.,. by using existing computational resources) and carry out research in ways that were not feasible before AI (e.g.,. by analysing large amounts of data or incorporating more complex models of prediction or by using AI methods to design and automatically control experiments[13]).

There are already discoveries anticipating the future of R&I when applying AI. For example, Google's AlphaFold, has made one of the most important discoveries in recent years. A multidisciplinary team of around 20 people (including chemists, physicists, and computer scientists) worked over 5 years on an AI model that has solved a problem that was at the core of biology for several decades. AlphaFold has modelled the folding of all known proteins (200 million) when before it took a PhD student several years to model a single protein. This means **an increase in productivity by a factor above 1 million**. And that discovery has already led to an enormous amount of additional work and discoveries by the scientific community.

Another innovation – OpenAI's ChatGPT – propelled the AI discussions and terminology straight into the mainstream. Based on the generative pre-trained transformer (GPT) family of language models, the tool is able to provide well-articulated human-like responses to prompts from a wide range of knowledge domains.

The functionalities of tools based on large language models (in addition to ChatGPT, there are also tools like Elicit and Perplexity) – the chatbot-style interface, enabling researchers to interact dynamically with the machine, to search for information, receive summaries of key points, to pose research questions and receive suggestions for potential research directions, to improve the researchers' prose – could turn these tools into virtual assistants to scientists, making their work more efficient and helping them to communicate their ideas more effectively.

[8] https://joint-research-centre.ec.europa.eu/jrc-science-and-knowledge-activities/trustworthy-artificial-intelligence-ai_en
[9] Nature Editorial, The scientific events that shaped the decade, Nature, 576 (2019), pp. 337-338
[10] Bianchini, S., Müller, M., & Pelletier, P. Artificial intelligence in science: An emerging general method of invention. Research Policy, 51(10), 104604 (2022).
[11] https://oecd.ai/en/wonk/ai-future-of-science
[12] In only an hour and a half, AI helped researchers narrow down thousands of potential chemicals to a handful that ultimately led to the discovery of a potential new powerful antibiotic: New superbug-killing antibiotic discovered using AI - BBC News.
[13] National Academies of Sciences, Engineering, and Medicine. 2022. Automated Research Workflows for Accelerated Discovery: Closing the Knowledge Discovery Loop. Washington, DC: The National Academies Press. https://doi.org/10.17226/26532

The success of ChatGPT triggered a race in AI investment[14] in the beginning of 2023 but also intensified the debate about the far-reaching consequences of the use of AI technology.

OpenAI emphasizes on the potential of AI to aid "in the discovery of new scientific knowledge that changes the limits of possibility". Other leading figures in the tech world have also pointed to the promise AI holds for science:

> *"I believe we are on the cusp of an exciting new era in science with AI poised to be a powerful tool for accelerating scientific discovery itself." "I believe (AI) could usher in a new renaissance of discovery, acting as a multiplier for human ingenuity"* (Demis Hassabis, CEO DeepMind)

> "*one of the things I find pretty promising about AI is the use of the AI in science*" (Yann LeCun, chief AI scientist for Meta)

… and to the urgent need for society to adapt to a world with powerful AI and for policy-makers to catch up with the latest technology developments[15].

Further into the future, there are predictions about AI being able to autonomously make scientific discoveries - the Turing Institute launched a challenge to develop by 2050 an "*AI Scientist*" capable of making Nobel-quality discoveries comparable, or superior, to the best human scientists[16].

The EU still has no dedicated and systemic policy to facilitate the uptake of AI in science. This is in spite of being among the most active global players in AI, and having a powerful and dynamic research community. The Commission launched different policy actions for the successful take-up of AI in the EU and development of "Core AI" technologies. These policies complement each other in different ways, and some of them would be key enablers to the adoption of AI in R&I. However, there is a risk of missing out on some benefits that AI could bring to science.

There is a need for a policy that can connect and complement the different AI initiatives that can impact the uptake of AI in science and for new, better targeted policies on its application. The successful adoption of AI by the scientific community should trickle down into more science-based start-ups, research spin-offs and deep-tech companies. Therefore, we as policy-makers need to anticipate these changes and steer them to ensure that accelerated scientific progress thanks to AI provides faster, larger, and positive societal outcomes.

There are specific needs and gaps in the adoption of AI in R&I that need targeted, systemic policy. AI opens a significant amount of opportunities for R&I but its successful adoption faces specific challenges, such as, the impact on the scientific process (to ensure accurate,

[14] https://www.economist.com/business/2023/01/30/the-race-of-the-ai-labs-heats-up , https://www.reuters.com/markets/deals/biontech-acquire-british-artificial-intelligence-startup-instadeep-2023-01-10/

[15] Pause Giant AI Experiments: An Open Letter - Future of Life Institute

[16] https://www.turing.ac.uk/research/research-projects/turing-ai-scientist-grand-challenge

robust and reproducible results, to avoid the misuse of AI, , to address issues with IP rights), the need for transdisciplinarity[17] in policy design and multi- and interdisciplinarity of researchers teams (bringing researchers with domain- and AI knowledge together), the optimisation of human-machine collaboration in R&I activities, ensuring that the R&I community has easy access to the right infrastructure and data[18], or the challenges to attract AI talent to work in R&I projects, dedicated AI technology for science etc. Well-designed policies to address these specific issues will provide earlier and more successful results.

The AI in R&I policy design should include new policies, but also adapt existing ones. In R&I the impact of AI is relevant in many different areas, and R&I policies should be AI-friendly or AI-ready. Following the proposal for an AI Act and the Coordinated Action Plan on AI, the adoption of sectorial policies to AI is starting in many areas (education, health, public sector etc.) and R&I policies should not be an exception. Furthermore, the advance AI could bring to research would have a spill-over effect on policy areas which rely on innovation and scientific breakthrough to deliver on societal challenges (such as medicine, climate, etc.)

While the rewards of successfully adopting AI are promising, the threat of lagging behind other global players is major. The US and China are investing massively in the development of AI, with US Big Tech leading many fields, and with large state support in China[19]. Assuming that the science of the future will be tied to the application of AI, that could lead to network effects where the most technological advanced in terms of AI will accumulate an even higher share of scientific discoveries at a faster pace. That could have strong implications in terms of technological and scientific sovereignty. Europe could be left out, or even worse, locked out of the next breakthrough discoveries.[20]

Additionally, current applications of AI in R&I are strongly conditioned by the private agenda and foreign-owned tools. Big companies are leading in many aspects the AI revolution, and that can lead to biased priorities, as some scientific areas might not be seen as immediately profitable. At the same time, they have a big influence on the technical solutions that then will be used by scientists. The EU needs to set its own agenda and build the adequate set of resources to ensure public goods in R&I, complementing the private sector.

[17] Editorial-Transdisciplinary-Innovation-August-2018.pdf (researchgate.net)
[18] Data are, as a general rule, considered to be facts and therefore do not give rise to intellectual property rights. However, in specific cases, e.g. the rights set out in the database directive (Directive 96/9/EC of 11 March 1996), data availability for scientific research purposes may be hampered.
[19] See, Geopolitical Lens: AI Policy and Grand-Strategy in 2030, page 10, Trends in Artificial Intelligence and Big Data, ESPAS paper
[20] Feijóo et al., Harnessing artificial intelligence (AI) to increase wellbeing for all: The case for a new technology diplomacy, Telecommunications Policy, Volume 44, Issue 6,2020

3. EU POLICY BACKGROUND

The European Commission's strategy on AI was first articulated in April 2018 with the Communication "**AI for Europe**", and was further operationalised in subsequent communications.:

In December of 2018 the first version of the **EU Coordinated Plan** was adopted. This was developed jointly with Member States, and listed a number of actions both at EU and at national level.

In April 2019 the Commission adopted the Communication "**Building Trust in a human centric AI**." It was accompanied by a Staff Working Document developed by the High Level Expert Group on AI, which proposed "Ethics Guidelines for trustworthy AI."

The White Paper on "**Artificial Intelligence: a European approach to excellence and trust**" adopted in February 2020 was the first deliverable of the von der Leyen Commission. It outlined a number of actions, which aimed at a) Developing an AI European ecosystem of Excellence in AI, and b) Developing an ecosystem of trust.
The White paper resulted in the adoption in April 2021 of:

- The cover Communication "**Fostering a European approach to Artificial Intelligence**"
- An updated **AI coordinated plan** corresponding to the "AI European ecosystem of excellence "requirement of the AI white paper,
- The proposal of the **AI act**, which corresponds to the "Ecosystem of trust" requirement of the AI white paper.

The **updated coordinated plan** details new and already running actions for boosting capacity on AI technologies and their use in Europe. It includes:

- Funding in Horizon Europe and Digital Europe Programmes. Examples:
    - AI networks of excellence centres designed to boost the development of AI technologies
    - Digital Innovation hubs with focus on AI, which provide companies with a possibility to test AI technologies before investing as well as related services, such as financing advice and advice on training and skills development that are needed for a successful digital transformation.
    - The AI on demand platform designed to give access to all relevant resources (eg software, algorithms, etc.) to innovators that would like to develop or use AI
    - Actions on Data including the creation of European Data Spaces,
- Actions on Skills

- The announcement of legislation that is designed to make more data available, such as the Data Governance Act, the Data Act, etc. The **AI Act**, sets requirements for the development of high risk AI systems. It also bans AI systems that are considered of unacceptable risk. In the process of negotiations on the AI Act, the co-legislators have explicitly maintained that the AI act does not apply to research. The Council general approach added an explicit exclusion for research.

Since it will take some time before the EU regulation on AI enters into force, and as pressure for a coordinated global action on AI is mounting[21], EU decision-makers have proposed measures to step up global cooperation on AI to establish minimum standards before legislation enters into force. Executive Vice-President Margrethe Vestager is consolidating efforts to create a voluntary Code of Conduct with the US government, which would see companies using or developing AI sign up voluntarily to a set of non-binding standards. Vice-President Věra Jourová has suggested[22] that companies deploying generative AI tools with the potential to generate disinformation should label such content. To anticipate the implementation of the AI Act, Commissioner for Internal Market, Thierry Breton, has started working with AI developers on an "AI Pact"[23], which would bring together, on a voluntary basis, the main EU and non-EU actors in the field to inform and raise awareness of the principles underlying the AI Act.

A European Centre for Algorithmic Transparency (ECAT)[24] was established with a commitment to improved understanding and proper regulation of algorithmic systems. It is set out to contribute to a safer, more predictable and trusted online environment for people and business, by providing technical assistance and practical guidance.

In 2022, the European Commission also published a set of **ethical guidelines for educators** on the use of AI and data in education[25]. Awareness raising on the use of AI in education is currently ongoing, including numerous articles, webinars and resources published on the European School Education Platform and a MOOC for teachers under preparation. Studies on the use of (generative) AI in education are underway, in collaboration between EAC and JRC, as well as studies on the future of education (including AI) and on the convergence of the green and digital transition in schools.

[21] 100506878.pdf (mofa.go.jp)
[22] AI generated content should be labelled, EU Commissioner Jourova says | Reuters
[23] https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_23_3344
[24] https://algorithmic-transparency.ec.europa.eu/index_en
[25] https://education.ec.europa.eu/uk/news/ethical-guidelines-on-the-use-of-artificial-intelligence-and-data-in-teaching-and-learning-for-educators

In 2023, in the context of the European Year of Skills, the Commission reiterated the importance of high-quality, inclusive and accessible digital education and skills, and published two proposals to address the lack of a whole-of-government approach to digital education and training, and the difficulties in equipping people with the necessary digital skills.

4. REQUEST TO THE GROUP OF CHIEF SCIENTIFIC ADVISORS

The request to the Group of Chief Scientific Advisors is:

How can the European Commission accelerate a responsible uptake of AI in science (including providing access to high quality AI, respecting European Values) in order to boost the EU's innovation and prosperity, strengthen EU's position in science and ultimately contribute to solving Europe's societal challenges?

The Group's advice should be based on a thorough assessment of the barriers which currently exist to a wider uptake of AI in science across domains at EU and national level, of the potential opportunities to seize and of the risks to anticipate and mitigate.

Keeping in mind the wide scope of the topic and its far-reaching consequences, and in order to inform the GCSA's policy recommendations, we ask the SAM to gather evidence in four key areas related to AI in science: **1/Vision and foresight, 2/Scientific process, 3/People, 4/Policy design.**

In addition, the evidence review phase should include two "deep dives": one on the **disruptive potential of AI in different fields of science** and one on the **impact of AI on everyday scientific practice and workflow.**

The Group is requested to finalize and publish their Scientific Opinion during the second quarter of 2024. An intermediate output specifically focused on the benefits of AI for scientific productivity and the European innovation ecosystem (Key area 1) is expected as soon as possible and at the latest before the end of 2023.

In the following, the guiding questions for each of these key areas and deep dives are presented.

Key area 1 – Vision and foresight

What impetus could AI give to scientific productivity and what benefits, incentives and challenges would AI-enabled research bring to the European innovation ecosystem and the society as a whole?

The Group's advice should be informed by evidence on the effect of the use of AI in science in the EU and on the expected impact of AI on the productivity, quality and accessibility of European science, as well as on EU's strategic priorities (climate neutrality, strategic autonomy, digitalisation, security, health, social fairness, etc.)

Key area 2 – Scientific process

What is the impact of AI on the scientific process, and its potential to re-shape science and its governance practices?

The Group's advice should be informed by evidence on how to best integrate AI tools, and the processes involved with using AI, in everyday scientific practice and workflow across domains (hypothesis generation, experiment design, monitoring and simulation, scientific publication) and on AI's potential to identify new research questions and opportunities, to develop new scientific fields, to improve networking, community-building and collaboration in science (including human-AI collaboration and the use of collective intelligence). The Group should also explore the potential gaps of AI technology, as well as AI tools that can be trusted in the scientific process. The Group should take into consideration the possible risks of applying AI in the scientific process and any specific workflows and checks that could be put in practice.

Key area 3 – People

How can the EU best prepare for the impact and requirements of AI on the education and careers of the scientists and researchers of today and tomorrow, and what skills and competencies should education policies prioritise in this context?

The Group's advice should be informed by an assessment of ways to ensure that researchers (at all stages of their education and professional development) and organizations have sufficient knowledge on using AI in science (and on related skills such as IT and computing, statistics, data analytics) and affordable access to infrastructure, data, computing capacity and AI tools and technologies. It should also consider which scientific jobs carry a high risk of being outsourced to AI-based technology; and the impact of AI (taking over some of researchers' tasks) on scientific workforce and researchers' careers. .

Key area 4 – Policy design

How should the Commission (through policy initiatives, regulation, communication, and outreach) facilitate responsible and timely AI uptake by the scientific and research communities across the EU?

The Group's advice should be informed by an assessment of the current regulatory context[26], and should give guidance on the role the Commission and other EU institutions should play to boost application of AI in science; on the potential needs and ways of promoting/communicating AI use in scientific communities; and on measures to ensure a level-playing field between big technology companies and public/smaller/independent research organisations, whilst ensuring that the EU does not lose the battle for talent in AI-powered research. The need for balancing costs and benefits (including the related issues of energy consumption and sustainability; of the interoperability, availability and reliability of data underpinning AI; and of diversity and inclusiveness in research, for example related to culture/language bias) should also be taken into account.

Deep dive 1 – AI's disruptive potential

Which scientific domains are experiencing (or could experience in the near future) the most positive impact of AI-enabled research, and in what areas does one expect major breakthroughs? Conversely, in which R&I fields is AI not sufficiently developed yet, also in comparison to other countries?

The evidence review should consider which scientific domains are better prepared to embrace AI and, conversely, in which the use of AI is not sufficiently developed yet; which are the barriers to ensure that AI is widely used in all scientific domains, overcoming potential technical issues; and what would be the impact of geopolitical divisions on AI-enabled research (e.g. on the access to diverse and quality scientific data and expertise).

Deep dive 2 – AI's impact on scientific practice

[26] In relation to this, a study commissioned in the framework of ERA Action 2 ("Propose and EU copyright and data legislative and regulatory framework fit for research") will i) identify the relevant provisions for researchers, research organisations, research infrastructures and research services providers under the AI Act and ii) assess and present how they can comply with the obligations and benefit from the rights they may have under this act.

What is the impact (positive and negative) of AI on everyday scientific practice and workflow (such as on hypothesis generation, experiment design, monitoring and simulation, scientific publication of research results, intellectual property rights, etc.)?

ANNEX 3 – POLICY LANDSCAPE

Introduction

The President of the European Commission Ursula von der Leyen highlighted artificial intelligence (AI) as *a very significant opportunity – if used in a responsible way*[7] in her speech at the World Economic Forum in Davos in early January 2024. Shortly before, she stressed the potential societal benefits of AI, while also acknowledging the risks in her 2023 State of the Union address[8] where she announced a new initiative to make Europe's supercomputers available to innovative European AI start-ups in to train their trustworthy AI models.

Late January 2024, the Commission adopted a package to support AI start-ups and innovation, including a proposal to provide privileged access to supercomputers for AI start-ups and the broader innovation community. Alongside this the Commission also initiated and EU AI Office, and other support initiatives for Europe's start-up ecosystem.

The policy landscape on AI develops fast. This section of the Scientific Opinion is a non-exhaustive overview at the time of writing (mid-March 2024).

The European approach to artificial intelligence

The legal basis

The common principles and values that underlie life in the EU are freedom, democracy, equality and the rule of law, promoting peace and stability[9]. The EU only has the competences conferred on it by the Treaties. Under this principle, the EU may only act within the limits of the competences conferred upon it by the EU Member States in the treaties to attain the treaties' objectives. Competences not conferred upon the EU in the treaties remain with the Member States.

[7] https://www.weforum.org/agenda/2024/01/ursula-von-der-leyen-full-speech-davos/
[8] https://state-of-the-union.ec.europa.eu/index_en
[9] https://european-union.europa.eu/principles-countries-history_en#:~:text=The%20common%20principles%20and%20values,law%2C%20promoting%20peace%20and%20stability.

Research and technological developments are shared competences[10].

The strategic importance of AI

The European AI ecosystem is characterised by its complex, interlaced and highly cooperative environment, with especially the latter setting it apart from other global AI ecosystems. Research and development activities are benefitting from the close cooperation between industry, academia, and cross-sectoral national hub networks that enable ideal knowledge and technology transfer if desired.

AI already has a broad impact in all fields of science and a high potential for boosting scientific productivity, which could result in novel ways of meeting global challenges[11]. AI can also significantly impact how scientists work and are trained.

Thus, the Commission is committed to improving the responsible uptake of AI in research and innovation, as there is a common understanding that the EU must be part of this productivity gain to enhance its strategic autonomy. The study "Trends in the Use of AI in Science"[12], shows the high growth rate of the use of AI in science as proof of a broad uptake in all fields of science. The commitment to seize the opportunities AI can offer in R&I is also shown by the policy brief on AI in Science published in December 2023[13], which advocates for a tailored European policy in this field and identifies initial science-specific areas of action. In March 2024, the Commission also published "Guidelines on the responsible use of generative AI in research"[14], living guidelines co-created by the Commission, Member States and stakeholders for researchers, research organisations and research funding organisations. In parallel, on top of the existing guidelines on AI in the ethics self-assessment for EU grants, the Commission is also in the process of developing "An ethics framework for AI research/Guidance notes on algorithmic governance and assessment, bias and informed consent", to ensure that the uptake of AI in science remains trustworthy and ethical. The

[10] https://eur-lex.europa.eu/EN/legal-content/summary/division-of-competences-within-the-european-union.html
[11] Artificial Intelligence in Science: Challenges, Opportunities and the Future of Research | en | OECD
[12] https://op.europa.eu/en/publication-detail/-/publication/2458267c-08df-11ee-b12e-01aa75ed71a1/language-en
[13] AI in science - Publications Office of the EU (europa.eu)
[14] Living guidelines on the responsible use of generative AI in research | Research and innovation (europa.eu)

Trustworthy AI portfolio of the Joint Research Centre of the Commission may also be instrumental in that regard[15].

The EU strategy for AI in the making

The EU has long recognised the strategic importance of AI as a tool that can bring major benefits to society and the economy. The EU's approach to AI centres on **excellence** and **trust**, aiming to boost research and industrial capacity while ensuring **safety** and **fundamental rights**.

In her 2023 State of the EU speech, President Von der Leyen[16] also stated that Europe, together with partners, should lead the way on a new global framework for AI, built on three pillars: **guardrails**, **governance** and **guiding innovation**. This would allow to develop a fast and globally coordinated response, building on the work done by the **Hiroshima Process**[17] and other efforts such as the G7 group on global principles. She also mentioned the need to develop and deploy AI in a human centric and responsible way and develop standards for ethical use of AI.

The EU has been actively working on shaping AI policy, focusing on a balanced approach, aiming to foster innovation while ensuring ethical AI deployment. The significant challenge is to strike a balance between innovation and a responsible and human-centric AI deployment with transparency and accountability. Policies such as the Regulatory framework proposal on AI (`**EU AI Act'**) propose regulatory frameworks to govern AI applications, especially those considered high-risk, but exclude research practices.

The Commission first launched a series of measures in April 2018 to improve European competitiveness in the field of AI, as outlined in the "**Artificial intelligence for Europe**"[18] Communication. This was followed in December 2018 by the first **Coordinated Plan on AI** prepared by the Commission and Member States to define actions and funding instruments for the development and uptake of AI. The Coordinated Plan aimed at enabling a landscape of national strategies and EU funding for **public-private partnerships and research and innovation networks**[19]. In April 2019, the Commission adopted the Communication "**Building Trust in Human-Centric Artificial**

[15] https://joint-research-centre.ec.europa.eu/jrc-science-and-knowledge-activities/trustworthy-artificial-intelligence-ai_en
[16] https://ec.europa.eu/commission/presscorner/detail/en/speech_23_4426
[17] https://www.mofa.go.jp/files/100573473.pdf
[18] EUR-Lex - 52018DC0237 - EN - EUR-Lex (europa.eu)
[19] https://digital-strategy.ec.europa.eu/en/policies/plan-ai

Intelligence"[20], which welcomed and supported the accompanying "**Ethics Guidelines for trustworthy AI**"[21] developed by the High-Level Expert Group on AI. The Guidelines were followed in June 2019 by "Policy and investment recommendations for trustworthy AI", which included among others recommendations on funding, promotion of interdisciplinary and multi-stakeholder research, talent formation, attraction and retention, access to infrastructure and data management and sharing. With the White Paper on "**Artificial Intelligence: a European approach to excellence and trust**"[22] adopted in February 2020, the Commission committed to both promoting the uptake of AI and addressing the risks associated with certain uses of this technology.

In April 2021, the Commission proposed new rules and actions to turn Europe into a global hub for **trustworthy AI**. It presented an **AI package**, including a **Communication on fostering a European approach to AI**, a **review of the Coordinated Plan on AI** (with EU Member States), a **Regulatory framework proposal on AI** (the '**EU AI Act'**) and relevant Impact assessment.[23] On 16 June 2023, the European Parliament Plenary adopted its negotiating position on the 'EU AI Act' with an overwhelming majority. To boost AI innovation and support SMEs, MEPs added exemptions for research activities and AI components provided under open-source licenses. The Act also promotes regulatory sandboxes to test AI before it is deployed. In December 2023, the provisional political agreement between the Council and European Parliament confirmed that the regulation would not apply to AI systems used for the sole purpose of **research and innovation**[24]. As part of the governance architecture to enforce the new rules on general purpose AI models[25], the European co-legislators agreed on setting up an **AI Office** within the Commission, advised by a scientific panel of independent experts that should contribute to the development of methodologies for evaluating the capabilities of foundation models, advise on the designation and the emergence of high impact foundation models, and monitor possible material safety risks related to foundation models. The agreement also foresees an **advisory forum** for stakeholders, such as industry representatives, SMEs, start-ups, civil society, and **academia**, will be set up to provide technical expertise to the **AI Board,** which will be formed by Member State

[20] EUR-Lex - 52019DC0168 - EN - EUR-Lex (europa.eu)
[21] Ethics guidelines for trustworthy AI | Shaping Europe's digital future (europa.eu)
[22] EUR-Lex - 52020DC0065 - EN - EUR-Lex (europa.eu)
[23] https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence
[24] Artificial intelligence act: Council and Parliament strike a deal on the first rules for AI in the world - Consilium (europa.eu)
[25] Artificial Intelligence – Q&As (europa.eu)

representatives and the European Centre for Algorithmic Transparency (ECAT) of the Commission. The AI Act was approved by the European Parliament in March 2024.

With the combination of comprehensive legislation and a Coordinated Plan with Member States, the Commission aimed at guaranteeing the safety and fundamental rights of people and businesses, while strengthening AI uptake, investment and **innovation** across the EU[26]. As summarised by Commissioner Ivanova, [the EU AI Act] *sets the stage for trustworthy AI with clear and balanced rules for ethical, safe, and secure technology. Europe is the global compass for tech governance!*

In January 2024, the Commission launched a new **AI package**[27], focused on support to European start-ups and SMEs in the development of trustworthy AI. In this AI package, the Commission proposed an amendment of the EuroHPC Regulation to set up AI Factories[28], facilitating access to AI-dedicated supercomputers to train large general purpose AI models and offering AI-enabling services; established an AI Office within the Commission[29] (which entered into force in February 2024), to ensure the development and coordination of AI policy at European level, as well as supervise the implementation and enforcement of the forthcoming AI Act[30]; published a **"Communication on boosting start-ups and innovation in trustworthy artificial intelligence"[31]** outlining additional financial support for generative AI through Horizon Europe and Digital Europe, venture capital and equity support, the acceleration of the development of the Common European Data Spaces[32] to make available to the AI community, and the "GenAI4EU" initiative to support development of novel use cases and emerging applications in Europe's 14 industrial ecosystems (including biotechnology and the sciences). The Commission also announced the establishment, with a number of Member States, of two European Digital Infrastructure Consortia[33]: the 'Alliance for Language Technologies' to develop a common European infrastructure in language technologies and support the development of European large language models; and 'CitiVERSE' to develop and enhance Local Digital Twins

[26] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_1682
[27] Commission launches AI innovation package (europa.eu)
[28] EUR-Lex - COM:2024:29:FIN - EN - EUR-Lex (europa.eu)
[29] Commission Decision Establishing the European AI Office | Shaping Europe's digital future (europa.eu)
[30] European AI Office | Shaping Europe's digital future (europa.eu)
[31] EUR-Lex - COM:2024:28:FIN - EN - EUR-Lex (europa.eu)
[32] Second staff working document on data spaces | Shaping Europe's digital future (europa.eu)
[33] European Digital Infrastructure Consortium (EDIC) | Shaping Europe's digital future (europa.eu)

for Smart Communities, helping cities simulate and optimise processes, from traffic management to waste management.

In their 2024+ Work Programme, the **European Court of Auditors** foresees to publish a special report on AI 'to assess whether the Commission was effective in creating a European ecosystem for the development of artificial intelligence'[34].

The European research and innovation landscape and artificial intelligence

The European Research and Innovation Area (ERA)

The **European Research and Innovation Area** (ERA) is an objective established in Article 179 of the Treaty on the Functioning of the European Union (TFEU). It aims at achieving an area in which researchers, scientific knowledge and technology circulate freely. The ERA Policy Agenda for 2022-2024 focuses on several priority actions that may intertwine with AI in Research and Innovation.

The proposal of revamped ERA Action 1 "Enabling open science via sharing and re-use of data, including through the European Open Science Cloud (EOSC)" involves on one hand establishment of European federation of EOSC Nodes and a web of FAIR (Findable, Accessible, Interoperable, Reusable) data, and on the other hand an upcoming proposal to make the EU's copyright and data legislative framework fit for research. These initiatives are intended to improve legal and technical conditions for access, share and reuse of publications and data for scientific purposes, which with facilitate more efficient utilisation of AI tools with a larger pool of data.

During 2024, the Commission will refine the draft ERA proposals in dialogue with member states and R&I stakeholders, including a conference in 2024Q3 to engage the broader stakeholder community. Following these consultations, the Commission will in 2025Q1 present a Council Recommendation on the ERA Policy Agenda 2025-2027, which is expected to be adopted by the Council in 2025 Q1-Q2.

[34] https://www.eca.europa.eu/ECAPublications/WP-2024/WP-2024_EN.pdf

The New European Innovation Agenda (NEIA)

The Commission's current innovation policy is based on the **New European Innovation Agenda** (NEIA) [35]. The Agenda was adopted in July 2022 as the overarching innovation strategy to position Europe at the forefront of the new wave of innovation (deep tech innovation). The NEIA aims to position Europe at the forefront of the new wave of **deep tech innovation** and **start-ups**. The objective is to help Europe develop new technologies to address the most pressing societal challenges and bring them to the market.

The European Innovation Scoreboard 2023 highlights a substantial improvement in the innovation performance of approximately 8.5% since 2016, confirming the EU's commitment to fostering a culture of innovation. However, despite progress, the EU's **innovation divide** persists and is predominantly shaped by geographic concentrations[36]. This divide emphasises the need for targeted efforts to bridge the innovation gap and foster equitable growth across the EU, which is one of the goals of the NEIA**.** Through strategic initiatives like the **Deep Tech Talent Initiative**[37], the **Innovation Talent Platform**[38], and the **Regional Innovation Valleys**[39], the EU aims to foster deep tech innovation and promote a start-up culture.

Addressing the innovation divide has remained a priority for EU policies, notably **cohesion and R&I policies**, with the adoption of many policy initiatives and the investment of significant resources. At the same time, the EU R&I policy focuses on how the EU can develop its technological capacities and achieve **technological sovereignty** (ensuring access to critical technologies) and **strategic autonomy** (acting independently and strategically in the geopolitical arena without jeopardising open economic models).

Horizon Europe

With a budget of 95.5 billion EUR, **Horizon Europe[40]** is the EU's key funding programme for research and innovation. It dedicates at least 35% of the overall budget to climate action and 10% to biodiversity. It goes however

[35] https://research-and-innovation.ec.europa.eu/strategy/support-policy-making/shaping-eu-research-and-innovation-policy/new-european-innovation-agenda_en
[36] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_3683
[37] https://www.eitdeeptechtalent.eu/
[38] https://euraxess.ec.europa.eu/euraxess/innovation-talent-platform
[39] https://ec.europa.eu/regional_policy/whats-new/newsroom/24-09-2023-regional-innovation-valley-matchmaking-map-now-available_en
[40] Horizon Europe - European Commission (europa.eu)

beyond technological advancements and breakthroughs, exploring governance, business and social innovation. The Commission, through the **Directorate-General for Research and Innovation** (R&I) designs and implement R&I policies and programmes with Member States, international partners, stakeholders and citizens. These policies and programmes, supported by investment and relevant regulation, deliver new knowledge and game-changing innovation for EU priorities, notably the **green and digital twin transformation**. The vision is of a sustainable, safe, fair and prosperous future for the people and the planet based on solidarity and respect for common European values. Modern technologies, sustainable solutions and disruptive innovation are needed to achieve climate neutrality and circularity, decarbonise the economy and the industry, modernise our infrastructures and buildings, and design sustainable food and water systems. R&I is also a geo-strategic asset: it can foster the EU's international position and enhance security by providing strategic capacities in key cutting-edge technologies such as **AI**, technologies critical for achieving the EU's political priorities (e.g., clean/green tech) or military capabilities.

While Horizon Europe offers opportunities to researchers and innovators from all over the world, restrictions can be introduced where necessary as foreseen by articles 22(5), 22(6) and 40 of the Horizon Europe regulation[41]. These articles introduce provisions to exclude third-country entities from calls in certain sensitive areas (art 22(5)), introduce additional eligibility criteria (for example for close-to-market innovation actions) (art 22(6)), and introduce the right for the Commission or the relevant funding body to object to transfers of ownership of results, or to granting of an exclusive licence regarding results (art 40).

The definition of the **work programmes 2025-2027** goes hand in hand with drafting the next ERA Policy agenda. It is also closely linked to the strategic planning of the second term of Horizon Europe as it needs to create synergies with other parts of the Horizon Europe programme and funding.

Since 2014, the number of projects managed by the **European Research Executive Agency** (REA) linked to AI has increased every year. Today, REA manages more than 1,000 projects with a focus on AI or that use AI tools. The projects received over 1.7 billion EUR in EU funding under the Horizon 2020 and Horizon Europe programmes[42].

[41] EUR-Lex - 32021R0695 - EN - EUR-Lex (europa.eu)
[42] European Commission.

Since 2021, DG RTD has provided the operational guidelines **Ethics By Design and Ethics of Use Approaches for Artificial Intelligence**[43] for grants under Horizon Europe. These guidelines aim to provide guidance for all research activities involving the development or/and use of AI-based systems or techniques, including robotics, building on the work of the Independent High-Level Expert Group on AI and their 'Ethics Guidelines for Trustworthy AI'. Through this guidance, researchers are encouraged to adopt an ethically-focused approach while designing, developing, and deploying and/or using AI based solutions and to follow specific steps in order to produce an AI which possess key characteristics that preserve and promote human agency; privacy, personal data protection and data governance; fairness; individual, social, and environmental well-being; transparency; accountability and oversight. AI is also included among the categories that require an ethics self-assessment by researchers applying for a EU grant under any EU programme[44].

Horizon Europe offers guidance on the use of generative AI tools for the preparation of proposals, asking to exercise caution and careful consideration. In particular, it says that *Applicants are fully responsible for the content of the proposal (even those parts produced by the AI tool) and must be transparent in disclosing which AI tools were used and how they were utilized*. In addition, if an activity involves the development, deployment and/or use of AI-based systems, the self-assessment should detail whether that could raise ethical concerns related to human rights and values, and detail how this would be addressed[45].

The European Research Council (ERC)

Also part of the Horizon Europe programme, the **European Research Council (ERC)** funds frontier research and is led by an independent governing body, the Scientific Council. The ERC has supported frontier research into and using **AI** since its inception and sees that recent advances, particularly in Generative AI, will bring profound changes both to society at large and the research process. In a recent statement, the ERC Scientific Council recognises that researchers regularly seek input from AI technologies or human third parties, for example to brainstorm or generate ideas, to search the literature,

[43] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/ethics-by-design-and-ethics-of-use-approaches-for-artificial-intelligence_he_en.pdf
[44] how-to-complete-your-ethics-self-assessment_en.pdf (europa.eu)
[45] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/temp-form/af/af_he-ria-ia_en.pdf

and to revise, translate or summarise text. The ERC Scientific Council emphasises that use of external help in preparing a proposal does not relieve the author from taking full and sole authorship responsibilities with regard to acknowledgements, plagiarism and the practice of good scientific and professional conduct. The ERC is following the fast developments in the area, and will renew its policies as needed[46].

To support the Commission's policy initiative on the use of AI in science, the ERC has conducted a first foresight survey among ERC grantees that are using AI in their research[47]. This survey focused on their present use of AI and their views on future developments by 2030, potential opportunities and risks, and the future impact of generative AI in science, such as large language models (LLMs).

Also as support to the Commission's initiative and within its feedback to policy (F2P) activities, the ERC conducted a portfolio analysis of projects using and developing AI. Since it was set up in 2007, the ERC has funded more than 1,000 projects across all scientific domains and types of grants. The Mapping Frontier Research (MRF) report highlights how ERC funded curiosity-driven research is developing or using AI in their scientific processes, and how it can help to define and implement policies related to its broad field and its cross-cutting applications[48].

The European Innovation Council (EIC)

The European Innovation Council (EIC) aims to identifying, developing and scaling up breakthrough technologies and game changing innovation. With a budget of over 10 billion EUR under Horizon Europe, this most ambitious innovation initiative focuses on deep-tech, high risk research and innovation[49]. EIC funds activities in the whole technological development spectrum, from early applied research on AI to supporting companies in developing specific applications, utilising AI. The EIC instruments with their open calls (bottom-up approach) aim to diversify the usual top-down approach in AI funding and create an innovation system driven by research discoveries and market needs.

Since its creation, the EIC has placed significant efforts to attract the brightest AI research and innovation ideas and help them go to market. In the period

[46] https://erc.europa.eu/news-events/news/current-position-erc-scientific-council-artificial-intelligence
[47] https://data.europa.eu/doi/10.2828/10694
[48] https://erc.europa.eu/sites/default/files/2024-03/report-AI.pdf
[49] About the European Innovation Council - European Commission (europa.eu)

2018-2023, it has supported 97 research and innovation projects through EIC Pathfinder and EIC Transition, developing AI related software, hardware or both, with 334 million EUR in grants at technology readiness levels from 1-5. In parallel, the EIC has supported 273 deep-tech companies developing AI based innovations, with over 557 million in grants and 619 million Euro in equity funding.

All these AI projects have worked on the development of various techniques, including Machine and Deep learning, Neural networks, AI algorithms, Natural language processing, Computer vision, Edge computing, Quantum computing, Virtual and Augmented reality, Generative AI, and AI chips.

The applications, where AI has been applied in all these projects are diverse. They include Scientific research, design & engineering, Robotics, Business & Industry, Financial markets & services, Media, communication, web & entertainment, ICT infrastructure, Health & wellbeing, Mobility & transportation, Agriculture, food, & fisheries, Environment, energy & sustainability, Public sector & citizens services, Learning & education, Safety & security, Space.

The EIC also launched AI-focused EIC Challenges calls. The current 2024 Work Programme includes a top-down EIC Accelerator Challenge call on Human Centric Generative AI made in Europe, with a budget of 50 million EUR[50].

The Marie Skłodowska-Curie Actions (MSCA)

The **Marie Skłodowska-Curie Actions (MSCA)** are the European Union's reference programme for doctoral education and postdoctoral training, as well interdisciplinary staff exchanges. If the activities proposed involve the use and/or development of AI-based systems and/or techniques, applicants must provide explanations on the technical robustness of the proposed system(s)[51].

By design, the MSCA approach to promoting the training, mobility and career development of researchers is increasing their intake of AI both in their ongoing research and for their future competitiveness in the labour market. Training researchers on transferable skills is a (mandatory) cornerstone of MSCA projects. While the exact topics of the training plans on transferable skills are not dictated by MSCA, it is likely that AI will become a prominent and regular feature in the transferable skills plans of MSCA projects at all

[50] EIC Work Programme 2024
[51] https://msca-net.eu/wp-content/uploads/2023/09/MSCANET_DN2023_final.pdf

career stages. At the same time, AI will change the landscape of the labour market for all professions including for researchers. This includes changes in market needs, but also changes in the skills needed to be competitive in the job market. A Career Development Plan (CDP) for each fellow is an obligatory deliverable in the main MSCA actions. The CDP should be an additional tool for enhancing the AI uptake by researchers.

MSCA is also directly contributing the research and innovation in the AI field. Given the bottom-up nature of MSCA, no specific research topic is specified in the calls for proposals. Research topics are chosen by the researchers who apply and they reflect the existing trends in the research community. Therefore, and given the growing importance of AI, it is expected that projects will increasingly revolve around AI from various angles (technical, legal, sociological, ethical, *etc*.). Indeed, in Horizon 2020, MSCA had the highest number of projects (530 projects) in the Excellent Science Pillar related to AI and with 6316 researchers involved. As for the ERC, authors of MSCA applications take full and sole authorship responsibilities with regard to acknowledgements, plagiarism and the practice of good scientific and professional conduct when using AI in preparing a proposal.

The European Partnerships

An important implementation tool of Horizon Europe are the 49 European Partnerships[52], which bring together the Commission and private and/or public partners to address some of Europe's most pressing challenges through concerted research and innovation initiatives. The European Partnerships aim to avoid the duplication of public and private investments and to contribute to reducing the fragmentation of the research and innovation landscape in the EU. Up to now, almost 65 billion EUR have been committed to European Partnerships: 24.8 billion EUR from Horizon Europe and 35.6 billion EUR from the partners other than the EU, out of which almost 65% come from industry.

The 49 Partnerships are divided across 5 areas (health; digital, industry and space; climate, energy and mobility; food, bio economy, natural resources, agriculture and environment; partnerships across themes). Horizon Europe Partnerships with a relevant AI component include:

[52] European Partnerships in Horizon Europe - European Commission (europa.eu)

- EuroHPC Joint Undertaking, to develop a world class supercomputing ecosystem in Europe (see Access to High Performance Computing section)

- AI, Data and Robotics Partnership, to drive innovation, acceptance and uptake of trustworthy, safe and robust AI, data and robotics, in a way that is compatible with EU values and regulations[53].

- Connected, Cooperative and Automated Mobility, which identifies AI among the "Key Enabling Technologies"[54] to support the development and implementation of automated mobility

The European Institute of Innovation and Technology (EIT)

The EIT and its Knowledge and Innovation Communities (KICs) partner up with leading education institutions, research organisations and businesses to boost the EU's technological and industrial capacity in AI, empower the education systems to pre-empt the socio-economic changes that will come with the rise of AI and modernise training and talent management systems that support the labour market and increase the employability of trainees.

An EIT Community AI[55] has been set up by six KICs to foster collaboration in, education about, and uptake of AI by European enterprises and society.

The EIT also coordinates the Deep Tech Talent Initiative (DTTI), which will train one million Europeans by the end of 2025 in deep tech fields like AI, machine learning, quantum computing, robotics, virtual reality, augmented reality and metaverse.

Digital Europe

With a budget of 7.5 billion EUR, the Digital Europe Programme (DIGITAL) is a EU funding programme focused on bringing digital technology to businesses, citizens and public administrations. It provides strategic funding to projects in five key capacity areas: in supercomputing, **AI**, cybersecurity, advanced digital skills, and ensuring a wide use of digital technologies across the economy and society, including through Digital Innovation Hubs. The key area AI, data and cloud (2.062 billion EUR) sets up EU-wide sectoral data spaces

[53] AI, Data and Robotics Association (Adra) (adr-association.eu)
c_2021_4113_f1_annex_en_v5_p1_1213798.pdf (europa.eu)
[54] Clusters - CCAM
[55] EIT Artificial Intelligence Community - Revolutionalise AI with us (eitcommunity.eu)

based on a cloud-to-edge federated infrastructure and promotion of testing and adoption of AI-based solutions. The programme is not built to work in isolation, but rather to complement the funding available through other EU programmes, such as Horizon Europe and the Connecting Europe Facility for digital infrastructure, the Recovery and Resilience Facility and the Structural funds[56].

The EU decentralised agencies

The 30 decentralised agencies contribute to the implementation of EU policies. They also support cooperation between the EU and national governments by pooling technical and specialist expertise and knowledge from both the EU institutions and national authorities. AI is a shared concern and the European Medicines Agency (EMA), for example, recently published an AI work plan to 2028. As pharmaceutical companies increasingly use AI-powered tools in research, development and monitoring of medicines, national competent authorities are responding by starting to use and develop AI tools. The EMA and Heads of Medicines Agencies intend to set out a collaborative and coordinated strategy to maximise the benefits of AI to stakeholders while managing the risks[57].

EU policies for the uptake of artificial intelligence in research and innovation

The Commission supports the uptake of AI in scientific research, either directly or indirectly, through a variety of existing policies and initiatives.

Data

For the Commission, **data** is an essential resource for economic growth, competitiveness, innovation, job creation and societal progress in general. The **European strategy for data,** which was published together with the White Paper on AI in February 2020, aims at creating a single market for data that will ensure Europe's global competitiveness and data sovereignty. Although not specific to research and innovation, the strategy for data focuses on putting people first in developing technology and defending and promoting European values and rights in the digital world.

[56] https://digital-strategy.ec.europa.eu/en/activities/digital-programme
[57] https://www.ema.europa.eu/en/news/artificial-intelligence-workplan-guide-use-ai-medicines-regulation

The **Digital Services Act** (DSA) and the **Digital Market Act** (DMA) form a single set of rules that apply across the whole EU[58]. The rules specified in the DSA primarily concern online intermediaries and platforms. The DMA includes rules that govern gatekeeper online platforms. Overall, key provisions include increased responsibilities for online intermediaries, obligations for transparency, and measures to address competition concerns in digital markets. The dual objective is to protect the fundamental rights of all users of digital services while fostering innovation, growth, and competitiveness.

Common European data spaces[59] will ensure that more data becomes accessible for use in the economy and society– including for training Machine Learning and AI models, while keeping the companies and individuals who generate the data in control. On 23 February 2022, the Commission proposed a Regulation on harmonised rules on fair access to and use of data (**Data Act**). The Data Act, which came into force in January 2024, is a key pillar of the European strategy for data. Its main objective is to make Europe a leader in the data economy by harnessing the potential of the ever-increasing amount of industrial data, appliances, Internet of Things and others, in order to benefit the European economy and society[60].

More specifically in research and innovation, beneficiaries of Horizon Europe must manage the digital research data in line with the **FAIR principles** (Findable, Accessible, Interoperable and Reusable data)[61]. EU Member States also support the FAIR principles in the Council Conclusions on Research assessment and implementation of Open Science adopted in June 2022[62].

Research infrastructures

Europe's Research Infrastructures are critical for achieving scientific breakthroughs and drive innovation in Europe. As research and innovation enablers, Research Infrastructures in general have increasing impact on society and on the economy. They are also innovation ecosystems where scientists work with high-tech companies that supply them with manufacturing capacity as well as state of the art services and technologies. The ERA underlines the importance of large-scale research infrastructures, not

[58] https://digital-strategy.ec.europa.eu/en/policies/digital-services-act-package
[59] Common European Data Spaces | Shaping Europe's digital future (europa.eu)
[60] https://commission.europa.eu/news/data-act-enters-force-what-it-means-you-2024-01-11_en
[61] Wilkinson, M., Dumontier, M., Aalbersberg, I. *et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci Data* ***3, 160018 (2016). https://doi.org/10.1038/sdata.2016.18***
[62] https://www.consilium.europa.eu/media/56958/st10126-en22.pdf

only as a backbone of research and innovation, but also as drivers for regional development by concentrating research skills and innovation talent around strategic scientific assets. AI is both used and supported by data-intensive research infrastructures. For example, in Physical sciences, the complexity of the data structures requires development of sophisticated data analysis approaches based on AI methods. Some research infrastructures are providing language tools directly relevant for the development of AI[63]. The transformative potential of **AI** In building responsible open science research infrastructures is further explored[64].

Open science

Open Science improves the quality, efficiency and responsiveness of research and it reinforces research integrity and public trust in science. It is a key policy priority of the EU, that is contained in several recent policy documents such as the 2023 Council Conclusions on scholarly publishing, the 2022 Council Conclusions on Research Assessment and Implementation of Open Science and the 2022 Council Conclusions on Research Infrastructures. Policy action aims to make open science the norm in research and innovation practices by mainstreaming open access to research publications, data, and all other digital objects produced along the research life cycle including methods, protocols, and software, and further developing and integrating the underpinning digital infrastructure and services. It also requires reforming research assessment to reward quality and impact. Equity – the lack thereof, is a growing concern in the development of open science. Open science enables broad access to research publications, data and other outputs and is therefore key for a stronger uptake of AI in science[65].

European Open Science Cloud (EOSC)

EOSC is an EU flagship initiative for deepening the ERA. It is recognised in the European Strategy for Data as the Common European **data space for science, research and innovation**, which shall be fully connected with other sectoral data spaces. The ambition of the EOSC is to provide researchers and innovators with a federated and open multi-disciplinary research environment where they can publish, access and reuse data, tools and services. It will provide a key resource at European level for machine-actionable and FAIR

[63] https://roadmap2021.esfri.eu/
[64] For example https://www.rd-alliance.org/role-artificial-intelligence-building-responsible-open-science-infrastructures
[65] See eg here: https://www.openaire.eu/blogs/ai-with-and-for-open-science for a discussion of the interplay of open science and AI in science.

research data and tools upon which AI applications for science and other value-added services can be built. The EU-funded project **AI4EOSC**[66] is developing an array of AI, machine learning (ML) and deep learning models, bundled for ease of use to researchers, and customisable so users can adapt them to their needs.

Intellectual property rights (IPR) and copyright fit for research

Access to and reuse of scientific publications and data is at the core of the EU open science policy. However, the **provisions relevant for research under EU copyright and data legislation present several challenges and negative impacts for researchers and their organisations**. For instance, differing interpretations of text and data mining provisions across EU Member States and general ambiguity surrounding text and data mining exceptions could put the EU in competitive disadvantage with regard to AI developments.

There currently are consideration for potential **legislative or non-legislative measures at EU level** to enable and foster access to and reuse of scientific publications and data and to align with the EU open science policy, which would also impact **AI**.

Against this context, Action 2 of the ERA policy agenda[67] has been put forward with the aim to achieve an **EU copyright and data legislative and regulatory framework that is fit for research**. Under this action, work is being carried out to identify barriers and challenges to access and reuse of publicly funded research results and of publications and data for scientific purposes, and to identify potential impacts on research. A comprehensive study on the impacts of potential measures is due to be published in 2024. Based on the results of the study, proposals for possible legislative and non-legislative measures in EU copyright, data and digital legislation will be prepared.

There is also a need to better understand and provide guidance on the interplay of output generated by AI and IPR. The **policy brief "Harnessing the power of AI to accelerate discovery and foster innovation"** published by the Commission in 2023 emphasises the challenges to assess implications for publishers and peer reviewers and use the right tools and

[66] https://cordis.europa.eu/project/id/101058593
[67] https://commission.europa.eu/system/files/2021-11/ec_rtd_era-policy-agenda-2021.pdf

expertise to clarify the IPR regime to ensure the **quality and integrity of scientific outputs**[68].

Access to high-performance computing (HPC)

Supercomputers are crucial for AI research, as it provides the necessary computing power for processing large datasets, complex simulations, and algorithm development. The European High Performance Computing Joint Undertaking is a joint initiative launched in 2018 between the EU, European countries and private partners to develop a world class supercomputing ecosystem in Europe. EuroHPC aims to develop and maintain in the EU a world-leading federated, secure and hyper-connected supercomputing, quantum computing, service and data infrastructure ecosystem; support the development and uptake of demand-oriented and user-driven innovative and competitive supercomputing systems; and widen the use of that supercomputing infrastructure to a large number of public and private users and support the development of key HPC skills for European science and industry. Most of the funding for EuroHPC comes from the current EU Multiannual Financial Framework (MFF 2021-2027) with a contribution of 3 billion EUR, from the Digital European Programme (acquisition, deployment, upgrading and operation of the infrastructures, the federation of supercomputing services, and the widening of HPC usage and skills); from **Horizon Europe** (support research and innovation activities for developing a world-class, competitive and innovative supercomputing ecosystem across Europe); and from Connecting Europe Facility-2 (improve the interconnection of HPC, quantum computing, and data resources, as well as the interconnection with the Union's common European data spaces and secure cloud infrastructures).

Access to computing time on EuroHPC is granted to researchers from European academic and research institutions, public authorities and public sector organisations, and industry and SMEs of participating states who apply to an open access call. Access is currently free of charge and should primarily be for open access public research and innovation purposes[69].

In the 2023 State of the Union address, President Von der Leyen announced that the Commission would table an initiative to open up European

[68] Harnessing the potential of Artificial Intelligence in science to boost Europe's global competitiveness - European Commission (europa.eu)

[69] EuroHPC JU Decision 25.2021 - Access policy. First amendment.pdf (europa.eu). Examples of projects which won calls for access time on EuroHPC can be found here: Our projects (europa.eu)

supercomputer capacity to ethical and responsible AI start-ups[70]. This was followed by the launch of the AI Boost "Large AI Grand Challenge"[71], which will provide monetary prizes and access to EuroHPC to up to four proposals from European SMEs, including start-ups, for civil applications. In January 2024, the Commission proposed an amendment to the EuroHPC Council Regulation to include a general-purpose AI perspective and facilitate access for SMEs and AI start-ups by setting up AI Factories[72] .

Digital education, digital skills and the role of universities

The **Digital Education Action Plan** (2021-2027) outlines the Commission's vision for high-quality, inclusive, and accessible digital education in Europe. It emphasizes the need for coordinated efforts to close the digital competence and skills gap, crucial for effectively integrating AI into scientific research[73] and to adapt the educational systems in order to leverage technological developments related to the fast-paced digital transformation, such as the ethical use of AI and data in learning[74]. The two Councils recommendations adopted in November 2023 on the enabling factors for successful digital education and training[75] and on improving the provision of digital skills and competences[76] in this area support the development of advanced and specialist digital skills in VET and Higher Education on AI, deep tech and in other key capacity areas, as well as strengthening the provision of digital skills and competences from primary and secondary education, in particular regarding generative AI systems. Integrating new approaches to active learning, focusing on creativity, curiosity, and exposure to technologies from early on is key, in particular with actions to promote science and the reasoned use of AI-based resources to arouse vocations and retain talent, especially among girls.

Action 13 of European Research and Innovation Area[77] follows the Council Conclusions on a European strategy for universities[78] (6 April 2022).

[70] State of the Union 2023 - European Commission (europa.eu)
[71] AI-BOOST (aiboost-project.eu)
[72] Proposal for a regulation amending Regulation (EU) 2021/1173 as regards an EuroHPC initiative for start-ups to boost European leadership in trustworthy Artificial Intelligence | Shaping Europe's digital future (europa.eu)
[73] https://education.ec.europa.eu/focus-topics/digital-education/action-plan
[74] https://education.ec.europa.eu/focus-topics/digital-education/action-plan/action-6?
[75] https://data.consilium.europa.eu/doc/document/ST-15741-2023-INIT/en/pdf
[76] https://data.consilium.europa.eu/doc/document/ST-15740-2023-INIT/en/pdf
[77] https://research-and-innovation.ec.europa.eu/document/download/0c2f5f95-3274-4ab8-9acb-d6673dc238b8_en?filename=ec_rtd_era-policy-agenda-2021.pdf
[78] Council conclusions on a European strategy empowering higher education institutions for the future of Europe (2022/C 167/03)

With a set of policy and programme measures, the objective is to raise excellence in science and value creation of the entire university sector and coordinate efforts between EU and Member States. The initiative also connects with the education policy and the investment pathway the Commission is developing for the future **European Universities Initiative**.

The EU's **Digital Skills Strategy** is a comprehensive plan to ensure Europe's digital transformation in a way that benefits people, businesses, and the environment. The Digital Europe Programme[79] provides strategic funding to support the development of a skilled talent pool of digital experts, through **specialised education programmes in key digital areas** such as AI, blockchain, robotics, quantum and High Performance Computing (HPC), provided by networks of higher education institutions, research centres and businesses. The **European Digital Skills and Jobs Platform**[80] is a new initiative launched under the Connecting Europe Facility Programme[81]. It offers information and resources on digital skills, as well as training and funding opportunities. The Digital Skills Strategy is linked to the **European Skills Agenda**[82], a five-year plan to help individuals and businesses develop and use more and better skills. In the European Skills Agenda, a specific mention is made to AI as a skill to support the twin green and digital transitions, while another action focuses specifically on upskilling scientists. In the context of the Pact for Skills the Commission is already supporting an Erasmus+ Alliance for Innovation, ARISA (Artificial Intelligence Skills Alliance[83]), to develop a sectoral skills strategy on AI.

Research careers

In July 2023, the Commission unveiled a set of measures targeted at strengthening the European Research Area (ERA), namely, to promote **attractive and sustainable research careers**. This is in line with the new ERA Communication and the European Skills Agenda adopted by the Commission in 2020, and includes links to the European Year of Skills[84].

In particular, the set of measures comprised the Commission proposal for a Council Recommendation on a European framework to attract and retain

[79] The Digital Europe Programme | Shaping Europe's digital future (europa.eu)
[80] Artificial Intelligence | Digital Skills and Jobs Platform (europa.eu)
[81] Connecting Europe Facility - European Commission (europa.eu)
[82] European Skills Agenda - Employment, Social Affairs & Inclusion - European Commission (europa.eu)
[83] https://aiskills.eu/
[84] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_3807

research, innovation and entrepreneurial talents in Europe, which was adopted by the Council on 18 December 2023 and which includes the new Charter for Researchers.[85] The European Competence Framework for Researchers (ResearchComp)[86] was also part of the measures launched in July 2023. It contains the transversal skills researchers should have for successful careers across sectors, including some that could be considered relevant for AI.

The measures launched in July 2023 play a substantial role in the implementation of Action 4 of the ERA Policy Agenda 2022-2024 on Research careers. Europe finally has a comprehensive framework to address key issues such as recruitment, working conditions, skills and career development, including a new Charter for Researchers replacing the 2005 Charter and Code for Researchers and which will be implemented via the Human Resources Strategy for Researchers (HRS4R). To date, more than 700 institutions have received the HR Excellence in Research Award based on the implementation of the old Charter and Code. Additional measures are on their way to improve the attractiveness of research careers within and beyond academia (see also MSCA). This includes the launch of an observatory on research and innovation careers, the set up of the ERA Talent Platform, and a Horizon Europe pilot to improve working conditions for early-career researchers.

Another ERA Policy Agenda 2022-2024 action is becoming concrete. Action 3 – **Reform of the Research Assessment**: The co-created 'Agreement on Reforming Research Assessment' and the Coalition for advancing research assessment (CoARA) support the policy of the Commission to recognise the diverse outputs, practices and activities that maximise the quality and impact of research. The Commission will facilitate interactions between CoARA and national authorities to lead to the desired reforms gradually.

Academic freedom and freedom of scientific research

It is a key priority for the EU as also expressed in several resolutions[87] of the European Parliament. Protecting academic freedom it is also enshrined in the Horizon Europe Regulation and in several voluntary commitments by Member

[85] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AC_202301640
[86] https://research-and-innovation.ec.europa.eu/jobs-research/researchcomp-european-competence-framework-researchers_en
[87] https://www.europarl.europa.eu/doceo/document/A-9-2023-0393_EN.html

States, including through the ERA Action 6 'Protect academic freedom in Europe'[88] and the Bonn Declaration on Freedom of Scientific Research[89].

Gender and equality

The EU AI approach focuses on ensuring that AI technologies are developed and used in a way that upholds EU values and fundamental rights such as non-discrimination, cultural and linguistic diversity, and inclusion. The **EU Gender Equality Strategy for 2020-2025**[90] recognises AI as an area of strategic importance and a key driver of economic progress, in which women must play a role as researchers, programmers and users. However, a recent analysis on the situation in North America showed that new AI PhDs are still overwhelmingly male[91]. The situation is similar in the EU, where overall more men than women have a degree in Information and Communication Technology studies[92]. The Gender Equality Strategy also recognises the risks of AI in repeating, amplifying or contributing to **gender biases** that programmers may not be aware of or that are the result of specific data selection. Under Horizon Europe, funding has been allocated to projects on addressing potential gender biases in AI, as well as on debunking gender stereotypes in all social, economic and cultural domains, supporting the development of unbiased evidence-based policies.

Projects like the JRC's "Diversity in AI" initiative[93] also aim to **develop indicators of diversity**, reflecting on the idea that diverse teams are necessary to ensure the inclusiveness and non-discrimination of AI systems, as recognised by the EU AI Act.

Industry 5.0 and SMEs

Industry 5.0 provides a vision of the future of European industry as an engine for systemic transformation. It contributes to three of the Commission's priorities: "An economy that works for people", "European Green Deal" and "Europe fit for the digital age". **AI** has been identified as one of the six key

[88] https://research-and-innovation.ec.europa.eu/document/download/0c2f5f95-3274-4ab8-9acb-d6673dc238b8_en?filename=ec_rtd_era-policy-agenda-2021.pdf
[89] https://www.bmbf.de/bmbf/shareddocs/downloads/files/_drp-efr-bonner_erklaerung_en_with-signatures_maerz_2021.pdf?__blob=publicationFile&v=1
[90] EUR-Lex - 52020DC0152 - EN - EUR-Lex (europa.eu)
[91] HAI_AI-Index-Report_2023.pdf (stanford.edu)
[92] Digitalisation in Europe - 2023 edition - Interactive publications - Eurostat (europa.eu)
[93] divinAI - European Commission (europa.eu)

areas that support Industry 5.0, especially in the context of the need to develop and implement human-centric technologies in the future.

According to a Flash Eurobarometer survey on **SMEs and skills shortages** published in November 2023[94], only 11% of the surveyed SMEs are expecting a significant impact of the deployment of AI on their skill needs. A majority of SMEs across most Member States have no concrete plans to start using AI and also do not expect a significant impact on their skill needs in case they would start using AI. However, among the SMEs founded after 2021, a higher share is already using AI or have concrete plans to do so. Of the SMEs already using AI, the highest share is in the 'Digital' sector, followed by 'Energy – renewables', 'Cultural and creative industries' and 'Electronics'.

Semiconductor chips are crucial to key digital technologies of the future, including AI, 5G, and edge computing[95]. The **European Chips Act**[96], which entered into force in September 2023, aims to strengthen Europe's technological leadership in semiconductor technologies and applications, and to address the global semiconductor shortages and supply chain challenges, by mobilising more than 43 billion EUR of public and private investments until 2030.

Standardisation

As noted in the Commission's White Paper "On Artificial Intelligence - A European approach to excellence and trust"[97], AI models for scientific discovery raise **standardisation challenges** for commonly agreed procedures, for common **safety rules** especially in high-risk AI applications, and for facilitating **interoperability of results**.

The AI Act relies on standardisation to provide technical solutions to providers to ensure compliance with this Regulation, in agreement with Regulation (EU) No 1025/2012 of the European Parliament and of the Council which regulates the European standardisation system and explains how to use European standards for products and services. Such European or harmonised standards are developed by a recognised European Standards Organisation (ESO): CEN, CENELEC, or ETSI, at the request of the European Commission. Where no

[94] SMEs and skills shortages - November 2023 - - Eurobarometer survey (europa.eu)
[95] EUR-Lex - 52022DC0045 - EN - EUR-Lex (europa.eu)
[96] Regulation - 2023/1781 - EN - EUR-Lex (europa.eu)
[97] commission-white-paper-artificial-intelligence-feb2020_en.pdf (europa.eu)

harmonised standards exist or where they are insufficient the Commission could instead adopt common technical specifications.

In 2023, the European Commission issued a request to CEN/CENELEC to begin work on the preparation of harmonised standards to support the development of safe, trustworthy AI[98]. This EU AI Standardisation Request specifically focused on the requirement for standards in respect of the following obligations applicable to high-risk AI: risk management systems, governance and quality of datasets, record keeping, transparency and information provisions for users, human oversight, accuracy specifications, robustness specifications and conformity assessment. CEN/CENELEC have set up a Joint Technical Committee 21 'Artificial Intelligence'.

As the AI act will stay at relatively high level, the technical standards that will be developed will finally be responsible for establishing many of the trade-offs between e.g., ethical aspects, supporting innovation, and flexibility.

Sectorial AI testing and experimentation facilities

To bring trustworthy AI to market more quickly and improve its uptake, the Commission co-funds together with EU Member States under the Digital Europe Programme sectorial AI Testing and Experimentation Facilities (TEF) focusing on four sectors, including health and agri-food. These TEFs will be specialised large-scale reference sites open to all technology providers across Europe to test and experiment state-of-the art AI-based soft-and hardware solutions and products, including robots, in real-world environments, and at scale. In addition, a TEF focusing specifically on developing AI-based solutions for the energy sector will be funded by the Horizon Europe programme[i99].

Knowledge valorisation

On 2 December 2022, the Council adopted the Recommendation on the guiding principles for knowledge valorisation to increase socioeconomic impact from R&I activities and align policy guidance[100]. The **EU Guiding Principles for Knowledge Valorisation** aim to maximise the transformation of research

[98] Commission implementing decision of 22.5.2023 on a standardisation request to the European Committee for Standardisation and the European Committee for Electrotechnical Standardisation in support of Union policy on artificial intelligence.
[99] Funding & tenders (europa.eu)
[100] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/commission-welcomes-adoption-council-recommendation-guiding-principles-knowledge-valorisation-2022-12-02_en

and innovation results into solutions that benefit society[101]. They are mainly addressed to national, regional and local policy makers.

A **Code of Practice on intellectual assets management** and a **Code of Practice on standardisation** were adopted as Commission Recommendations on 1 March 2023 to support the implementation of the guiding principles by providing more detailed guidance on these areas of knowledge valorisation[102]. They do not mention AI though. Two new **codes of practice on industry-academia co-creation and citizen engagement** were developed in communities of practice involving a broad range of stakeholders and are expected to be adopted as Commission recommendations in spring 2024.

The context worldwide

Europe remains a scientific powerhouse. Although it has less than 7% of the world's population, it represents about one fifth of the world's publications, patents, and R&D[103]. The EU shows a higher level of technological diversification, compared to other global innovators such as the US and China. However, it specialises in technologies that are easier to replicate such as transportation or machinery. The EU's capacity to lead technological change in areas related to more sophisticated technologies such as digital technologies is weaker than that of the US and China. Despite recent improvements, the EU scientific ecosystem suffers from brain drain to the rest of the world.

The situation is rapidly evolving, and the following does not mean to be exhaustive but only give a flavour of concerns and issues shared worldwide.

The AI regulatory approach in the world

While the **United States of America (USA)** had initially taken a lenient approach towards AI, calls for regulation have recently been mounting. The Cyberspace Administration of **China** is also consulting on a proposal to

[101] https://research-and-innovation.ec.europa.eu/research-area/industrial-research-and-innovation/eu-valorisation-policy/knowledge-valorisation-platform/guiding-principles-knowledge-valorisation-implementing-codes-practice_en#:~:text=The%20EU%20Guiding%20Principles%20for,Council%20on%202%20December%202022.
[102] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/commission-adopts-recommendations-codes-practice-management-intellectual-asset-and-standardisation-2023-03-07_en
[103] https://commission.europa.eu/system/files/2023-03/Communication_Long-term-competitiveness.pdf

regulate AI, while the **UK** is working on a set of pro-innovation regulatory principles. At international level, the Organisation for **Economic Co-operation and Development (OECD)** adopted a (non-binding) Recommendation on AI in 2019, **UNESCO** adopted Recommendations on the Ethics of AI in 2021, and the **Council of Europe** is currently working on an international convention on AI[104]. Furthermore, in the context of the newly established EU-US tech partnership (the Trade and Technology Council), the EU and USA are seeking to develop a mutual understanding on the principles underlining trustworthy and responsible AI. EU lawmakers issued a joint statement in May 2023 urging President Biden and European Commission President Ursula von der Leyen to convene a summit to find ways to control the development of advanced AI systems such as ChatGPT.

The example of the USA

In October 2023, President Biden signed the "Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence"[105] to guide the development and deployment of AI in a safe, secure, and trustworthy manner. While it is not legislation, this order to federal agencies sets new standards for AI safety and security, aims to protect Americans' privacy, and promotes innovation and competition. It includes directives for developing standards, tools, and tests to ensure AI systems' safety, security, and trustworthiness, along with measures to protect against risks like AI-enabled fraud and deception. The Executive Order makes explicit mentions of the risks of the use of AI in fields such as biotechnologies and makes provisions to ensure American leadership in AI innovation and competition by initiatives such as catalysing AI research across the United States through a pilot of the National AI Research Resource and expanded grants for AI research in vital areas like healthcare and climate change. Moreover, the Order includes a focus on attracting and retaining highly skilled talent in critical areas through a modernisation of the visa process. The Biden Presidency also committed to continuing the international collaborations on ensuring the safe, secure, and trustworthy deployment and use of AI worldwide, by engaging in the efforts to establish international frameworks for harnessing AI's benefits and managing its risks while ensuring safety, accelerating development and implementation of AI standards with international partners and in standards organizations, and promoting the safe

[104] https://www.coe.int/en/web/artificial-intelligence/cai
[105] FACT SHEET: President Biden Issues Executive Order on Safe, Secure, and Trustworthy Artificial Intelligence | The White House

and responsible development and deployment of AI abroad to solve global challenges.

In research and innovation, the US is increasing funding via the National Science Foundation to promote responsible AI R&I by launching new National AI Research Institutes[106]. These institutes, 25 across the country, aim to encourage collaborative efforts across institutions of higher education, federal agencies, industry, and others with the goal of advancing AI to drive breakthroughs in critical areas, including climate, agriculture, energy, public health, education, and cybersecurity. The US is also investing in building a National AI Research Resource (NAIRR)[107], a national research infrastructure to broaden access to resources essential to AI development, including computational resources, high-quality data, educational tools, and user support. The US is also launching the US AI Safety Institute, to support efforts to create safe and trustworthy AI, within the National Institute for Standards and Technology.

In 2023, the EU and the US signed an **"Administrative Arrangement on Artificial Intelligence for the Public Good"[108]**, to strengthen collaboration on AI and computing to address global challenges for the public good in five identified key areas: climate change, natural disasters, healthcare, energy and agriculture.

The example of the UK

In March 2023, the UK government published a white paper on "A pro-innovation approach to AI regulation"[109], in which they lay out their approach to AI regulation. The paper identifies five key principles for regulators to assess how they could apply to AI technologies without developing ad hoc legislation and focuses on the context in which the AI is deployed rather than targeting specific technologies. The UK government also announced the establishment of a regulatory sandbox for AI to bring together regulators to support innovators directly.

[106] FACT SHEET: Biden-Harris Administration Announces New Actions to Promote Responsible AI Innovation that Protects Americans' Rights and Safety | The White House
[107] Strengthening and Democratizing the U.S. Artificial Intelligence Innovation Ecosystem: An Implementation Plan for a National Artificial Intelligence Research Resource (ai.gov)
[108] The European Union and the United States of America strengthen cooperation on research in Artificial Intelligence and computing for the Public Good | Shaping Europe's digital future (europa.eu)
[109] AI regulation: a pro-innovation approach - GOV.UK (www.gov.uk)

The UK is investing in supercomputing through the AI Research Resource, which will be made available to researchers, the Frontier AI Taskforce working on AI risk mitigation and the UK AI Safety Institute. AI is included in the sectors supported by the UK Global Talent Network[110], which aims at attracting international talent to the UK, specifically from India and the USA, and new Master and PhD courses on AI were launched[111]. Increased funding through UK Research and Innovation has also been dedicated to AI and the data economy, to implement the UK National AI Strategy[112]. In particular, the funding is dedicated to AI technology missions in the fields of the energy transition, healthcare, productivity in low AI maturity sectors (e.g., agriculture, construction, transport and creative industries) and development of responsible and trustworthy AI.

The UK took a leading role in the global conversation on considering the risks of AI, especially at the frontier of development and how internationally coordinated action can mitigate them, by organising the UK **AI Safety Summit** in November 2023. The resulting Bletchley Declaration on AI Safety, agreed upon by the countries attending the Summit, including the EU, the US, and China, marked a commitment to a new global initiative focused on AI safety.

The example of China

In 2017, China announced an ambitious programme for its domestic development of AI technology, with the aim of becoming the world's 'major AI innovation centre' by 2030. China plans to expand AI in many spheres of production, governance and defence by that deadline. China ranks second globally in AI, although it still has to overcome major challenges, in particular in terms of talent and the production of very sophisticated semiconductors, and is heavily investing in funding for talent training, acquisition of chip technology and supercomputing.

China and Europe are becoming more important AI research partners, although many European-Chinese AI research outputs have military or surveillance applications[113]. China is also moving to manage data resources and flow at a more centralised state level, introducing tight restrictions on cross-border data flows, as data is seen as a national resource and a factor of

[110] Join the Global Talent Network - great.gov.uk
[111] 2,500 new places on artificial intelligence and data science conversion courses now open to applicants - GOV.UK (www.gov.uk)
[112] £250m to secure the UK's world-leading position in technologies of tomorrow – UKRI
[113] AI entanglements: Balancing risks and rewards of European-Chinese collaboration | Merics

production[114]. Moreover, China has also introduced rules on Generative AI, which include an exemption from scrutiny for, among others, all research and development activities[115].

International cooperation and major fora

In the 2019 Communication on Building Trust in Human-Centric AI[116], the Commission identified the international dimension as an essential component to ensure the development of human-centric AI. The Commission pledged to continue engaging with like-minded partners and multilateral fora such as the G7 and G20 to build a consensus on international AI guidelines.

The EU has been actively involved in the **G7 Hiroshima process**, which aimed to develop principles, guidelines, and best practices for the responsible use of AI, taking into account issues such as privacy, transparency, accountability, and the potential impact of AI on society. In October 2023, the Commission welcomed and endorsed the agreement by G7 leaders on the resulting International Guiding Principles on Artificial Intelligence (AI) and the International Code of Conduct for Organizations Developing Advanced AI System[117], both seen as a complement, at global level, to the EU AI Act.

The EU also contributed to the development of the Organisation for Economic Cooperation and Development **(OECD) AI Principles**[118] adopted in May 2019. These principles aimed at promoting a use of AI that is innovative and trustworthy and that respects human rights and democratic values. The OECD AI Principles formed the base of the **G20 AI principles**[119] endorsed by G20 leaders in June 2019. The EU has joined the Global Partnership on AI[120], launched in June 2020 and hosted by the OECD, to foster responsible development of AI. The OECD also developed the **OECD Framework for the Classification of AI systems[121]**, a tool to evaluate AI systems from a policy perspective, that can be applied to the widest range of AI to guide an innovative and trustworthy approach to AI as outlined in the OECD AI Principles.

[114] China's data management: Putting the party state in charge | Merics
[115] China's censors back down on generative AI | Merics
[116] Communication: Building Trust in Human Centric Artificial Intelligence | Shaping Europe's digital future (europa.eu)
[117] Hiroshima Process International Code of Conduct for Advanced AI Systems | Shaping Europe's digital future (europa.eu)
[118] AI-Principles Overview - OECD.AI
[119] 20190609 Ministerial Statement on Trade and Digital Economy (full) (oecd.ai)
[120] Global Partnership on Artificial Intelligence - GPAI
[121] OECD Framework for the Classification of AI systems | en | OECD

At UN level, the EU has contributed to discussions on the ethical and responsible use of AI within the UN framework and has been cooperating with **UNESCO** on the implementation of their **Recommendation on the Ethics of AI**[122], adopted by all UNESCO members in November 2021. To implement the Recommendation, in 2023 UNESCO further developed the **Readiness Assessment Methodology**[123] and the **Ethical Impact Assessment**[124], tools for UNESCO Member States which aim at assessing and promoting the resilience of existing laws, policies and institutions to AI implementation in the country, as well as the alignment of AI systems with the values and principles set out in the Recommendation. In 2019, UNESCO Member States reached the Beijing Consensus on AI and education[125], providing guidance and recommendations on how to best use AI to improve education. In September 2023, UNESCO released their "**Guidance for Generative AI in education and research**"[126]. The World Health Organisation (WHO) has also developed guidance **on Ethics & Governance of Artificial Intelligence for Health**[127]**,** recognising that while technologies that use AI have the potential to improve diagnosis, treatment, health research and drug development and to support public health functions, including surveillance and outbreak response, such technologies must put ethics and human rights at the heart of its design, deployment, and use. In January 2024, WHO released an update to this guidance to reflect the impact of generative AI technologies, "**Ethics and governance of artificial intelligence for health: guidance on large multi-modal models"**[128]**.** The updated guidance outlines recommendations to ensure the appropriate use of LMM for health, including scientific research and drug development among the 5 broad application areas identified.

In research and innovation, the EU develops joint commitments with international partners based on reciprocal openness, promotion of a level playing field and reciprocity and strengthening of bilateral and multilateral partnerships. With **Horizon Europe**, the Commission aims to take a leading role in supporting international research and innovation partnerships, and to deliver innovative solutions to make our societies green, digital and healthy.

[122] Recommendation on the Ethics of Artificial Intelligence - UNESCO Digital Library
[123] Readiness assessment methodology: a tool of the Recommendation on the Ethics of Artificial Intelligence - UNESCO Digital Library
[124] Ethical impact assessment: a tool of the Recommendation on the Ethics of Artificial Intelligence - UNESCO Digital Library
[125] Beijing Consensus on Artificial Intelligence and Education - UNESCO Digital Library
[126] Guidance for generative AI in education and research - UNESCO Digital Library
[127] Ethics and governance of artificial intelligence for health (who.int)
[128] Ethics and governance of artificial intelligence for health: guidance on large multi-modal models (who.int)

The Commission promotes a multilateral dialogue on the principles and values of international cooperation in R&I with Member States, associated countries, countries with Science and Technology agreement with the EU and international partners such as OECD and UNESCO. AI does not feature prominently on the agenda though. With the **US**, both sides see eye to eye on the importance of cooperation on science and society issues to make scientific systems more resilient to disinformation, and to promote evidence-based decision making. **China** is a cooperation partner but mostly through the Food, Agriculture and Biotechnology and the Climate Change and Biodiversity flagships.

Foreign interference in research and innovation

In January 2022, the Commission published a toolkit on how to mitigate **foreign interference in research and innovation**. The publication outlines best practices to support EU Higher Education Institutions and Research Performing Organisations in safeguarding their fundamental values, including academic freedom, integrity and institutional autonomy, as well as to protect their staff, students, research findings and assets[129]. The Staff Working Document[130] requires caution when opening up research data in particular with regards to the potentials of future deployment of machine learning and **AI**. In this context, and as set out in the Communication on the European Economic Security Strategy[131], the Commission is preparing a Council Recommendation on enhancing Research Security[132]. This Recommendation aims to address possible risks related to the international nature of scientific research and technological development, in particular risks related to undesirable transfer of knowledge, foreign interference, and ethical or integrity violations, by setting out guiding principles for responsible internationalisation and key policy actions at national and sectoral level to boost research security.

In addition, one of the objectives of ERA Action 6 '**Deepening the ERA through protecting academic freedom in Europe'** is to address foreign interference in research and innovation by organising a Mutual Learning Exercise among Member States to counter R&I foreign interference and the

[129] https://research-and-innovation.ec.europa.eu/news/all-research-and-innovation-news/commission-publishes-toolkit-help-mitigate-foreign-interference-research-and-innovation-2022-01-18_en
[130] https://op.europa.eu/en/web/eu-law-and-publications/publication-detail/-/publication/3faf52e8-79a2-11ec-9136-01aa75ed71a1
[131] EUR-Lex - 52023JC0020 - EN - EUR-Lex (europa.eu)
[132] EUR-Lex - COM:2024:26:FIN - EN - EUR-Lex (europa.eu)

development of a one-stop shop on foreign interference. This will serve as an inventory of available resources that can help researchers and R&I institutions navigate this complex topic.

The European economic security strategy

In June 2023, the Commission and the High Representative published a Joint Communication on a **European economic security strategy**[133]. This Joint Communication focuses on minimising risks arising from certain economic flows in the context of increased geopolitical tensions and accelerated technological shifts, while preserving maximum levels of economic openness and dynamism.

This strategy sets out a common framework for achieving economic security by promoting the EU's economic base and competitiveness; protecting against risks; and partnering with the broadest possible range of countries to address shared concerns and interests. The strategy proposes to carry out a thorough assessment of risks to economic security in four areas, including risks to physical and cyber security of critical infrastructure and risks related to technology security and technology leakage, where AI is explicitly mentioned as a dual use technology. Among the new actions, the Communication identifies the exploration of options to ensure adequate targeted support for research and development of dual-use technologies and the proposal of measures to improve research security.

Critical technology areas

In October 2023, the Commission adopted a **Recommendation on critical technology areas** for the EU's economic security, for further risk assessment with Member States. The Commission identified **AI as one of the four technology areas** that are considered highly likely to present the most sensitive and immediate risks related to technology security and technology leakage. Because of their wide range of dual-use applications and they are crucial in particular for processing large amounts of data and making decisions or predictions based on this data-driven analysis, the Commission recommends that Member States, together with the Commission, initially conduct **collective risk assessments on AI technologies** (high performance computing, cloud and edge computing, data analytics, computer

[133] EUR-Lex - 52023JC0020 - EN - EUR-Lex (europa.eu)

vision, language processing, object recognition) by the end of 2023. Further activities and open dialogue will follow[134].

Dual use technologies

The 'civilian part' of Horizon Europe (which does not include the European Defence Fund, EDF), has an exclusive focus on civil applications that does not allow the support of dual use technologies. However, the Horizon Europe legal basis has an annex about synergies which covers also potential synergies with EDF. In 2021, the Commission released the Staff Working Document 'Enhancing security through research and innovation'[135] (with some hints at AI as a sensitive area when strengthening EU strategic autonomy) and is currently preparing the European Security Strand on 'research security', which includes the preparation of options to ensure targeted support for research and development of dual use technologies. In January 2024, the Commission published a "White Paper on options for enhancing support for research and development involving technologies with dual-use potential "[136].

Focus on some stakeholders

Typically, associations of **research performing- and research funding-organisations** have been calling for more investment in fundamental research on digital and AI[137] and for striking a right balance between safety guarantees for users and developers of AI systems, and a legal environment that allows researchers to experiment and develop new applications[138]. Some also express concerns about made-up 'facts' or how data is collected and report the challenges for universities regarding the assessment of work produced with the help of AI[139]. Others are concerned to make more data available to enable AI applications and enforce existing laws on copyright[140].

The latter is also a concern raised by **scholarly publishers**, who also focus on impact of generative AI in scholarly communication within the existing

[134] https://ec.europa.eu/commission/presscorner/detail/en/IP_23_4735
[135] Brussels, 15.12.2021 SWD(2021) 422 final
[136] EUR-Lex - COM:2024:27:FIN - EN - EUR-Lex (europa.eu)
[137] For example https://www.the-guild.eu/news/2023/the-guild-calls-for-more-investment-in-fundamental-research-on-digital-and-ai.html
[138] For example https://scienceeurope.org/our-priorities/eu-legislation/artificial-intelligence/
[139] For example https://eua.eu/events/277:beyond-chatgpt-what-next-for-generative-ai-in-higher-education.html
[140] For example https://eare.eu/european-researchers-and-innovators-call-for-european-institutions-to-reconsider-copyright-obligations-introduced-in-the-ai-act/

copyright framework[141]. In line with these concerns, the study of European Research Area Action 2[142] is showing broad support from publishers as well as research performing organisations for harmonised regulations to ensure clearer and more inclusive research exceptions in the EU's copyright acquis. Moreover, while the Text and Data Mining exceptions of the EU's copyright rules are broadly seen as important, publishers and research performing organisations agree that more guidance on these exceptions is needed to enable the application of AI in research.

Start-ups across Europe tend to welcome the creation of a harmonised framework for AI and the promotion of regulatory sandboxes. In the political agreement on AI Act, lawmakers have sought to meet this demand by exempting pre-market research from the legal requirements. From its implementation, it is to be evaluated how the exception will be applied and to what extent it meets the objective of boosting AI in research and research in AI.

At the same time, as smaller economic players with limited resources, they also are worried about the EU AI Act that they see as a complex and burdensome regulatory initiative[143]. Similarly, research performing organisations can in certain areas be considered as providers and users of high-risk systems. Respectively, if a university for examples partners with a public authority on building an AI system or utilises an AI system to assess students in an educational context. Therefore, research performing organisations need to prepare how to comply the specific requirements of the AI Act.

Stakeholders across the AI community have also come together in groups such as the Partnership on AI[144], with the stated goal of sharing knowledge and fostering the responsible development of AI. The Commission itself has sought to engage stakeholders such as citizens, civil society, business and consumer organisations, trade unions, academia, public authorities and experts, by launching the European AI Alliance[145] within the framework of its AI Strategy.

[141] For example https://www.stm-assoc.org/wp-content/uploads/STM-GENERATIVE-AI-PAPER-2023.pdf
[142] https://research-and-innovation.ec.europa.eu/events/improving-access-and-reuse-ri-results-publications-and-data-scientific-purposes_en
[143] For example https://alliedforstartups.org/2023/12/11/press-release-steptoe-and-allied-for-startups-join-forces-to-support-startups-with-ai-act-compliance/
[144] Partnership on AI - Home - Partnership on AI
[145] The European AI Alliance | Shaping Europe's digital future (europa.eu)

ANNEX 4 - LIST OF ADDITIONAL EXPERTS CONSULTED AND STAKEHOLDERS

Expert Elicitation Participants

Name	Current Institution
Stefan LARSSON	Department of Technology and Society, University of Lund
Stefan LEIJNEN	University of Applied Sciences, Utrecht
Cecilia RIKAP	Institute for Innovation and Public Purpose, University College London
Steve ROBERTS[146]	Somerville College, University of Oxford

Sounding Board Meeting Participants

Name	Current Institution
Olga DEMLER	Eidgenössische Technische Hochschule (ETH), Zürich
Stefan LEIJNEN	University of Applied Sciences, Utrecht
Dave LEWIS	Trinity College, Dublin

[146] Joint contribution with Profs Ben LAMBERT and David GAVAGHAN

Alistair NOLAN	Organisation for Economic Co-operation and Development (OECD)
Cecilia RIKAP	Institute for Innovation and Public Purpose, University College London

Stakeholder Meeting Participants

Name	Current Institution
Mattias BJÖRNMALM	CESAER (Conference of European Schools for Advanced Engineering Education and Research)
Jérome BOBIN	CEA (Commissariat à l'énergie atomique et aux énergies alternatives)
Beatrix BUSSE	Coimbra Group
Nicola Francesco DOTTI	Science Europe
Chris HANKIN	Association for Computing Machinery (ACM)
Fredrik HEINTZ	Adra / Linköping University
Hans-Christian HOPPE	ParTec AG
Louiza KALOKAIRINOU	ELIXIR

Jean-Pierre PANZIERA	ETP4HPC (European Technology Platform for High Performance Computing)
Maxime RICARD	Allied for Startups
Johan ROORYCK	cOALition S
Birgit SCHMIDT	LIBER (Association of European Research Libraries)
Ondrej SOCUVKA	Google EU
Tim UEBELEN	BayFOR (Bavarian Research Alliance)
Raquel VEGA RUBIO	YERUN (Young European Research Universities Network)
Sameer VELANKAR	EMBL (European Molecular Biology Laboratory)
Benjamin WHITE	IFLA (International Federation of Library Associations)

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Artificial Intelligence (AI) technologies are one of the most disruptive general purpose applications at the service of research and innovation. It acts as a catalyst for scientific breakthroughs and is rapidly becoming a key instrument in the scientific process in all areas of research.

In this Scientific Opinion (SO) the Group of Chief Scientific Advisors examines how the European Commission can accelerate the responsible take-up of artificial intelligence in science in the European Union. It focuses on a responsible uptake of AI in science – including providing access to high-quality AI, respecting European values, and strengthening the position of Europe in science to boost innovation and prosperity in the EU.

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